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Thursday 08 July, 2021

Biomechanical Comparison of Locking and Non-locking Constructs in a Feline Ilial Fracture Model – an ex vivo Cadaveric Study

Paulick PL[1], Knell KSC[1], Smolders SLA[1], Pozzi PA*[1], Ferguson FSJ[2], Schmierer SPA*[1]*

[1]Vetsuisse University of Zurich, Zurich, Switzerland, [2]ETH Zurich, Institute for Biomechanics, Zurich, Switzerland.

Introduction
Screw loosening after lateral plating of feline ilial fractures is a frequent complication (50%). The purpose of the study was to analyze the biomechanical behavior of four commonly used locking plate systems and one non-locking plate system.

Material and Methods
A standardized simple oblique ilial fracture was created on fifty feline cadaveric hemipelves. Fractures were fixed with straight plating systems, resulting in the following groups (n = 10 in each): (1) Advanced Locking Plate System (ALPS 5); (2) Advanced Locking Plate System (ALPS 6.5); (3) Locking Compression Plate (LCP 2.0); (4) FIXIN (FIXIN 1.9-2.5 Series) and (5) Dynamic Compression Plate (DCP 2.0). Stepwise sinusoidal cyclic loading was applied, until failure (10 mm displacement).

Results
All groups showed superior construct stiffness compared to ALPS 5 specimens ($P < .05$). Locking plate specimens (except ALPS 5) withstood more cycles ($P < .05$) to higher loads (5-, 10 mm displacement) compared to DCP constructs. Screw loosening was the predominant mode of failure with non-locking specimens (10/10), whereas bone slicing occurred consistently in locking plate constructs.

Discussion/Conclusion
Locking fixation groups (except ALPS 5) showed higher resistance to cycling than non-locking groups, especially at higher loads. Non-locking implants may be reserved for dorsal plating or low-risk conditions.

Long-term clinical outcome and osteoarthritis score for 54 dogs affected by osteochondritis dissecans of the humeral head treated with arthroscopic debridement or not: a retrospective multi-center study.

Job C[1], Caron A[2], Cachon T*[3], Carozzo C*[3], Viguier E*[3], Deprey J[3], Brincin M[2], Guillemot A[2], Maitre P*[1], Bureau S*[1]*

[1]Clinique vétérinaire Alliance, Bordeaux, France, [2]CHV Atlantia, Nantes, France, [3]VetAgroSup, Marcy l'Etoile, France.

Introduction
The purpose of this study was to assess the long-term clinical outcome and osteoarthritis score (OAS) for dogs diagnosed radiographically with humeral head OCD (HHOCD), and treated with arthroscopic debridement in clinical cases, or not treated in the absence of clinical signs.

Materials and Methods
Medical records of dogs that had a radiographic diagnosis of HHOCD at 3 institutions between 2011 and 2019 were reviewed. The long-term follow-up was based on completion of CBPI and LOAD questionnaires and, when possible, an orthopedic exam and bilateral shoulder radiographs.

Results
The diagnosis was made in 121 shoulders (93 dogs) of which 114 joints were managed arthroscopically. Long-term follow-up (median time 34 months) was obtained for 54 dogs (60 arthroscopic procedures). An excellent / good long-term outcome was obtained after arthroscopy in 98% of dogs with a minimal OAS. For 5 non-treated shoulders reviewed clinically, 80% were lame and moderate / severe OAS was noted in 80%.

Discussion/conclusion
Arthroscopic debridement is an effective method to treat HHOCD, with a good long-term outcome. This treatment should be considered despite the absence of clinical signs at the time of diagnosis.

Micro-computed tomographic (Micro-CT) assessment of different contrast preparations for canine cadaveric microangiographic assessment of the hindlimbs

*Inness PRP, Hall E, Johnson KA**

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Introduction
A reliable method of microvascular identification is essential for quantitative assessment. Barium sulfate is utilised for ex-vivo Micro-CT assessment without sample processing with resin, producing more accurate quantitative vascular measurements. Degree of perfusion, intensity and homogeneity are all important characteristics. The use of Micro-CT to obtain quantifiable vascular measurements in dogs has not been reported. The aim of this study was to identify the ideal preparation for perfusion and quantitative vascular assessment of intraosseous microvasculature in dogs.

Materials/Methods
Cadaveric specimens were perfused with Barium+Saline (BSS), Barium+Gelatine (BSG) or Barium+Resin (BSS+R) solutions, with hindlimbs sectioned for micro-CT assessment.
Homogeneity and Intensity (n=20) - Assessment via Mean Signal Intensity and Coefficient of Variation [vessels >1mm^2, 0.3mm^2-1mm^2 and <0.2mm^2].
Intraosseous perfusion (n=12) - Assessment of metaphyseal and diaphyseal intraosseous vessels within the femur, tibia and patella (< 200µm) – Vessel size identification and distribution.

Results
BSS and BSG exhibited greater mean intensity compared with BSS+R (P=<0.001) across all vessel sizes, with BSG producing the most homogenous solution. Both BSS and BSG outperformed BSS+R by at least two-fold. All solutions enabled identification of intraosseous vessels down to two scan voxels in diameter, with BSS exhibiting the smallest mean vessel size, greatest proportion (P<0.001) and number of different sized vessels <100µm.

Conclusion
The resin solution performed poorly within all characteristics. BSS and BSG produce a more homogenous solution; with a higher mean intensity across all vessel sizes. BSS provided the greatest identification of intraosseous microvasculature, and is therefore the most appropriate solution for quantitative intraosseous microvascular assessment.

Comparison of canine femoral torsion measurements using the axial and biplanar methods on 3-dimensional volumetric reconstructions of computed tomography images

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[1]AniCura Diergeneeskundig Verwijscentrum Dordrecht en Haagelanden, Dordrecht, Netherlands,
[2]Cummings School of Veterinary Medicine, Tufts University, North Grafton, MA, USA.

Objective
To compare the measurement of femoral torsion using the axial measurement method (AMM) and the biplanar measurement method (BMM) on 3-dimensional volumetric reconstructions of computed tomographic images (3D-CT) to a reference standard using stereolithographic bone models (SBM)

Study design
Ex vivo study.

Sample populations
3D-CT and SBM from 23 femurs of 14 dogs with hind limb lameness presented for orthopedic evaluation.

Methods
3D-CT and SBM of each femur were created from CT-scan data. Femoral torsion was measured using the AMM on 3D-CT [AMM (CT)] and the BMM on 3D-CT [BMM (CT)] and compared to a reference standard, the AMM on SBM [AMM (SBM)].

Results
No significant differences were noted between the measurement methods. Mean measurement of FT using the AMM (CT) was 32.8 +/- 7.7 degrees; the BMM (CT) was 37.7 +/- 7.4 degrees, and the AMM (SBM) was 32.1 +/- 9.2 degrees.

Conclusion
No significant differences exist between the AMM (CT), the BMM (CT) and the AMM (SBM).

Clinical significance. Both AMM (CT) and BMM (CT) can be used to measure femoral torsion in dogs with orthopedic disease.

Effect of working length and plate-bone distance on 2.0mm locking construct stiffness in a diaphyseal fracture gap model

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Objectives
To determine the effect of working length and plate-bone distance on 2.0 mm locking compression plate (LCP) stiffness in 4-point bending and torsion in a fracture gap model.

Study Design
In vitro biomechanical study

Materials & Methods
A mid-diaphyseal fracture gap model of delrin tubing stabilised with a 12-hole 2.0mm LCP with three bicortical screws per fragment and a 6mm fracture gap was tested over three different working lengths (WL) and three different plate-bone distances (PBD). Six constructs of each configuration were tested (n=54) in 4-point compression bending and torsion to determine overall construct stiffness. Comparison between configurations was evaluated with a 2-way ANOVA.

Results
In compression, there was a significant effect of working length ($P<0.0001$), with increasing working length resulting in decreased stiffness, however there was no effect of increasing plate-bone distance on construct stiffness. In torsion, a significant effect of both plate-bone distance and working length was observed. For the shortest and longest working length, the stiffness was significantly lower for the larger plate-bone distance ($P<0.0001$, and $P=0.047$, respectively). For each plate-bone distance, there was an incremental decrease in construct stiffness as working length increased ($P<0.0001$).

Conclusion
In this model, increasing the working length decreased construct stiffness in both compression bending and torsion. Increasing the plate-bone distance decreased construct stiffness in torsion, but not compression bending.

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Effect of Osteotomy and Plate Orientation on Rock-Back Following Tibial Plateau Leveling Osteotomy Using a Tibial Gap Model

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Introduction
While rock-back (RB) is a known TPLO complication, its cause has not been elucidated. We proposed that RB is affected by 1) osteotomy orientation with respect to the caudal tibial cortex (uphill, normal and downhill) and 2) plate inclination with respect to the tibial mechanical axis (parallel. i.e. straight, and inclined). We hypothesized that greatest and smallest RB would result from the combination of a downhill osteotomy with an inclined plate and an uphill osteotomy with a straight (parallel) plate, respectively.

Materials and Methods
Tibial bone models were 3D printed from CT images of a 26kg dog with a 26-degree TPA. Models featured one of the 3 osteotomies with a 1mm interfragmentary gap. For each osteotomy, a 2.7mm TPLO plate (DePuy-Synthes) was applied either parallel to or at a 20-degree angle to the tibial mechanical axis. Specimens were cyclically loaded to ~400N using a custom press. Electromagnetic sensors affixed to the tibial plateau and crest were used to compare tibial plateau RB about the mediolateral axis.

Results
Within each osteotomy group, RB was ~1.5 times greater with inclined than straight plates ($p<0.0001$). Conversely, the orientation of the osteotomy had no significant effect on RB.

Discussion/Conclusions
Our findings suggest that our model can replicate RB seen in vivo and that RB likely results from an accentuated disruptive force couple generated by an inclined plate as compared to a plate placed parallel to the tibial mechanical axis.

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CT evaluation of completeness of arthroscopic subtotal coronoidectomy for treatment of canine medial coronoid disease

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Introduction
Arthroscopy is the treatment of choice for medial coronoid disease (MCD), it bears the risk of inadvertent incomplete removal of the pathologic medial coronoid process (MCP). The aim of this study was to evaluate completeness of medial coronoid debridement and to detect the most vulnerable locations of failure.

Material and Methods
Client owned dogs diagnosed with MCD were prospectively included in this study. Diagnosis of MCD was confirmed and MCP lesions were classified by computed tomography. Arthroscopic debridement of the diseased MCP was performed and a post-operative CT was made to evaluate completeness of removal of pathologic lesions.

Results
Pathologic changes were confined to the coronoid apex in 57.6% or combined with radial incisure lesions in 42.4% of cases. Post-operatively, apical lesions were completely removed in 71.7%, radial incisure lesions in 5.1% of cases. Bony remnants were detected in 72.8%; they were located at the tip of the MCP (46%), at the base of the MCP (23.9%), free within the elbow joint (9%), and/or within the instrument portal (84%). Pathologic changes observed on CT classified as fissures were positively associated with the occurrence of bony remnants ($p = 0.038$), and a 37% higher probability was found for incomplete removal of radial incisure lesions ($p = 0.001$).

Discussion and Conclusion
In this study incomplete removal of radial incisure lesions was most commonly observed, therefore this region is highly recommended to be thoroughly assessed during arthroscopy.

Modified Fulkerson Procedure (MFP): A potential new osteotomy technique to treat concurrent cranial cruciate ligament disease and medial patella luxation in dogs.

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Objective
To report the theoretical morphometric effects of an oblique tibial tuberosity osteotomy to achieve combined tibial tuberosity advancement (TTA) and transposition based on the Fulkerson and TTA procedures, and to investigate whether this oblique osteotomy can be accurately, repeatedly, and reliably performed freehand.

Study design
Ex-vivo study and computer simulation

Methods
Computer simulation was used to calculate the theoretical advancement and lateral translation of the tibial tuberosity using a combination of tibial tuberosity advancement with a modification of the traditional osteotomy angle plane (Fulkerson osteotomy at 25, 30 and 35 degrees) causing an advancement and lateral displacement of the tibial tuberosity. In the ex-vivo studio, preoperative and postoperative CT measurements from cadaveric specimens were reviewed to evaluate the accuracy and repeatability to create a 30 degree freehand tibial tuberosity oblique osteotomy.

Results
In the theoretical trigonometric model, for a given osteotomy angle, we obtained the percentages of lateralization and cranialization acheived when an advancement is performed parallel to the oblique osteotomy. For angles of 25º: 42.3% and 90.7%; 30º: 50.0% and 86.7%; 35º: 57.3% and 82%, of lateral displacement and cranial advancement were acheived, respectively. The mean actual freehand oblique osteotomy angulation was 32.27º +/- 3.4º, this was considered to be statistically significantly different from the intended 30º planned osteotomy (p=0.03).

Clinical Significance
A predictable and measurable tibial tuberosity cranio-lateralisation can be potentially achieved when performing a Modified Fulkerson Procedure (MFP). The use of custom-made cutting guides should be investigated in order to improve the accuracy and predictability of the results.

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Mechanical contribution of the fibula to torsional stiffness and strength of the canine crus.

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Introduction
In humans, the fibula was found to provide a small role in axial compression and torsional stability. To our knowledge, no experimental data are available regarding the mechanical contribution of the fibula to torsional stiffness and strength of the canine crus.

Materials and Methods
Thirteen specimens were divided into 2 groups and submitted to external torsional load until failure.
Group I: *Phase 1*: tibia and fibula intact. *Phase 2*: fibula intact after tibia had fractured.
Group II: 1cm proximal ostectomy of the fibula, with tibia intact.
Specimens were tested at a constant 0.2 degree/second rate. Working length and diameter of bones were measured. Torque and twist angle at failure were reported. Twist angle relative to working length and torsional stiffness were calculated. A Wilcoxon test was used to compare group I to group II. A p-value<0.05 was considered significant.

Results
Torque at failure of the fibula represented 6% of the torque of the tibia and fibula combined. No significant differences were found between groups I and II for twist angle relative to working length, ultimate torsional strength, ultimate twist angle and torsional stiffness.

Discussion / Conclusion
The twist angle at failure of the tibia of all specimens was comparable to data already published. The twist angle at failure of the fibula was much higher than the values reported in the literature. In the canine crus, the contribution of the fibula to torsional strength and stiffness does not seem to be significant.

Comparative kinematic evaluation of TPLO and TPLO combined with extra-articular stabilization: a biomechanical study

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Introduction
Pivot shift, a phenomenon describing rotational and translational stifle instability, has been reported as a cause of ongoing lameness in dogs after TPLO, and has encouraged surgeons to combine TPLO with an extra-articular lateral stabilization in selected cases, such as hyperlax stifles. At present, no clinical tests evaluate combined rotational and craniocaudal instability.

Material and Methods
Traditional tibial compression test (TCT), and TCT combined with an external (pTCText) and internal (pTCTint) rotational moment were performed on cadaveric hind limbs. Kinetic and 3D-kinematic data were collected and compared between the conditions 1) intact 2) cranial cruciate ligament deficient 3) TPLO and 4) TPLO combined with lateral suture augmentation (TPLO-IB).

Results
TCT did not detected a difference in cranial tibial translation when comparing intact to TPLO ($p = 0.17$), while pTCText and pTCTint resulted in greater translation after TPLO ($p < 0.001$). Cranial translation with TCT, pTCText and pTCTint was not different between intact and TPLO-IB. pTCText led to internal tibial rotation relative to the starting point, and was greater in TPLO compared to intact ($p = 0.002$), but not different between intact and TPLO-IB ($p = 1$).

Conclusion/Discussion
Our results provide evidence that, in contrast to traditional TCT, a rotational moment combined with TCT leads to severe cranio-caudal and rotational instability in TPLO-stabilized stifles. TPLO-IB neutralized both cranial tibial thrust and internal rotational instability when performing any of the tests. Further clinical studies should evaluate the application of these new tests in the assessment of rotational stability before and after TPLO.

Comparison of conventional ligatures and a vessel sealing device during open ovariohysterectomy in rabbits

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Objectives
To compare surgical times, perioperative complications and outcome whilst performing ovariohysterectomy (OVH) using 3-0 Glycomer 631 (Biosyn, Medtronic, Minneapolis) conventional ligatures (CL) or a vessel sealing device (LigaSure Dolphin Tip 5-mm, Medtronic, Minneapolis) (LS5) to achieve hemostasis in intact rabbits.

Study design
Prospective clinical single centre study. Animal population: 23 female rabbits randomly assigned to the CL group (n=12) or the LS5 group (n=11).

Methods
Overall surgical times (OST), uterine resection times (URT), perioperative complications were recorded. Clinical evaluations were performed two weeks postoperatively. The surgical times were compared using Student's t-tests ($p<0.05$). Intra and postoperative complications were compared using Fisher's exact tests ($p<0.05$).

Results
OST was 14.1 +/- 4.4 minutes. URT were significantly shorter in the LS5 group than in the CL group (5.3 +/- 1.7 minutes versus 4.8 +/- 0.9 minutes; $p=0.004$). No intraoperative complication was encountered in the LS5 group. Bleeding occurred in 3 cases in the CL group. One rabbit in the LS5 group developed steatonecrosis one month postoperatively.

Conclusion
The use of a L5S to perform open OVH was associated with shorter surgical times compared to the use of ligatures. No intraoperative bleeding developed with the LS5.

Clinical significance: A LS5 significantly reduces surgical time of open OVH in intact rabbits whilst providing both safe and efficient hemostasis.

Effect of patient positioning on retrieval of cystoliths by percutaneous cystolithotomy in dogs.

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Introduction
Percutaneous cystolithotomy (PCCL) is a minimally-invasive technique for removal of cystoliths. There is currently no information regarding optimum patient positioning during PCCL. The objective of this study was to assess whether patient positioning affected ease of cystolith retrieval via PCCL.

Materials and Methods
PCCL was performed to retrieve 10 artificial “cystoliths” in 3 canine cadavers. “Cystolith” retrieval was performed by retrograde flushing and use of a flexible stone basket, with the dog in 10o Trendelenburg, 10o reverse Trendelenburg, or neutral position. The location of the “cystoliths”, number retrieved during flushing, and total time for retrieval were recorded and compared between positions.

Results
The mean total time for “cystolith” retrieval was 392 ±131s, with 162 ±20s for flushing and 221 ±123s for basket-retrieval. The mean number of “cystoliths” retrieved via flushing was 3 ±2. No significant differences were detected when comparing retrieval times between different positions. The predominant location of the “cystoliths” within the bladder varied depending on the position of the dog. In neutral, 93% were located adjacent to the ureteric openings, in 10o reverse Trendelenburg, 100% were located by the urethral orifice and in 10o Trendelenburg, 60% “cystoliths” were at the tip of the cannula.

Discussion/Conclusion
Cystolith retrieval during PCCL can be performed in either neutral, Trendelenburg or reverse Trendelenburg position. Changing the dog’s position may be useful in cases where cystolith retrieval is challenging, to move the cystoliths to a more optimal position.

Histologically tumour-free margins following planned marginal excision of soft-tissue sarcomas and mast cell tumours with intent for radiotherapy

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Objectives
To report the rate of histologically complete margins (using the residual tumour classification scheme) following planned marginal resection of soft-tissue sarcomas and mast cell tumours in dogs where follow-up radiotherapy was intended.

Methods
Clinical records at a single specialist referral centre were reviewed retrospectively to identify dogs undergoing planned marginal excision with intent for subsequent radiotherapy (2016-2019). Referring vets were contacted for follow-up. Slides were retrospectively reviewed by a single pathologist.

Results
Data for 47 planned marginal excisions were included in the study. 31/47 (66%) surgeries resulted in histologically complete margins. Use of wider (10mm) surgical margins resulted in a significantly greater likelihood of complete excision of MCT (93% vs 44% completely excised, $P<0.02$) but not STS (57% vs 59% completely excised, $P=1$). Use of the residual tumour classification scheme reduced subjectivity of histopathological reporting. Radiotherapy was not indicated in 62% of cases in which it was originally intended. The overall rates of recurrence (14%) and tumour related death (6%) were low.

Significance
Planned marginal excision, ideally comprising a 10mm lateral margin and a deep fascial plane, remains a good option for management of low-grade peripheral soft tissue sarcomas and mast cell tumours when other options are not available, with a low rate of complications, recurrence, tumour related death, and subsequent radiotherapy.

Comparison of a single-access glove port with a SILS™ port in a surgical simulator model using MISTELS

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Introduction
Recent advances in laparoscopy have looked at means of being less invasive by using single-port access surgery (SPAS) as opposed to multiport access surgery. The glove port has gained popularity as a cost-effective alternative to commercially available single-port access devices. The primary aim of this study was to compare the glove port to the SILS™ port in a simulator model using the first two MISTELS (McGill inanimate system for training and evaluation of laparoscopic skills) tasks (peg transfer and pattern cutting). A secondary aim was to compare these ports to conventional two-port laparoscopy.

Materials and Methods
Twenty-two novices were enrolled in this experimental study. They performed the first two MISTELS tasks using two-port laparoscopy followed by completion of the tasks using both single ports, in a random order. A self-evaluation questionnaire was completed by each participant. Scores were calculated using task completion time and errors.

Results
Significantly ($p < 0.05$) higher scores were achieved using the glove port compared to the SILS™ port. Participants achieved higher scores when using two-port laparoscopy compared to SPAS; however, only the score differences between the two-port laparoscopy and the SILS™ port were found to be statistically significant. The SILS™ port was classified as exceedingly difficult to use and received the lowest ranking.

Conclusions
Participants consistently achieved significantly higher task scores when performing the first two MISTELS tasks using the glove port compared to the SILS™ port. Neither of the single ports could match the performance scores achieved by two-port laparoscopy.

Comparison of outcome between dogs with gastric dilatation volvulus syndrome surgically treated immediately after a brief resuscitation or after a prolonged fluid resuscitation.

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Objective
To compare the outcome of dogs surgically treated for gastric dilatation volvulus (GDV) after a short medical resuscitation and dogs treated after a long medical resuscitation.

Study Design
Prospective cohort study, mono-institutional.
Sample population: 164 dogs with GDV (n=89 treated >90min, n=74 treated >6h).

Methods
One group of dogs (IMMEDIATE) was operated once estimated stable after a short medical resuscitation (at least 90 minutes), whereas in the other group (DELAYED) dogs were surgically treated after at least a 6-hour resuscitation. Most data reported as prognostic factors in previous studies were monitored constantly during hospitalization. Survival to discharge and one month postoperatively were recorded.

Results
Survival rate was not significantly different between IMMEDIATE and DELAYED dogs at discharge (78% and 82% respectively, P=0,54) and at one month postoperatively (76% and 77% respectively, P=0,92). In the DELAYED group more 0 degree and less 180- and 270-degree torsions were observed (P=0,007) and the stomachs presented more discrete lesions compared to dogs in the IMMEDAITE group(P=0,026). Dogs in the IMMEDIATE group where significantly more likely to die during anesthesia compared to the dogs operated later (P=0,007). High lactatemia after resuscitation, extensive gastric lesions at surgery and additional procedure to gastropexy were associated with an increased mortality risk.

Conclusion
Dogs surgically treated after at least a 6-hour resuscitation do not carry a significantly worse prognosis compared to dogs treated after a 90-minute resuscitation.
Clinical relevance: These results may suggest that GDV syndrome is a medical emergency but not a surgical one.

Long-term outcome of surgical treatment of perineal hernia in 36 cats (2013-2019)

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Introduction
Perineal hernia is a well-defined condition in dogs. This report aims to describe the clinical presentation and long-term outcome after herniorrhaphy in cats.

Materials and Methods
Retrospective study of cats treated with internal obturator muscle transposition (2013-2019).

Results
Thirty-six cats were included. Thirty-four had bilateral perineal hernias. 58% were Domestic Shorthairs. Maine Coons were significantly younger on presentation (p=0.017). One cat had a rectal prolapse at 48 hours post-operatively. Twelve cats (33%) experienced short-term post-operative tenesmus. This resolved in 9 cats, 3 cats had persistent tenesmus secondary to megacolon. A subtotal colectomy was advised in these cats but declined by 2 owners. Three cats required herniorrhaphy after subtotal colectomy to manage tenesmus. Long-term follow-up (> 6 months) was available for 31 cats (86%). 24/31 (77%) were free from clinical signs. 10/31 (32%) received stool softeners on a daily basis. Four (13%) with evidence of megacolon were treated with a prokinetic. Fifteen cats had a distended colon pre-operatively, 11 of these cats had a good outcome after herniorrhaphy. Twenty-four owners (77%) scored the final surgical result as good, 7 owners (23%) scored the final result as fair but with an improvement in quality of life.

Discussion/Conclusions
Perineal hernia should be considered in cats presenting with tenesmus or recurrent constipation. When patients are selected appropriately, surgical repair of perineal hernia in cats results in a good long-term outcome.

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Comparison of median sternotomy closure-related complication rates using wire and suture in dogs: a multicentric retrospective study

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Objective
To determine and compare the incidence of closure-related complications following median sternotomy (MS) closure using sutures or wires in dogs.

Methods
Medical records of dogs with MS between January 1, 2004 to August 1, 2020 were examined across nine referral centres. Signalment, clinical presentation, surgery, patient outcomes and complications were recorded and rated (Accordion Severity Classification). Follow-up was performed via patient records and email/ telephone contact. Descriptive statistics, logistic regression and treatment effect analysis were performed.

Results
Data on 331 dogs were collected, 68 were excluded. MS closure was performed with wire in 115 dogs (21 dogs <20 kg and 94 ≥20 kg) and suture in 148 (62<20 kg and 86 ≥20 kg). Main indications for MS were pneumothorax (85), pyothorax (90), mass removal (70) and traumatic injury (11). Thirty-seven dogs experienced closure-related complications (14.1%), 20 in the wire group and 17 in the suture group. Twenty-two were listed as mild, four as moderate and 11 as severe. No complication-related deaths were noted. Treatment effect analysis showed a 1.8% reduction in closure-related complications associated with using suture vs. wire [95%CI: -8.6% to +5.1%]. In multivariable logistic regression the only factor associated with increased risk of closure-related complications was dog size (P= 0.01). The effect of this risk factor was not influenced by the type of closure (interaction term: OR=0.99 [95%CI:0.96/1.01]).

Conclusion
The closure-related complication rate after MS was low. The risk of developing a closure-related complication was equivalent between sutures and wires independent of dog size.

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Intraoral approach for zygomatic sialoadenectomy in dogs: an ex-vivo study

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Introduction
Surgical removal of the zygomatic salivary gland is challenging due to its anatomical location. The current recommended approach to zygomatic sialoadenectomy is via lateral orbitotomy with osteotomy of the zygomatic arch while preserving the insertion site of masseter muscle. An intraoral approach was evaluated as an alternative technique.

Material and Methods
Bilateral zygomatic sialoadenectomies were performed in 10 canine cadavers; one side by an intraoral approach and the contralateral by lateral orbitotomy. For the intraoral approach, the dogs were positioned in dorsal recumbency, with their hard palates in a horizontal position. A 3 cm caudomedially oriented sharp incision was made in the oral mucosa caudal to the 2nd maxillary molar tooth; the remaining dissection was blunt. Surgical time and challenges were recorded. Wilcoxon signed-rank tests were used.

Results
Removal of the entire zygomatic salivary gland was successful in all dogs with the exception of two specimens in which remnant tissues were present after performing the intraoral approach. Zygomatic sialoadenectomy was significantly shorter by an intra-oral approach than by lateral orbitotomy (41.98 (33.47-49.55) versus 65.70 (54.93-76.38) minutes; $P < 0.005$).

Discussion/Conclusions
We demonstrate that zygomatic sialoadenectomy can be approached via the oral cavity. Since the zygomatic salivary gland lies for the greater part against the floor of the orbit, we hypothesized that this novel approach may offer several advantages. The intraoral approach results in minimal need for tissue dissection as compared to the lateral extraoral approach and is significantly faster. Intra-operative visibility proved good and the approach was relatively easy.

Outcome for septic peritonitis in cats treated surgically in the United Kingdom

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Introduction
There are a limited number of studies evaluating septic peritonitis (SP) in cats and survival rates of between 20-70% are described. The aim of this study was to review the cause, management and outcome of SP in cats and investigate factors affecting survival.

Materials and Methods
Records from ten UK referral hospitals were retrospectively reviewed (2008-2018). Survival to discharge was used as the outcome measure. Serum albumin, glucose, lactate and ionised calcium concentration; presence of intraoperative hypotension and correct empirical antibiosis were analysed via logistic regression for association with survival.

Results
Ninety-five cats were included of 123 identified. The overall survival rate was 66%. Lethargy (89%) and anorexia (74%) were the most common clinical signs and gastrointestinal tract leakage was the most common cause. The presence of an abdominal mass on clinical examination was not strongly predictive of presence of neoplasia on histology and did not confer a worse prognosis. Cats presenting with enterotomy/enterectomy dehiscence did not have a worse prognosis than those presenting with other aetiologies. Intraoperative hypotension (odds ratio 0.173, 95% confidence intervals 0.034 to 0.866, P=0.033) was associated with non-survival. Cats surviving beyond 1 day postoperatively had an improved likelihood of survival (87.5%). All cats that survived beyond 6 days were successfully discharged.

Discussion and conclusions
This study represents the largest group of cats with SP, with an overall survival rate of 66%. The presence of an abdominal mass on clinical examination or having dehiscence of a previous gastrointestinal surgery did not confer a worse prognosis.

Long-term outcomes following cholecystectomy in cats

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Objectives
To describe the clinical presentation, treatments and long-term outcomes following cholecystectomy in cats.

Methods
Clinical records were retrospectively reviewed for cats undergoing cholecystectomy between 2005-2020. An owner questionnaire assessed long-term outcomes.

Results
Twenty-two cats were identified. Vomiting, jaundice and abdominal pain were the most common clinical signs; median duration of signs was four days (range, 1-21). Cholelithiasis was the indication for cholecystectomy in 16/22 cats, followed by an abnormally thickened gall bladder causing obstruction (4), an obstructive cystic duct lesion (1) and traumatic biliary rupture (1). Concomitant duodenotomy and choledochal stent placement were performed in 19 and seven cats respectively. Intraoperative hypotension was recorded in 18 cats and perioperative anaemia developed in 11 cats with seven requiring a blood transfusion. Cardiopulmonary arrest occurred in six cats within four hours of anaesthetic recovery, resulting in the death of five.
Seventeen cats survived to discharge. Long-term follow-up was available for 15 cats at a median of 1079 days (range, 218-4995). The most common short- and long-term postoperative complication was recurrent vomiting, in four and six cats respectively.
One cat was euthanized 14 days postoperatively due to clinical deterioration, four were euthanised for unrelated reasons and four were lost to further follow-up.
Owners assessed postoperative outcome as excellent in all cats and quality of life as excellent or good.

Conclusions
Cats undergoing cholecystectomy that survive to discharge can have an excellent long-term prognosis. Long-term owner evaluation of clinical outcome was considered excellent.

Small Animals

Current strategies for:

Friday 09 July, 2021

Current strategies for dealing with critical bone defects / non-union

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My background in this area
Recently I was a member of a group of clinicians and bioengineers at the University of Glasgow who are developing a novel system for managing critical-sized bone defects. The novel system uses plasma polymerisation to coat allogenic bone chips or hydroxyapatite/tricalcium phosphate granules with the polymer poly (ethyl acrylate) (PEA). Fibronectin is then adsorbed to the PEA coated surface of the graft material. Fibronectin adsorbed to PEA maintains a fibrillar conformation and will bind bone morphogenetic protein-2 (BMP-2), facilitating efficient delivery of an ultra-low dose of growth factor to sites of problematic bone healing. A low BMP-2 dose may reduce the potential for adverse effects, and treatment cost. Three small animal clinical cases treated using this system (in combination with autograft), will be briefly described.

The problem
Non-union of bone fractures is an uncommon occurrence in dogs, cats and humans. Critical-sized bone defects are more rare still, and note that all critical-sized bone defects are non-unions, but the reverse is not true. Critical-sized defects are most commonly caused by severe trauma, infection or tumour resection. I will review defects caused by the first two. In humans, multiple factors influence whether a bone defect will heal spontaneously, or not: the bone affected, the region of the bone, health of the soft tissue envelope, patient age, comorbidities such as diabetes and obesity, smoking and non-steroidal anti-inflammatory drugs. Some of these are almost certainly relevant in small animals, together with breed and species, but further investigation of risk factors for non-union in dogs and cats is warranted. Because multiple factors determine whether a bone defect will heal spontaneously, defining “critical-sized” by size alone is problematic and a clinical judgement must be made. In the human tibial diaphysis, 2.5cm is thought to be a useful threshold, above which a defect is unlikely to heal, but this measurement is specific to one region of one bone. A clinical definition of “critical-sized defect” is one which will not heal, despite stabilisation, without specific management of the gap between fracture surfaces.

Solutions
Critical-sized bone defects have been managed successfully using many methods, and the literature contains impressive case reports and series. I have focused on management techniques that are clinically accessible (rather than experimental). *Autogenous bone grafting* remains a gold-standard osteogenic, osteoinductive and osteoconductive method, but may cause patient morbidity, has a limited supply, and increases anaesthetic and surgical time. The *induced membrane or Masquelet technique* utilises cancellous graft to fill the defect, but first manages an infected fracture site by inducing formation of a highly vascular and osteogenic membrane around a polymethyl methacrylate plug or spacer. The induced membrane contains and prevents resorption of the cancellous autograft, with a positive effect on bone healing. *Allografts* may be cortical or cancellous bone, and fill a defect with osteoconductive material. *Demineralised bone matrix* is an osteoinductive allograft material but does not provide structural support. *Ceramics* such as hydroxyapatite/tricalcium phosphate composites are osteoconductive, synthetic alternatives to allogenic bone products. *Platelet rich plasma* and *bone marrow aspirate concentrate* have been used as osteoinductive and osteogenic adjuncts respectively, alongside osteoconductive materials. *Bone morphogenetic protein-2* (BMP-2) has received much interest as a powerful osteoinductive growth factor that is manufactured using recombinant technology and is available in Europe as InductOs®. The question of whether BMP-2 can completely replace

autografting remains to be answered, and safety concerns have been raised in humans. Nevertheless, recent canine case reports demonstrate the undoubted osteoinductive power of BMP-2. Finally, *distraction osteogenesis* can bridge critical-sized defects with highly vascular bone that is resistant to infection. This treatment can be prolonged, and non-union at the docking site may still require bone grafting.

Conclusions

Critical-sized bone defects can be managed in a variety of ways, and at present no single technique can be considered superior. In clinical practice each critical-sized defect and patient is unique. I suggest considering a number of the published solutions, and combining ingredients for successful union, and recovery of the patient: stability, vascularity, eradication of infection, osteogenesis, osteoinduction, osteoconduction, acceptable patient risk and morbidity, early patient mobilisation and management of significant patient co-morbidities where possible.

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Dealing with cartilage defects

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When dealing with cartilage defects, we have to distinguish two entities of defects: (1) defects as a consequent of osteochondritis dissecans (OCD) in juvenile dogs and (2) degenerative defects, as the consequence of some form of mechanical disease, inducing accelerated wear of hyaline joint cartilage over time. The latter occurs mostly in older dogs, but excessive forms of hip or elbow dysplasia for example, can wear of a joint already before the patient reaches maturity.

Basically, hyaline cartilage defects can be treated using one of the 4 R's:

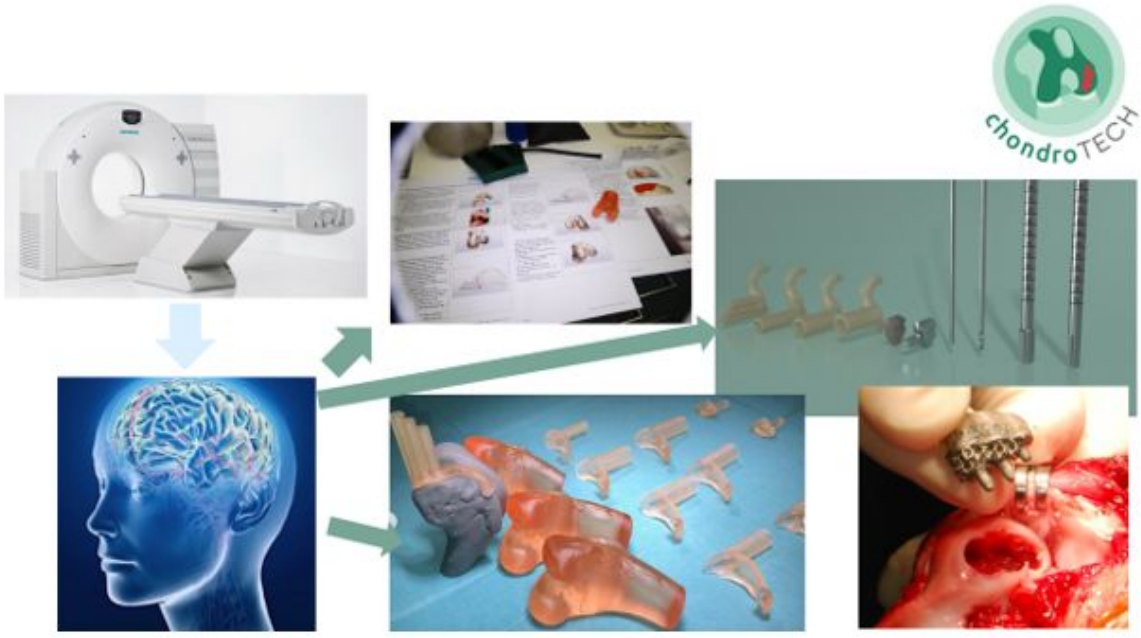
- Restored
  - Healing or regeneration of the joint surface, including the hyaline articular cartilage and the subchondral bone
- Replaced
  - Allograft or prosthesis
- Relieved
  - Osteotomy that unloads and decreases the stresses at the lesion site
- Resected
  - With or without an interposition arthroplasty

In small animal surgery, we are typically confronted with advanced stages of cartilage disease, e.g. grade 3 to 5 on the modified Outerbridge scale. In juvenile dogs with OCD, treatment is directed at restoring fibrocartilage infill of the debrided lesions site. Typically, this is done in a minimal-invasive way using arthroscopy. Unfortunately, with big lesions, located within the high pressure zones of the affected joints, functional outcome might be unsatisfactory. Especially with OCD affecting the elbow, stifle and hock joint, functional prognosis is guarded. Strategies to overcome these limitations of traditional OCD treatment comprise auto- and allograft transfer as well as synthetic resurfacing of the lesion site. Biological reconstruction should always be considered first, before using synthetic implants! However, the limitations associated with harvesting the osteochondral transplants from the stifle joint to reconstruct an OCD in the elbow or shoulder joint, have become a real concern. Therefore, either allograft transplantation or synthetic implants, both eliminating the potential risk at the donor site, have become increasingly important. With the (regulatory) restrictions in many countries associated with donation or harvesting of biological tissues from freshly euthanatized dogs, synthetic implants, closely mimicking the biomechanical characteristics of hyaline joint cartilage, might become the first choice in treating large OCD lesions within and outside of the stifle joint. Latest studies, reporting on the clinical outcome of such synthetic reconstruction in the shoulder and the stifle joint are very promising. OCD in the hock are very delicate lesions, as there is no matching donor area within the canine body, eliminating any form of autologous transplantation. Allografting in contrast, allows for anatomical reconstruction of the affected talar ridge and the associated clinical outcome is very good, at least in the short- and mid-term. Valid information on the long-term function (>5 years) for both auto- as well as allograft are not available and have only been reported anecdotal.

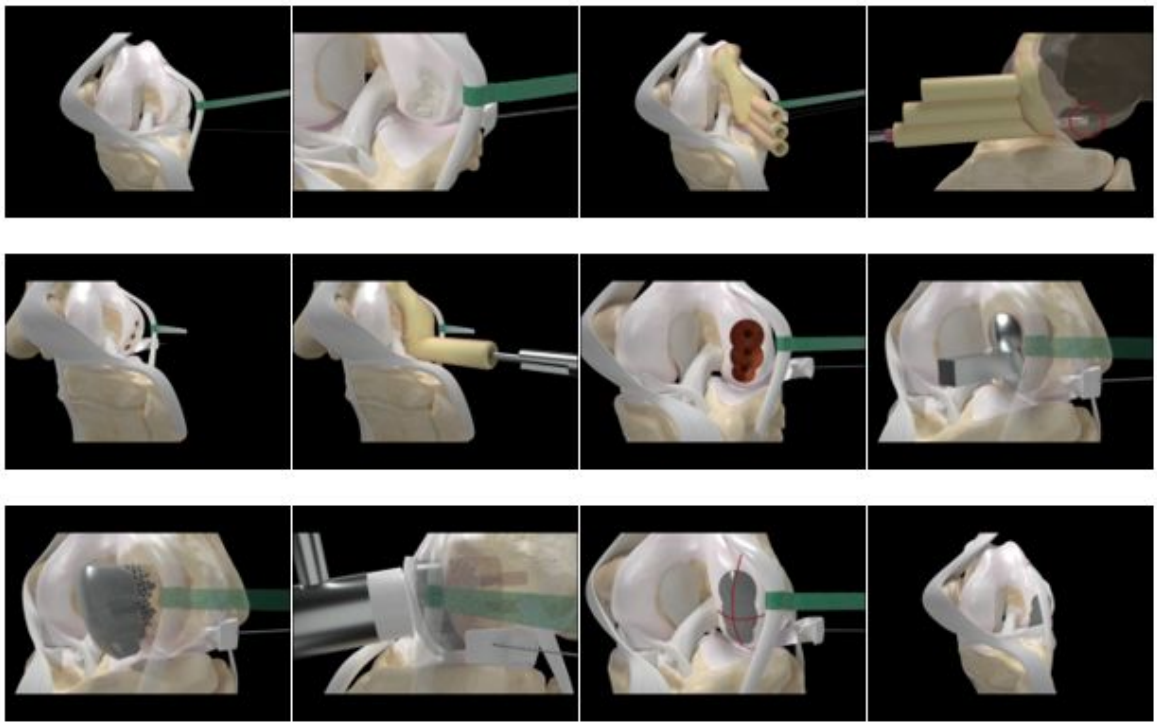
Proposed treatment algorithm for OCD lesions

1. Traditional treatment comprising debridement and induction of subchondral bone bleeding in every shoulder OCD, except for those which are located centrally and are of large size (>15 mm – in small dogs, already 10 mm may be considered large). OCD affecting the elbow or stifle joint should be resurfaced using advanced techniques.
2. The first choice for OCD resurfacing is always a biological way.
   a. Within the stifle joint for small to medium defects autografts are preferred, taken from the same joint or – preferably – an allograft to improve surface math and to eliminate all aspects of donor site morbidity.

Large defects should be approached using an allograft.
    b. Outside of the stifle joint autografts are no longer recommended, just because of potential adverse side effects at the donor stifle. Therefore, the biological resurfacing in the elbow and shoulder joint would always be an allograft, which is associated with good clinical outcome.
    c. However, allografts are not readily available and one would need specific instrumentation for harvesting; instrumentation which is different to the OATS-set.
3. With any form of biological graft, when using the established surgical techniques, matching the physiological surface contour at the recipient site will always be a challenge. Based on studies done in animal models, reconstructing the surface curvature “perfectly”, is the single most important factor for long-term function of biological grafts. Having said this, ending up with a perfect fit is the most challenging aspect of biological OCD resurfacing and usually you will rarely perform the technique perfectly. Using surgical templates for graft harvesting and drilling the recipient bed significantly improves surface match and should be considered to become standard technique.
4. For OCD affecting the talus, there is only allografting available today, as no area around the stifle joint is closely matching the curvature of the talar ridges. Basically, there is no matching donor anywhere within the patient itself. Therefore, you will have to use an allograft in every case with significant lesions size. Allografted talar OCD cases are dieing very well, and with appropriate surgical technique, surface match is excellent. The downside is once again availability of a suitale donor.
5. For those cases where an autograft nor an allograft is applicable or available, synthetic resurfacing should be considered. The single most important advantage of of the shelf synthetic osteochondral substitutes is availability. The second advantage, ease and speed of the surgical procedure. The most important limitation of synthetics is, that they are made of synthetic material, which will undergo wear and fatigue – and of course – there is no one single synthetic implant available today, which completely mimics the biomechanics of native cartilage and subchondral bone. These are the reasons, why synthetics are never the first choice.
6. For relatively symmetric (round) defects and a recipient site with a relatively flat curvature, synACART is the implant of choice. Oval lesions are not ideal for synACART, as the implants cannot be overlapped. In any way, due to the predefined shape of the implant you need perpendicular access to the lesion, which is not always possible (e.g. stifle with lesion extending far caudally).
7. For every (large) OCD affecting the talus, large oval/longitudinal lesions, areas which significant curvature (e.g. femoral condyles), and every lesion which cannot be accessed perpendicular, patient specific implants with surgical guides for proper positioning and orientation, provide a potential solution.
    a. Based on a CT-model the matching implant is designed. The physiological joint curvature is estimated either by using statistical shape models or the contralateral joint, in case the patient is affected unilaterally.
    b. A matching set of drill guides is also designed, to allow perfect replication of the simulated procedure in the OR.
    c. The appropriate reamers and guide pins are also provided – so there is no need for proper instrumentation, other than standard orthopaedic instrumentation.
    d. Plastic 3D-models of the diseased joint allow for practicing the whole procedure, including the use of the surgical guides, reaming and implantation of a trial implant, before proceeding to the real patient.
    e. The implant is composed of a titanium socket with lattice for improved bony ingrowth and a TPU cup as the gliding surface. From a material science point of view, this is very similar to a synACART.
    f. Due to the fact that implantation is fully guided by the provided drill guides (placement of the guide pins is done using the surgical guides and the depth of the following reaming procedure is controlled also), there is no need to access the lesion perpendicular. During the simulation of the procedure om the computer, the “best real-case” trajectory is defined and by using the provided drill guides everything will follow automatically.
    g. Longitudinal or “free-form” defects are approximated by overlapping holes
    h. There is no limit in matching the physiological surface contour, as everything is done for the specific case using additive prototyping.



Based on a CT (or MRI) data set of the affected joint, a medical engineer designs the patient specific implant. This includes the determination of the trajectory when reaming the recipient bed. Along with the implant, a set of guides, 3D models of the affected bone and step-by-step written instructions are provided.



Schematic drawings of the surgical steps performed when treating an extensive OCD lesion affecting the central and caudal aspect of the lateral femora condyle with a patient specific implant. Temporary release of the lateral meniscus should be avoided if possible.

When dealing with degenerative / mechanical cartilage loss, two factors have to be taken into account. (1) will the resurfacing material withstand the abrasive mechanical forces at the lesion site and (2) what about cartilage lesions affecting the matching opposing joint surface? The first point is especially important when considering biological treatments, such as fibrocartilage indication of osteochondral transplantation (either autologous or using an allograft). In human medicine, it is strictly forbidden to do any form of osteochondral resurfacing until the pathological mechanics within the joint cannot be corrected. For veterinary medicine, this means, that almost no degenerative lesion should be treated by biological means, as the replacement tissue will undergo wear in short time. This is why some form of prosthesis is usually used, either as a total or partial joint replacement. Unfortunately, beside total hip replacement,

well stablished prosthesis for the other joints with comparable functional outcome, are missing. The commercially available solutions for the elbow, stifle and tarsus promise significant improvement, and to some part return to full function, but because of the potential risk to end-up with an arthrodesis or amputation in case of complications, owners as well as surgeon are reluctant to take on with these techniques.

Therefore, less invasive strategies in the form of small implants, only resurfacing parts of the denuded joint surface, might appear more attractive. The CUE is one of these systems and has been shown to have good potential for return to athletic function.

Shearing injuries and open fractures

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Open fractures of the appendicular skeleton have an incidence of approximately 0.1% in both cats and dogs. When looking at fracture configuration, open fractures are commonly observed with comminuted and oblique fractures. The tarsal region is reported to have the highest risk of developing an open fracture[1]. Shearing injuries of the distal appendicular skeleton are observed in both dogs and cats most commonly following road traffic accidents due the paucity of soft tissue coverage in the distal limb[2,3,4,5]. Open fracture classification in both the human and the veterinary world is largely guided by the early work done by Gustilo and Anderson in 1976[6]. Gustilo's classification aided in the decision making and management of open fractures in people subsequently reducing infection rates. The initial classification system divided fractures into categories I-III. This was later amended to acknowledge the differing severity of injuries that were observed within type III open fractures. In 1984 Gustilo and colleagues sub-categorised type III open fractures further into a, b and c[7].

Fracture Classification	**Description**
Type I	Clean and wound is less than 1cm
Type II	Large wound greater than 1cm. Mild soft tissue trauma with no flaps or avulsions.
Type IIIa	Vast soft tissue laceration or flaps associated with high energy trauma. Soft tissue available for wound coverage.
Type IIIb	Extensive soft tissue injury. Bone exposed with concurrent periosteal stripping.
Type IIIc	Compromise of arterial supply to the limb necessitating arterial repair.

The fundamental guidelines for management of open fractures have remained the same since Gustilo proposed classification in 1976. However, nuances to the initial proposed guidelines in people exist. Guidelines of management for open fractures in the veterinary literature are poorly established. This lecture proposes current best practice for the acute management of open fractures extrapolating current best evidence from guidelines in people[8].

- Administration of a first generation cephalosporin, ideally within 1 hour.
- Neurological and vascular examination of limb.
- Photographs of the wound should be obtained
- The patient should be anaesthetised and gross contamination removed from the wound. This includes placement of a water soluble lubricant into the wound and generous clipping of all fur surrounding the wound.
- If a surgeon is unavailable then the wound should be dressed with a wet-dry dressing and covered with an occlusive dressing e.g. negative pressure wound therapy and transferred to a facility with combined orthopaedic and soft tissue cover. If a surgeon is available and all other systemic factors being stable, the patient can have surgical debridement in theatre.
- A thorough surgical debridement should be performed within 24 hours.

- The usefulness of bacteriology swabs has been questioned more recently. Bacteriology swabs obtained prior to debridement identified the offending pathogen responsible for infection in only 29% of cases. This increased to 60% of post debridement cases[8]. The author would recommend submitting deep tissue samples for culture following debridement.
- The wound should be copiously lavaged. The type of fluid does not seem to be as important as the total volume of fluid use. The author would recommend the use of an isotonic solution without additives. The higher the fracture grade the greater the volume of flush used. Current guidelines in people is that type III fractures should be flushed with 9L of saline.
- There is some evidence that high pressure delivery methods may drive contamination further into the wounds and hence are not recommended. However, low pressure delivery methods may not be as effective in removing contamination when delayed for greater than 4 hours. Following thorough lavage and surgical debridement in theatre the wound is considered clean.
- If the wound can be simultaneously closed then a definitive orthopaedic procedure can be performed in the same sitting. New instruments, drapes, surgical gowns and gloves should be used.
  Previously Gustilo recommendation was that type II and III open fractures should be managed with an ESF. However, with current recommendations and the advent and development of internal fixation devices this no longer lies true e.g. the use of antimicrobial impregnated implants.
- If the wound can't be closed the injury should be spanned and wound management instituted prior to definitive closure. Definitive closure should be performed as soon as possible.
- Soft tissue reconstruction involves the use of local flaps, distant flaps and free skin grafts.

Type IIIc fractures carry a grave prognosis in the veterinary field; there is approximately a 42% amputation rate in people[9]. This number is undoubtedly much higher in the veterinary field. In the author's experience by the time type IIIc injuries present to their clinic the limb is no longer viable. Options at this stage include amputation, intraosseous transcutaneous amputation prothesis or a stump socket prosthesis[10,11].

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Sentinel lymph node mapping in the clinical staging of oncological patients: indications, techniques and results

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Sentinel lymph node (SLN) identification and lymph node mapping is a well-known concept in human oncology. Each area in the body has a dedicated lymphatic drainage pathway, which can be associated with multiple lymph nodes organised in clusters (lymphatic basin). Veterinary clinical experience shows that the draining lymph node will not always be necessary the regional anatomic lymph node. The SLN is defined as the first lymph node to drain a specific body area**.** Consequently, if an area is affected by a tumour, and since tumour staging implies systematic nodal assessment, the SLN should be the first one to show metastases and therefore should be the lymph node to be assessed in priority. In human oncology, especially breast cancer and cutaneous melanoma, the specific identification and sampling of one lymph node within a lymphatic basin, for staging purpose, prevent potentially unnecessary extensive lymphadenectomy and its associated morbidity**.** Should the SLN being positive for tumoural spread however; further local radical lymphadenectomy might be recommended although clinical value of radical lympadenectomy in these indication remains unclear.

Human standard of care for SLN identification is peritumoural injection of radioactive marker and subsequent scintigraphy. SLN identification in surgery is performed with a portable gamma camera in combination with vital dye injection as a direct visual help.

Worley et al. reported the application of a similar protocol in a cohort of 19 dogs affected with mast cell tumours (MCT). Technetium was used for the scintigraphy and methylene blue (MB) was used for vital colouration. In this study, 42% of dogs diagnosed with nodal metastases were advised to received adjuvant therapy, which would have otherwise not been advised had SLN mapping not been performed. All but two of the “hot” extirpated lymph nodes had positive uptake of MB. Unfortunately, scintigraphy is not widely accessible in veterinary hospitals. Therefore, efforts were made to look for alternative solutions.

Indirect lymphography (IL) is defined as the deposit of a contrast medium in the periphery of lymphatic vessels in the view of being absorbed and drained by the lymphatic system. Imaging after contrast uptake (radiography, computed tomodensitometery (CT-IL), ultrasonography or MRI, subsequently allows the identification of contrast enhanced lymph nodes and lymphatic vessels.

In veterinary medicine X-rays, CT, Ultrasonography have been used successfully over the last 5 years to allow pre-operative mapping.

Peroperative mapping is now currently performed using traditional colorant (methylene blue) and indocyanine green. The principles seem to be successful although not always reliable in certain conditions such as lung neoplasia.

Lipiodol based SLN mapping
A lipid-based contrast medium: Lipiodol Ultra-Fluid TM (iodised ethyl-esters of the fatty acids o poppy seed oil, Guerbet, Aulnay-sous-bois, France; 480 mg iodine per ml) was used. Injection was performed

with a 25G needle into the 4 quadrants encircling the tumour. A slow rate infiltration (2 to 4 ml, over 1 to 5 minutes) was used as described previously. The injection was done in the tissue from which the mass was originating from or directly within the mass if it was not to change further surgical approach (i.e. no modifications of the boundaries or risks of capsule damages): For example, if the mass was cutaneous the injection was intra-dermal, if it was affecting the oral cavity the injection was submucosal. Care was taken not to perform intravenous injection or inject within fluid-filled cavities.

R-IL (two orthogonal views) or CT-IL was performed 24 hours after IO injection.

Methylene blue (Proveblue TM (methythionium choride, 5mg/mL, Proverpharm SAS-Cenerexi, Fontenay-sous-bois, France) was injected similarly to IO at the time of surgery, fifteen minutes before first surgical incision. Total volume of MB injected was between 0.5 and 1 ml. In animals weighing less than 10 kg, a diluted solution (1:1, in dextrose 5%) was used.

In a population of 30 dogs with various types of solid tumours, IL allowed successful identification of SLN in 29/30 (96.6%) of the studies. Positive agreement between IL and MB studies was observed in 84.6% of the cases.

In 20/25 (77.9%) of the tumours, the SLN was extirpated through a different surgical site than the primary tumour resection site.

In this population, the SLN was positive for metastasis in 7 out of the 25 cases.

Iohexol and iopamidol and CT for SLN mapping
Different contrast media have been used for R-IL or CT-IL: Iohexol and iopamidol are hydrophylic contrast medium and have been successfully used in humans and animals but is associated with quick lymphatic uptake and clearance. This might make it more useable in association with CT. Interestingly two human trials reporting IL-CT with iohexol in association with MB study for breast cancer reported 99% identification of SLN when both methods are associated which match results using standard isotopic and colorimetric study.SLN mapping with iopamidol was performed in 17 patients affected with breast cancer. The author reported full agreement between IL-CT and surgical observation and concluded that this SLN mapping protocol has to be considered as a good alternative to scintigraphy.

Over the last 2 years several studies have shown the clinical power CT-IL for different tumours including mast cell tumours and anal sac carcinoma.

The Image acquisition at 0, 5, 10 and possibly 15 minutes after injection appears to be the best protocol with SLN being identifier at 10minutes for most of the reports. Massaging the injection sites for few minutes before image acquisition has been proven to improve contrast uptakes by the lymphatics.

Other mappings techniques
Near-infrared fluorescence, contrast ultrasonography have been used successfully for mapping. Studies show good agreement of fluorescence with indirect lymphography and methylene blue studies. There are reports of scintigraphy for MCT and anal sac carcinomas. All these techniques have been shown promising results but have the major drawback of their respective cost .

Result of SLN mapping
After the early reports from There is multiple studies showing difference between sentinel node and regional node (up to 63% of the cases for MCT using scintigraphy and methylene blue).

Are there any evidence of the benefits of SLN removal other than for staging?
Although SLN removal is usually considered prognostic rather than therapeutic in human medicine, recent data might indicate therapeutic benefits according to a recent publication on MCT showing better survival for Grade II cutaneous MCT when SLN was removed. Similar results might have to be expected for tumors such as anal sac carcinoma or melanoma but need to be investigated.

The so far unclear question and unresolved debate is the need for adjuvant therapy for the tumours (especially MCT) with really early detection of nodal metastasis that would have otherwise not qualified for treatment based on the usual prognostic indicators (histological grading, immunohistochemistry).

As an indirect consequence of SLN mapping and the renew interest in lymph node extirpation, there is more scrutiny and local nodectomy for tumour removal. This is associated with discovery of unexpected

early metastases for tumors with classically good prognosis after surgical treatment. Further studies will be needed (as for MCT) to refind specific staging and indications for adjuvant treatments

The clinician has to understand the principle and limitations of the process, SLN mapping has little value in the face of obvious metastatic disease or at least macroscopic nodal changes. The clinical observation of the author as well as Majeski's report shows that abnormal nodes will not uptake contrast due to marked lymphatic changes.

Therefore SLN mapping although very useful is to be considered essentially in the absence of gross lymphatic changes.

The basis of the staging process is TNM, and to the best of the authors' knowledge the most relevant node (N) to identify and analyse is the SLN· Indirect lymphangiography with peritumoural injection of iode-contrast is feasible and allows non-invasive identification of SLN with no significant adverse effects. It would allow decreased surgical footprint, improved tumoural staging and unnecessary lymphadenectomy. Likewise, the peroperative use of coloured contrast is helpful to identify the nodes especially in complicated area such as the axilla.

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Conservative approach of the management of soft tissue sarcomas - guidelines and controversies

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Soft tissue sarcomas (STS) are a heterogeneous group of mesenchymal tumors characterised by local invasiveness but low tendency to distant metastasis (up to 20%, but up to 40% with high histological grade). STSs include perivascular wall and peripheral nerve sheath tumor, undifferentiated sarcoma, myxosarcoma, liposarcoma and fibrosarcoma. Cutaneous and subcutaneous STSs account for 15% of skin and subcutaneous tumors in dogs.

Excision of STS has been traditionally addressed to as a wide margin *en bloc* resection (lateral margin of 3 cm and 1 fascial plane in the depth) to aim to local control. The question is *"is it really always necessary to perform it?"*. The skin above subcutaneous STS is usually included in the *en bloc* excision, however, no information regarding its neoplastic infiltration was available in the veterinary literature until a recent study that has shown that, especially for low grade STS, dermal infiltration is demonstrable in the area of the skin overlying the STS but not in that traditionally included as lateral margins.[1] A potential problem may be the underestimation of the grade of the tumor of the preoperative incisional biopsy.[2]

This pre-clinical evidence offered by Del Magno and coll. (2021) may open to the possibility to leave in place more skin to help in the reconstruction of the surgical wound, especially in anatomical region difficult to reconstruct, such as the distal limbs. This concept is corroborated by papers that have shown that the recurrence rate for low grade STS is low;[3-6] additionally, it has been shown that, in case of perivascular tumor of less of 5 cm, the time-to-recurrence may be protracted.[7] A further paper has also shown that, when compared to mast cell tumors, both grade I and grade II STSs are characterized by more compact growth, with less extensive circumferential and deep invasion, thus potentially allowing a less aggressive surgery.[8] Regarding the intraoperative evaluation of STS excision margins, the use of coherence optical tomography has been recently investigated, with encouraging results for its future intraoperative use.[9,10]

In case of incomplete or marginal excision, recurrence can be influenced by tumor location and histological grade.[11] In case of incomplete excision, possible treatments are re-excision,[12] radiation, elettrochemotherapy, and metronomic chemotherapy[13,14] to prevent or delay recurrence. For high grade STS, standard chemotherapy would be indicated.

Finally, special cases of apparently conservative resections are those involving STS completely included in a muscle, thus allowing a compartmental excision.[15.16] Attention is paid during surgery to both function (vessels and nerves) and preservation of the muscular fascia, being the latter a barrier to neoplastic invasion.

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Canine Apocrine Gland Anal Sac Adenocarcinoma: A Clinical Staged Approach for Optimizing Treatment Options and Prognosis

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Apocrine gland anal sac adenocarcinoma (AGASACA) accounts for 2% of all skin tumors in dogs and is commonly associated with paraneoplastic hypercalcemia and regional lymph node metastasis. Paraneoplastic hypercalcemia is common with up to 90% of dogs with AGASACA presenting with either symptomatic or asymptomatic hypercalcemia. Hypercalcemia of malignancy is caused by the production of parathyroid hormone-related protein by tumor cells in either the primary tumor or metastatic lymph nodes. Hypercalcemia resolves following surgical resection of the primary tumor and metastatic lesions, if present, and hypercalcemia recurs in dogs that develop either local tumor recurrence or metastatic disease postoperatively.

Metastasis is common in dogs with AGASACA. At the time of diagnosis, 47%-72% of dogs have metastasis to the sublumbar lymph nodes and a further 7%-9% have metastasis to the lungs and other sites such as the spleen, bone, pancreas, heart, and mediastinum.

Clinical signs
The two major reasons for dogs to present with AGASACA are local effects caused by the tumor ± enlarged metastatic sublumbar lymph nodes and hypercalcemia. However, the many dogs are also diagnosed incidentally during routine rectal examinations. The size of AGASACAs varies widely from non-palpable to very large, although most AGASACAs are palpable. When small to moderate-sized, these masses correlate with the normal position of the anal sacs at 4-5 o'clock on the right side and 7-8 o'clock on the left side. For larger masses, the entire perineal space can be occupied by the AGASACA. These masses may be visible to the owner, but more commonly dogs present because either the anal sac mass ± enlarged metastatic sublumbar lymph nodes cause constipation, tenesmus, and/or a change in fecal shape (usually flattened or ribbon-like). Other dogs will present because of clinical signs associated with hypercalcemia, such as polyuria, polydipsia, and urinary incontinence. Rarely, dogs will present with pain, lameness, or neurologic disease due to regional bone metastasis or direct extension into the lumbar vertebrae from metastatic sublumbar lymph nodes.

Diagnosis
Physical and rectal examinations are essential to identify the side of the anal sac mass and to palpate enlarged sublumbar lymph nodes. Bilateral AGASACAs are uncommon, but they do occur and hence both anal sacs should be carefully palpated.

A fine-needle aspirate of the anal sac mass can be performed to confirm the diagnosis of AGASACA and differentiate AGASACA from non-neoplastic anal sac diseases such as anal sacculitis and anal sac abscesses. Carcinoma is readily diagnosed in the majority of dogs with AGASACA. Incisional biopsy is rarely required for diagnosis and delays definitive treatment.

Blood tests include hematology, serum biochemistry, ionized calcium levels, and possibly parathyroid hormone and parathyroid hormone-related protein assays. Although total calcium levels can be used for the diagnosis of hypercalcemia, ionized calcium levels are preferred because they represent the

physiologically active component of calcium balance. Dogs with hypercalcemia may have biochemical evidence of renal failure including elevated creatinine, urea, and phosphorus. Parathyroid hormone and parathyroid hormone-related protein assays may be required in dogs with hypercalcemia but no evidence of an anal sac mass or other causes of hypercalcemia, such as lymphoma, primary or secondary hyperparathyroidism, vitamin D toxicity, and hypoadrenocorticism. Dogs with paraneoplastic hypercalcemia will have increased levels of parathyroid hormone-related protein and normal parathyroid hormone concentrations.

Clinical staging
Clinical staging involves assessment of local tumor size and evaluating for the presence of metastatic disease. Advanced imaging modalities are preferred for clinical staging. Abdominal ultrasonography is commonly performed for abdominal imaging, but significantly less sublumbar lymph nodes, particularly the sacral lymph nodes within the pelvic canal, are detected with abdominal ultrasonography compared with either abdominal MRI or CT scans. Three-view thoracic radiographs or CT scans are recommended for evaluation of pulmonary metastasis.

Surgery
Surgery is recommended for the treatment of dogs with either non-metastatic AGASACA or AGASACA with metastasis to the sublumbar lymph nodes.

Severe hypercalcemia is uncommon in dogs with AGASACA but, if present, aggressive medical management may be required prior to surgery. This includes the administration of prednisone, calcium-free intravenous fluids (i.e., isotonic saline) to reverse hypercalcemia-induced extracellular fluid volume contraction, and calciuretic loop diuretics (i.e., furosemide) to increase the rate of renal calcium excretion following volume expansion.

Anal sacculectomy
For resection of AGASACA, dogs should be positioned in sternal recumbency with the tail reflected dorsally. The rectum should be manually emptied of feces, but enemas are not recommended because they liquefy intestinal contents and increase risk of spillage during surgery. The risk of spillage is further reduced by inserting gauze swabs or tampons into the rectum. A purse-string suture can also be used, but this may interfere with surgical resection. The use of antibiotics is controversial and is dependent on the surgeon.

A pararectal surgical approach has traditionally been described to resect the AGASACA. The affected anal sac and mass are excised by a closed anal sacculectomy technique. A pararectal incision around the anal sac duct opening is an alternative technique which results in resection of the entire anal sac duct; this may have advantages in reducing the local recurrence rate and postoperative complications. An open technique is not recommended because of the risk of contaminating the surgical site and increasing the risk of local tumor recurrence. Marginal resection is recommended because the perineal space contains no structures amenable to achieving wide resection. Both the external anal sphincter and caudal rectal nerve should be identified and preserved if possible. The tumor rarely involves the rectum, but if partial rectal resection is planned then the owner should be warned about the risk of fecal incontinence if greater than 50% of the anal sphincter is resected; however, fecal incontinence is still uncommon in these cases.

The surgical complication rate following resection of the anal sac mass, sublumbar lymph nodes, or both is 12%. These complications include intraoperative hemorrhage, infection, dehiscence, rectocutaneous fistula, seroma, fecal or urinary incontinence, hypocalcemia, and tenesmus.

Sublumbar lymph node excision
Resection of metastatic sublumbar lymph nodes is indicated in dogs with sublumbar node metastasis and hypercalcemia or tenesmus. In dogs with hypercalcemia, both the anal sac mass and metastatic sublumbar lymph nodes need to be resected to achieve resolution of hypercalcemia because the cells responsible for production of the parathyroid-related hormone are present in all tumor sites, both the primary tumor and metastatic lymph nodes.

The sublumbar lymph nodes are resected through a caudal midline ventral celiotomy. Despite descriptions in anatomy textbooks, the sublumbar lymph nodes are not restricted to the medial iliac and hypogastric lymph nodes, but actually consist of a lymphatic bed from which a number of enlarged lymph nodes can arise, including the internal and external iliac lymph nodes and medial and lateral sacral lymph nodes. These lymph nodes are often located at the terminal aorta between the branches

the external iliac, internal iliac, and median sacral arteries. The caudodorsal abdominal cavity should be carefully palpated to identify all enlarged lymph nodes. Lymph node resection can be difficult because of poor visibility, limited access, and the proximity of vascular structures. Sublumbar lymph nodes can be resected in the majority of cases, but resectability cannot be determined preoperatively and large sublumbar nodes do not preclude resection. Some metastatic lymph nodes are cystic and can easily rupture during attempted dissection. Omentalization of a ruptured cystic sublumbar lymph node has been described in one dog. Tumor seeding and carcinomatosis are rarely observed in dogs with ruptured metastatic lymph nodes. Fatal hemorrhage is reported in approximately 5% of dogs during sublumbar lymph node resection.

Some surgeons are reluctant to perform sublumbar lymph node resection because of unfamiliarity with the anatomy or reluctance because of the complexity of the anatomical structures in the caudal abdomen. However, intraoperative problems are rarely encountered with review of the anatomy and a careful dissection technique. Furthermore, in one retrospective study, excision of metastatic sublumbar lymph nodes significantly improved survival times. These authors also suggested that metastatic lymph nodes less than 4.5 cm in diameter should be surgically excised, but dogs with metastatic lymph nodes larger than 4.5 cm in diameter should be treated with chemotherapy and their response monitored. However, there was no evidence to support this approach. For dogs with sublumbar lymph nodes greater than 4.5 cm, surgery or radiation therapy is recommended for regional tumor control.

Radiation therapy

Radiation therapy has a number of potential roles in the treatment of dogs with AGASACA. Intraoperative radiation therapy has been used to irradiate the sublumbar lymph node bed to minimize the risk of further metastatic lesions developing. Because of the risk of local tumor recurrence and sublumbar lymph node metastasis, full-course external beam radiation therapy of the perianal and pelvic regions has been recommended for all dogs following surgery. However, in the preliminary results of 756 dogs with surgically treated non-metastatic AGASACA, adjuvant radiation therapy did not have an impact on local tumor recurrence (16.3% with and 19.9% without radiation therapy, p=0.36) or the development of sublumbar lymph node metastasis (21.0% with and 26.4% without radiation therapy). Radiation therapy can also be used for inoperable or recurrent AGASACA and inoperable metastatic sublumbar lymph nodes. The major disadvantage of full-course fractionated external beam radiation is the radiation field contains many radiation-sensitive organs, such as the colon and bladder, resulting in debilitating acute radiation effects such as colitis, proctatitis, bladder fibrosis, and urinary incontinence.

Hypofractionated radiation therapy has been investigated for the palliation of dogs with AGASACA. In one study of 77 dogs with measurable AGASACA, 38% of dogs had a partial response to radiation therapy. An improvement in or resolution of clinical signs was noted in 63% of symptomatic dogs. Hypercalcemia resolved in 31% of dogs with palliative radiation therapy alone and in additional 46% of dogs with palliative radiation therapy was combined with prednisone and/or bisphosphonates. In a second study comparing surgery alone (15 dogs) to hypofractionated radiation therapy alone (8 fractions of 3.8 Gy/fraction over 2.5 weeks for a total dose of 30.4 Gy; 13 dogs) for dogs with stage 3b disease, dogs treated with palliative radiation therapy had a significantly better median progression-free interval (347 days compared to 159 days) and median survival time (447 days compared to 182 days).

Chemotherapy

The role of chemotherapy is being defined for dogs with AGASACA. Chemotherapy is likely not required in the adjuvant setting for dogs with non-metastatic AGASACA but is recommended for dogs presenting with sublumbar lymph node or distant metastasis. In a study of 756 dogs with non-metastatic AGASACA, chemotherapy did not have a significant impact on the development of regional (30.3% with and 23.5% without chemotherapy) or distant metastasis (7.6% with and 6.8% without chemotherapy, p=0.69) or survival time (1,516 days with surgery alone and 1,362 days with surgery and chemotherapy).

Adjunctive chemotherapy is recommended for dogs presenting with AGASACA metastatic to the sublumbar lymph nodes and for dogs that develop postoperative distant metastasis. A number of different chemotherapy protocols have been described, but none are superior to surgery alone, especially for the treatment of primary disease, local tumor recurrence, and postoperative lymph node metastasis. These protocols include platinum drugs, melphalan, doxorubicin, mitoxantrone, gemcitabine, and dual-agent therapy with alternating carboplatin and doxorubicin. Non-steroidal anti-inflammatory drugs are often used in combination with these protocols for their putative anticancer effects. Tyrosine kinase inhibitors, such as Palladia, have been shown to have objective responses in

approximately 25% of dogs with measurable AGASACA with partial responses in 25% of dogs and stable disease in 62.5% of dogs with AGASACA.

Prognosis

The prognosis for treated dogs with non-metastatic AGASACA and AGASACA metastatic to the sublumbar lymph nodes is good. Prognostic factors in dogs with AGASACA include tumor size, hypercalcemia, untreated nodal metastasis, lung metastasis, and treatment type.

The median survival time for dogs with tumors ≥10 cm^2 is 292 days and significantly worse than the median survival time of 584 days for dogs with smaller tumors. In another study, dogs with tumors >2.5 cm diameter had a significantly worse prognosis with a median survival time of 722 days compared to 1,205 days for dogs with tumors <2.5 cm diameter, however this was not evident in the prospective arm of their study. In other studies, 4 cm and 5.25 cm were reported as cutoffs for prognosis, and for every 1 cm increase in tumor size there is a 20% increase in hazard of death due to disease.

The median survival time for dogs with hypercalcemia is 256 days and significantly worse than the median survival time of 584 days for dogs with no hypercalcemia. However, the prognostic significance of hypercalcemia is not a consistent finding.

The median survival time for dogs with lung metastasis is 219 days and significantly worse than the median survival time of 584 days for dogs with no lung metastasis. In a recent study, the presence of sublumbar lymph node metastasis was associated with a significantly worse prognosis, but extirpation of metastatic nodes resulted in a significantly better outcome which highlights the important of surgical excision of metastatic sublumbar lymph nodes in dogs with AGASACA.

Finally, the median survival time for dogs with AGASACA is significantly worse if surgery is not incorporated into the treatment regimen (402 days) or dogs are treated with chemotherapy alone (212 days).

In an unpublished study of 1,331 dogs treated surgically, the overall median survival time for dogs with non-metastatic AGASACA was > 1,745 days with median survival times of 1,516 days for surgery alone, 1,362 days for surgery and chemotherapy, and >1,163 days for surgery and radiation therapy. For dogs with AGASACA metastatic to the sublumbar lymph nodes, the overall median survival time was 551 days with median survival times of 358 days if treated with anal sacculectomy alone (i.e., sublumbar lymph nodes are not excised), 546 days if treated with anal sacculectomy and sublumbar lymph node excision, and 1,927 days if treated with anal sacculectomy, sublumbar lymph node excision, and chemotherapy. Excision of the sublumbar lymph nodes results in a significant improvement in survival times over anal sacculectomy alone, and the addition of chemotherapy results in a significant improvement in survival times over surgery alone. The local tumor recurrence rate following anal sacculectomy was 18%. Surgical treatment of postoperative events, such as local recurrence, contralateral AGASACA, and sublumbar lymph node metastasis, resulted in significantly better cure rates and outcomes than no treatment or treatment with chemotherapy alone. Other than postoperative splenic metastasis, where splenectomy trended toward a survival advantage ($p=0.05$), dogs with other sites of distant metastasis had a significantly better outcome when treated with chemotherapy compared to no treatment or other treatment modalities.

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Session: **ECVS + VSSO**
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Prosthetic Reconstruction in Oncologic Surgery PART I+II

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PART I
This lecture covers Imaging, Export and Segmentation, Communication, Feasibility, Design and Manufacturing. It is designed to help surgeons to work with engineers and vice versa.

The imaging modality should be the best suited for each individual case. CT and CBCT are best for hard tissues. CBCT lacks contrast and is not ideal for soft tissue tumour surgery planning, however the resolution is remarkably high. MRI usually does not supply sufficient spatial resolution for adequate 3D-Modelling. 3D-Scanners (e.g.: Intraoral Scanners) offer excellent resolution but only for surfaces as they cannot penetrate tissues. Multiple modalities can be combined to achieve optimal results. A CT-scan should, if possible, always be performed with the smallest slice thickness as all future steps are based on it.

The next step is export and segmentation. If desired, this step can also be performed by the surgeon. A high-quality 3D-model of the patient's anatomy should be generated by a repeatable workflow. The model should be reviewed by surgeon as well as the engineer.

Communication is key to a successful collaboration and case management. Especially time needed for design, manufacturing and shipping should be discussed in detail. Some types of surgery do not benefit of patient specific implants. It is important not to be carried away by the theoretical possibilities new technology offers.

Risks and possible complications should be discussed. Dehiscence and implant exposure are common when soft tissue covering is insufficient. Some shapes and surface finishes should be avoided. If time is an issue, two stage operation (tumour excision and defect reconstruction) should be considered.

Using CAD-Software can be frustrating at first. The learning curve is steep. However, there are several free or inexpensive software solutions to make first steps. If you are interested in doing own design and surgery planning as a surgeon software like Meshmixer is a good way to get started. This also improves the understanding of the work an engineer would do.

3D-Modelling ranges from simple models to patient specific cutting guides and implants and virtual surgery planning. 3D-Models of anatomic structures are relatively easy to do, and the skills needed can be acquired in a few days. This should always be the first step.

The last step will always be manufacturing. In the case of patient specific devices and implants the method of choice will be additive manufacturing (3D-printing) as it is less expensive to print complex structures. Simpler shapes can be done with CNC-Machining. Some cutting guides and especially anatomic models can be printed on relatively inexpensive consumer 3D-printers. Local manufacturing should be preferred as time needed for shipping and customs can be significant. Last minute changes or the production of a second implant can be feasible if manufacturing is nearby.

PART II
The use of computer-aided design (CAD) and computer-aided manufacturing (CAM) for the production

of customized and patient-specific implants is becoming more commonplace in both veterinary and human surgical practice. Customized 3D-printed prostheses provide a number of theoretical advantages compared to other techniques for reconstruction of non-standard defects, such as designing the prosthesis to match the geometry and weight of the original anatomic region to better withstand the bending, torsion and shear forces associated with normal function, and the incorporation of tissue engineering technology into the prosthesis to promote osseous integration of the prosthesis. Other advantages of CAD-CAM technology include creating 3D models of the affected region for surgical planning (such as preoperative planning, intraoperative orientation, prebending and improved fitting of titanium plates, optimization of bone-to-bone contact, and decreased surgical times) and creating prefrabricated intraoperative cutting guides (for more accurate osteotomies, decreased surgical times, improved fitting of titanium plates and improved postoperative cosmetic appearance and function).

Computer-Aided Design and Manufacturing Process

The first step in the manufacture of a customized, 3D-printed titanium prosthesis is a CT scan of the diseased region. The stereolithographic files of the CT scan of the diseased region are then electronically sent to an external laboratory for CAD-CAM of the customized 3D-printed titanium prosthesis. CAD of the prosthesis is usually an iterative process involving frequent communication between the surgeon and the designer; the surgeon provides details on the tumor to be resected and the surgical plan (including margins for resection), the designer provides initial design concepts, and then the surgeon and designer fine tune the initial design until an acceptable design is agreed upon by both parties. The designer then sends the CAD to a laboratory for CAM for 3D printing of the customized, patient-specific titanium prosthesis.

As the surgeon, my only involvement in this process is communication with the designer during the CAD process. However, the CAD-CAM process has provided specific challenges on individual cases which have been learning experiences. Some of these have included the length of time taken for the CAD-CAM process, time taken for delivery of the prosthesis (which is largely dependent on the location of the CAM laboratory), and a mismatch between the designer’s desire to protect their intellectual property and my desire to treat the case as expediently as possible. While I have had some negative experiences in this CAD-CAM process, I have also had some very positive experiences with motivated and clinically orientated designers.

Surgical Implantation of 3D-Printed Implants

Surgical implantation of the 3D-printed, customized, patient-specific implant is often aided by CAD-CAM of specific cutting guides. These guides are fitted to an adjacent anatomic structure or the tumor to provide accurate positioning of the osteotomies. In turn, this optimizes the fit of the implant, decreases surgical time, and decreases the risk of postoperative mechanical implant-related complications. This surgery is not too different to standard reconstructions (i.e., fracture repair), but can be complicated by the limitations of the laboratory responsible for the CAM of the implants. For instance, for some of my earlier cases, the laboratory did not have the ability to manufacture locking screw holes in the prosthesis.

The other challenge when using CAD-CAM technology for reconstruction of oncologic defects is the potential for tumor growth in the time between acquisition of the CT and delivery of the 3D-printed implant. Tumor growth during this time interval can result in the inadequate margins and the potential for local tumor recurrence if the surgeon performs the surgery according to their original plan, or creation of a larger defect and poor fit of the prosthesis if the surgeon resects the tumor according to the larger dimensions. To circumvent this problem, the two main options include treatment with intra-arterial chemotherapy during this time interval (which has been shown to be more effective in stabilizing tumor size than either intravenous chemotherapy or radiation therapy) or a two-stage surgical procedure whereby the tumor is resected appropriately at the time of the CT scan and then the defect is reconstructed upon delivery of the 3D-printed implant.

Surgical margins: Past, Present and Future

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Not unreasonably, many surgeons believe that successful treatment of the cancer patient will only be achieved when every last vestige of cancerous cells has been removed from the body. For years, surgical dogma has focused on finding an optimal “measured margin” about the tumour as the solution to cancer control. Despite intensive investigations over the last 50 years or more, the ability to determine the extent of tissue that must be removed about a mass to achieve local control remains elusive. Indeed, the very ability to define when a satisfactory resection margin has been achieved has also not been determined. In this presentation, I plan to review the current status of surgical margins and present a proposal for the future.

Defining the margin status: The present
Most clinical studies support the notion that complete resection of the tumour will translate to improved patient outcomes. However, the precise width of clean margin necessary to completely eliminate recurrence has not been determined, despite extensive examination.

Despite its importance to the outcome of cancer, the ability to define “an adequate margin” is complicated and highly influenced by variations in individual tissue elasticity, tissue fixation, histological processing and interpretation. The ability of a surgeon to maintain an appropriate boundary about the entire tumour circumference throughout the dissection is also an important variable that may influence patient outcomes. Due to processing artefacts, the histologic measurement of a tumour margin will likely underestimate the actual extent of the tumour-free margin, and the measured histologic tumour-free margin will likely be considerably smaller than the actual surgical margin obtained.

Recently, there has been a proposal to adopt a more consistent terminology to define the histologic margin. For similar reasons, the Residual Tumour Classification (RTC) was adopted in human oncology in the mid-1980s. Through continued study and validation with large population studies, this classification method provides some clarity on the likely prognosis of patients. However, the RTC still relies on a subjective interpretation that all visible cancer cells have been eliminated, using light microscopy alone. There is now compelling evidence that tumour recurrence may occur not only due to the presence of isolated tumour cells located some distance from the original tumour, but also from circulating tumour cells and residual molecular derangements within the tissue stroma. Direct extrapolation of the reliability of the classification system from human studies regarding the prognostic prediction of the RTC status is also blurred by the routine incorporation of adjuvant radiotherapy into more treatment strategies for malignant tumours.

Defining the margin status: The future
In the past few years, sequencing-based high-throughput technologies have become widely available, highly reliable, fast, and affordable. These technologies can provide detailed, genome-wide molecular characterization of all cancer cells at various stages of tumor progression. Using this strategy, high-throughput gene expression analysis of the tissue can identify genes that are overexpressed when compared with non-tumour bearing normal tissues. This analysis generates a subset of genes – the molecular signature - that collectively has the largest coefficient for recurrence.

Identification of gene signatures that relate to an increased risk of early relapse, or local recurrence of a tumour after surgery, have been developed for prostatic, breast, oesophageal and lung cancer in

humans. In head and neck cancers, where local recurrence rates of 30% or more are commonly reported despite clean histological margins, identification of genetic mutations within the surgical margins has been shown to correlate significantly with recurrence.

Changing the dialogue: it's not just about size

Current evidence illustrates that a continued focus on a complete microscopic cellular margin should not remain our only determinant of outcome for patients with cancer. It seems likely that a purely cellular focus as an indicator of treatment success will provide an incomplete interpretation; a more holistic analysis of the cancer is required. If we are to move ahead from our current situation and allow treatment plans to be more intelligently tailored to meet the requirements of each individual tumour, we need to improve our utilisation of techniques that provide a more comprehensive interrogation of tumour biology.

Firstly, we need to change our dialogue about margins. This conversation should not just be about the millimetres or centimeters of tissue that need to be removed about a mass, with a measure of hope that that will be enough. In the future, any conversation about a surgical margin needs to include a consideration of tumour biology alongside the physical characteristics of the resection.

The veterinary oncology community is in a unique position to forge a new path in resolving this question. For our patients, routine incorporation of radiotherapy is unlikely to become commonplace, so surgery will likely remain the predominant weapon in the control of localised cancer. The known similarities in the biology of many of our common cancers provides a rich resource with which to understand the many complexities of this issue.

Defining an ideal margin: A Biologic Index?

Emerging evidence provides support for a strategy where a suite of different prognostic markers could be used to provide a biologic index for a patient. Statistically-derived algorithms that combined numerous elements of patient or tumour characteristic can be used to provide an individualised risk assessment to help guide prognostic or treatment decisions. Due to the complexity of cancer, such a strategy is better at predicting individual tumour behavior than relying on one single attribute alone.

Conclusion

William Enneking MD was a very influential thinker in the management of soft tissue sarcoma. In 1981 – 37 years ago – he recognised that tumour biology was the critical factor in determining the surgical margin required for local control. This fact has been proven time and again for multiple tumour types in humans and dogs. It is time for tumour biology to become more thoroughly integrated into our discussion on surgical margin, incorporating some of the advances in the molecular understanding of cancer into our strategies.

References can be provided on request.

Surgical Margins, Histologic Margins: Trying to Make Sense of it All

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The terminology used for describing margins in veterinary oncology can be confusing. The two relevant descriptors of oncologic margins are surgical resection margins and histologic margins. Surgical resection margins are the margins of grossly normal adjacent tissue used to resect a tumor, whereas histologic margins describe how close the tumor extends microscopically to the surgical resection margins. The histologic margins are further complicated by the impact of specimen shrinkage and the widespread, but inappropriate, use of terminology such as narrow or close margins.

Surgical Resection Margins
The aggressiveness of surgical resection, or surgical dose, is categorized as intralesional (or debulking), marginal, wide, and radical. These categories were first proposed for human musculoskeletal sarcomas but have since gained wide acceptance for all solid tumors in veterinary oncology. These surgical resection margin descriptions relate to the distance of the surgical margin from the tumor, its reactive zone, and its anatomic compartment. This system has been validated for musculoskeletal sarcomas in humans, but not for other tumor types or other species. The most common mistake in surgical oncology is to use too low a surgical dose, particularly because of a fear of being unable to close the resultant defect. In human medicine, two surgical teams are sometimes involved in the wide resection of tumors, one team for surgical resection and another team for subsequent reconstruction, to avoid this situation. Because this is unrealistic in veterinary medicine, the use of sterile surgical markers to delineate margins prior to incision assists in orientating the surgeon and overcoming the subconscious concerns of wound closure.

Wide and Radical Surgical Resections
Wide and radical resections are considered curative-intent surgeries because the intention is to resect both macroscopic and microscopic disease, including biopsy tracts, and thus improve both local tumor control and overall survival times. Wide or radical surgical resection is recommended in the management of the majority of solid tumors because the first surgery provides the best chance for a cure, and wide surgical resection is significantly more likely to result in a complete histologic excision. The ability to achieve a complete histologic excision is significantly associated with tumor size, with a 1.4% increase in risk of incomplete excision per cm^2 increase in tumor size, and body weight, both presumably because the larger tumor size relative to body weight results in wide surgical resection being less viable.

For wide and radical resection of tumors, a margin of normal appearing tissue should be excised en bloc with the gross tumor to account for microscopic extension of the tumor. Surgical resection margins should be determined on the basis of tumor type, histologic grade if appropriate (e.g., mast cell tumor [MCT]), biologic behavior, anatomic location, and the barrier provided by surrounding tissues. Despite the importance of surgical resection margins in obtaining complete histologic excision, the preponderance of surgical resection margin recommendations are anecdotal and arbitrary. The only surgical resection margins which have been studied are lateral surgical resection margins for grade I and II MCTs <5 cm, intestinal tumors in cats and dogs, and acanthomatous ameloblastoma (AA) in dogs.

For canine cutaneous MCTs, lateral surgical resection margins of 1 cm results in complete histologic excision of 100% of grade I MCTs and 75% of grade II MCTs, whereas 2 cm lateral surgical resection

margins result in complete histologic excision of 100% of grade II MCTs. In one study, local tumor recurrence was not reported following resection of canine cutaneous MCTs with histologic tumor-free margins (HTFMs) ≥10 mm laterally and ≥4 mm deeply. The authors of this paper and a subsequent review paper stated that the goal of surgical resection of canine cutaneous MCTs <4 cm should be “at least 1 cm lateral margins and a deep margin of at least 4 mm.” This recommendation is clinically inappropriate because it either confuses surgical resection margins with histologic margins or makes the assumption that surgical resection margins and histologic margins are equivalent, which is an incorrect assumption because of specimen shrinkage between resection and histologic assessment and tumor infiltration into grossly normal margins.

For feline intestinal tumors, complete histologic excision was achieved with surgical resection margins of 1 cm for intestinal carcinomas, 4 cm for intestinal sarcomas, and 5 cm for intestinal MCTs; however, complete histologic excision was uncommon for intestinal lymphomas regardless of the surgical resection margins with only 18 of the 33 examined histologic margins being tumor free with 7 cm surgical resection margins. For canine intestinal tumors, complete histologic excision was achieved with surgical resection margins of 2 cm for intestinal sarcomas and 3 cm for intestinal carcinomas. Similar to cats, complete histologic excision was uncommon for canine intestinal lymphomas regardless of the surgical resection margins with tumor infiltrating beyond 4 cm to 8 cm in five of the six lymphoma cases. Other than these examples, recommendations for surgical resection margins are anecdotal.

In a study of 263 dogs with oral AA, histologic excision was defined as incomplete (HTFM <1 mm), narrow (HTFM 1-5 mm), and complete (HTFM >5 mm). To the best of the author’s knowledge, this is the only veterinary publication which referenced the definition used for incomplete, narrow, and complete histologic excisions; however, the references pertained to oral squamous cell carcinoma in people, a different and malignant tumor type in a different species with a different biologic behavior compared to benign and locally invasive AAs. For dogs with 1.0 cm surgical resection margins, 33%, 33%, and 33% had complete, narrow, and incomplete histologic excisions, respectively. For dogs with 1.5 cm surgical resection margins, 25%, 50%, and 25% had complete, narrow, and incomplete histologic excisions, respectively. For dogs with 2.0 cm surgical resection margins, 50%, 50%, and 0% had complete, narrow, and incomplete histologic excisions, respectively. None of the 263 dogs in this study developed local tumor recurrence, which highlights the tenuous relationship between incomplete histologic excision and local tumor recurrence.

The majority of surgeons use predetermined distances depending on tumor type (metric margins); however, there is evidence that tumor size also influences the extent of microscopic tumor extension, with larger tumors of the same histologic type having greater microscopic extension and hence requiring larger surgical resection margins than smaller tumors (proportional margins). Margins are three-dimensional and hence lateral and deep margins must be considered when planning surgical resections of tumors. Lateral margins are determined by tumor type and biologic behavior. For example, 1 cm lateral margins are recommended for benign tumors and most malignant carcinomas, 2 cm lateral margins are required for grade I and II MCTs and soft tissue sarcomas (STSs), and 5cm lateral margins are recommended for feline vaccine associated sarcomas (VASs). There is some clinical evidence to suggest that more conservative wide margins may result in equivalent local tumor control rates with less morbidity. For instance, a 0% local recurrence rate was reported in 14 dogs with 15 STSs resected with 1 cm lateral margins; however, these findings require validation with controlled studies.

Deep margins are determined by natural tissue barriers because 1 cm to 3 cm deep margins are often not possible in regions such as the extremities (e.g., limbs and head) and trunk. Fat, subcutaneous tissue, muscle, and parenchymal tissue do not provide a barrier to tumor invasion and are not adequate for deep margins. Connective tissues, such as muscle fascia and bone, are resistant to neoplastic invasion and provide a good natural tissue barrier. Hence, deep margins should include a minimum of one uninvolved fascial plane, while two uninvolved fascial planes are recommended for surgical resection of feline VASs. In one study investigating microscopic invasion patterns of low-grade canine MCTs, invasion was significantly greater in a circumferential rather than a deep direction, emphasizing the importance of deep margin quality (i.e., fascial barriers) rather than quantity (i.e., metric measurement). Lateral and deep surgical resection margins should be greater if the tumor is high grade, invasive, recurrent, or inflamed.

Radical resection, which is defined as the removal of a body part, is occasionally required for complete excision of a tumor, such as splenectomy for splenic hemangiosarcoma or limb amputation for appendicular osteosarcoma (OSA).

Marginal Surgical Resection
Marginal surgical resection is defined as excision of all gross disease, but with possible residual microscopic disease. Marginal surgical resection is often confused with incomplete histologic excision and these terms are occasionally used synonymously; however, this is incorrect. While marginal surgical resection is more likely to result in an incomplete histologic excision and local tumor recurrence, complete histologic excision is still possible despite the more conservative surgical approach. In one study of 236 dogs with marginal surgical resection of subcutaneous STSs, 25% of these STSs had complete histologic excision with histologic margins ≥1 mm. In another study of 35 dogs with grade I STSs treated with marginal surgical resection, 66% of dogs had complete histologic excision with histologic margins ≥1 mm. These findings are supported by a study investigating microscopic invasion patterns in canine grade I and II STSs where STSs were shown to have a compact growth pattern with minimal circumferential (median, 0.0 mm; range, 0.0-17.0 mm) and deep (median, 0.0 mm; range, 0.0-3.8 mm) microscopic invasion.

Marginal surgical resection can either be planned or unplanned. Planned marginal resection is when the tumor type is known based on preoperative biopsy. Planned marginal surgical resections are a useful limb-sparing technique for MCTs and STSs of the distal extremities because this results in removal of the gross tumor burden while preserving limb function and not compromising wound closure.

Unplanned marginal surgical resections are when excisional biopsies are performed without prior knowledge of tumor type. Unplanned marginal resections should be avoided by obtaining appropriate preoperative biopsies and surgical planning. Unplanned resections are associated with a higher risk of incomplete histologic excision and can have a significant negative impact on future treatment options and outcomes by either increasing the aggressiveness of therapy required to appropriately manage the tumor or making further treatment impossible.

Intralesional Surgical Resection
Intralesional surgical resection, or debulking surgery, is defined as the incomplete resection of a tumor with residual gross disease. Debulking surgery is rarely an acceptable treatment for neoplastic diseases because tumor regrowth is usually rapid and the presence of a macroscopic tumor burden makes adjunctive local treatments, such as radiation therapy, less effective.

Specimen Preparation and Submission
There are a number of technical factors which have that potential to limit the assessment of histologic margins, especially the width of these margins, between resection of the tumor to interpretation of the microscopic slide. These include quality of margin inking, shrinkage of the resected tumor specimen following surgical resection and fixation in formalin, trimming of the fixed tissue, histologic processing, and morphologic slide evaluation.

The application of ink to the surgical resection margins is recommended to orientate the pathologist and provide accurate histologic identification of the true surgical margins. Purple or red colored inks are not recommended because the surgical margins are difficult to identify of the similarity of these colors to hematoxylin and eosin stained slides. In one study in which a consistent ink application method was used, the ink dissected along fascial planes in 28.1% of samples and inadvertently adhered to surfaces other than the surgical margin in 68.1% of samples. Despite the importance of inking surgical margins, inking has the potential to confound the interpretation of histologic margins.

Shrinkage of the tumor specimen can result in tumor cells being closer to the surgical resection margins than in vivo. The majority of this specimen shrinkage occurs immediately after surgical resection because of the effects of myofibril contractility and tissue elasticity following release from adjacent tissues. In one study of 216 canine tumor specimens, the total overall shrinkage was 15.6% with 13.7% shrinkage occurring immediately after surgical resection and only 1.7% after formalin fixation. Similarly, in cats with VASs, the overall HTFM width was decreased by 33% between surgical resection and histologic examination of the specimen, with 29% of this shrinkage occurring immediately after surgical resection. These findings are supported studies of specimen shrinkage following skin tumor resection in humans. In one study of 111 skin tumor specimens, there was a 17.0% reduction in length and 9.5% reduction in width between in vivo and post-fixation measurements, with 81.8% and 92.3% of the total shrinkage in length and width occurring between in vivo and ex vivo measurements. Furthermore, the majority of this post-resection shrinkage occurs in the grossly normal skin surrounding the tumor. In one study of 19 resected canine cutaneous MCTs, the overall specimen shrinkage was 17.7% with 24.4% shrinkage in the grossly normal adjacent skin and only 4.5% shrinkage in the tumor. Other studies have also found a significant effect of both histologic processing and biologic factors, such as tumor infiltration

into the grossly normal surgical margin, on shrinkage of specimens. Regardless, specimen shrinkage will result in HTFMs being less than the true tumor-free margins obtained during surgery. In one study of 51 cutaneous and subcutaneous MCTs resected with curative-intent from 46 dogs, the mean histologic margins were 58% to 65% smaller than the surgical resection margins, representing a 35% to 42% decrease in margin width. Despite these significant reductions in margin width, this is unlikely to convert a complete histologic excision to an incomplete histologic excision if complete histologic excision is defined as >0 mm HTFMs.

Once fixed, the tumor specimen is then trimmed and sectioned. There are four main trimming techniques: radial, parallel, modified combination of radial and parallel, and tangential. Radial trimming is the most commonly used technique in veterinary pathology. Radial trimming involves bisecting the tumor through its shortest axis and then each half is bisected along its longest axis, resulting in four quarters. This results in five margins (cranial, caudal, ventral, dorsal, and deep) for assessment. Disadvantages of radial sections for histologic margin assessment include only a small proportion of the total surgical margin is assessed and this sectioning technique does not account for irregularities in tumor geometry, particularly for tumors with asymmetric or infiltrative growth patterns. Parallel trimming (or bread loafing) evaluates a greater proportion of the surgical margins, but is more time consuming and expensive, and may not be sufficiently sensitive to offset the costs of this technique. Using a 4 mm bread loafing model for basal cell carcinomas, the sensitivity of detecting incomplete histologic excision was only 44%. In another study, the estimated chances of detecting incomplete histologic excision with bread loafing at 1, 2, 4, and 10 mm intervals for melanoma in situ were 58%, 37%, 19%, and 7%, respectively. Tangential sections are used to evaluate the surface area of the surgical margin. Multiple 2 to 3 mm sections are shaved off the edge of the sample and laid into cassettes with the cut surface down. This technique allows for a more thorough evaluation of the completeness of histologic excision. In one study, incomplete histologic excision was diagnosed in 49% of samples sectioned using a tangential technique, but only 15% of samples sectioned using a radial technique following breast conserving surgery for breast cancer. In a study of low grade and subcutaneous canine MCTs, incomplete histologic margins were detected in a significantly higher proportion of sectioned using a tangential technique compared to a radial technique, with 23.1% of margins classified as complete (HTFM >0 mm) on radial sections being incomplete on tangential sections. While tangential sectioning provides superior assessment of the completeness of histologic excision to other sectioning techniques, the entire of the surface area of the tumor is not examined (32.6% in one study following breast conserving surgery for breast cancer) and the width of the HTFMs cannot be assessed. The latter may be an important consideration if the width of the HTFM has prognostic significance for the risk of local tumor recurrence, but not if a binary assessment of complete versus incomplete histologic excision is the only requirement to determine this risk, as defined in the Residual Tumor Classification scheme.

Following trimming and sectioning, the tissue is processed for histologic interpretation. This involves alcohol dehydration with subsequent removal of lipids and other alcohol soluble substances, clearing in a hydrocarbon reagent (e.g. xylene), infiltrating and embedding (usually in paraffin wax), microtomy, and mounting on a slide. In one study of feline cadaveric skin, there was a mean reduction of 80% in the width or length of the specimen and and a mean increase of 180% in the thickness of the specimen between the completion of tissue fixation and generation of the hematoxylin and eosin stained slide. The effect of these changes on assessing the completeness of histologic excision is unknown.

Finally, the assessment of histologic margins is performed by a pathologist. This is a microscopic and morphologic interpretation and requires accurate identification of the surgical margin as well as differentiating peritumoral tissue from tumor, which can be both challenging and subjective. Significant inter-pathologist variation has been reported in the determining margin status as well as other histologic features. For these reasons, molecular margins are being investigated as supplementary tests of the adequacy of surgical resection and local tumor control. The concept of molecular margins takes into consideration genetic ± epigenetic modifications in subpopulations of neoplastic cells. These molecular signatures may precede phenotypic manifestations of overtly neoplastic cells. As this field develops, molecular margin status might also take into account the tumor microenvironment, now recognized as a hallmark of many cancers. For instance, cancer initiating stem cells have been identified in the skin adjacent to completely excised basal cell carcinomas in people and, despite complete histologic excision, the existence of these stem cells may be responsible for local tumor recurrence.

Histologic Margins

Histologic margins are commonly described as being incomplete or complete, with incomplete histologic margins being defined as neoplastic cells extending to the edge of the surgical resection margins. However, in some studies, an incomplete histologic excision has been arbitrarily defined as a HTFM ≤1

mm, ≤2 mm, or ≤5 mm. The assessment of histologic margins is further complicated by the common use of “close” or “narrow” histologic margins in veterinary oncology. This term is rarely used in human oncology and the use of this term is not recommended according to a consensus paper by the American College of Veterinary Pathologists Oncology Committee on the evaluation and reporting of histologic margins in veterinary oncology. Furthermore, there is no consensus on what constitutes a close margin and this has not been clinically validated; 1 mm, 2 mm, 3 mm, 5 mm, and 10 mmhave been variably used in published veterinary studies, and 4 mm was preferred according to an online poll of veterinary pathologists. In some studies, close histologic excisions have been combined with incomplete histologic excisions, but there is no supporting literature to consider these two groups as equivalent because their outcomes have not been assessed separately, either as categorical or continuous variables.Lastly, there is minimal evidence that close HTFMs result in a clinically relevant increased risk of local tumor recurrence in comparison to tumors excised with wider HTFMs.

To date, there has only been one study published in the veterinary literature which found close histologic margins have an impact on local tumor control. This study included malignant tumors from 40 dogs and 20 cats and these were grouped into STSs, MCTs, and carcinomas; however, these groups were highly heterogenous with a wide range of tumor types and histologic grades, and included tumors with a low risk (e.g., hemangiopericytoma) to a high risk of local recurrence (e.g., VAS). Histologic margins were defined as complete (HTFM >2 mm), close (HTFM 0-2 mm), and incomplete. Overall, surgical resections were complete, close, and incomplete in 48%, 18%, and 34% of animals, respectively. The overall local recurrence rate was 45%, including 80% of dogs with incomplete histologic margins and 73% of dogs with close histologic margins. These local recurrence rates are disproportionately higher than reported in the vast majority of other veterinary studies. The clinical applicability of these results is questionable because of low sample size, heterogeneity within the groups, disproportionately high local recurrence rates, and the lack of other supporting published studies.

Numerous studies have shown that close histologic excisions have no prognostic significance for local tumor control in dogs with subcutaneous and cutaneous MCTs. In one study of 340 dogs with cutaneous MCTs, the local recurrence rates were 3.3%, 4.9%, and 16.9% for dogs with complete (HTFM >5 mm), narrow (HTFM 0-5 mm), and incomplete histologic excision. There was no significant difference in local recurrences rate between dogs with complete and close histologic excisions. In another study of 73 dogs with complete histologic excision of 90 low-grade MCTs, the local tumor recurrence rates were 4% and 0% for dogs with complete (HTFM >3 mm) and narrow (HTFM 0-3 mm), respectively; local tumor recurrence was reported in two dogs, one with a HTFM of 4 mm and the other with a HTFM of 20 mm. In a study of 28 dogs with 30 incompletely excised MCTs, the local recurrence rates were 23% and 27% when incomplete excision was defined as HTFM ≤1 mm and 0 mm, respectively; none of the dogs with an incompletely excised MCT which subsequently developed local recurrence had tumor cells within 1 mm of the surgical resection margin. Similarly, there was no significant difference in local recurrence rates for dogs with oral squamous cell carcinoma resected with narrow (HTFM ≤ mm) and complete (HTFM >2 mm) histologic margins. In one study of 263 dogs with oral AAs, no dog developed local tumor recurrence despite incomplete (HTFM <1 mm) and close (HTFM 1-5 mm) histologic excisions in 22% and 44% of dogs, respectively.

However, despite this evidence, there is an unfounded dogma in veterinary surgical oncology that close histologic excision is equivalent to incomplete histologic excision, and that treatment recommendations for cats and dogs with close histologic excisions should be the same as an incomplete histologic excision (e.g., re-excision or radiation therapy). This approach has even been advocated in the published literature. In one study of 64 dogs with 70 incompletely or closely (HTFMs ≤3 mm) MCTs, the effect of re-excision or radiation therapy as further local treatment on survival was investigated. The reason for combining incompletely and closely excised MCTs was not reported. While further local treatment significantly improved survival time in these dogs, this effect was lost when dogs with close histologic excisions were excluded from analysis. In another study of 115 dogs with incompletely (78%) or closely (defined as HTFM <5 mm, 22%) excised cutaneous MCTs, 23 dogs were not treated and 92 dogs received further local treatment. No statistically significant differences were found in local recurrence rates, disease-free intervals, metastatic rates, survival times, and 1- and 2-year survival rates between treated dogs and non-treated dogs, or between dogs treated with different modalities. Treatment complications associated with further local treatment were reported in 22% of dogs treated with re-excision and 90% of dogs treated with radiation therapy. In another study of 27 dogs with incompletely or closely excised MCTs, where incomplete excision was defined as < 2 mm and close excision was defined as 2-5 mm, treated with vinblastine and prednisone for local tumor control, 13% of doses were associated with adverse effects and one dog died as a result of treatment. The exposure of dogs with close histologic excisions of their MCTs to further treatment, especially when the additional

costs and morbidity of this treatment are considered, seems unnecessary when there is no evidence of an increased risk of local tumor recurrence in these dogs.

A similar situation has been reported with invasive breast cancer in women. The completeness of histologic excision had been arbitrarily divided into incomplete, close (≤2 mm), and complete (>2 mm). Women with close histologic excisions were often treated with further local therapy despite the majority of meta-analyses, cooperative group trials, and single institution studies showing no significant differences in local recurrence rates between close and complete histologic margins following appropriate adjuvant therapy. In one meta-analysis, there were no significant differences in local recurrence rates with HTFMs of 1 mm, 2 mm, and 5 mm following resection of multidisciplinary breast conserving therapy for invasive breast cancers. This is further supported by a study of 577 women treated with either skin-sparing mastectomy or simple mastectomy where 8-year local recurrence rates were significantly higher for R1 resections than R0 resections (HTFM >0 mm). As a result of this study, the Society of Surgical Oncology and American Society of Radiation Oncology jointly published consensus guidelines on histologic margins for breast conserving therapy with no ink on the margin (i.e., HTFM >0 mm) being defined as an adequate surgical margin. Despite these recommendation, re-excision rates of up to 70% have been reported following close HTFMs of invasive breast cancer. Re-excision in patients with close HTFMs, when close HTFMs have no prognostic significance on outcome, results in increased costs, poorer cosmetic results, emotional distress, increased risk of postoperative complications, and a delay in starting adjuvant therapy. In a cost-analysis study investigating the costs associated with re-excision of invasive breast cancers, if all invasive breast cancers with close HTFMs were re-excised, then this would represent an $18.8 million increased annual cost of surgical treatment per annum in the United States, 9% greater than if re-excision were not included in the recommended multimodality treatment plan. These costs did not include hospital costs or the costs of managing complications following re-excision.

Clinical Relevance of Histologic Margins: Assessing the Risk of Local Tumor Recurrence
The completeness of histologic excision is used to determine the risk of local tumor recurrence and the requirement for further local treatment, such as re-excision or radiation therapy. However, incomplete histologic excision does not necessarily result in local tumor recurrence (see below for specific examples), and other factors can have an impact on local tumor recurrence, such as tumor size, tumor type, tumor subtype, mitotic rate, histologic grade, degree of invasiveness, proliferation markers, and molecular factors (e.g., mutations in KIT exon 11 in canine cutaneous MCTs).

Sarcomas
For dogs with subcutaneous or cutaneous STSs, local recurrence rates of 17%, 19%, and 28% have been reported following incomplete histologic excision. In a systematic review and meta-analysis of the impact of the completeness of histologic excision on local tumor recurrence in dogs with subcutaneous or cutaneous STSs, complete histologic excision was defined as a HTFM > 0 mm and studies which included close histologic margin terminology were considered completely excised. Ten studies were included in this meta-analysis with a total of 278 STS surgical resections; the local recurrence rates for completely and incompletely excised STSs were 9.8% and 33.3%, respectively. In one study of 236 marginally excised subcutaneous STSs, the local recurrence rate was 0% following complete histologic excision and dependent on histologic grade if incompletely excised with local recurrence rates of 7%, 34%, and 75% in dogs with incompletely excised grade I, II, and III STSs, respectively. Local recurrence is 10.5 times more likely after incomplete excision, and the relative risk for local tumor recurrence was 0.396 for completely excised versus incompletely excised STSs in a recent meta-analysis. Incomplete histologic excision has been inconsistently associated with local recurrence of canine STSs with some studies finding a significant association and others finding no association with local recurrence.

Feline VAS is a locally aggressive disease with local tumor recurrence rates of 35% to 59% following surgery and 26% to 52% following surgery combined with adjuvant therapies, such as pre- or post-operative radiation and chemotherapy. In earlier studies where wide surgical resection was defined as 2-3 cm lateral margins and one uninvolved fascial plane for deep margins, only 46% to 80% of cats had complete histologic excision; however, 97% of 91 cats had complete histologic excision following resection of the VASs with 5 cm lateral margins and two uninvolved fascial layers for deep margins.(In two studies, cats with incomplete histologic excision have significantly higher local recurrence rates (58% to 69%) than cats with complete histologic excision (19% to 22%). Furthermore, complete histologic excision is associated with a significantly longer time to first recurrenceand tumor-free interval than incomplete histologic excision of feline VASs. Local tumor recurrence significantly decreases survival times, emphasizing that complete histologic excision with aggressive, wide surgical resection is the primary goal for cats with VASs.

Mast Cell Tumors

For dogs with cutaneous MCTs, overall local recurrence rates of 17%, 18%, 27%, and 30% have been reported. Similar to canine STSs, local recurrence rates are also dependent on histologic grade with local recurrence reported in 0% to 1%, 0% to 33%, and 19%(of incompletely excised grade I, II, and III MCTs, respectively. In the vast majority of published studies, there is no statistically significant association between incomplete histologic excision and local tumor recurrence, with only one study reporting an association with local recurrence and decreased disease-free interval.Histologic grade and proliferation indices are more important predictors of local tumor recurrence than incomplete histologic excision. In one study of 90 dogs with completely excised cutaneous MCTs, the local recurrence rates for dogs with low- and high-grade MCTs were 4% and 36%; high-grade tumors were significantly more likely to recur locally with an odds ratio of 13.7. Proliferation indices, such as Ki67, PCNA, Ki67 combined with PCNA, and AgNOR, are predictive of local tumor recurrence following incomplete excision of low grade and grade II MCTs.

In one study of 306 dogs, 56% of subcutaneous MCTs were incompletely excised (HTFM ≤1 mm). The local recurrence rates were 8% overall, 12% in dogs with incompletely excised subcutaneous MCTs, and 2% in dogs with completely excised subcutaneous MCTs. Incomplete histologic excision, a mitotic rate > 0 per 10 hpfs, and tumors with an infiltrative histologic pattern were independent prognostic factors for local tumor recurrence. The importance of contributing factors to local tumor recurrence was highlighted in this study with the risk of local tumor recurrence being 130 times in dogs with a mitotic rate >4/10 hpfs (compared to a mitotic rate of 0/10 hpfs) and 5 times in dogs with infiltrative subcutaneous MCTs (compared to circumscribed subcutaneous MCTs). These factors also had an impact on the median time to local recurrence with predictions of 70 days, 365 days, and 1,000 days for incompletely excised subcutaneous MCTs with an infiltrative histologic pattern, incompletely excised subcutaneous MCTs with a circumscribed histologic pattern, and completely excised subcutaneous MCTs with an infiltrative histologic pattern, respectively. Similar to cutaneous MCTs, Ki67 (>21.8, odds ratio 9.0), AgNOR (>2.7, odds ratio 9.0), the combination of Ki67 and AgNOR (>55.0, odds ratio 11.1), and cytoplasmic KIT localization pattern (diffuse versus focal or stippled, odds ratio 19.8) were significantly associated with local recurrence on univariable exact logistic regression analysis in dogs with subcutaneous MCTs.

In cats with MCTs, the completeness of histologic excision is not associated with local tumor recurrence. Tumor recurrence has been reported in up to one-third of cats with cutaneous MCTs, regardless of completeness of surgical excision. The reported recurrence rate for periocular MCT is lower (<5%), but also shows no correlation with completeness of surgical excision.

Head and Neck Cancers

In the majority of studies published on head and neck cancers in dogs, the completeness of histologic excision is not reported, included as descriptive statistics only and not analyzed, or analyzed for survival outcomes but not local tumor control.

In a study of 21 dogs with surgically treated oral squamous cell carcinoma, histologic margins were defined as incomplete, close (HTFMs ≤2 mm), and complete (HTFMs >2 mm). Histologic margins were incomplete in two dogs, narrow in four dogs, and complete in 15 dogs; local recurrence was reported in one dog with incomplete histologic excision and no dogs with either narrow or complete histologic excisions. Histologic margins were not associated with local tumor recurrence.

In one retrospective of 29 dogs with oral fibrosarcoma, complete and incomplete margins were not defined, but 15 dogs had complete histologic excision and 11 dogs had incomplete histologic excision. Seven dogs were diagnosed with local tumor recurrence, and five of these dogs had incomplete histologic excision of their oral fibrosarcomas. Dogs with incomplete histologic excision were significantly more likely to develop local tumor recurrence.

In a study of 183 dogs with mandibular, maxillary, or calvarial OSA, histologic margins were defined as complete (HTFM >0 mm) or incomplete. 74% of dogs were treated surgically (93% mandible, 49% calvarium, 73% maxilla). The overall local recurrence rate was 30% in surgically treated dogs, with local recurrence or disease progression reported in 24% of dogs with calvarial OSA, 16% with mandibular OSA, and 40% of dogs with maxillary OSA. In a multivariate analysis, complete histologic excision was an independent predictor of local tumor control (hazard ratio 0.4); calvarial OSAs had a significantly higher risk of local tumor recurrence (hazard ratio 2.1).

Mammary Carcinomas

The vast majority of studies of mammary carcinomas in both cats and dogs have not investigated the completeness of histologic excision and local tumor recurrence, which is surprising considering this is one of the most important outcomes reported in breast cancer studies in women. In a 2011 review of prognostic factors for mammary tumors in dogs, histologic margins and local tumor recurrence were not discussed. In one study of 145 dogs with mammary tumors, completeness of histologic excision and local tumor recurrence were independent predictors for survival, but the effect of incomplete histologic excision on local tumor control was not investigated. Similarly, in a retrospective review of 94 dogs with mammary carcinoma treated with either surgery alone or surgery and chemotherapy, histologic margins were an independent predictor for survival on multivariate analysis, but the effect of incomplete histologic excision on local tumor control was not investigated. To the best of the author's knowledge, no study of mammary carcinomas in dogs has investigated the relationship between incomplete histologic excision and local tumor recurrence.

In the only study to investigate histologic margins in cats with mammary carcinomas, margins were defined as incomplete, close (HTFMs ≤2 mm), or complete (HTFMs >2 mm). For cats treated with unilateral mastectomy, 9%, 15%, and 76% had incomplete, close, and complete histologic excisions, respectively. For cats treated with bilateral mastectomy, 2%, 7%, and 90% had incomplete, close, and complete histologic excisions, respectively. Local tumor recurrence was significantly more likely following unilateral mastectomy; however, local tumor recurrence was defined as both true local tumor recurrence and de novo tumor development. For the 94 cats surviving the postoperative period, the prevalence of local progression increased significantly for cats with complete to close to incomplete histologic excision.

The reasons for why incompletely excised tumors do not uniformly recur have not been elucidated. Some proposed theories are related to the post-surgical healing environment and tumor cell heterogeneity, and some are tumor-specific, such as for MCTs. Inflammatory cells recruited to the surgical site, in conjunction with release of cytokines or disturbance of local vasculature, may play a role in phagocytizing residual neoplastic cells. Neoplastic cells from the periphery of the tumor may represent a more committed cell type than those located centrally, and these peripheral cells may not be able to survive because of a lack of key growths factor may inhibit growth. Anti-invasion factors have been isolated from connective tissues and these may have an inhibitory effect on residual tumor cells.The relatively low recurrence rate of incompletely excised canine cutaneous MCTs has been associated with low proliferation indices, such as Ki67, PCNA and AgNORs. Mast cells observed at the periphery of histologic sections of resected MCTs may be associated with a local inflammatory reaction, which highlights the difficulty in differentiating between normal and neoplastic mast cells.

While complete histologic excision is the goal of oncologic surgery, complete histologic excision does not preclude the possibility of local tumor recurrence. Local recurrence rates of 3% to 22% have been reported following complete histologic excision of cutaneous and subcutaneous STSs, 2% of dogs with subcutaneous MCTs, and 2% to 11% of dogs with low-grade cutaneous MCTs and 36% of high-grade cutaneous MCTs. In one meta-analysis of cutaneous and subcutaneous STSs in dogs, the overall local recurrence rate was 9.8% following complete histologic excision, defined as a HTFM >0 mm, in the 10 included studies. However, as discussed previously, the histologic assessment of the completeness of excision in all planes can be highly flawed. The majority of commercial veterinary laboratories report of three to six margins using a radial sectioning technique, but it has been calculated that approximately 4,000 sections would be required to assess the entirety of a 1 cm tumor resected with 2 cm margins. These limitations can result in false negative histologic margin assessments. Furthermore, the accuracy of histologic margin assessment can be complicated by difficulties in identifying normal fascial tissues microscopically, differentiating normal mast cells from neoplastic mast cells and tumor heterogeneity, and the structure and degree of invasiveness of the pseudocapsule.

Residual (R) Tumor Classification Scheme

In contrast to veterinary surgical oncology, the R tumor classification scheme was recommended by the American Joint Committee on Cancer (AJCC) in 1977 and has been used by the AJCC, Union for International Cancer Control (UICC), and World Health Organization (WHO) for nearly 40 years because of its "outstanding prognostic importance". One of the original advantages of this classification scheme was its simplicity; originally, the three classifications were R0 (complete histologic excision with HTFM >0 mm), R1 (incomplete histologic excision), and R2 (intralesional resection with residual gross disease), and this classification scheme was only used for definitive surgical resections at the primary tumor site, not lymph nodes or distant metastatic sites. However, the UICC expanded the scope of the R

tumor classification scheme in 1987 to include locoregional and distant residual tumor burdens, and this was soon adopted by the AJCC and WHO.

The expanded R tumor classification scheme describes the tumor status following treatment and denotes the absence or presence of residual tumor after treatment. Whereas the initial R tumor classification scheme was primarily a histopathologic assessment, the expanded scheme is based on a combination of clinical and histopathologic findings. This scheme has been further expanded to include R0 ≤1 mm, R0 >1 mm, R0(un), R1(is), and R2a, R2b, and R2c classifications; where R0 is subclassified according to HTFMs, R0(un) refers to a complete histologic excision but with incomplete clinical staging, R1(is) is the presence of carcinoma in situ at the surgical margin, and R2a, R2b, and R2c signify gross residual local disease, gross residual metastatic disease, and gross residual disease at both sites, respectively. The reliability and reproducibility of this expanded scheme relies on using standardized clinical staging methods, tailored to each tumor type, and a standardized, thorough histologic examination of surgical margins.

After surgical treatment, assessment for the R tumor classification requires close cooperation between the surgeon and pathologist in a two-step process. The pathologist should report on the absence (R0) or presence (R1/R2) of tumor at the surgical resection margins, using a standardized method to prepare specimens and examine histologic margins. However, when using the expanded R tumor classification scheme, the R0 status also depends on clinical staging results and is not solely dependent on a pathologic assessment of margins. For this reason, the assignment of an R classification should be performed by a designated individual who has access to the complete medical record of the patient. The reliability and reproducibility of this expanded R tumor classification scheme relies on using standardized methods of clinical staging and preparation and assessment of histologic margins. In a survey of experts in certified lung cancer centers in the United States, there was high heterogeneity in the application and interpretation of the R tumor classification scheme. These discrepancies included the methods of routine margin assessment, interpretation of the criteria for R0, R1, and R2 classifications, and whether R status was being determined locally or regionally and distantly. As a result of these difficulties, many pathologists have advocated a further refinement to the R tumor classification scheme where the pathologist uses the original definition described in 1977 (pR or pTNM classification) and clinicians can then modify this based on the results of clinical staging (cR or cTNM classification).

The R tumor classification scheme has been shown to be a strong independent prognostic factor for virtually all malignant tumors in people. For the vast majority of malignancies, prognosis differs significantly according to the R classification and hence this scheme merits inclusion in any prognostic system investigation. In human oncologic studies, prognostic factors are recommended to be analyzed separately for each of the R0, R1, and R2 classifications; furthermore, for multivariate analyses of prognostic factors, sub-stratification of tumors within the same stage grouping by the R classification is also recommended.

Histologic Safety Margin

Histologic safety margin is the minimal HTFM required to significantly decrease the risk of local tumor recurrence. The histologic safety margin has been defined for basal cell carcinoma in people, but not for other tumor types in human oncology and not at all in veterinary oncology. Few studies have assessed HTFMs as a continuous variable; whereas others have investigated the arbitrary assignment of HTFMs as a categorical variable.

In some studies, conflicting results have been found and hence it is difficult to convincingly determine the histologic safety margin. For extremity and truncal STSs in people, some studies have found no difference in local tumor recurrence rates between HTFMs ≤1 mm and >1 mm, or HTFMs <1 mm, 1-4 mm, 5-9 mm, 10-19 mm, and ≥ 20 mm; however, HTFMs ≥10 mm were an independent predictor of local recurrence free interval compared to 0 mm and 1-9 mm in one study, and increasing HTFM width resulted in significantly better local tumor control rates (with 0 mm being worst and >4 cm being best), distant metastasis-free intervals, and overall survival times in another study. Based on these studies, a histologic safety margin for extremity and truncal STSs in people is commonly considered as “no ink on tumor” (i.e., HTFM >0 mm). Similarly, R0 resections with HTFMs >0 mm are sufficient for local tumor control following limb-sparing surgery for patients with OSA.

In contrast, similar to many veterinary studies, arbitrary histologic safety margins are used with no supportive evidence, such as HTFMs >1 mm margins for gastric cancer.

A disadvantage of histologic safety margins is that the width of these margins do not account for shrinkage of specimens following resection and fixation and during histologic processing. Equations have been developed to account for this shrinkage following surgical resection of cutaneous melanomas in people; these equations have an accuracy rate of approximately 85% for determining the pre-excision histologic margin within ± 3.5 mm. A similar equation was used to account for specimen shrinkage following surgical resection of canine cutaneous MCTs, but the accuracy of this equation was only 18%. The inaccuracy of these equations is because of the assumption that the entire specimen shrinks in a uniform matter; however, numerous studies have demonstrated that healthy adjacent tissue shrinks to a greater extent than the tumor itself. As a result, the HTFM will be less than the true tumor-free margin obtained during surgery.

Treatment Algorithms

While the R classification scheme may be overly simplistic in its original definition, it is a starting point for veterinary oncologists because the status of the histologic margins is an important determinant of whether further local treatment should be recommended. This scheme is admittedly simplistic as incomplete histologic excision does not inevitably result in local tumor recurrence and there are other factors that have a contributory role, such as mitotic rate, histologic grade, degree of invasiveness, and molecular factors. Some of these factors are more universal and others are more specific to certain tumor types. As a result, future endeavours should be directed at developing treatment algorithms for specific tumor types which incorporate the completeness of histologic excision with some or all of these possible contributory factors to decide on the preferred treatment options. Some effort has been made in developing treatment algorithms for cutaneous and subcutaneous STSs in dogs and cutaneous MCTs in dogs; while these are encouraging, some of these recommendations are based on either poorly designed studies or arbitrarily decided cutoffs. Future treatment algorithms should be based on the results of rigorously performed studies specifically investigating the effects of certain criteria on local tumor recurrence rates.

Conclusions

The R classification scheme, in both its original and expanded versions, is a simple and highly prognostic scheme used for over 40 years in human oncology. The use of a standardized definition for complete histologic excision (HTFM >0 mm), especially a definition that is less prone to the effects of specimen shrinkage and other variables, simplifies the decision-making process for recommending adjuvant local therapy and provides a standardized benchmark to perform clinical research studies to determine the true effect of the completeness of excision on local tumor control. Similar to human oncology, the R classification scheme has the potential to be modified with the addition of contributory factors for local tumor control, such as histologic grade or tumor invasiveness, if validated through rigourously performed, highly powered studies. The adoption of the R classification scheme in veterinary oncology would minimize the existing confusion regarding the adequacy of surgical resection and minimize the number of patients treated unnecessarily with further local therapy.

A comparative study between the ability of high definition volumetric imaging computed tomography and multi-slice computed tomography in the detection of acute thoraco-lumbar disc extrusions in dogs.

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Computed tomography (CT) is commonplace in the imaging and diagnosis of intervertebral disc disease in small animal practice. Computed tomography can detect a high percentage of disc extrusions without the need for a CT myelogram. The most common CT imaging in small animal practice is multi-slice CT (MS CT). Recently a smaller high definition volumetric (HDVI) mobile CT unit has been marketed. Our goal was to compare the detection of acute disc extrusion between HDVI CT and MS CT in a blinded retrospective study.

In total 123 cases had HDVI CT scans with surgically confirmed acute disc extrusions. The disc material was identified in 88 dogs on pre-contrast HDVI CT. The remaining 35 cases required a HDVI CT myelogram to identify the site of acute disc extrusion. The ability of the HDVI CT for identifying the lesion without contrast CT myelography across all breeds of dogs was 72%. In total 96 cases had MS CT scans with surgically confirmed acute disc extrusions. The acute disc extrusion was identified in 78 dogs on the pre-contrast MS CT. The remaining 18 cases had a MS CT myelogram performed to identify the site of acute disc extrusion. The overall ability of MS CT in this study to identify an acute disc extrusion across all breeds of dogs without a CT myelogram was 82%.
The ability of MS CT for detecting intervertebral disc extrusion without the need for a CT myelogram in dogs is lower than HDVI CT in this study (P=0.032).

A comparison of post-operative complications following total ear canal ablation with lateral bulla osteotomy in brachycephalic and non-brachycephalic canine breeds.

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Introduction
Brachycephalic pets are increasing in popularity. Brachycephalic breeds have a conformational mismatch between the proportion of soft tissue within the skull and brachycephalic tympanic bullae malformation has been descried. Total ear canal ablation with lateral bulla osteotomy (TECA-LBO) is anecdotally more challenging in these breeds. The objective of this study was to compare complication rates following TECA-LBO in brachycephalic vs non-brachycephalic breeds.

Materials and Methods
Medical records of canine patients that underwent TECA-LBO at a single institution were retrospectively evaluated. Data including breed, age, gender, presenting complaint, lateralisation and occurrence of post-operative complication were recorded. The aim of the study was to determine complication rates in brachycephalic breeds and non-brachycephalic dogs following TECA-LBO.

Results
TECA-LBO's were performed on 42 brachycephalic and 120 non-brachycephalic breeds (n=146) between 2010-2019. Brachycephalic breeds most frequently presented for neurological signs (50%), whereas non-brachycephalic dogs most frequently presented with otitis externa (75%). The overall complication rate was 36.9%, with a complication rate in brachycephalic and non-brachycephalic breeds of 35.7% and 37.5% respectively.

Conclusion
This study is the first to compare post-operative complication rates following TECA-LBO in brachycephalic and non-brachycephalic breeds. Overall, complication rates were similar to those previously reported. This information is valuable for pre-operative client communication and surgical planning.

A modified approach to closed anal sacculectomy in the dog for treatment of anal sac neoplasia

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Introduction
Anal sacculectomy is performed in dogs for neoplasia and following failure of medical therapy for processes including impaction, anal sac sinuses, sacculitis, and abscessation. Closed and open anal sacculectomy has been described, with closed having relatively low rates of postoperative complications. A modified closed anal sacculectomy technique was conceptualized, which involves excision of the anal sac duct and utilizes the anal sac duct to facilitate tumor dissection. The objective of this study was to describe the surgical technique and report the outcomes of dogs with anal sac neoplasia that underwent the modified closed anal sacculectomy surgery.

Materials and Methods
A single-institution retrospective case series was performed, including 16 client-owned dogs referred to the authors' institution for anal sac neoplasia between January 1st, 2018, and September 30th, 2020. Medical records were reviewed, and data collected included preoperative, intraoperative, and postoperative data, such as any complications, disease recurrence, and death/euthanasia.

Results
Neoplastic diagnoses were apocrine gland adenocarcinoma (n=15) and collision tumor (n=1). None of the dogs had intraoperative complications, and one dog had a minor postoperative complication that resolved. Two dogs had local recurrence of disease, and two dogs were euthanized due to disease progression. The median duration of follow up was 286 days postoperatively (range 67-777).

Discussion/Conclusions
The modified closed anal sacculectomy is a well-tolerated procedure with minimal complications. This study provides evidence to justify performing this procedure in larger numbers of dogs to evaluate if it significantly decreases postoperative complication rates and prolongs disease-free interval.

Bacteriological analysis of analgesic diffusion catheters used in mastectomies without postoperative antibiotic treatment.

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Introduction
Mastectomy is a potentially very painful surgical technique, so multimodal analgesia is used in these patients, including analgesic diffusion catheters (DC). Despite the clinical benefits of such devices, they are sometimes considered a potential source of wound contamination by some surgeons, which may limit their use. A pilot study was performed to investigate whether commercially available DC that are routinely used in mastectomy patients are a source of wound contamination.

Materials and Methods
Eleven spayed dogs undergoing regional or radical unilateral mastectomy for the treatment of mammary tumors were included. These included all consecutive cases from the same surgeon from October 2019 to December 2020. Cephazolin was used 20 minutes before surgery. DC were placed during surgery. Soft sterile wound dressings and a tubular mesh were placed to cover the wound. Patients were discharged 24 hours after surgery. Post-operative treatment included carprofen and opioids. No post-operative antibiotics were used. Owners were instructed to perform bupivacaine instillations q6h for 3-4 days, after which DC were removed, processed and cultured in blood agar and MacConkey agar.

Results
A total of 13 DC were placed and cultured. None of them had any bacterial growth on them. Wounds healed uneventfully.

Discussion/Conclusions
DC can be safely used in clean mastectomy surgeries and are not a common contamination source for potential SSI, even when left for a few days, provided wounds are protected.The use of DC does not imply a need for post-operative antibiotics.

Biomechanical comparison of Polyaxial Locking System versus Dynamic Compression Plate constructs in cadaveric canine scapulae.

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Introduction
Construct failure is a frequent complication of canine shoulder arthrodesis and is often related to insufficient bone purchase in the scapula. This concern could be addressed using the Polyaxial Locking System (PLS) which allows free orientation and locking of the screws up to 15° angulation. The aim of this study was to compare the scapular stability of Dynamic Compression Plate (DCP) and PLS constructs. We hypothesized that the PLS would yield a higher linear stiffness and pullout strength than the DCP construct due to the 15° sagittal divergence of the implantation of the locking screws.

Material and Methods
Eight pairs of scapulae were implanted with DCP and PLS 3.5mm. 3D printed surgical guides were used to acheive correct angles. Quasi-static orthogonal traction tests were applied at 2mm/min and recorded at 100Hz. Failure strength, failure mode, and system linear stiffness were compared.

Results
Failure strength (mean±sd, N) was similar between PLS (784±203) and DCP (755±217) (p=0.78). Failure modes for PLS and DCP respectively were bone deformation (n=3; n=2), plate bending (n=2; n=5) and screw pullout (n=3; n=1). System linear stiffness (mean±sd, N/mm) was slightly weaker with PLS (149±41) than DCP (173±47) but no statistical difference was found (p=0.29).

Discussion/Conclusion
Canine scapular PLS constructs seem to offer stability at least as good as DCP constructs when used for shoulder arthrodesis. Further investigations including cyclic testing are required before concluding on the clinical relevance in the dog.

Biomechanical evaluation of a novel tenorrhaphy technique in the canine gastrocnemius tendon

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Introduction
Gap formation significantly impedes tendon healing and reduces the tensile strength following tenorrhaphy. A gap greater then 3mm impedes the healing process. A suture pattern that provides greater resistance to gap formation than the three-loop pulley will provide a basis for choice in clinical cases.

Material and Methods
This randomized, cadaveric study aimed to determine if a novel four-loop pulley suture pattern is biomechanically superior to a three-loop pulley suture pattern. Thirty canine gastrocnemius tendons were repaired with either a three-loop pulley or four-loop pulley suture pattern. A tensile load was applied at 25 mm/min until construct failure. The load required to form a 1mm gap, 3mm gap and maximum load at failure were recorded.

Results
The mean (SD) load to form a 1mm gap was 45.06N (10.01N) in the four-loop pulley, and 28.31N (5.21N) in the three-loop pulley. The mean (SD) load to form a 3mm gap was 52.13N (9.62N) in a four-loop pulley and 37.56N (5.76N) in the three-loop pulley. The mean (SD) load to failure in the four-loop pulley was 52.70N (9.661N) and 41.03 (7.68N) in the three-loop pulley.

Discussion
A four-loop pulley pattern is biomechanically superior to the three-loop pulley, requiring a greater load to form a 1mm and 3mm gap, and resisting a greater load to failure. Results of this study provide a basis for choice of a four-loop pulley in clinical cases.

Clinical feasibility of the GV20 acupuncture point for sedation of canine patients undergoing imaging studies in Orthopaedics

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Introduction
Orthopaedic radiographic studies for outpatients require an effective sedation protocol that allows rapid interventions without compromising safety and patient comfort. Pharmacopuncture with dexmedetomidine was shown to increase sedative effects of this drug compared to intramuscular (IM) administration in dogs. The objective of this study was to determine the clinical feasibility of using the Governing Vessel 20 (GV20) acupuncture point for sedation in dogs undergoing radiography.

Materials and Methods
Fifty-nine dogs were injected with dexmedetomidine (200µg/m^2) for orthopaedic radiography. In this clinical, prospective, blinded study, patients were randomly allocated into 3 groups (n=19, n=22; n=18; IM, intravenously (IV), GV20, respectively). Onset of action and degree of sedation [(Numerical Rating Scale (NRS) and Dynamic and Interactive Visual Analogue Scale (DIVAS)]; ease to perform radiography (DIVAS); duration of radiographic study; number of radiographs performed; heart (HR) and respiratory rates (RR); and adverse events were recorded. Statistical two-way ANOVA and multiple comparison tests were performed. Statistical significance was set at $p < 0.05$.

Results
Sedation was insufficient to perform radiography in 5 dogs of the IM group. No significant differences were observed for onset of action, NRS and DIVAS scores between IV and GV20 groups. The IM group had significantly longer onset of action ($p < 0.001$), and NRS and DIVAS scores were significantly lower for the first 15 minutes of evaluation ($p < 0.01$).

Discussion/Conclusions
Pharmacopuncture with dexmedetomidine at the GV20 point provided effective sedation in dogs for clinical radiographic studies. GV20 administration provided comparable quality of sedation to the IV route, and more efficient and faster sedation than the IM route.

Comparison of dogs with septic peritonitis due to S. lupi aberrant migration and dogs with other gastrointestinal causes of septic peritonitis.

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Introduction
Spirocerca lupi (S.lupi) has a worldwide distribution, and is more prevalent in tropical and subtropical areas. Aberrant nematode migration may occur to various organs. Aberrant migration may cause thrombi which obstruct the tributaries of the mesenteric artery, causing local ischemia and segmental necrosis of the intestines.
The aims of this study were to compare clinical and clinicopathologic parameters of dog presenting with septic peritonitis (SP) associated with aberrant S.lupi migration (SL) and those with SP of other gastrointestinal causes.

Materials and Methods
Records of dogs diagnosed with aberrant S. lupi migration and dogs with SP due to other gastrointestinal causes during 2017-2020 were reviewed.

Results
Eighteen dogs in the SL group and 17 dogs in the SP group were included. In the SL dogs, 12/17 dogs were presented in the hot season (June-September). Eosinophils in the abdominal effusion were more common in the SL compared with the SP group (4/5 vs 0/4 dogs, respectively, P=0.048). All dogs underwent resection and anastomosis. Dehiscence occurred in 6/18 of the SL groups and in 3/17 in the SP group (P=0.23). Hospitalization time was significantly longer in the SL compared with SP group (median 4.0 days vs. 2.5 days, P=0.021). The mortality was higher in the SP dogs compared with SL dogs (8/17 (SP) dogs vs 1/18 (SL), P = 0.007).

Conclusions
Aberrant S. lupi migration causing intestinal necrosis has a favorable outcome, however, these cases require intensive and long hospitalization. Presence of eosinophils in the abdominal effusion is highly suggestive of S.lupi aberrant migration.

Diagnostic value of liver function tests and abdominal ultrasonography in dogs clinically suspected of congenital portosystemic shunts

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Introduction
Diagnosing a congenital portosystemic shunt (cPSS) in dogs can be challenging. The aim of this study is to report test characteristics of fasting ammonia (FA), preprandial, postprandial and paired serum bile acid (SBA) concentrations and abdominal ultrasound (aUS) in their ability to diagnose cPSS.

Materials and methods
Medical records of dogs suspected of having cPSS were retrospectively reviewed. Dogs were included the presence of cPSS was confirmed or excluded based on computed tomography angiography (CTA), transsplenic portal scintigraphy (TSPS) and/or surgical exploration. Test characteristics including confidence intervals of the different blood tests and aUS were calculated.

Results
In total, 192 dogs suspected of cPSS were included: a cPSS was confirmed in 147 dogs and ruled out in 45 dogs. Fasting ammonia had the best combined sensitivity and specificity (77.4% and 93.3%, respectively) to diagnose cPSS and had an outstanding positive predictive value (97.8%). The negative predictive value was 100% for paired SBA, making paired SBA the best test to rule out cPSS (sensitivity 100% and specificity 16.7%). Sensitivity and specificity of aUS were 80.8% and 90.0%, respectively.

Discussion/Conclusions
In dogs with clinical signs compatible with cPSS, elevated FA rules in cPSS whereas normal paired SBA make the presence of a cPSS unlikely. Although aUS is a useful tool to diagnose cPSS, additional imaging is required to visualize the cPSS in nearly one fifth of cases. Furthermore, the localization of the cPSS can be misdiagnosed, especially in case of extrahepatic cPSS that do not insert into the prehepatic vena cava.

Epicardial use of an endocardial leadless pacemaker in dogs

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Introduction
Conventional pacemakers do not have the appropriate size and pacing lead length for use in low-weight animals. On the other hand, Micra™, the small-sized endocardial leadless pacemaker developed by Medtronic, USA, is being currently used clinically in adult patients. Therefore, we aimed to use this endocardial leadless pacemaker in the epicardium of dogs because of its small size.

Materials and Methods
Leadless pacemaker implantation was performed in five beagles (age, 8 months–1.3 years; body weight, 8.5–10 kg) with the approval of the Azabu University Animal Care and Experimentation Committee. The pacemakers were placed in the right atrium (n = 1) or right ventricle (n = 4) after radiofrequency ablation of the sinus node.

Results
During the acute stage, a junctional rhythm was found in four out of five dogs and an atrioventricular block in one. During the chronic stage, an atrioventricular junctional rhythm (AVJR) was observed in three dogs, and junctional ectopic tachycardia was noted in two dogs. Pacing was successful in the AVJR cases that were implanted with a ventricular pacing device, and the mean pacing threshold was 2.3 ± 0.6 V with a stimulus of 1.0 ms. Tricuspid annular plane systolic excursion showed low values after implantation of the Micra™. It reached the lowest values 1 month ($p < 0.05$) after implantation and recovered to the preoperative values by 3 months.

Discussion/Conclusions
These results suggested the feasibility of the clinical use of Micra™ in dogs as an epicardial leadless pacemaker in the near future.

Evaluation of Staple Line Reinforcement Following Partial Gastrectomy Closure in an Ex vivo Canine Model

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Objective
To determine the influence of stapling on leakage pressures following canine partial gastrectomy.

Study design
Ex-vivo study.

Sample population
Gastric specimens from 24 adult canine cadavers.

Methods
Partial gastrectomy constructs were assigned to one of three closure techniques (n=8): stapled closure using a 90mm-thoracoabdominal stapling device and 4.8mm staple cartridge (group 1), hand sewn double-layer inverting suture closure using 3-0 Glycomer-631 (group 2) and staple line reinforcement (SLR) using an inverting Cushing suture pattern (group 3). Leakage and pressure testing were performed. Initial (ILP) and maximal leakage pressure (MLP) and leakage-location (LL) were recorded. Significance was set at $p<0.05$.

Results
Placement of a Cushing suture (group 3) increased ILP and MLP by 3.2x and 2.8x respectively, compared to stapled closures alone ($p<0.001$). Constructs closed with double layer suture closure reached ILP and MLP 4.5x and 3.0x greater respectively than those with stapled closures alone ($p<0.001$). MLP did not differ between groups 2 and 3 ($p=0.14$). Leakage occurred from the inverting suture line in all constructs of groups 2 and 3 but from staple holes in 6/8 group 1 constructs.

Conclusions
Double layer suture closure of canine partial gastrectomies achieved superior biomechanical properties than stapled closure techniques. Reinforcing staple closures with an inverting suture line improved resistance to leakage.

Clinical Significance
Reinforcing single layer closure of partial gastrectomies with an inverting Cushing pattern is recommended to improve resistance to leakage. In-vivo investigation is warranted to evaluate influence of closure technique on gastric healing, post-operative stasis, ischemic injury and postoperative dehiscence.

Feline perineal urethrostomy: retrospective study of 216 cases treated for urethral obstruction between 2006 and 2018 with a modified perineal technique

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Introduction
Perineal urethrostomy is a commonly performed procedure but wound complication occurrs in 25% of cats and urethral stricture is reported in up to 17% of cases. The goal of the study was to retrospectively describe short- and long-term complications in cats that underwent a modified Perineal Urethrostomy (mPU) that aim to decrease wound tension and inflammation.

Materials and methods
Medical records of cats that underwent mPU between 2006 and 2018 were reviewed. All cats had anchoring of both bulbourethral glands and ischiocavernosus muscles to the skin and mucosal to skin apposition with a rapidly absorbing monofilament suture (Glycomer 631) with either interrupted or simple continuous pattern. Information regarding signalment, perioperative conditions, surgeon experience, complications were collected.

Results
mPU was performed in 216 male cats (interrupted pattern in 88% of cases). Short-term wound complications (dehiscence/haemorraghe/urine scald dermatitis) occurred in 15%. Urethral stricture was described in 5% (median time of 2[1-8] months postoperatively). All in all, major complications occurred in 6% and minor complications in 15%.
No difference in complication rate was observed between interrupted and continuous pattern or with the surgeon experience. No risk factor of urethral stricture was underlined.

Discussion/Conclusions
Wound complication and urethral stricture rates were in the lower ranges than those previously described suggesting that both anchoring bulbourethral glands and ischiocavernosus muscles to the skin and using a rapidly absorbing monofilament suture (interrupted or continuous pattern) is a safe and effective technique that may help reducing complication rates and to permit a good long-term functional outcome.

Fully guided synthetic osteochondral resurfacing of a large stifle OCD lesion using a patient-specific implant and drill guides

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Introduction
Osteochondral autografts, allografts and synthetic osteochondral resurfacing have recently shown promising results in the treatment of large OCD lesions. However, restoration of large OCD lesions can be challenging as the shape of the currently available implants does not perfectly match the convex surface of the cartilage surface. This is further complicated by the inherent inaccuracy in any free-hand implant positioning, such as osteochondral resurfacing.

Case Description
A 6-month old female German Shepard presented with hindlimb lameness attributed to a 15x7.8x4.3 mm (length x width x depth) subchondral defect at the lateral femoral condyle.

Computed tomography derived 3D models were processed to design a patient-specific osteochondral resurfacing implant, using the contralateral unaffected condyle as a template. Reaming of the recipient bed was fully guided using a set of 3D-printed drill-guides, replicating the in silico pre-planned implant trajectory. The bi-layered implant, consisting of a titanium socket and a polycarbonate urethane bearing surface was press-fitted into place, followed by routine closure and postoperative care.

Results
The combination of patient-specific implant and matching drill guides resulted in a visually perfect restoration of the normal joint curvature and defect area. Radiographic examination 6 weeks postoperatively showed stable bone integration. The 6 month follow-up gait analysis indicated nearly equal loading area and body weight distribution between both hindlimbs. Clinical examination at 6 weeks showed no visible lameness and no complications were identified postoperatively.

Conclusion
This novel surgical approach is a promising treatment option for large OCD lesions.

Gene expression of vascular inducing factors in mesenchymal stem cells derived from the femoral head of dogs with Legg-Calvé-Perthes disease.

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Introduction
Legg-Calvé-Perthes disease (LCPD) is associated with an idiopathic juvenile avascular necrosis of the femoral head in humans, and a similar condition occurs in skeletally immature dogs. To date, factors that cause ischemia of the femoral head have not been identified. The purpose of this study was to isolate mesenchymal stem cells (MSCs) from LCPD-affected femoral heads and to quantify mRNA expression of vascular inducing factors.

Materials and Methods
MSCs were isolated and cultured from LCPD-affected femoral heads following femoral head and neck ostectomy as a treatment of the affected patients (LCPD group: n=3). Bone marrow derived MSCs (BMSCs) from healthy dogs were used as controls (control group: n=3). mRNA expressions of HIF-1α, VEGF, PDGF-B, FGF-2, HGF, ANGPT1, and ANGPT2 were quantified by RT-qPCR and statistically compared between two groups.

Results
MSCs were successfully isolated from the femoral heads of dogs with LCPD (mean age of affected dogs 9.3 ± 3.5 months, mean bodyweight of affected dogs 3.1 ± 0.1 kg) and easily expanded; their morphology and proliferative potency were similar to BMSCs. FGF-2 and HGF mRNA expression in the LCPD group tended to be lower than in the control group ($P<0.1$).

Discussion/Conclusion
This is a preliminarily study in which stem cells were isolated from LCPD-affected femoral heads and their mRNA expression of vascular inducing factors was evaluated. Based on the results, FGF-2 and HGF were considered as the candidate factors involved in the pathology of LCPD. This study may contribute to elucidation of the pathogenesis, and development of therapeutic targets, for LCPD.

Intra-thoracic gossypiboma removal by thoracoscopy in a dog.

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Introduction
Gossypiboma (textiloma) are surgical swabs creating an iatrogenic granulomatous inflammatory lesion in the body when left behind after a surgical procedure. So far, intra-thoracic gossypiboma have been poorly described in veterinary literature. We report the first intra-thoracic gossypiboma removed by thoracoscopy in a dog.

Case description
A 10 years old Belgian Shepherd presented with hyperthermia and a history of exploratory thoracotomy performed seven months earlier for a suspected thoracic foreign body based on a thoracic CT scan exam. A control thoracic CT scan was performed at our hospital and revealed a rounded and consolidated lesion located in the right middle lobe lung compatible with a granuloma or a neoplastic process. The dog underwent an exploratory thoracoscopy and a partial lung lobectomy of the right middle lobe was performed with an endo GIA stapler. A biopsy of the sternal lymph node which was enlarged was carried out at the same time. Samples were sent for histopathology.

Results
The histopathology results confirmed an encapsulated gossypiboma in the lung lobe tissue and a chronic granulomatous lymphadenitis compatible with an inflammatory process most likely resulting from the gossypiboma. Those findings suggested a surgical swab was left in situ during the previous thoracotomy procedure. The dog recovered well and left the hospital 24 hours post-operatively.

Discussion/Conclusion
Intra-thoracic gossypiboma removal can be successfully achieved by thoracoscopy hence reducing the post-operative pain usually encountered after a classic thoracotomy procedure and allowing a faster recovery period of the patient.

Left pancreaticoduodenostomy following removal of the right lobe and the body of the pancreas including the pancreatic papillae in a cat

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Objective
To report the surgical technique for pancreaticoduodenostomy and outcome in a cat.

Case description
A 14-year-old female spayed domestic cat was referred for anorexia and a large cystic abdominal mass. Abdominal ultrasound revealed a heterogeneous cavity in the left pancreatic lobe as well as a large, thick-walled, hypoechoic cystic lesion continuous with the right pancreatic duct and involving the body and the right lobe of the pancreas. Surgery was elected and consisted of the removal of the right lobe, the body and part of the left lobe of the pancreas. Due to the large resection, including the minor and major pancreatic papillae, a left pancreaticoduodenostomy was performed.

Results
Histology revealed lesions of chronic pancreatitis with reactive lympadenopathy. A good clinical outcome was observed during the follow-ups and the pancreas retained good function. The cat was presented 225 days after surgery for cough, nasal discharge and dysorexia. Thoracic radiographs revealed multifocal alveolar areas and nodules throughout the lung parenchyma. An enlarged liver infiltrated by heterogeneous masses, polylymphadenopathy and peritoneal effusion were also noted on ultrasound. Due to the poor prognosis, the cat was euthanized. Postmortem histology revealed metastatic carcinoma.

Conclusion
The pancreaticoduodenostomy preserved the left pancreatic lobe and should be considered for extensive pancreatectomy involving the pancreatic papillae. Good outcome was observed in this case but additional studies are required to determine the complication rate of this procedure. To the authors' knowledge, this report represents the first surgical description and clinical outcome for pancreaticoduodenostomy in cats.

Long term survival of a dog with ovarian adenocarcinoma treated with surgery and intraperitoneal carboplatin.

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Introduction
Ovarian tumours are uncommon in dogs owing to the routine practice of ovariohysterectomy. The prevalence of ovarian tumours in entire females is 6.25%. Approximately 50% of them are epithelial and 64% of them malignant, adenocarcinoma being the most common.

Case description
A 9-year old female intact English Bulldog was presented with abnormal vaginal discharge. Abdominal mass was suspected on ultrasound, and CT scan detected a 15 cm diameter mass originated from the left ovary without involvement of adjacent organs or lymph nodes.

Results
Both ovaries and uterus were removed. Histopathology diagnosis was ovarian adenocarcinoma with high pleomorphism and nuclear atypia. Three doses of intracavitary carboplatin were administered 21 days apart. 365 days following surgery a nodule was detected by control ultrasound and CT scan confirmed its location in the left kidney. Complete nephrectomy was performed. Owners declined further chemotherapy and dog was euthanized 361 days later due to presumed brain metastases.

Conclusions
Previously reported treatments for canine ovarian carcinoma are mostly limited to surgical resection of gross tumor tissue. Another study retrospectively reviewed the use of intracavitary carboplatin and/or mitoxantrone in dogs with carcinomatosis, sarcomatosis, or mesothelioma; however, there were no cases of ovarian carcinoma included. Recurrence of disease was controlled for 367 days with 3 doses of intracavitary carboplatin and total survival time was of 726 days. This protocol was very well tolerated and although there is no stablished median survival time for ovarian carcinoma in dogs, an acceptably long survival time was achieved.

Long-term complications of extraluminal prosthetic tracheal rings as treatment for tracheal collapse in a Boxer

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Introduction
Surgical treatment options for tracheal collapse in dogs consist of extraluminal treatment with prosthetic tracheal rings or intraluminal treatment with stents. Reported long-term outcome for extraluminal prosthetic tracheal rings is good, with 65% of dogs not needing additional medical therapy in one study. Here we report the development of prosthesis-related complications 7 years after the original surgery.

Case description
An eight year-old female Boxer was presented with dyspnea, a laryngeal stridor and severe exercise intolerance. When the dog was one year old, it was diagnosed with grade II-III cervical tracheal collapse and treated with placement of extraluminal prosthetic tracheal rings surrounding the cervical trachea. The dog recovered uneventfully from this surgery and was symptom-free for seven years.

Results
A CT scan and tracheoscopy were performed and severe narrowing of the tracheal lumen, due to extraluminal compression at the level of the first external ring was found. A ventral midline cervical exploratory surgery was performed and the first two prosthetic rings were found to be surrounded by granuloma tissue and fluid. The affected prosthetic rings were removed and replaced. Postoperative tracheoscopy showed clear improvement of the tracheal diameter. After initial persistent dyspnea, possibly due to swelling follow-up at 4 months after surgery showed a good outcome with complete resolution of the dyspnea.

Discussion/conclusions
After an initial good outcome, long term complications of extraluminal prosthetic tracheal ring placement are possible, but can be successfully treated with revision surgery and replacement of the prosthetic rings.

Long-term follow-up of laparoscopic deroofing and fulguration of a dysembryoplastic simple renal cyst in a dog

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Introduction
Simple renal cysts (SRCs) are often diagnosed incidentally in both human and veterinary patients not displaying any clinical signs. When pain, systemic hypertension or urinary obstruction occur in people, however, treatment is recommended by percutaneous drainage and sclerotherapy or laparoscopic deroofing but few reports are available in small animals. The objective of this report was to describe laparoscopic treatment and long-term outcome of a dysembryoplastic SRC in a young dog experiencing clinical signs of chronic kidney disease (CKD).

Case description
A 10-month-old male cross-breed dog was presented with a 4-week history of polyuria and polydipsia and chronic vomiting with flank pain for 6 months. Laboratory tests revealed IRIS stage 1 CKD (symmetric methylarginine-SDMA=17 µg/dL). Diagnostic imaging showed a well-defined unilateral renal mass containing anechoic fluid consistent with a SRC.

Results
The cyst was drained but recurred 3 months later along with associated clinical signs. The cyst was deroofed and fulgurated and the kidney was subsequently closed and omentalized under laparoscopy. The resected cystic wall was histopathologically consistent with a dysembryoplastic renal cyst. The dog showed good recovery with resolution of the flank pain, emesis as well as polyuria and polydipsia. Renal function was normal (SDMA=5µg/dL) at last follow-up 3 years postoperatively without ultrasonographic evidence of recurrent disease.

Discussion/Conclusion
This case is the first description of a symptomatic dysembryoplastic SRC surgically treated. Laparoscopic deroofing, fulguration, and omentalization appears to be a valuable minimally invasive approach to achieve cure in dogs with clinical SRCs.

Long-term outcome after arthroscopic treatment of 23 dogs affected by osteochondritis dissecans of the medial humeral condyle.

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Introduction
Medial humeral condylar OCD in dogs is considered to have a guarded prognosis, which has led to the development of invasive restorative techniques. This study aims to evaluate the long-term outcome after arthroscopic treatment of this disease.

Materials & methods
Twenty-three dogs (30 elbows) were included in this retrospective multi-centre case series. OCD was confirmed by computed tomography and arthroscopy. Arthroscopic treatment consisted of removal of the flap, curettage of the cartilage bed and micro-picking of the subchondral bone. The dogs were evaluated preoperatively and during long-term follow-up (> 6 months) by lameness assessment, brachial circumference and elbow range of motion measurements and international elbow working group (IEWG) scores on radiographs. Owners completed the canine brief pain inventory (CBPI) score and a visual analogue scale (VAS). Outcomes were assessed on the basis of lameness and CBPI long-term scores. Results were compared using Wilcoxon statistical tests.

Results
Long-term (median 22 months, range: 6 – 98 months) postoperative VAS, CBPI and lameness scores were significantly lower ($P<0.01$) than preoperative ones. Long-term radiographic IEWG scores were the same as preoperative ones in 56% of elbows and had progressed by 1 grade in 44%. Long-term complications consisted of persistant grade 1 lameness and occurred in 23% of dogs. Long-term outcomes were very satisfying, rated as good to excellent in 94% of dogs and intermediate in 6%.

Conclusion
Arthroscopic treatment is a suitable surgical procedure for management of medial humeral condylar OCD in dogs, providing good long-term results.

Mechanical Comparison of a Novel Angle-Stable Interlocking Nail to a Locking Plate Construct in a Fracture Gap Model

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Introduction
Interlocking nails (ILNs) are increasingly used in veterinary surgery to treat comminuted fractures. The purpose of our study was to describe a novel angle stable ILN (NAS-ILN) and to compare those mechanical properties to a locking compression plate construct (LCP) in a fracture gap model.

Materials and Methods
Synthetic bone models simulating a 50 millimeter diaphyseal comminuted canine tibial fracture were treated with either a 6mm NAS-ILN or 3.5 LCP. Maximal axial and angular deformations, stiffness, as well as load, torque and bending moment to failure in compression, torsion and 4-point bending were statistically compared ($p<0.05$).

Results
Axial deformation in compression and bending was significantly lower for NAS-ILN than for LCP, with a mean of 0.11mm in compression and 3.19mm in bending versus 1.10mm and 4.17mm respectively. Ultimate load to failure in compression was significantly higher for NAS-ILN, with a mean of 803.58 N, than for LCP, with a mean of 328.40 N.Ultimate bending moment to failure in bending was significantly higher for NAS-ILN, with a mean of 25.73 Nm, than for LCP, with a mean of 16.29 Nm. In torsion, angular deformation was not significantly different but maximum torque was significantly higher for NAS-ILS with a mean of 22.45Nm versus 19.10Nm for LCP. NAS-ILN construct stiffness was significantly higher in compression and bending.

Discussion/Conclusions
This study demonstrated that in this fracture gap model the NAS-ILN was superior to the LCP construct. Based on those results, NAS-ILN is a suitable alternative to LCP to treat comminuted fractures.

Nebulised epinephrine in the postoperative management of brachycephalic obstructive airway syndrome complications and short-term outcomes in 90 cases (2014 – 2020)

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Introduction
Corrective surgery for brachycephalic obstructive airway syndrome (BOAS) can lead to post extubation upper airway obstruction secondary to laryngeal and pharyngeal oedema. In human patients with upper airway obstruction nebulised epinephrine is used to reduce laryngeal oedema. Nebulisation with epinephrine has recently been reported to reduce the BOAS index of dogs pre and postoperatively. In that study no systemic effects of epinephrine were reported. In human medicine, the incidence of systemic side effects of ephinephrine following nebulisation is low. The aim of this study is to retrospectively assess the complications of administration of nebulised epinephrine in the postoperative management of BOAS.

Materials and Methods
Retrospective single-centre study of 90 dogs nebulised with epinephrine following corrective surgery for BOAS. Data recorded included surgery performed, signalment, heart rates, respiratory rates, nebulisation protocol, patient compliance and days to follow up as well as short term outcomes.

Results
Nebulisation with epinephrine was well tolerated in 86/90 (96%) of dogs. No dogs suffered tachycardia following or during administration of nebulised epinephrine. Median heart rates during and following nebulisation with epinephrine were similar. Follow up for a median of 24 days was available for 76 dogs and outcome was judged to be satisfactory in 68 (89%).

Conclusions
Nebulised epinephrine can be considered as part of postoperative management of BOAS patients. Systemic side effects relating to epinephrine administration were not reported in this study.

Outcome after Decompressive Laminectomy and Vertebral Stabilisation for Thoracolumbar Vertebral Instability in 7 Pekingeses.

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Introduction
Intervertebral disc degeneration causes loss of stiffness in the disc resulting in vertebral instability and disc protrusion/extrusion. Vertebral instability resulting from congenital vertebral or articular process anomalies has been reported in French bulldogs, Pugs and some other breeds, although its severity may not correlate with the degree of anomalies. We report thoracolumbar vertebral instability treated by decompression combined with stabilisation at affected sites in 7 Pekingeses.

Materials and Methods
Medical records (2007-2020) of Pekingeses (n=7) with spinal cord injury due to thoracolumbar vertebral instability treated with a hemilaminectomy and vertebral stabilisation were reviewed. Data on pre- and postoperative neurologic status, diagnostic findings, surgical techniques and follow-up clinical evaluations were retrieved.

Results
Presenting clinical signs were progressive ambulatory paraparesis (n=5) or paraplegia (n=2). No dog had survey radiographic (n=7), CT (n=4) or MRI (n=1) findings of the vertebral or articular process anomaly. All dogs had thoracolumbar dynamic spinal cord compression that was exacerbated by the stress myelographic study. Vertebral instability was confirmed by intraoperative manipulation of affected vertebral segments in all dogs. All dogs recovered with no (n=6) or mild (n=1) neurological deficits 1-2 months postoperatively and at last follow up (median: 24 months, range: 3-123 months).

Conclusions
Pekingeses appear to have thoracolumbar vertebral instability that is not associated with the vertebral or articular process anomaly. Stress myelography and/or intraoperative manipulation of the spine is indicated to diagnose this condition. Decompressive laminectomy with vertebral stabilisation was an effective treatment resulting in long-term neurological improvement in all dogs.

Outcomes and postoperative complications after transpelvic urethrostomy used as first-line surgery in 31 male cats with obstructive lower urinary tract disease

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Objectives
To report short- and long-term outcomes after transpelvic urethrostomy (TPU) as a first-line surgery to treat obstructive lower urinary tract disease (OLUTD) in male cats

Methods
Client-owned male cats with OLUTD undergoing a TPU as first-line surgery (2013-2019) were included in this single-centered study. Data was collected from medical records and from an owner phone questionnaire conducted at least one year after the TPU. Short-term outcome was evaluated in the first four weeks postoperatively, long-term outcome after the first four weeks.

Results
31 male cats were included. Short-term complication rate was 16%. Idiopathic LUTD (ILUTD) and stomal stenosis (SS) were the two main short-term complications. Long-term complications were reported in 39% of the cats, with ILUTD, urinary tract infection, SS being predominant. The mortality rate was 6.7%. TPU totally satisfied 81% of the owners. The main reason for discontent was the occurrence of SS. Failed TPU were resolved after a median of 2 re-interventions. The long-term quality of life was considered good to very good by 87% of the owners. Eighty-eight percent of the cats were disease-free at questionnaire completion.

Conclusions and relevance
Most cats experienced a satisfying quality of life after TPU. Most of the complications were transient or manageable medically. Results suggest that TPU is an acceptable first-line surgical technique to treat cats with OLUTD. However, because re-intervention on a failed TPU can be challenging, a prospective study comparing TPU and perineal urethrostomy (PU) is needed to validate the use of TPU as an alternative to PU.

Patient specific synthetic resurfacing of a talar OCD

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Introduction
Tarsal OCD is well described in dogs. Most commonly the medial ridge is affected and lesions can be extensive. Reported treatment options are frequently associated with a guarded prognosis. This case report describes the long-term outcome of a custom-made partial tarsal replacement.

Case Description
A 7-month old male Rhodesian Ridgeback was presented with progressive left hind limb lameness, which was attributed to an extensive medial talar ridge OCD. Due to the severity of the lesion, a resurfacing procedure was chosen. Based on CT data, a bi-layered resurfacing implant, consisting of a titanium socket and a polycarbonate urethane bearing surface, was constructed. For intraoperative guidance, a set of matching drill guides was 3D-printed, along with some models of the affected talus, to allow for dry-lab training. Surgical implantation, using a distal sagittal tibial osteotomy to approach the lesion, went without complication. Follow up orthopedic examinations were conducted at 10 days, and radiographic examinations were included at the 4 week, 12 week, 6 month, and 12 month follow ups.

Results
Function improved greatly during the follow up period with a lameness Grade of 0-I/IV at the 12 month follow up. ROM differed by 15° in flexion compared to the contralateral side, while there was no difference in extension. Moderate peri-articular fibrosis was present at 12 months. Implant positioning was unchanged at follow up-radiographic examination and there was only mild progression of OA.

Discussion/Conclusion
Fully guided tarsal OCD resurfacing with a synthetic custom-made implant proved to be an effective treatment option.

Precision of femoral torsion computer generated in actual canine cadavers

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Introduction
Current methods of surgical planning for correction of limb deformities involve the use of computer simulation or 3D printed models. There is a lack of information about how precisely the computer simulation relates to the actual surgical correction**.** The purpose of this study is to evaluate the final femoral torsion achieved in canine cadavers planned using computer simulation.

Material and methods
A CT scan was performed of both pelvic limbs of 5 canine cadavers, and a stereolithography (STL) file was obtained for each femur. Using Computer Aided Design (CAD) software, a distal femoral torsion of 10^{o}, 20^{o} and 30^{o} internally and externally was simulated. Bone plates were designed and 3D printed to custom fit the femoral diaphysis and to induce the femoral torsion. Bone plates were created with 0^{o} ,10^{o}, 20^{o} and 30^{o} of internal and external torsion, and an osteotomy guide for the selected point in the diaphysis was also produced. The plates were designed to fit the same location on the cadaveric femoral diaphysis, and so a single set of screw holes were drilled and could be used for each plate. A CT scan was repeated for 0^{0} and each of the rotation angles, and a new STL file was obtained for each. Pre and post torsion STL files were compared by measuring torsion at the level of the femoral condyles using CAD software for the computer simulation and cadaveric femurs.

Results
Of the 10^{o}, 20^{o} and 30^{o} of intended torsion, the torsion achieved with the computer simulation at the level of the femoral condyles was 10+/-0.4^{o}, 20+/-0.5^{o} and 30.1+/-0.6^{o} degrees respectively, and 8.1+/-1.8^{o}, 17+/-1.9^{o} and 26.7+/-2.5^{o} in the canine cadavers.

Discussion/Conclusions
Computer simulated femoral torsion is precise and can be translated into an accurate cadaveric torsion. The cadaveric torsion is more precise the higher the torsion angle. The torsion achieved was never higher than planned.

Retrospective cross-sectional cohort study evaluating surgical treatment and outcome in dogs with septic peritonitis secondary to neoplasia.

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Introduction
Septic peritonitis is a life-threatening disease that demands appropriate stabilization, timely surgical intervention to address the cause, and meticulous aftercare. There is minimal data evaluating outcome in patients with septic abdomen resulting from neoplasia. The objective of this study was to evaluate if there was a difference in short-term survival between neoplastic and non-neoplastic causes of septic peritonitis.

Materials and Methods
This is a single-institution cross-sectional cohort study. Medical records for dogs that had surgical treatment of septic peritonitis from January 1st, 2010 to November 1st, 2020 were reviewed. Information collected included preoperative, intraoperative, and postoperative data.

Results
Eighty-eight dogs were included – septic peritonitis was caused by neoplasia in 15 dogs, and non-neoplastic diseases in 73 dogs. The most common neoplasia were gastrointestinal lymphoma (n=3) and hepatocellular adenoma (n=3). The most common non-neoplastic cause of septic abdomen was dehiscence of a previous gastrointestinal surgical site (n=16). The mean Animal Trauma Triage (ATT) scores were 2.5 and 1.9 for neoplastic and non-neoplastic groups, respectively. The mean Acute Patient Physiologic and Laboratory Evaluation (APPLE) full/fast scores were 33/20 and 28/21 for neoplastic and non-neoplastic groups, respectively. 40% of neoplastic cases died before discharge (6/15), compared to 26% of non-neoplastic cases (19/73; p=0.2).

Discussion/Conclusions
Neoplasia as a primary cause of septic peritonitis was not a significant negative short-term prognostic indicator. The diagnosis of neoplasia should not deter an owner from seeking surgical treatment for septic peritonitis.

Stabilization of femoral capital physeal fractures with cortical positional screws in 39 cats

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Introduction
Femoral capital physeal fractures in cats can be caused by trauma or capital physeal dysplasia. The aim of this report is to describe the surgical technique and short-term outcome following the use of cortical positional screws for the treatment of these fractures in cats.

Materials and Methods
Medical records and radiographs of cats with femoral capital physeal fractures stabilized with cortical positional screws were retrospectively reviewed. Signalment, bodyweight, femoral head affected, fracture classification, fracture reduction, position of screws, size of screws, number of screws, concurrent orthopaedic injuries, degenerative joint disease, osteolysis, osteosclerosis, complications, and 6-week postoperative clinical results were recorded.

Results
Forty-six fractures in 39 cats are included in this study. Overall, 89.7% of the cats showed a normal gait and 76.9% had no reaction on passive movement of the affected hip at six-week follow-up. Complications occurred in two cases and involved a seroma in both. There was a significant increase in radiographic degenerative joint disease ($p=0.037$) and osteolysis ($p=0.001$) and a significant decrease in osteosclerosis ($p<0.001$) at radiographs six weeks postoperatively. Domestic Shorthair cats had 7.58-fold greater odds (95% CI: 1.42-51.24, $p=0.024$) of developing osteolysis compared to other breeds. Degenerative joint disease, osteolysis and osteosclerosis did not affect clinical outcome.

Conclusion
Femoral capital physeal fractures in cats can be treated successfully with the use of cortical positional screws. This technique can be considered as an alternative to primary fixation with Kirschner-wires or salvage procedures in cats.

Sublumbar abscessation in dogs : Clinical signs, CT results, surgical technique and outcome in 16 cases

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Introduction
Sublumbar abscessation is an unusual disorder with a common non-specific clinical presentation. We know little about this condition because of the few published studies and their small sample size. The aim of this retrospective study is to provide new data on the pathology.

Materials and methods
Medical records of dogs treated for sublumbar abscessation were retrieved over a 7-year period. Patient details, clinical signs, preoperative computed tomographic findings, bacteriology results, surgical technique, complications and long-term outcome were recorded.

Results
Main clinical signs were lumbar or flank swelling or fistula (75% 12/16) and lumbar pain (68,75%, 11/16). Computed tomographic images revealed abscesses of various sizes localised in the psoas muscles (100%, 16/16), spondylitis (75%, 12/16), locoregional adenomegaly (68,75%, 11/16), vertebral osteomyelitis (37.5%, 6/16), discospondylitis (12.5%, 2/16) and epidural inflammation (50%, 8/16). Pulmonary lesions of suspected migrating plant material were present in 40% of cases (4/10). Surgical technique consisted in abscess drainage, debridement and omentalisation via an abdominal approach in most cases. Vegetal foreign material was found in 7 patients. Perioperative complications consisted of slight hemorrhage in one case. Among the 15 animals that were followed-up, 13 showed no recurrence over a mean period of 36 months (86,7%).

Conclusion
Surgical treatment of sublumbar abscesses gives good long-term results. CT or MRI is required to have a good preoperative abscess assessment and for proper surgical planning. Our study highlights that vertebral lesions are commonly associated with sublumbar abscesses (prevalence of 87.5%) and that foreign body migration from the lung is frequently suspected. Concomitant epidural inflammation was successfully treated medically in most cases.

Subtotal epiglottectomy and photoablation of unilateral arytenoid cartilage as surgical treatment of grade III laryngeal collapse in twelve dogs.

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Introduction
Aim of this study was to evaluate the clinical outcome of subtotal epiglottectomy (STE) associated with photo ablation of unilateral arytenoid cartilage tissue performed in twelve dogs affected by III stage of laryngeal collapse

Materials and methods
Inclusion criteria were dogs affected by stage III of laryngeal collapse and persistent severe dyspnea. For each dog information including signalment, clinical signs, physical examination findings were recorded. At the clinical examination owners were asked to rate their dog according to the clinical signs as follows: severe (exercise tolerance < 3 minutes in their home, evidence severe respiratory signs, stertor), moderate (exercise tollerance >3min and < 5with moderate respiratory signs, stertor) mild (exercise tollerance > 5 min with no evidence respiratory signs).

Results
Preoperatively the owners graded clinical sign severe in seven cases, moderate in four cases and mild in one cases. Surgical procedures performed prior to epiglottectomy and photo ablation of arytenoid cartilagine tissue in all dogs (12/12). Surgical mean time was 32 minutes (range 25 to 41 minutes). In two dogs temporary tracheostomy was performed due to evidence of laryngeal edema. One year after surgery owners rated dogs as follow: excellent in five cases, good in five cases and fair two cases.

Discussion
STE associated with photo ablation of unilateral arytenoid cartilage may be used to treat stage III laryngeal collapse in order to increase the amount of air passing through the larynx, and reduce both airway resistence and negative intraglottic luminal pressure.

Surgical management of a large lacrimal cyst in two adult dogs.

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Introduction
Lacrimal cyst is a rare condition in dogs that may be congenital or acquired secondary to an obstruction of the nasolacrimal duct. These cysts may be invasive and penetrate the nasal cavity. Pre-operative planning seems to be essential for a complete surgical removal.

Case description
A 6-year-old female Cane Corso and a 7-year-old male White Swiss Shepherd Dog were referred for a chronic unilateral epiphora and a voluminous swelling adjacent to the medial canthus of the eye. CT scan showed a large cystic lesion associated with osteoproliferation and osteolysis of the maxillary bone. Surgical treatment consisted of a careful dissection and en bloc resection of the cyst after lacrimal point catheterization. Strong adhesions were present with the underlying bone and nasal concha. Histological examination was compatible with a cyst of lacrimal duct origin. At 10 months and 3 years follow-up respectively, there was no sign of recurrence.

Discussion/Conclusion
Lacrimal cyst should be included in the differential diagnosis of soft facial mass around the eye. Diagnosis is based on diagnostic imaging (CT, dacryocystography) and histology. Surgical excision of large cysts can be challenging because of the cyst's thin wall and adhesions to adjacent structures. Recently, alternative treatments have been described (marsupialization, injection of fibrosing agent). However, recurrence is more prone to occur with these techniques. In these cases, 3D imaging allowed assessment of the extent of the lesions and a precise surgical planning. Surgical cyst removal was curative and without complication.

Total prostatectomy for prostatic carcinoma in a cat

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Introduction
Neoplasms of the prostate gland are uncommon in cats . The objective of this report is to describe a well documented case of total prostatectomy for prostatic carcinoma in a cat. Only a few cases of prostatic carcinomas in cats have been reported none of which resulted in CT scan study and post-operative urine continence.

Case description
We describe a case of prostatic carcinoma in a male cat that resulted in obstruction of the urethra. A 9-year-old neutered male domestic was evaluated for pollakiuria, and urinary obstruction, but also weight loss, inappetence, lethargy and constipation due to dorsal displacement of the rectum.
Blood work, urine examination and abdominal ultrasound was performed. An ultrasound guided fine needle aspirate was submitted for cytology. Total body CT scan resulted in no metastasic disease and well confined enlarged prostatic gland.
A total prostatectomy was carried out via a caudal celiotomy. It was not necessary to increase exposure with bilateral pubic osteotomy. A section of prostatic urethra was resected together with the prostate gland. An end-to-end urethral anastomosis resulted in requirement of a tension suture. A prepubic urethrostomy was necessary. A foley catheter was placed postoperatively.

Results
There were no major complications. Histopathology diagnosed a prostatic carcinoma with a clean margin of excision. This feline patient maintained urinary continence.

Discussion
The literature survey would suggest that feline prostatic neoplasia is an uncommon disease. Total prostatectomy is a potential choice for small and well circumscribed prostatic carcinomas in cats. Urinary incontinence may not be a concern in this case.

The usefulness of physiotherapy in occult lameness

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Introduction
The goal of physiotherapy is to relieve pain, improve the range of motion, promote mobility, muscle mass and strength, to stimulate limb use and to improve the condition of the patient. There is a tendency to admit dogs for physiotherapy when no orthopaedic diagnosis is available, in other words: in cases of occult lameness. The idea is that physiotherapy would help the animal because of the beneficial effects.

Local effects are obtained with manual therapy such as massage, stretching, traction, cold packs, hot packs, electricity (TENS, NMENS) ultrasound and laser.

General effects (mobility, muscle mass and strength, limb use and condition) can be obtained with hydrotherapy, the underwater treadmill, and passive, assisted or active exercise.

The treatment protocol is a combination of the different modalities and is defined by the disorder, the stage of the problem and the status/condition of the animal. In the acute phase physiotherapy focuses on the local effects: pain relief, reduction of the inflammation and restoration of the range of motion (ROM). In the repair phase the focus is on muscle strength and functional stability (general effects). In the functional phase the aim is to return to the pre-trauma state by an improved limb use and condition of the patient (general effects).

Practical approach via clinical cases
Occult cases can be divided in two groups:

1. localization of the problem but no evident pathology, e.g. painful elbow

2. no localization of the problem

In this lecture, attention is given to the benefits and the disadvantages of physiotherapy in cases of occult lameness. The usefulness of physiotherapy will be determined in several examples of clinical cases. It will become clear that without a specific diagnosis, physiotherapy may only help in a limited number of cases. In most of the occult cases, a more thorough diagnostic workup is necessary and will lead to a specific diagnosis. Several causes of occult lameness and how to diagnose them, will be illustrated by means of the clinical cases.

References
A clear overview of the available physiotherapy methods can be found in this review:

1. Physiotherapy in small animal medicine, Y. Samoy, B. Van Ryssen, J. Saunders Vlaams Diergeneeskundig Tijdschrift, 2016, 85, 323-334.

The role of electrochemotherapy in multimodal cancer treatment

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Introduction

Electrochemotherapy
Chemotherapy drugs are effective provided that they reach their site of action. The primary obstacle for chemotherapy agents is the cytoplasmic membrane, especially for lipophobic agents such as bleomycin. Electrochemotherapy (ECT) couples the administration of an anticancer agent (usually bleomycin or cisplatin), to the delivery of electric pulses having appropriate waveforms. The application of permeabilizing pulses leads to perturbation of the cell membrane with the formation of transient pores (or aggregation of transmembrane proteins that generate larger openings), thus resulting in increased uptake of chemotherapeutic drugs, ultimately leading to cell apoptotic death.[1,2] The formation of pores involves the following moments: 1) Electric perturbation with formation of membrane openings 2) The membrane lipids change their orientation orienting the idrophobic tails away from the pore in order to face the pore with the hydrophilic heads 3) stabilization of the pores by means of water binds 4) Free flow of molecules. The standard protocol varies between in vitro and in vivo applications. In vitro are used electric protocols ranging from one to eight unidirectional pulses (square or rectangular) with a voltage of 100 to 300 V, while in vivo the standard protocols call for eight permeabilizing pulses at a voltage of 1300 V/cm adopting either monophasic or biphasic electric pulses. The duration of the single pulse Is usually 100 µs. The window of opportunity to enhance the uptake of drugs after the application of electric pulses is 5-15 minutes for larger molecules (greater than 50000 Daltons) and up to 40 minutes for smaller molecules.

Electrochemotherapy Equipments
Different waveforms have been adopted by investigators: exponentially decaying, square, rectangular or biphasic. In general, the number of pulses delivered is set in 8 single pulses applied per cm of tumor area at a voltage of 1300 V/cm (800 V/cm for intraoperative use), with a duration of 100 µs and a frequency of 1-5 Hz. Treatments are repeated until the whole tumor area is covered. We recently developed a shortened protocol with decreased morbidity and maintained efficacy.

Results in Veterinary Medicine using Square Pulses based ECT
The first clinical trial in veterinary patients involved the treatment of feline sarcomas recurring after radiation therapy using bleomycin and Interleukin 2 producing cells coupled with square pulses. The authors did not report any clinical response but claimed prolonged control for cats undergoing ECT compared to untreated patients. More recently, CDDP or bleomycin based ECT has been reported to treat cutanous neoplasms in dogs and cats.

Evaluation of Biphasic Pulses Based ECT in Pets

Melanoma
Ten patients with malignant melanoma (MM) of the oral cavity were enrolled in a phase II study. The overall response rate was 80% (median time to recurrence 6 months), with a 50% of patients in remission after 1 year. Of interest, most of the long term responders experienced a vitiligo like discoloration at the treatment site, potentially suggestive of recruitment of the immune system after uncovering of deep antigens.

Feline soft tissue sarcoma
A total of 72 cats affected by soft tissue sarcoma were assigned to three different groups: 1) surgery alone, 2) surgery coupled with intraoperative ECT, 3) surgery coupled with post-operative ECT. The median control times were respectively 4, 12 and 19 months. In this study were identified some prognostic factors such as previous treatment and tumor size. A cat with a recurring hemangiopericytoma was also referred at the time of the study for adjuvant ECT and obtained a lifelong tumor control. The only side effects were tumor dehiscence in 2 patients and focal inflammation in 2 patients. Systemic side effects were not reported among the enrolled patients.

More recently, ECT has been exploited to reintroduce potentially toxic drugs in the oncology protocols. Specifically, a cohort of 64 cats with incompletely excised soft tissue sarcoma have been enrolled in a study involving the use of cisplatin as ECT agent and matched with a control cohort of 14 cats treated with surgery. All the cats tolerated the treated very well, despite the high reported toxicity of the drug when administered systemically. In terms of tumor control mean time to recurrence was 666 days and 180 days, respectively.

Canine soft tissue sarcoma
In the first study, adjuvant ECT was adopted to increase local control in a group of 22 dogs, obtaining a mean time to recurrence of 730 days, with 50% of the dogs still disease free at the time of writing. In one dog with a large, unresectable sarcoma, ECT has been used to decrease tumor size and allow surgical excision. A more recent report describes the outcome of 54 canine sarcoma treated with systemic bleomycin ECT reporting a recurrence rate for intraoperative and adjuvant ECT of 23 and 25%, respectively. Another recent article describes the outcome of 30 dogs with incompletely excised sarcomas treated with systemic bleomycin and local CDDP combined with ECT reporting a median disease free interval of 857 days.

Mast cell tumor
ECT has been extremely effective at directly attacking canine mast cell tumors or in adjuvant fashion, using either bleomycin or cisplatin with high response rates and long term control times.

Feline cutaneous squamous cell carcinoma
Several articles reported the favorable outcome of cats treated with ECT for squamous cell carcinoma (even at advanced stages) with response rates ranging from 77 to 90%, limited side effects and long term controls, often using different doses of bleomycin.

Conclusion
ECT is a safe and efficacious approach to small animal malignancies. Its low cost and ease of administration makes it a valuable addition to the currently available oncological therapies. One advantage of this technique is the possibility of repeated treatments in case of local recurrence and the recruitment of the patients' immune system, as suggested by the low incidence of metastatic disease among most treated patients and by the tumor selection observed among some pets with recurring disease.

References on request

The role of immunotherapy in multimodal cancer treatment

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Current therapy in veterinary oncology includes surgery, chemotherapy and radiotherapy; even the use of tyrosine-kinase inhibitors (TKI) is a routinary practice for their either specific anti-tumor effect or anti-angiogenic function. TKIs are often used in a metronomic regimen together with small, fractionated doses of other drugs (cyclophosphamide or chlorambucil, thalidomide, anti-cox2, etc.); metronomic chemotherapy is used for inoperable and/or metastatic tumors or to maintain a stable disease after more conventional adjuvant treatments. Nevertheless, for high grade tumors with high metastatic rate (hemangiosarcoma, appendicular osteosarcoma, oral malignant melanoma, grade III soft tissue sarcoma, mammary carcinoma, etc.), little improvement has been made in the last 5-15 years with regard to prognosis. Hence, new therapeutic strategies are warranted, already effective on their own and potentially to be combined with conventional treatments in an attempt to improve prognosis. Immunotherapy is the most promising among the new therapeutic modalities in oncology. The goal is to stimulate the host's immune system against cancer cells while sparing the normal ones. Immunotherapy may be active or passive, and specific or nonspecific; it includes monoclonal antibodies (Mabs), nonspecific immunotherapy activated by bacteria, vaccines, gene therapy, and lymphokine-activated killer cell therapy.[1,2]

Passive immunotherapy is when preformed immunological agents are transferred to the patient (cells – passive cellular or adoptive, - or MAbs – passive humoral). *Active* immunotherapy activates the host's immune system against the tumor. When the so called "biological response modifiers" (bacterial products or cytokines, or antibodies aiming to inhibit specific *immune checkpoints*) are used, we refer to nonspecific active immunotherapy. *Checkpoint inhibitors* serve to prevent cancer evasion from the immune system; at the moment, the experience in the veterinary field is limited. Immunotherapy is specific when a vaccine against a *stable* specific tumor target is used (*tumor associated antigen – TAA*) but its efficacy may be impaired when the disease is not controlled locally and/or the tumor has already spread. An ideal TAA should play a fundamental role in the oncogenesis (*oncoantigen*) and the antibodies elicited should recognize it as "non-self"; additionally, vaccination should ideally induce a long-term immunity ("memory"), thus delaying disease progression and prolonging survival. TAAs may be intact tumoral cells or well characterized tumoral antigens.

Immunotherapy in veterinary oncology
Apart from some preclinical trials aiming to the potential application also to humans of specific treatments [3], the experience in the veterinary field has involved mainly lymphoma, melanoma and sarcoma. Canine lymphoma is monoclonal in origin and Mabs and vaccines may be developed against specific superficial B lymphocyte antigens.

Canine melanoma
Local surgical control only results in a median survival time of 335 days (1-year survival rate, 29%); reported negative prognosticators are tumor's size, advanced age and marginal excision.[4] Immunotherapy is added to surgery in an attempt to improve survival as the results of adjuvant chemotherapy have been disappointing.

- Dendritic cell vaccine targeting the human melanoma antigen gp100.[5]

- Oncept$_{TM}$ (Merial) (approved by FDA in February 2010 but not approved by EMA) is a DNA vaccine used adiuvantly for stage II/III canine oral melanoma.[6,7] It is based on a bacterial plasmid gene encoding the *human tyrosinase* gene. Results have been sometimes contrasting;[4, 8-11] it has also been utilized in combination with radiotherapy[12] and may also be offered for canine digital melanoma.[13]
- DNA vaccine developed by the author's group against *human chondroitin sulfate proteoglycan-4 (CSPG4)*, a superficial TAA of melanocytes involved in proliferation, migration and invasion of tumoral cells, with limited distribution in normal tissues, and overexpressed by different tumors. Adjuvant vaccination of dogs with locally controlled stage II/III oral melanoma resulted in 12-, 18- and 24-month survival rate of 73.9, 47.8 and 30.4%, respectively and MST of 684 days.[14,15] *En bloc* (first surgery) vs. marginal excision appears beneficial (MST 1333 vs 470 days).[16]
- Allogeneic vaccine carrying human interleukin-2 (IL-2) and human granulocyte macrophage colony-stimulating factor (hGM-CSF) genes.[17]
- Mabs targeting immune checkpoint inhibitors (anti-PD-L1).[18,19]

Canine osteosarcoma
Immunotherapy should be an adjunctive to current "gold standard" (surgery plus adjuvant chemotherapy).

- Vaccine with alive Salmonella encoding for IL-2 A.[20]
- A vaccine with recombinant *Listeria monocytogenes* expressing chimeric human HER2/neu improved the outcome in 18 dogs;[21] however, some safety problems arised.[22,23]
- Autologous cancer vaccination, adoptive T-cell transfer, and IL-2 administration; it has been used in 14 dogs (MST 415 days with 5 dogs surviving > 730 days).[24]

Feline Injection site sarcoma
Recombinant canarypox virus vaccine expressing feline IL-2 (Oncept IL-2) after surgery/brachytherapy; further evaluation is warranted.[25.26]

Canine hemagiosarcoma
A vaccine has been constructed with lysates of allogeneic canine hemangiosarcoma cell lines added with liposome-DNA complexes.[27]

Evaluation of the response to immunotherapy
Active immune response can take some time before being effective. It may be indicated to evaluate the clinical response as correlated with specific markers and, in case of vaccination, with also the induced antibody titer. [14.15,28]

Ongoing research
Oncolytic virotherapy, radioimmunotherapy, chemoimmunotherapy[29], checkpoint blockers[18,19,30,31], reformulation of previously successful strategy (e.g., attenuated *Listeria* expressing chimeric human HER2/neu protein for canine osteosarcoma)[32], autologous vaccines, immunotherapy for canine mammary carcinoma, anti-angiogenic vaccines[33], etc. Our current project is the anti-CSPG4 electrovaccination together with surgery and adjuvant carboplatin for canine appendicular osteosarcoma.

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The role of metronomic chemotherapy in multimodal cancer treatment

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Introduction
The schedule of conventional cytostatic treatment is based on the “maximum tolerated dose” (MTD) approach where high doses of a chemotherapeutic agent are given at 2–4 week intervals and target rapidly dividing cells. As a result, the long breaks between therapy cycles can allow tumor cells to recover and develop resistance, consequently resulting in disease progression. In the past years, new approaches to chemotherapy itself have been proposed; including metronomic chemotherapy (MC). Although metronomic chemotherapy is defined as long-term administration of chemotherapeutic agents at relatively low, minimally toxic doses and with no prolonged drug-free breaks, the term metronomics also includes repositioning and repurposing of non-chemotherapeutic agents. This type of therapy aims at inhibiting tumor proliferation through several cell cycle independent mechanisms while considerably mitigating undesirable toxic effects.

The Concept of Metronomic Therapy

Anti-angiogenic effect
Tumor growth is dependent on the proliferation rate of tumor cells and on the ability of endothelial cells to deliver nutrients through newly formed blood vessels. Dose intensive protocols require prolonged periods between treatment cycles to allow normal cells to recover and resume their activity. During these pauses, endothelial cells in the tumor may also repair some of the damage induced by the chemotherapy and resume growth. It appears that continuous administration of low doses of cytotoxic drugs, may bypass this hindrance and induce tumor regression by elimination of endothelial cells involved in angiogenesis. Animal studies showed that metronomic chemotherapy could induce apoptosis of endothelial cells within the tumor bed, independently from the chemosensitivity or chemoresistance of tumor cells.

Continuous cytotoxic effect
MC can be considered as a variation of “dose-dense” therapy. The “maximum dose” approach generally requires breaks of two to four-week duration to allow recovery from damaging side effects; reducing these interruptions is referred to as “dose density”.

Immunomodulatory effect
Several cytotoxic drugs are able to induce immunogenic cell death. In preclinical studies, metronomic chemotherapy was shown to selectively reduce numbers of circulating regulatory T cells and thus curtail their immunosuppressive potential, resulting in a better control of the disease. Recent studies evidenced that antitumor immune responses obtained through metronomic treatment may evoke long-term immune memory leading to a rejection of tumor re-challenge in mouse models. This appears to be secondary more on its effects on the CD8+ T cells rather than NK cells.

Current adoption of metronomic chemotherapy in veterinary oncology

Exploitation of standard metronomic chemotherapy in veterinary patients
There are a few studies on MC in veterinary literature, where the combinations of different drugs have been used to directly attack inoperable neoplasms, as an adjuvant after incomplete tumor excision or to prevent/delay metastatic spread or as a maintenance after MTD chemotherapy. All studies included an alkylating agent such as cyclophosphamide or chlorambucil, combined with a NSAID such as piroxicam

or firocoxib. Tolerability of the combination was good and mostly confined to low grade gastrointestinal toxicities, while the major complication was the occurrence of sterile hemorrhagic cystitis in patients receiving cyclophosphamide in their protocol. Attempts to decrease such a regrettable complication led to the introduction of diuretics such as furosemide in the protocol or the replacement of cyclophosphamide with other alkylating agents, such as chlorambucil. The most extensively investigated application of MC has been as an adjuvant after incompletely excised splenic hemangiorcoma. The first study, authored by Lana et al., suggested that MC might be as effective as conventional chemotherapy at delaying metastases in stage II canine hemangiosarcoma. Further MC studies, using different combinations and protocols, yielded conflicting results in terms of the best use of MC against this neoplasm. Other studies evaluated the effectiveness of MC against solid tumors, showing promising results in terms of tolerability and effectiveness. In terms of multimodality approach to solid neoplasms, it has been described the effectiveness of MC at increasing local control after surgical incomplete excision of soft tissue sarcoma. On the other hand, MC failed at increasing patients' survival in dogs with osteosarcoma, as maintenance after the completion of standard chemotherapy.

Metronomic Chemotherapy as a Combination Partner for Targeted Therapy and Antiangiogenic Agents
In humans, there are several trials on the use of MC combined with Targeted Therapy such as anti-Her2 drugs or kinases inhibitors such as lapatinib and neratinib. In veterinary oncology toceranib is often added to standard MC to increase effectiveness. Moreover, there are numerous reports of the combination of MC with the administration of antiangiogenic drugs such as bevacizumab and an EGFR-inhibitor erlotinib or thalidomide. In veterinary oncology, due to the cost of most antiangiogenic monoclonal antibodies, only thalidomide has been investigated so far.

Metronomic Chemotherapy as a Combination Partner for patient alkalization
The acidic microenvironment caused by changes in the pH gradient between the intracellular and the extracellular compartments as well as the pH gradient between the cytoplasm and the intracellular organelles can be significantly involved in the mechanism of drug resistance. There are several mechanisms involved in this phenomenon, including decreased uptake or neutralization of weakly basic drugs by the acidic tumor microenvironment (ion trapping) or the sequestration of chemotherapy drugs within lysosomal vesicles. A single arm, non-randomized phase II open study, with historical control group suggested that alkalization could greatly improve the efficacy of metronomic chemotherapy with minimal side effects.

Conclusions
Metronomic chemotherapy has been proposed as an alternative to conventionally scheduled cytotoxic treatment following the "maximum tolerated dose" rule. In the metronomic concept the notion of "the higher the dose, the better" has been replaced by "high time, low dose", with the aim of administering systemic therapy continuously for as long as possible with minimal side effects. Metronomic chemotherapy has gained considerable interest in the field of alternative therapies to solid tumors. Metronomic chemotherapy is also a valid option in metastatic setting. Studies are needed to identify patients that are more likely to benefit from this approach and to standardize the protocols. Ease of administration, low toxicity, affordability and reasonable effectiveness make this approach appealing to clinicians and pet owner and is gaining popularity in daily practice.

References upon request

Outcomes and complications reported from a multi-centre canine total hip replacement registry over a ten-year period

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Introduction
A multi-centre registry was launched in 2010 to collect information on the indications, techniques, complications and long-term outcomes of canine total hip replacement (CHR). Our aim was to report results from the CHR registry from 2010 to 2020.

Materials and methods
CHR cases submitted over a ten-year period were reviewed with all data held on a secure Microsoft SharePoint registry. An on-line questionnaire including post-operative complications, owners' satisfaction and a perceived preoperative and postoperative Liverpool Osteoarthritis in Dogs (LOAD) score was emailed to owners. Data were analysed to determine any associations of variables as well as agreement of veterinarian and owners with complications.

Results
1329 dogs had unilateral and 523 dogs had bilateral CHRs. Common indications were hip dysplasia and osteoarthritis (n=784). Reported surgical implants for the first CHR were Kyon (n=756), Biomedtrix CFX (n=437), Hybrid (n=229), Biomedtrix BFX (n=183) and Helica (n=92). Veterinarian-reported complication incidence was 8.5% (n=202). 28% (n=461) of owners responded to the questionnaire, with a significant improvement in LOAD scores reported before and after CHR ($p<0.001$). According to the owner questionnaire, the incidence of owner-reported complications was 22.9%, poorly agreeing with those recorded by the veterinarian ($k=0.44$). No significant association was identified by uni-variable and multi-variable analysis between weight, age, gender, breed, or indication for CHR and the incidence of complications.

Conclusions
Client assessed outcomes suggest that CHR results in significantly improved mobility for dogs undergoing the procedure. However, complications may be under-reported by veterinarians compared to owners in this multicentre CHR registry.

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Biomechanical evaluation of a novel barbed suture pattern with epitendinous suture augmentation in a canine flexor tendon model

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Objective
To determine the effect of a novel barbed suture pattern (NBSP) compared to a three-loop-pulley pattern (3LP) with and without epitendinous suture (ES) augmentation on the biomechanical strength and gap formation of repaired canine tendons.

Study design
Ex-vivo, cadaveric, randomized, experimental study.

Sample population
Forty, adult superficial digital flexor tendons (SDFT).

Methods
SDFT were randomly assigned to 1 of 4 groups (n=10/group). Sharp tenotomy was performed and repaired with 3LP, NBSP, 3LP+ES and NBSP+ES. Constructs were tested to failure while evaluating yield, peak, and failure loads, loads at 1 and 3mm gap formation, and failure mode.

Results
ES augmentation significantly increased yield ($p<0.001$), peak ($p<0.001$) and failure ($p<0.001$) loads by more than 80%, with no difference between 3LP+ES and NBSP+ES constructs regarding peak ($p=0.614$), and failure forces ($p=0.865$). Occurrence of 1mm ($p=0.003$) and 3mm ($p<0.001$) gaps differed between groups with and without ES augmentation. Failure mode differed between groups ($p<0.001$). Failure occurred predominantly due to suture pull-through in 3LP and NBSP groups compared to tissue failure in ES augmented constructs.

Conclusions
The NBSP used in this study demonstrated similar force resistance to 3LP. NBSP+ES improved the biomechanical properties of repaired constructs. NBSP+ES decreased the occurrence of gap formation while requiring significantly higher loads to cause occurrence of 1mm gapping.

Clinical Relevance
This study is the first to demonstrate effectiveness of a similar sized barbed core suture compared to monofilament suture used for canine tendon repair without the need for knot tying. This NBSP warrants further focused exploration in-vivo.

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Biomechanical analysis of accessory tendon graft augmentation for primary gastrocnemius tendon reconstruction in dogs

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Objective
To evaluate the effect of accessory tendon graft (ATG) augmentation in addition to a primary core locking-loop (LL) and epitendinous suture (ES) repair in a hindlimb gastrocnemius tendon (GT) model.

Study design
Randomised, ex-vivo, biomechanical.

Population
24 canine GT musculotendinous constructs.

Methods
GT were randomly divided into 2 groups (n=10/group). After transection, paired GT were repaired with LL+ES or with ATG augmentation. Yield, peak and failure loads, tensile loads required to create 1 and 3mm gapping, and failure modes were analyzed. 4 GT were used as intact controls for testing methodology validation.

Results
Yield (P<0.0001), peak (P=0.0001) and failure loads (P=0.0003) were significantly greater when ATG was utilized for repair. Significantly greater force was required to cause a 1mm (P=0.0001) and 3mm (P=0.0002) gap in the ATG group, however frequency of gap formation to 1mm (P=1.000) and 3mm (P=0.998) did not differ. Constructs failed exclusively by suture pull-through (P=0.100).

Conclusions
Addition of an autologous ATG graft to a LL+ES primary GT repair increased yield, peak and failure forces by 1.6x, 1.9x, 1.8x respectively and required 2.1x greater force to create a 1 and 3mm gap respectively compared to LL+ES repairs alone.

Clinical significance
ATG augmentation for isolated GT repair may increase repair site strength and act as a biological scaffold while allowing ease of surgical graft harvest. ATG may provide the benefits of vascular ingrowth and tenocyte supply to improve tendinous healing. Additional in-vivo studies are required to determine the effect of ATG on clinical function and patient outcome.

Effect of Sedation on Patellar and Withdrawal Reflexes in Healthy Dogs

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Introduction
It is unknown how neurological examination and specifically patellar and withdrawal reflexes are affected by sedation, and, if present, how long any effect might last. The purpose of the study is to investigate the effect of sedation on the evaluation of select common limb spinal reflexes in otherwise orthopedically and neurologically healthy dogs.

Methods
14 healthy dogs were included. The patellar reflex, pelvic and thoracic limb withdrawal reflexes were tested and recorded at different time points: prior to sedation (awake), 15 minutes and 30 minutes following administration of sedation, and 15 minutes and 30 minutes following administration of the reversal agent. Reflex angle endpoint, change in angle, and change in time to reflex completion were measured each time.

Results
For patellar reflex, stifle end angle increased from 91.5^{o} to 108.55^{o} ($p<0.0001$) 15 minutes following sedation, and remained increased at 104.5^{o} ($p<0.0001$) 30 minutes following sedation. Stifle change in angle increased from 9.6^{o} to 24.4^{o} ($p<0.0001$) 15 minutes following sedation. These increases in angles generated a change in time for patellar reflex from 0.12s (awake) to 0.129s (15min sedation) which was statistically significant ($p=0.041$). Tarsal joint angle in pelvic withdrawal and elbow joint angle in thoracic withdrawal reflexes did not differ at any timepoint of sedation or reversal compared with awake, for end angle, change in angle or change in time.

Discussion/Conclusions
Sedation does not affect the evaluation of the withdrawal reflex in any limb but improves the visualization of the patellar reflex in this group of neurologically normal dogs.

Hot topics in antimicrobial resistant surgical site infections

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Surgical site infections (SSI), defined as an infection occurring at the surgical site within 30 days following a procedure or within one year of placing an implant, can cause increased morbidity, increased costs and even death. The criteria for determination of an SSI include the presence of purulent drainage, the aseptic isolation of organisms (a positive culture) or a combination of several of the following clinical signs (pain, tenderness, localised swelling, redness or heat). Ultimately, the definition of an SSI can be made at the discretion of the attending clinician. This does lead to inherent variability in what is considered an SSI and what isn't. Work is ongoing to provide clearer guidance as to characterisation and classification of SSIs; this is important as you can't measure what you can't define.

Rates of SSI vary according to procedure but typically fall in the 0.8-18% range in small animals. Lower rates of SSI (5.5%) were recently reported for clean surgical procedures (orthopaedic/neurosurgery and soft tissue). As culture is not always performed to define an SSI, the proportion that are causes by multi-drug resistant organisms (MDROs) is uncertain. Where reported MDROs are identified in between 1 and 7% of cases.

Antimicrobial resistance (AMR) is implicated in the death of 700 000 people per year globally and also causes millions of disability-adjusted life-years (DALYS). Antibiotic use is recognised as a key driver of AMR increasing the threat from MDROs. Therefore, it is the responsibility of all prescribers to use antibiotics in a rational manner. Unrestrained antibiotic use in small animals can, and will, contribute to the development of antibiotic resistance in bacteria that pose a threat to both animal and human health.

Bi-directional transfer of MDROs from companion animals to people has been recorded. Antimicrobial resistance may arise from de novo mutation during therapy (uncommon), via horizontal transfer of a resistance gene (e.g. plasmid) from other bacteria or due to opportunistic contamination by an MDR organism from the environment. This latter mechanism is likely most important in the context of MDR SSIs.

Pathogens of particular relevance for MDR SSIs include methicillin-resistant *Staphylococcus aureus* (MRSA), methicillin-resistant *Staphylococcus pseudintermedius* (MRSP), ESBL producing *Escherichia coli*, Acinetobacter spp and Pseudomonas spp. Nasal colonisation with MRSA is recognised in 5-10% of the general population, with increased carriage reported in healthcare professionals and to an even greater extent among veterinarians. Approximately 0-7% of companion animals were also found to carry MRSA. Most MRSA cases in animals are community acquired, but hospital outbreaks can occur.

Methicillin resistance which also confers resistance to penicillins (including potentiated penicillins), cephalosporins and carbapenems is afforded by the mecA gene which encodes an altered penicillin binding protein. Given the high importance of this pathogen in human hospitals, European surveillance networks have been created to monitor the proportion of Staphylococcal infections that demonstrate multi-resistance. This information can guide policymakers to set targets and review interventions. Moves are afoot to create similar tools for use in veterinary medicine (EARS-Vet).

Staphylococcus pseudintermedius is a more important pathogen from the small animal perspective and is the most common cause of canine pyoderma and can also be isolated from the majority of healthy dogs (common sites of colonisation include the nose, mouth and perineum) and a smaller percentage of cats. MRSP is the most frequent of the MDROs identified in studies of SSIs and is also isolated from

1.5-3% of healthy dogs (carriage state). Although as yet unproven, it is likely that MRSP carriers incur an increased risk of MRSP infection. Zoonotic risk to people is lower than for MRSA. Resistance is again mediated via carriage of the mecA gene although, MRSP also commonly acquires additional features conferring an extended spectrum of resistance including to fluoroquinolones, lincosamides, marcolides, potentiated sulphonamides and tetracyclines. Although MRSP is not inherently more virulent than its susceptible cousin, the pattern of resistance can leave few appealing antimicrobial options. Some superficial infections may be treated topically with chlorhexidine, silver sulfadiazine, fusidic acid, mupirocin or even honey. Where systemic antimicrobial therapy is warranted drug selection should be based on in-vitro antimicrobial susceptibility testing (AST). Both patient (co-morbidities) and drug factors (penetration at site of infection) should also be taken into account. Fluoroquinolone resistance can emerge quickly and inducible clindamycin resistance is common in MRSA (less so in MRSP). Highest priority critically important antibiotics (HPCIAs) should be avoided wherever possible and reserved for human use.

Among the gram negative bacteria, there are intrinsic and acquired resistance mechanisms. Extended spectrum beta lactamases (ESBLs) confer resistance to all beta lactam antibiotics (penicillins, cephalosporins and carbapenems). While some ESBL producing bacteria remain susceptible to amoxicillin-clavulanate, the AmpC β-lactamases are resistant. Multidrug resistant *E.coli* associated with ESBL production has been identified in dogs with SSIs. Again treatment options should reflect results of AST and should avoid recourse to HPCIAs.

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Important clinical concepts for infection prevention

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Preventative strategies represent the most effective means of reducing surgical site infections (SSI). Avoidance of SSIs that involve multi-drug resistant organisms (MDROs) is especially important given the limited therapeutic options available and the potential transmission to humans. Infection prevention measures include the rational use of antimicrobial prophylaxis (AMP), limiting transmission around the hospital (hand hygiene and personal protective equipment) and management steps to avoid environmental contamination.

Antimicrobial stewardship (selecting the right antimicrobial for the right indication (right diagnosis), the right patient, at the right time, with the right dose, and route, causing the least harm to the patient and future patients) is an important pillar in the battle against antimicrobial resistance (AMR). The goal of perioperative antimicrobial therapy is to reduce the SSI risk with minimal negative impact on the patient and no increased resistance. Multiple national guidelines have been produced including the PROTECT ME guidelines (UK) and Antibiotic Use Guidelines for Companion Animal Practice (Denmark). A consistent feature in the majority of guidelines is the avoidance of antimicrobial use for clean or elective surgical procedures. While this is hopefully standard of practice for the majority of readers, studies in the UK and Australia have found concerning discordance between guideline recommendations and what is actually happening in practice. It is incumbent upon all veterinary prescribers to ensure that antimicrobial use reflects the clinical requirement.

Routes of transmission include direct contact, fomite, airborne (aerosol), oral and vector-borne. Direct contact transmission represents the most common and highest risk route for transmission to and from patients and their caregivers (veterinary personnel). Understanding these routes can help devise an infection control plan that is specific to the practice. It is recommended to nominate a practice infection control champion who can coordinate hygiene measures and assess their impact on SSI rates within the hospital.

Hand hygiene is the simplest but an oft overlooked measure in limiting pathogen transmission. Hand washing should be performed before patient contact, before a clean/aseptic procedure, after body fluid exposure risk, after patient contact and after contact with patient surroundings. While this is recognised as the single most important factor in controlling hospital acquired infections, observational studies indicate a depressingly low adherence to guidelines among veterinary professionals. While 87-100% of vets self-report optimal behaviour in this regard, overall compliance was only 32% in a Swiss study.

Implementation of practical infection control measures is integral to limiting the rates of SSI in veterinary clinics. Surveillance information (SSI rate ideally grouped by procedure type) offers key baseline infection rates and an appreciation of these numbers can guide adoption of targeted infection control measures. This should include post-discharge surveillance as a significant percentage of SSIs are detected after the pet has returned home.

The objective of preoperative surgical site preparation is to eliminate potential pathogens without causing local damage that may favour bacterial colonisation and SSI development. Hair clipping should be performed after induction and just before the surgical procedure. Skin preparation can be achieved with various different biocides including povidone iodine, chlorhexidine and alcohol-based solutions. All these products seem to have an equivalent impact on bacterial growth and SSI rate. While the use of

sterile gloves may be considered a given, double gloving or the use of reinforced glove material should be considered especially where lengthy procedures are anticipated.

The incision site is vulnerable to opportunistic infection from the patient's own microflora, from the hospital environment, or from hospital personnel. Covering incision sites for a minimum of 24-48h postoperatively is recommended. Improvements in infection control can help keep SSI rates in check and also counter the emergence of multidrug-resistant pathogens. Auditing your clinic's infection control can facilitate evaluation of current practice policies/processes and highlights important gaps. Tools such as fluorescent tagging or ATP bioluminescence monitors can help assess the efficacy of cleaning protocols. Cultures from environmental surfaces is an expensive tool but may be warranted in the face of a serious MDRO outbreak.

Early recognition and reaction to SSIs, guided by antimicrobial susceptibility testing is crucial to optimise case management. Further, understanding the pathogens involved can offer clues as to their provenance and suggest opportunities for improvement to infection control protocols that may quench a potential outbreak. The tenets of infection prevention may seem like simple hygiene measures but their successful implementation depends on engagement of the entire veterinary team. Regular monitoring of rates provides a baseline and means that the impact of new infection prevention measures can be determined.

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Shoulder injuries in canine athletes

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The popularity of canine competitions has increased exponentially in the last few years, and with this, the diagnosis of injuries specific to these athletes. Orthopaedic injuries are common among competition dogs, with shoulder and back injuries being the most common. Most injuries involve soft tissues, such as muscles, tendons and ligaments. Conditions of the shoulder are frequent en canine athletes, especially those affecting tendons surrounding this joint. The most common shoulder injuries we may find in working and sporting dogs include:

Supraspinatus tendinopathy
Affected animals may present with chronic lameness that doesn't completely resolve with rest and NSAIDs. Orthopaedic examination usually shows pain or muscle spasm when the shoulder is flexed and on direct palpation over the affected muscle. Mineralization may be observed radiographically, and musculoskeletal ultrasound (MSK US) and MRI are the recommended diagnostic techniques The recommended treatment includes rest, rehabilitation and regenerative medicine, (MSC and PRP), which has been reported to offer a good to excellent response in 90% of the cases. Extracorporeal shockwave therapy (ESWT) has been reported to improve clinical signs and kinetics in 64-85% of animals with shoulder conditions, However, patients that don´t respond to conservative treatment can be managed surgically, which can to provide good to excellent results in 50-64% of the cases.

Biceps tendinopathy
Clinical presentation of dogs with bicipital tendinopathy is very similar to those with supraspinatus tendinopathy, and they frequently present together. A positive biceps test can be found. Osteophytes in the bicipital groove may be seen radiographically (skyline) but MSK US and shoulder arthroscopy are the recommended diagnostic techniques. Acute conditions might be treated conservatively with rest and anti-inflammatories (NSAIDs orally or IA injection of steroids), but chronic cases, would benefit from rehabilitation and regenerative therapy, or shoulder arthroscopy and tenotomy of the biceps tendon. In human medicine tenodesis is performed in active patients and for cosmetic reasons, and in veterinary medicine tenodesis may be indicated in sporting dogs. This can be performed with an orthopaedic staple, a screw and washer or with an anchor system.

Ruptured bicipital tendon of insertion
This traumatic condition has been reported in racing Greyhounds. This condition causes an acute and unilateral forelimb lameness, with limb circumduction when walking. Affected animals show hyperextension of the elbow and a positive biceps test. If return to sport is desired, surgical management is the recommended treatment, with reattachment of the affected tendon. Conservative management may be an option in animals not returning to competition, with resolution of the lameness.

Biceps tendon luxation
This is a rare condition that has been described in a limited number of working dogs (i.e. GSD, Greyhound, Border Collie) where the bicipital tendon luxates medially. This condition is most likely secondary to rupture of the Transverse Retinaculum of the Humerus (TRH), which could be traumatic or degenerative. Animals with this condition present with a weight bearing lameness, abduction and external rotation of the limb, with limited resistance during shoulder flexion with elbow extension. MRI and musculoskeletal US are useful in the diagnosis of this pathology. Surgical management is recommended by means of reconstruction of the TRH (with sutures, plate, screw, staple, etc) or biceps tenotomy.

Medial shoulder instability
This condition is associated with injury to the medial supportive structures, such as the medial glenohumeral ligament (MGHL), the subscapularis tendon and the medial aspect of the joint capsule. The main cause is repetitive trauma and overuse. This pathology is frequently associated with other shoulder conditions.. Abduction angles of the affected shoulder are generally greater than 50º, and more marked than the opposite shoulder. Diagnostic techniques should include arthroscopic evaluation of the shoulder structures, and the treatment varies depending on the degree of injury observed arthroscopically: from rest, rehabilitation and hobbles; to synthetic capsulorraphy, tightrope, transposition of the bicipital tendon, etc).

Infraspinatus contracture
This condition is associated with repetitive trauma to the tendon, which is overrepresented in working animals. Affected animals show a distinctive gait characterized by external rotation of the limb with elbow adduction. Treatment of this pathology includes surgical tenotomy/tenectomy of the tendon.

Ossification of the infraspinatus tendon bursa
This has been reported in Labrador retrievers that develop a progressive lameness and pain on palpation over the tendon. Some dogs may respond to conservative management, but if no improvement is seen, the surgical resection of the tendon and removal of the bursa and ossifications is recommended.

Teres minor myopathy
The teres minor muscle is a shoulder flexor and it can become injured causing pain on shoulder extension and weightbearing lameness with no circumduction. A painful and firm band can be felt deep to the spinal head of the deltoid muscle, and MSK US of the area shows increased echogenicity. Conservative management may be useful early in the disease, but chronic cases would require surgical resection of the muscle.

Other
Avulsion of the infraspinatus and supraspinatus tendons have been reported en juvenile Labrador retrievers with intermittent lameness and pain on shoulder manipulation. Diagnostic imaging (Radiography and CT) help visualising a radiolucent defect in the greater tubercle and proximal lateral humerus, at the insertion points of these tendons. Conservative management is the recommended treatment. It can be associated with other shoulder pathologies.

Shoulder instabilitiy: myth or reality?

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Introduction
Shoulder instability is considered as a frequent cause of shoulder pain, next to OCD and biceps tendinopathy. In recent years 'medial shoulder syndrome' has appeared as an alternative term which refers to lesions in the medial compartment of the shoulder which may lead to instability. (ref))

Shoulder instability is a controversial diagnosis because of the varying occurance: while some claim that it is a frequently diagnosed disorder (Bardet, 1998), others rarely see it (personal communications).

The few publications on the shoulder instability and medial shoulder syndrome do not provide a consistent diagnostic protocol and mention variable and vague pathology. Initially diagnosis was based on the shoulder abduction angle. In more recent reports diagnosis is based on a comparison of both shoulder joints and on the presence of pain during flexion, extension and abduction. Treatment has evolved from a surgical treatment aiming to stabilize the joint, towards a more conservative treatment with physiotherapy.

Materials and methods
A study of three different centers in Belgium (Flanders) was performed to investigate the frequency of shoulder instability and/or medial shoulder syndrome, the type of patients, the diagnostic method, treatment and results. The files of a distinct period were explored in order to find dogs affected with shoulder instability or medial shoulder syndrome, define the type of affected dogs, the diagnostic method, treatment and outcome.

Results

1. Ghent University, small animal orthopedics
The distribution of shoulder joint lesions was based on the arthroscopic findings in 71 joints during a period of 3 years. The most frequent diagnosis was OCD in 54.9% (n=39), followed by biceps tendinopathy (14.1%, n=10), fragmentation/calcification of the caudal glenoid cavity (8.4%, n=6), primary OA (5.6%, n=4), instability (luxation in small breeds) (2.8%, n=2), secondary OA (primary cause OCD, fracture) (2.8%, n=2), severe synovitis (1.4%, n=1), capsular neoplasia (1.4%, n=1), infection (1.4%, n=1), synovial chondromatosis (1.4%, n=1) and calcification of the supraspinatus tendon (1.4%, n=1). In that series there were no typical types of patients nor lesions that could be linked to shoulder instability or medial shoulder syndrome.

2. Physiotherapy center
A search in the database revealed 43 dogs presented for treatment of shoulder instability or medial shoulder syndrome. Since 2017 the diagnosis had increased considerably. One third of the dogs were Border Collies. Age varied between 9 months and 12 years and the mean age was 5 years. Half of the dogs were sport dogs (mainly agility). Reason of admission for treatment was lameness in all dogs except for two (reduced sports results) and in only four dogs an injury was mentioned at the onset of the problem.

Diagnosis was made by the physiotherapists of the center in 33 out of 43 dogs and was based on palpation. Ten dogs were referred by their veterinarian who diagnosed the problem via palpation or arthroscopy (5 dogs).

Obviously, the dogs were treated with physiotherapy. The database did not include follow-up results so no conclusions about the effectiveness could be drawn.

3. *Private practice specialized in orthopedics and sports medicine*
During a period of 3 years 11 dogs were diagnosed with shoulder instability/medial shoulder syndrome on a total of 127 patients. Three dogs were Border Collies. Age varied between 1.5 and 11 years. All dogs were active in sports and were presented with lameness after heavy exercise.

Diagnosis was based on palpation (difference in instability between left and right), radiographs and arthroscopy. In some cases CT and contrast CT was performed. Arthroscopic findings were lesions of M. subscapularis and the medial glenohumeral ligament, synovitis and cartilage erosions.

Treatment of this center evolved from surgical stabilization to a multimodal conservative treatment including intra-articular injections of PRP, shock wave therapy and physiotherapy. Results were estimated as fair to good, considering the fact that return to sport is a gradual and long process.

Discussion
Cases of shoulder instability and medial shoulder syndrome were frequently seen in sports dogs. The physiotherapy center that cooperated in this study is well known in the sports world, so sport dogs are frequently presented for treatment. Diagnosis of shoulder instability/medial shoulder syndrome however was only based on palpation and was not documented by imaging or arthroscopy in most cases. Some doubt about the correctness of the diagnose is justified.

The relatively small number of dogs diagnosed with in the private practice specialized in orthopedics and sports medicine confirms the idea that shoulder instability/medial shoulder syndrome is not a frequent problem in the population of companion dogs in Flanders and only half of the affected dogs were sporting dogs.

It is remarkable that no confirmed cases were seen at the university hospital. In some shoulders no clear primary diagnosis was available, but none of the doubtful cases had a history or pathologic findings that matched with description of shoulder instability or medial shoulder syndrome. Besides the different type of clients compared to the physiotherapy center and the private practice, a more thorough diagnostic approach may have revealed other less obvious pathology such as medial coronoid disease, flexor enthesopathy and toe pain.

Conclusions on the treatment outcome cannot be made because of insufficient follow-up data. Often those data are not available because patients are not routinely evaluated on the middle and long term.

Conclusion
The controversy that exists among ‘believers’ and ‘non-believers’ of shoulder instability/medial shoulder syndrome is also reflected in the data of the 3 centers in Flanders. While the environmental difference of the landscape is excluded, differences can be explained by the type of center, the type of clients and the diagnostic methods. A review of the limited available literature could not provide clear answers. The evolution in the treatment approach from a surgical stabilization illustrated in the literature towards a conservative treatment to a multimodal conservative treatment is also seen in this study.

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Rehabilitation of the shoulder girdle complex

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Shoulder girdle lameness poses a significant rehabilitation challenge, both in its diagnosis and management. During normal motion, the shoulder girdle must function to provide a stable base for the transfer of forces from the trunk into the forelimb but must also retain stability in motion. Both these functions are reliant on the appropriate sequential activation of the regional musculature within a normal kinetic chain of activity and it is these muscle groups thashould be the major focus of any rehabilitation programme.

A better understanding of the needs of rehabilitation can be achieved by taking a biotensegrity approach to movement whereby living organisms are viewed as a complex balance of force vectors that function to maintain a stable equilibrium. During shoulder joint motion, a degree of glenohumeral translation must be facilitated. For this to occur, both the regional musculature and the joint capsule must show a reasonable degree of flexibility with muscle force vectors maintaining the humerus in the correct position within the glenohumeral joint. All of these factors rely on correct scapular motion. Loss of scapular stability is termed scapular dyskinesis and must be addressed within any shoulder rehabilitation programme (Green RA, 2013)

Injury whether traumatic or iatrogenic results in altered shoulder function (Kibler et al 1998, 2013) and as a consequence of injury, movement integration is lost. This can lead to a number of changes including:

- Altered functional neuromotor control
- Muscle inhibition
- Agonist-Antagoinsit imbalance
- Development of compensatory movement patterns
- Changes to joint range of motion

Functional rehabilitation should start with the establishment of a stable base of support and muscle facilitation in the pelvic limbs and trunk, Once this has been achieved the focus can then shift to the scapula and shoulder joint with the focus remaining on the restoration of functional ability rather than the resolution of symptoms.

Recent animal model studies have shown that a short period of unloading is required after acute soft tissue injury but that longer periods of unloading are harmful, adversely affecting tissue biomechanics and morphology (Bring DK et al, 2009). Through mechanical loading. cellular structural changes are prompted - the mechanotransductive effect (Khan et al 2009).

In response to reduced activity whether encountered secondary to immobilisation, surgery, ageing etc, characteristic changes are seen within the muscle which include:

- A change in fibre type
- Loss of muscle protein
- Decreased mean fibre area
- Cellular inflammation and cell death
- Reloading and re-perfusion injuries

Often the focus with rehabilitation has been on increasing muscle mass and through this erroneously assuming that we are directly improving muscle strength. Lean muscle mass and strength however fo not necessarily incorporate global movement patterns that are reflective of motor function. Rather, short term improvements in strength are largely due to improved neural activation through a:

- Greater efficiency in neural recruitment
- Increased motor neurone excitability
- Increased CXNS activation
- Improved motor unit synchronisation and increased firing rates
- Lowering of neural inhibitory reflexes
- Inhibition of the Golgi tendon Organ

The immune system has also a role to play in skeletal muscle adaptation to resistance exercise with macrophage responses being critical for efficient muscle repair and hypertrophic adaptation (Pizza et al 2009).

In terms of practical rehabilitation, early application of biomechanical and muscle activation strategies are critical. Appropriate pain management techniques should be employed to facilitate exercise based therapy but without impeding tissue healing

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Muscular injuries in the hindlimb

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Muscles and tendon can become injured acutely due to trauma, or chronically due to repetitive overuse. These injuries can be contusions, strains or lacerations. Muscle strain involves rupture of the muscle fibres, which is generally due to excessive eccentric contraction or over stretching. Muscle strain can be graded from grade 1 to grade 3. There are several muscular injuries that can affect the muscles in the hindlimb:

Iliopsoas muscle strain
This condition can be primary or secondary: Primary iliopsoas strain is caused by excessive and repetitive force on this muscle, especially during eccentric contraction with the muscle lengthened. The secondary form is chronic and it appears secondary to other conditions that cause abnormal gait or posture, such as CCLD, CHD, back conditions, etc. Affected animals show a weightbearing lameness with decreased hip extension (shorter stride) and marked pain on direct palpation over the affected muscle, as well as pain during hip extension with internal rotation of the limb. Ultrasound evaluation may show enlargement and hypoechoic foci or fibrosis Conservative management is recommended initially for these patients, including rest, muscle relaxants, rehabilitation, physical modalities and in some cases regenerative medicine. Those animals that don´t respond, have frequent relapses or suffer from contracture of the iliopsoas muscle are best treated surgically with tenotomy of the iliopsoas tendon.

Gracilis rupture
This acute condition most commonly affects racing Greyhounds. This injury involves an acute rupture of a significant number of muscle fibres in the gracilis muscle, and it may be partial or complete. The muscle may rupture proximally, causing a bulge in the distal aspect of the inner thigh, or distally, causing a swollen and painful proximal bulge. Lameness, pain, and bruising are also present. Management depends on the degree of injury and clinical signs, but ideally surgical repair is recommended.

Gracillis myopathy/contracture
This pathology most commonly affects working German shepherd dogs, between 3 and 7 years of age. A very characteristic gait can be observed. In the past, complete resection of the gracillis muscle was the recommended treatment, but lameness reappeared weeks to months later secondarily to contracture of adjacent structures. Nonsurgical management, with intensive rehabilitation, is the recommended treatment at present. Massage, stretching exercises and physical modalities (i.e. therapeutic ultrasound) would help maintaining the flexibility of this muscle and the range of motion of the joints. Although this therapy does not resolve the condition, it would help patients remain on active duty and improve their gait.

Quadriceps contracture
This is a devastating complication of femoral fracture management. This condition is most commonly encountered in puppies with suboptimal stabilization of femoral fractures or after limb immobilisation in a bandage. Progressive fibrosis of this muscle leads to hyperextension of the stifle. Prognosis is poor unless this condition is detected early in the process. If that is the case, adequate fracture stabilization, release of the quadriceps muscle and a device to keep the stifle flexed can be applied, with daily physiotherapy performed. If fibrosis is present but there is the prospect of some joint function, a lengthening plasty have been reported, although it is not expected to have a good return to limb function. If irreversible and severe joint changes are present then a salvage procedure is necessary, such as arthrodesis or amputation.

Avulsion of the gastrocnemius muscle

This is not a common injury to the gastrocnemius muscle, which can be partial or complete. Generally an acute trauma causes avulsion of the proximal aspect of the lateral or medial head of the gastrocnemius muscle, causing acute lameness, pain when pressure is applied over the caudal aspect of this joint. Swelling, bruising and tarsal flexion may also be present. Radiographs or CT of the stifle joint may show distal displacement of the affected fabella, while MSK US would help visualise the ruptured fibres and haemorrhage in the area. Conservative management may be sufficient in partial avulsions with rest, therapeutic ultrasound and analgesics. However surgical reattachment of the avulsed muscle head is recommended in complete injuries, by means of cerclage wire, leader line or non-absorbable suture anchored through or around the displaced fabella, and anchored to the supracondylar femur through bone tunnels. Postoperatively it is important to prevent extension of the stifle or flexion of the tarsus by means of ESF, external coaptation or an orthotic.

Avulsion of the popliteal muscle

Avulsion of this muscle is an uncommon injury that generally affects young large breed dogs (<1year old). Clinical signs include weightbearing lameness, pain on extension of the stifle and when pressure is applied over the caudal aspect of the stifle and swelling in the lateral aspect of the stifle. Distal displacement of the popliteal sesamoid and/or avulsion fracture in the lateral condyle can be observed radiographically. The recommended treatment is surgical reattachment of this muscle to the femoral condyle or to the Long Digital Extensor tendon. Postoperatively restriction of stifle extension by means of external coaptation is recommended.

Injury to the common calcaneal tendon

Injury to the tendon can be caused by acute trauma or lacerations that lead to partial or complete rupture of the tendon. Avulsion from the bone can also occur. Chronic injuries in the common calcaneal tendon can be due to overuse. Lameness of different degrees, depending on the severity of the lesion, is the main complaint from owners. Complete ruptures lead to plantigradism while partial ruptures present with increased tarsal flexion and flexion of the digit in a claw-like fashion. Treatment most commonly involves surgical debridement of the tendon edges and suture or reinsertion of the tendon in the calcaneal bone. Some mild partial ruptures and chronic degeneration of the tendon can be managed with orthotics and rehabilitation.

Distal extremity injuries - ligaments and tendons

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The distal extremity of dogs is a highly complex structure consisting of 32 bones, 48 individual joints, 26 muscles and tendons and over 85 ligaments connecting the bones to each other. Considering the tremendous strains tendons and ligaments of the distal extremity are exposed to during sporting activities, it's not surprising that injuries are likely and probably more common than thought. Many of these injuries require a high level of suspicion to diagnose, as they are not always easy to detect.

Injuries to the plantar or palmar structures are more likely, as the flexor apparatus is supporting the dog's weight during ambulation and is responsible for propulsion. Together with the palmar/plantar ligaments it has to absorb and store the energy generated when decelerating, rapid turning or landing and redirect this energy into forceful propulsion.

Many injuries affect several structures of the foot at the same time, as seen in the classical hyperextension injuries of the carpus or ruptures of the plantar ligament of the tarsus.

Other not so common or well described injuries involve specific localized structures of the foot. Some examples of these are presented here :

Flexor Carpi Ulnaris Tendinopathy
A tendinopathy is usually the result of chronic overloading with repetitive microtrauma, that never had a chance to heal. It has not an inflammatory but rather degenerative nature. Either the myotendinous juncture or the enthesis of the tendon at the accessory carpal bone is affected. It occurs as a primary form of overloading in sporting dogs, or secondary as a result of chronic weight shifting to the front in non-sporting dogs. It has a gradual onset with no history of obvious trauma and is slowly getting worse. Lameness is obvious in advanced cases. Affected dogs typically do not respond to NSAID's. Clinical exam reveals a swollen and painful tendon at the insertion of the os carpi accessories. Ultrasound is the technique of choice to confirm the diagnosis, to assess the extent of the injury and its primary location. It is also helpful to evaluate the healing progress. Radiographs are not as sensitive, but still helpful to r/o other carpal pathologies and to stage the disease. In early cases nothing or a swelling of the tendon can be seen. In chronic cases, calcification of the tendon and bony reactions such as spurs around the accessory carpal bone can be seen. Therapy of choice is exercise modification: explosive or high impact activities and muscle fatigue have to be avoided. A carpal support bandage is helpful to limit extension of the carpus and to protect the muscle. Eccentric training of the affected muscle is considered the most effective treatment modality in humans, but is difficult to implement in dogs. However, exercises to strengthen the muscles are a good alternative. Stretching and massage of the tendon is used in early cases. A local antiphlogistic / hyperemic cream can be used at the same time High intensity laser and shockwave therapy are other treatment modalities we use in most cases. In chronic advanced cases we stated to combine shockwave therapy with local injections of platelet rich plasma.

Luxation of the superficial digital flexor tendon (STF)
This problem is seen most likely in shelties with the tendon luxating usually to the lateral side. The cause remains unclear. There might be a conformational predisposition such as a dysplasia of the calcaneus with a shallow groove at the tip or a weak medial retinaculum Onset of lameness is usually acute, but with no history of trauma. Lameness is intermittent or persistent, depending if the degree and

frequency of the luxation. Hallmark is a swelling in the area of the calcaneal bursa, as the tendon usually is in place. The tendon easily can be displaced by applying some pressure to the medial side, while extending the foot. Therapy of choice is surgical repair of the ruptured retinaculum and protecting the repair for 4 – 6 weeks with a bandage. I have not seen a benefit of deepening the groove at the top of the calcaneus without damaging the insertion site of the achilles tendon.

Injuries affecting the Flexor tendons of the foot

Rupture of the deep digital flexor tendon
When this tendon ruptures, the third phalanx loses its flexing capability. As the dorsal elastic ligament is no longer counteracted by the pull of the muscle, the toenail is pulled dorsally ("knocked up toe"). Occasionally the pad may not touch the ground anymore and the skin will be irritated. There is no treatment need and the dogs return to full function

Avulsion or rupture of the superficial digital flexor tendon
This will result in a so-called "dropped toe". The normal flexion of the interphalangeal joint is lost and the digit lies flat on the ground. The third and fourth digit of the front feet are most commonly affected. Dogs might initially be painful and obviously lame. Later the lameness disappears and the injury has minimal influence on performance of the sporting dogs. Occasionally several tendons or the myotendionous junction of the flexor muscle is injured resulting in a "flat foot". These dogs loose some of their ability to grasp the ground with the toes while turning.

Tendinitis of the digital flexor tendons
There is usually no obvious history of trauma and the onset of the lameness is slowly progressive. The flexor tendon of all digits can be affected but most commonly it is seen in the third and fourth digit of the front leg. The tendons, that can easily palpated just ventral to the proximal phalanx are thick /swollen and painful on pressure. Infection should be r/o but then there is usually a more diffuse swelling, excessive heat and local lymph nodes are enlarged. Therapy is conservative with exercise restriction and immobilization of the foot with a bandage or a shoe. A local antiphlogistic cream can be applied to the area of the tendon. Infiltration of the tendon with a local steroids is another good option. In very chronic cases not responding to any conservative therapy, surgery might be considered to transect the painful tendons.

Ligamentous injury

Collateral ligament injuries of the digits
Probably the most common ligamentous injury in agility sporting dogs is a rupture of the collateral ligament of the toes. Every joint can be invovled but most commonly the proximal interphalangeal joint of the 2nd or 5th digit is injured. Usually the medial CL is torn or stretched. The affected toe stays either luxated or snaps back into position, but can easily reluxated. The injured joint is swollen and painful. The majority of these injuries can be treated conservatively by strapping the affected digit. Surgical management is indicated, if conservative management failed, if the metacarpal-phalangeal joint is affected or there is a complete disruption of the joint. Suturing of the ruptured ligament and joint capsule should be attempted. This is easier done in large breed dogs than in a small border collie. Ligament replacement or augmentation should be considered if suturing is not possible Nail amputation is another option to reduce the risk of reoccurrence.

Medial carpal disruption
A rare but challenging injury is the disruption of the medial middle carpal and carpo-metacarpal joint with medial subluxation. The MCLs of the radiocarpal joint are intact. Dogs present with an acute non-weight bearing lameness, painful swollen carpus with medial instability. There's usually no to minimal carpal hyperextension. Radiographs with stress views demonstrate the extent of the injury, which is often rather complex. Fractures or dorsal slab fractures of the base of the Metacarpals (MC3!) can be seen. Stress views in hyperextension are needed to rule out palmar instability.

The type of surgical stabilisation is dictated by the type of injuries. If there is no carpal hyperextension medial instability is prevented with a figure of 8 wire, anchored in the plamaromedial process of the radiocarpal bone and the base of MC 2. If the injury is more complex, additional screw fixation or even small plates should be considered to re-stabilize the injured area. If there is palmar instability, partial carpal arthrodesis is another option. A splinted bandage is used to protect the repair for six weeks and the activity is restricted for three months.

Rupture of the short collateral ligament of the tarsal joint
The short collateral ligaments stabilize the tarsal joint during hyperflexion and prevent rotational instability, lateral tilt and caudal luxation of the tarsus in relation to the tibia. Rupture of the short tarsal CL's is a rare, but easily missed injury.

The lateral side seems to be more commonly injured than the medial side. The short collateral ligaments consist of two components, which can be injured separately. Rupture of only one component results in minimal instability. Dogs present with an acute onset of non-weight bearing lameness which usually improves quite rapidly. The joint is painful and swollen. There is no obvious instability in standing position. To test the sort CL, the joint is placed in 90° flexion and the tibia firmly fixed. If the short MCL is ruptured there is an increased internal rotation of the foot, as the MCL is the major stabilizer against subluxation of the foot towards medial. With a rupture of the short LCL there is an increased external rotation, as the ligaments is the major stabilizer against subluxation towards lateral. Radiographs are usually non-diagnostic but helpful to rule out concurrent injuries such as an avulsion fracture of the malleolus or a fracture of the talar ridge and other tarsal pathologies. CT of the tarsus is an easier and better way to assess these injuries.

Conservative therapy can be considered in small breed dogs, otherwiese surgical repair is the best option. Due to the short and flat nature of the ligaments, primary ligament repair is difficult with exception of the fibolcalcaneal ligament. This is strong and can easily be sutured. Ligament augmentation or replacement with a heavy braided suture is indicated in all other cases. The sutures can be anchored proximally through bone tunnels in the malleolus, distally through bone tunnels in the calcaneus on the lateral side or using bone anchors placed in the talus medially. Post up exercise is restricted for six weeks.

A splinted bandage is use to prevent hyperflexion and to protect the repair for four weeks. Thereafter a protective neoprene sports bandage to prevent hyperflexion is applied, when the dog is active. Prognosis is very good and dogs can return to full function and sporting activity.

References
Will be provided on request

Rehabilitation and orthotics for distal extremity injuries

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Orthotics are defined as external devices placed to support or protect a body part, by limiting motion or immobilising a joint or joints. More comprehensively, there are 3 broad categories for the use of orthoses: Firstly, orthoses may also be used to immobilise and protect an injury, such as a fracture, a mechanically weak fracture repair (for example many repairs of fractures of the manus and pes), or a joint luxation following reduction or an arthrodesis if following implant removal if required due to infection. Secondly, they may be placed to limit movement of a joint – typically restricting movement in a single direction, avoiding a movement associated with a joint instability due to a ligament injury or to reduce strain on a muscle or tendon injury or ligamentous or tendinous repair. Thirdly, orthoses may also be used to assist or promote a specific motion in a joint, for example to maintain carpal extension in a patient with a radial nerve injury.

Orthotics are more long-term solutions than bandages. They may be manufactured to the specific requirements of the patient, based on their size, the joint or joints requiring immobilisation or support and the degree of restriction needed. They may be considered as non-surgical solutions for unstable joints in selected patients who are at increased risk of post-operative complications due to comorbidities, advanced age, anaesthetic safety concerns, or where surgical costs are prohibitive. In these circumstances, the limitations of the device must be discussed with the client and they are clearly not necessarily anticipated to achieve the same outcome as a surgical treatment in every case. In some circumstances when proven to be efficacious they may be considered as a long-term solution. They may also be used temporarily to allow for management of comorbidities or accumulation of funding for surgery and use may be discontinued and other treatment options reconsidered in cases where sufficient improvement is achieved. An orthosis may for example allow temporary stabilisation of an injury in a patient with a bilateral condition as a means of avoidance of a potentially higher risk bilateral single session surgical treatment.

If we are considering the use of an orthotic – then there are different types of orthotic which may be used. These need to be tailored to the specific needs of the patient – hence the requirement for thorough physical and orthopaedic examination, discussion of the clinical concerns for the patient with the client and then consultation of the orthotist. Orthoses can be flexible, semi-rigid or rigid. Design of an orthosis for a specific patient is a two-way discussion between the surgeon and the orthotist of the clinical conundrum and patient requirements. The design considers patient size, weight, injury, areas of pre-existing or future predictable pressure sores and degree of support anticipated to be required initially but also later during the rehabilitation process. The design of an orthosis also considers skin condition and thickness and hair coat coverage.

Currently there is a very limited evidence base for the use of orthotics for distal limb injuries with only 5 peer reviewed case reports and case series.

In this lecture we will review those articles as well as well as my own experience with the use of orthotics.

Small Animals

Canine/Equine Regenerative Medicine

Saturday 10 July, 2021

Veterinary Regenerative Medicine: What we know – a canine perspective.

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Background
The concept of regenerative medicine goes back to the Ancient Greeks who observed the ability of the liver to regenerate, hence naming it hepar, after hepaomai meaning 'repair oneself'. This idea is further reflected in the Greek myth of Prometheus, punished by Zeus for introducing fire and knowledge to human beings. In this myth, Prometheus is tied to a rock and everyday an eagle eats part of his liver which then regenerates. In the late 1800s, there was an awareness of a need for a source of cells 'stem cells' to allow certain tissues, such as blood, skin, bone, to renew continuously over a lifetime. Stem cells are undifferentiated cells that can self-renew by cellular division, and depending on from where and when they are isolated, are variably able to differentiate terminally down a variety of cell lineages. Totipotent stem cells can form an entire organism from a single cell and this ability is restricted to the stem cells of the embryo 'embryonic stem cells', prior to the eight cell morula stage. Pluripotent stem cells can form all the embryonic germ layers tissues (endo-, meso-, ectoderm) and finally multipotent stem cells are further lineage restricted. Stem cells are considered as either embryonic or adult, with adult being defined as those found in the postnatal animal. Finally, there is a category of artificial adult stem cell, created in the laboratory from an adult terminally differentiated cells; the induced pluripotent stem cell. The term "regenerative medicine" is widely considered to be coined by William Haseltine during a 1999 conference on Lake Como. But what do we mean by regenerative medicine, tissue engineering and cell therapy? These terms are frequently used interchangeably, but there are differences (Cossu et al 2018).

- *Regenerative medicine* is a medical endeavour to regenerate tissues/organs and thus restore function. It could be achieved by cells, medical devices, gene therapy or small molecules
- *Tissue engineering* relates to the implantation of artificial tissues or organs and may or may not use cells.
- *Cell therapy* involves the delivery of cells as a medicine. It may not be regenerative, and most reported veterinary work in regenerative medicine is actually cell therapy.

In the 1960s, adult stem cells were extensively researched from experiments examining the potential of bone marrow to recapitulate the blood system, and researchers started to becoming aware if its osteogenic potential. Alexander Friedenstein identified the responsible osteogenic sub population of bone marrow stromal cells as fibroblastic-like cells, isolated by their adherence to tissue culture plastic and ability to form colonies. These bone marrow stromal cells, or skeletal stem cells, or mesenchymal stem cells (MSCs) - a term coined by Caplan in the 1990s (Caplan 1991), have unique defining properties namely, tissue culture plastic adherence, self-renewal, and *in vitro* tri-lineage differentiation (bone, cartilage and fat). Notably, when bone marrow stromal cells are transplanted *in vivo*, they can develop into a fully fledged 'bone organ' (Bianco et al. 2013). The *in vitro* definition of MSCs adopted by Caplan began to be applicable to adult derived cells in many tissues, most notably adipose, leading to a theory of a universal mesenchymal stem cell found in all mesenchyme derived tissues. The MSC from one any adult mesenchyme tissue source was envisaged to be able to regenerate all mesenchymal tissues (bone, fat, cartilage, muscle, nerve, tendon/ligament) irrespective of its adult tissue source, and hence an explosion of research applications of MSCs for in particular musculoskeletal regeneration. After initial experiments it was evident that *in vivo* outcomes were unpredictable, and their status as a stem cell was ultimately questioned, leading to rebadging as a mesenchymal *stromal* cell. What also become apparent was that MSCs had significant paracrine signalling potential (Ucelli et al. 2008)

Application

A PubMed search in May 2021 for “mesenchymal stem cells” returned 70,846 results, whereas “dog mesenchymal stem cells” yielded 833 results, which includes experimental studies. When considering veterinary studies involving clinical patients the number of studies dwindle (Kang & Park 2020). There were a handful of clinical studies on dermatological (wounds, atopic dermatitis) and cardiovascular applications (dilated cardiomyopathy), 11 neurological studies, mostly focused on spinal cord injury. Of these 7/11 had showed a beneficial effect but only three of those had a control population.

The most prevalent application of ‘regenerative medicine’ in clinical dogs is for osteoarthritis treatment. The rationale for MSCs in canine osteoarthritis has a good basis in experimental research. A landmark caprine study (Murphy et al 2003) demonstrated cartilage healing a meniscal regeneration with a single intra-synovial injection of mesenchymal stem cells. Numerous experimental studies in a range of animals including dogs have also shown that MSCs improve or facilitate the healing of cartilage defects (Sasaki et al 2019), although there are mechanistic contradictions; for example, labelled canine MSCs have been traced in dog studies to contribute to direct cartilage healing by chondrocyte differentiation (Mokbel 2011), whereas some rodent studies only show a stimulation of healing and not direct tissue formation (Satue et al 2019). Basic science MSC research also quite clearly demonstrates anti-inflammatory, immunomodulatory paracrine effects of these cells (Iyer & Rojas 2008). There is therefore a significant potential for MSCs to interact and have a positive impact in clinical disease through immunomodulation rather than all or any effects being by tissue regeneration.

The table below highlights a few canine osteoarthritis studies which were interesting for a variety of reasons including study design (placebo controlled), the number of patients, or use of objective outcome measures. Broadly, there is evidence for some beneficial impact of MSCs to treat the clinical osteoarthritic dog, but the variation between these studies make it hard to clarify the clinical indication and expected response. When asked what is happening in the dogs that respond to stem cell therapy, the answer is we do not know. Clinical veterinary studies are not able to routinely apply advanced MRI techniques, or second look arthroscopy, although one case of second-look arthroscopy showed promising results (Kriston-Pál et al 2017).

Location	Numbers	Cells	Assessments	Author
Hip	18 dogs divided to stem cell and control group (injection of placebo material)	Autologous AD-MSCs; intraarticular injection; 4.2–5 × 10^6 cells	At 30, 60, and 90 days; the results showed significantly improved scores for lameness and the compiled scores for lameness, pain, and range of motion.	Black 2007
Hip	9 dogs in stem cell group; 5 healthy dogs in control group	Autologous AD-MSCs; intraarticular injection; 30 × 110^6 cells	At 30, 90, 180 days; improvement of limb function in dogs with hip OA was objectively seen	Vilar 2014
Hip	8 dogs in stem cell group; 5 healthy dogs in control group	Autologous AD-MSCs; intraarticular injection; 30 × 10^6 cells	At 30, 90, 180 days; reduced lameness due to OA was observed after stem cell therapy.	Vilar 2013
Hip	18 dogs in stem cell group; 17 dogs in PRGF group	Autologous AD-MSCs; intraarticular injection; 30 × 106 cells	At 1, 3, 6 months; Both groups showed safe and effective outcome and compared to PRGF, cell group showed better results at 6 months.	Cuervo 2014
Hip	10 dogs in stem cell group; 5 healthy dogs in control group	Autologous AD-MSCs; intraarticular injection; 30 × 10^6 cells	At 30, 90, 180 days; MSC therapy significantly improved limb function in dogs with hip OA.	Vilar 2016
Hip, Elbow, Shoulder, combinations	74 dogs Prospective, randomised, placebo- (saline injection) controlled	Allogenic AD-MSCs 12x10^6	Significant improvement treated CSOM scores, vet pain score, vet global score, owner global score vs control 60 days.	Harman 2016
Elbow	68 dogs, double blinded, placebo controlled (saline injection)	Allogenic Umbilical cord derived MSCs; intraarticular	No change on Force plate improvements in CBPI 6months	Kim 2019
Elbow	13 dogs, no controls	3 intravenous allogenic AD-MSCs, 1-2 x10^6/kg, q 2 weeks	CROMS showed significant improvement (CBPI, LOAD, CSOM), Force plate & accelerometers no change, synovial biomarkers no change	Olsen 2019

How do we value different studies?

Studies utilising client reported outcome measures (CROMS), if validated such as CBPR or LOAD are valuable if they are applied to a randomised controlled trial. If not, they can be prone to caregiver placebo effect. Objective measures (force plate, pressure mat, accelerometers) are generally unaffected by the placebo effect, and hence have greater reliability in studies which do not include controls or placebos, but are most powerful when they do. The contradiction seen in some studies between objective measures and CROMs does not necessarily mean the CROM result is spurious. It is entirely possible for a benefit of stem cell therapy to be identified using CROMs and not identified using objective data measures of movement, particularly in a multi-joint diseased dog, whereby their options for weight-redistribution are limited. Likewise, more qualitative aspects of a more comfortable joint, which are relevant to the patient may not be identified in gait analysis but show-up when using a CROM. It is worth noting that the FDA and EMA now accept CROMs as a key outcome measure. With due consideration of the study set-up both CROMs and objective outcome measures can be useful, and probably they are best when combined, but it should not be expected that they will give allied results. Beyond study design, are there other reasons why clinical studies are so variable? Consider the following:

1. Is the therapy regime correct? The analogy is prescribing a pharmaceutical such as an antibiotic.
    a. Correct dose & duration = cell number, frequency application, duration application?
    b. Correct indication = early vs late disease? Which joint?

    c. Correct drug = Correct stem cell type? Correct vehicle – saline, PRP etc?
    d. Correct route = intravenous, intraarticular?
2. Is the MSC source appropriate – “apples and oranges”.
    a. Source tissue, allogenic, autogenic, cellular subtypes – may be determined by functional assays or cell surface markers. Individuals may have MSCs with different potency, which we cannot account for.
3. Do experimental models accurately represent clinical osteoarthritis?
    a. Acute damage leads to upregulation of chemical stem cell attractants such as SDF1 (Penn et al 2010). This may facilitate the administered stem cells binding to sites where healing needs to occur. Chronically diseased osteoarthritis joints do not significantly express these homing signals.
    b. Chronic OA environment may be detrimental to stem cells (Kiefer et al 2015).

What next - Is it reasonable to use stem cell therapy for OA in dogs?

Management of osteoarthritis in dogs is clinically significant problem for which we are still relatively limited in our treatment options, particularly in late-stage disease. MSC therapy does not have any reported complications (Kriston-Pál et al 2020), and there are indications of benefit. Clearly, more veterinary clinical trials are needed but they need to make consideration and improved reporting of bio-composition (cell source, culture techniques, and any validation studies – surface marker expression, live:dead etc). In the currently unregulated landscape of stem cell therapy for dogs, this could be improved by imposed regulation from appropriate bodies (VMD, EMA). Studies also require greater consideration of their design including n-number, inclusion criteria, baseline evaluations, what outcome measures should be used. CROMs are accessible and should be layered onto studies which have the luxury of objective measures. A control group, and better still, a placebo-controlled group will clarify the potential and help us to determine the correct ‘prescription’ of regenerative medicine in veterinary medicine.

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What's up: Regenerative medicine strategies for canine and equine patients – Orthogen

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Orthogen is a biotech company producing the medical devices Orthokine®vet irap (10ml and 60mL) and Osteokine®ProGen. The devices are used to produce Autologous Conditioned Serum (ACS) / Blood Cell Secretome (BCS) and Platelet Rich Plasma (PRP) respectively. Veterinarians as well as human doctors may process these Autologous Blood Products (ABPs) in their own practice for use on their own patients.

To define a strategy to treat certain indications it is pivotal to understand the differences between the ABPs used in practice. They differ strongly in means of content and composition after being processed. We see ACS / BCS as an anti-inflammatory and regenerative therapeutic for synovial structures and inflamed soft tissue while PRP is rather used for pathologies with substantial tissue loss in tendons and ligaments to support regeneration and restauration of function.

New insights on the mode of action of ACS/BCS can be drawn from a human knee OA study examining biochemical changes of synovial fluid. Changes in parameters like Nitrate, Dienes and synovial fluid viscosity show that clinical effect of ACS/BCS may not only be attributed to IL-1Ra blockage. The complex composition of the Blood Cell Secretome may have an effect on immune cells probably stimulating a shift in macrophage polarization.

Neonatal Cell Therapy In Two Animal Species For Osteoarthritis Management

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Several Mesenchymal Stromal Cells (MSC) types are currently being investigated in veterinary medicine for different purposes in different animal species, initially for horses then dogs and now cats. Conditions which are investigated the most frequently are those affecting locomotor system. The initial assumption was to take advantage of the in vitro potential of those cells to differentiate in a desired cell type specific of a tissue under laboratory condition, to recreate in vivo a new tissue as functional as the native one injured in a regenerative attempt. This objective is not met yet and the related assumption is not yet verified today. However, MSC display a strong immunomodulatory and anti-inflammatory activity through cell-to-cell contact and bioactive molecules secretion which can be harnessed in vivo to control and modulate chronic inflammation and promote harmonious healing of injured tissue. This is the rational for investigating their use in the medical management of osteoarthritis (OA) in an attempt to slow down cartilage degradation and eventually promote its healing.

Allogeneic use of MSC (patient is treated with cells from a healthy donor) is very attractive to democratise this approach compared to autologous approach (patient is the donor) and is gained more and more interest by pharmaceutical companies to develop them as a standard veterinary medicine. However allogeneic setting raises questions, such as cell immunogenicity, transmission of an extraneous agents from the donor to the patient...

Compared to their adult counterparts from adipose tissue, peripheral blood or bone marrow, neonatal MSC retrieved from neonatal tissues such as umbilical cord connective tissue, placenta, amniotic membrane, have special features that make them very attractive for such approach of OA management: i) their recovery is “easy” and harmless for the healthy animal donor - ii) they are less prone to carry extraneous agents than adult tissues (Denys et al. Biopreserv & Biobank. 2020) - iii) they display more potent immunomodulatory activity (Saulnier et al. Vet Immunol Immunopathol 2015) - and iv) they retain a low immunogenicity under inflammatory conditions (Cabon et al. Front Vet Sci. 2019).

In a preclinical model of rabbit mild OA induced by meniscotomy (Saulnier et al. Osteoarthritis and Cartilage 2015) we showed that neonatal MSC injected in the knee during the inflammation peak were more proficient than if injected after, to decrease inflammation (IL1b), catabolic markers (MMPs), cartilage fibrillation and degradation (Col2A marker).

Considering the recognised short half-life of MSC when injected intraarticularly, we investigated in a randomised and double blinded clinical study with client-owned horses with moderate to severe OA, if a second injection of neonatal MSC one month after could improve the clinical benefit observed with a single administration (Magri et al. Front Vet Sci 2020). Data show that despite the positive clinical improvement observed after first injection, second injection did not bring additional benefit.

Interestingly, in a second study (Cabon et al. Front Vet Sci 2019) in client-owned dogs suffering from moderate to severe OA and refractory to other treatments, a second injection at 6 months was able to prolong for 6 additional months the clinical benefit observed during the initial 6 months period in all dogs. 75% of owners reported a two-year health benefit and mobility improvement. In this study we

investigated a potential humoral response against allogeneic MSCs but was hardly detectable in only one dog after a second injection.

In both dog and horse setting, there was a reasonable number of occurrences of minor to mild proinflammatory adverse events appearing shortly after injection and resolving in most cases in a few days without pharmacological intervention. Only in exceptional cases a moderate to severe inflammatory events were observed regressing under anti-inflammatory pharmacological intervention, but with surprisingly good clinical and sportive evolution. No long-term safety concerns were recorded over the two years follow up period for dogs.

Those studies, despite their inherent biases, bring further evidence that MSC and in particular neonatal MSC are a promising therapeutical tool to manage for the long-term management of OA, without compliance and mid-long tolerance problems, representing a significant advance over current pharmacological treatments. Vetbiobank is committed to bringing this innovation to the market for the benefit of animals' wellbeing.

Boehringer Ingelheim's regenerative medicine strategies for canine and equine patients

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Musculoskeletal diseases in horses and dogs often results in an early retirement from an athletic career or in reduced mobility and pain resulting in diminished quality of life. Most available treatment modalities aim to reduce the pain and improve the animal's comfort. However, these therapies usually do not prevent further tissue degeneration and may even result in a progression of the disease. Regenerative medicine strategies are being explored in order to create sustainable treatments with long-term beneficial effects breaking the degenerative cycle and improving longevity and quality of life of both athletes and family members (including pets).

Peripheral blood is being used as a source of mesenchymal stem cells (MSCs) because of its ease of collection, large availability, and low immunogenic nature. In this regard, chondrogenic induced equine peripheral blood-derived MSCs in an excipient of equine allogeneic plasma (EAP) was the first stem cell product obtaining marketing authorization by the European Commission[1,2].

The regenerative strategy for horses is a local injection into a diseased joint or tendon. In order to give the cells the correct signals to target a certain disease, predifferentiation towards cartilage or tendon cells is induced *in vitro* and confirmed on a gene and protein level. This approach results in promising clinical outcomes[3-9].

The regenerative strategy for small animals, such as dogs is a systemic application for the ease of use, general application and multimodal approach. In this presentation the immunomodulatory potential and biodistribution pattern of MSCs after intravenous application of technetium-labelled MSCs in dogs is further being elaborated on.

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Adjunct regenerative Therapy in spinal Surgery

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Introduction
Intervertebral disc disease (IVDD) is a multifactorial disease process influenced by age, genetics, mechanics, overweight, malnutrition and trauma. All of these causes result in reduction of disc cells and an increase in catabolic remodelling of extracellular matrix (ECM). Additionally, molecular changes induced by the degenerative cascade including upregulation of matrix-degrading enyzmes and altered collagen synthesis by nucleus pulposus cells result in dehydration, loss of mechanical properties and reduction in the ability of the IVD to withstand load. The disase is also associated with inflammatory processes and pro-inflammatory markers and macrophages have been detected in canine degenerated discs. A degenerated disc is prone for pain and dysfunction mainly by mechanical or inflammatory stimulation of neurological or spinal structures.

Intervertebral disc disease can be treated conservatively and surgically but all procedures are directed to alleviate pain or resolve dyfunction by decompression/stabilisation without addressing the underlying degenerative disease process, which is incurable to date.

For this reason, cell-based therapies for treating intervertebral disc degeneration have gathered increasing attention in the past decade in human and veterinary medicine. Because canine IVDD shares many similarities with the human counterpart of the disease, dogs represent a valid large animal model for experimental studies but also for application of new technologies in patients with clinical disease. Results of these translational investigations are about to be introduced in clinical veterinary practice.

Among appropriate cell sources including nucleus pulposus cells (NP), disc chondrocytes, notochordal cells, mesenchymal stem cells (derived from bone-marrow or adipose tissue) have been used most frequently owing to their ease of preparation, self-renewal properties, multilineage potential, safety and immunosuppressive properties. Elegant in vitro studies have demonstrated their efficacy in rescuing and reactivating nucleus pulposus cells isolated from degenerative discs by enhancing ECM synthesis and by promoting upregulation of NP phenotypic markers. Bone-marrow derived MSC (BM-MSC) have been shown to regenerate IVD of dogs with experimentally induced degeneration measured by MRI, disc-height index and demonstration of increased content of proteoglycans/ECM and disc cells. In humans with clinical IVDD intradiscal application of MSC has demonstrated to improve disability in most patients. However, disc height indexes and disc regeneration based upon T2-hyperintensity (mostly expressed as improvement in the Pfirrmann score) have been found sporadically only. According to a recent systematic review, randomized clinical studies in people are lacking thus far and true effectiveness of disc regeneration using MSC is only based upon pilot studies and clinical trials.

Investigations in dogs with naturally occurring IVDD
We have investigated the potential of intradiscally delivered autologous BM-MSC in a total of 25 dogs (including 6 animals used as controls) with degenerative lumbosacral stenosis due to IVDD followed propectively. Different forms of delivery (MSC in saline, MSC bound to microcarriers, MSC bound to microcarriers crosslinked to growth factor TGF-beta 1) were used as adjunct therapy to decompressive surgery. Outcome was measured using a clinical scoring system for function and the Pfirrmann grading system for assessment of the disc status. Overall, results yielded an improvement in the clinical score in all dogs. Regeneration of the lumbosacral disc expressed as a decrease in the Pfirrmann score, could not be demonstrated in any of the treatment groups. Formation of Schmorl’s nodes was an undesired

side effect in dogs treated with a larger volume of injected microcarrier scaffolds. However, this complication did not affect the clinical outcome at the end of the study.

Based upon our results, intradiscal delivery of BM-MSC in naturally degenerated IVD does not result in regeneration that can be demonstrated with MRI. In this context it is important to note that assessment of disc health and hydration by T2-weighted MRI is an incomplete tool to assess disc function. Conversely, disc hydration most likely correlates with with increased ECM production yet increased ECM is not a definitive proof of successful regeneration. Based upon improved clinical score in humans treated with intradiscal MSC without improved disc hydration other benefits of MSC including activation of endogenous repair mechanisms through a variety of bioactive substances and suppression of the inflammatory environment produced by degenerated IVD have been suggested

Outlook

Dogs from our investigations were followed outside the study period and with two exceptions (control dogs) were not reported with recurrent signs of DLSS during 5-8 years after treatment. Although this information was based on owner information and absence of imaging in most cases it suggests that the effects of MSC treatment may have long lasting benefits and further study to investigate effectiveness of regenerative treatments for IVDD seem justified. A great deal needs to be done (in dogs and people) before cell-based therapies can become an effective new medicine for the treatment of IVDD. Major challenges include the design of robust clinical studies, the introduction of outcome measures in clincal patients that distinguish between symptom-modifying and disease-modifying effects and translation of promising cutting-edge technologies into clinical applications.

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Regenerative therapy for tendon disorders: equine and human

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Tendons can be injured through over-strain at a number of different sites. When injured outside a synovial cavity (extra-thecal), injuries frequently repair by fibrosis but this tissue is functionally deficient compared to normal tendon. Regenerative therapy offers the prospect of improving this repair to restore function and enable a successful restoration of activity while minimising the risk of re-injury. Regenerative therapies are probably best termed 'orthobiologic' therapy as there is currently minimal evidence that any of these therapies can induce true regeneration although many appear to beneficially modify the healing process. These therapies can be subdivided based on their main mechanisms of action into growth factor therapies (PRP and IRAP) and immunomodulatory therapies (stem cells and IRAP).

Naturally-occurring equine superficial digital flexor tendon (SDFT) overstrain injuries in the horse usually have a contained lesion, thereby enabling simple intra-tendinous injection. The equine injury has many similarities to human tendon disease although the correlates are matched more by function than by anatomy due to the differences in tendon loading between bipeds and quadrupeds. This makes the horse a useful model for human tendon disease.

Assessment of efficacy of the orthobiologics has been evaluated both experimentally and in small clinical case series[1-4]. Both PRP and IRAP have shown some benefit in these studies but conclusive evidence for efficacy in clinical cases is limited. The evidence within the human field is divided but a recent large multicenter clinical trial for the treatment of Achilles tendon rupture showed no benefit of PRP.

Mesenchymal stem cells have been in use clinically since the first reported use in 2003[5]. There are multiple sources for the cells but products differ more by their method of preparation – 'minimally manipulated' through direct extraction of a cellular component through enzymatic treatment of the tissue (eg fat) versus ex vivo culture. The latter provides a better defined and more homogeneous cell population and can be combined with bone marrow supernatant to provide an additional growth factor stimulus but necessitates a two-stage process (eg bone marrow extraction and subsequent implantation 2-3 weeks later). To test the hypothesis that stem cells will enhance tendon healing, a controlled experimental study of naturally-occurring SDFT injuries (n=12) has been performed[6]. MSC treatment appeared to 'normalise' many of the relevant tissue parameters so that they were closer to the contralateral, relatively normal, and untreated tendons than saline-injected controls, in spite of labelling experiments showing the majority of cells being lost within 24 hours[7; 8]. A second adequately powered and independently analysed study evaluated the clinical outcome of naturally occurring SDFT injuries treated using this technique (n=113) which showed a significantly reduced re-injury rate[9]. MSCs have also been used to treat a wider variety of other tendon and ligament injuries. The treatment is tolerated well but numbers are too small and injuries too variable to make any firm conclusions on efficacy. This same technique has been translated into the human medical field and a Phase 11a clinical study for Achilles tendinopathy has shown it to be safe and resulted in significant improvement in 8/10 patients.

Intrasynovial (intra-thecal) tendon tears usually communicate with the synovial cavity where the synovial environment is particularly challenging for successful repair because off the lack of a paratenon and adverse effects of synovial fluid on tenocytes within the tendon[10]. However, experimental assessment of MSCs administered intra-synovially have failed to improve healing in either equine (naturally-

occurring) and ovine (induced) deep digital flexor tendon (DDFT) tears[11]. Labelling of the implanted cells showed them to lodge within the synovium with no cells present in the tendon defect. Hence, currently, the use of stem cells administered intra-synovially into tendon sheaths are not indicated and scaffolds are likely to offer better advantages for enhancing repair of intra-thecal tendon tears[12].

In conclusion, all orthobiologics are proving popular for the treatment of equine (and human) tendon and ligament injuries although conclusive proof of efficacy is lacking. Care should therefore be taken when using these products and select the most appropriate cases and orthobiologics to use.

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MSC based therapy for severe osteoarthritis of the knee

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Among the degenerative diseases associated with aging, osteoarthritis is the most common pathology and affects 16% of the female population over 65 years. The ADIPOA project started in January 2010 with the goal to develop a new cell based strategy for patients suffering from knee osteoarthritis (OA). Up to now, no therapeutic option exists to obtain a sustainable improvement of joint function beside knee arthroplasty. This prompted us to propose adipose derived stem cells as a possible cell therapy.

Adipose derived mesenchymal stromal cells (ASC) are adult stem cells exhibiting functional properties that have open the way for cell-based clinical therapies. Primarily, their capacity of multilineage differentiation has been explored in a number of strategies for skeletal tissue regeneration. More recently, MSCs have been reported to exhibit immunosuppressive as well as healing capacities, to improve angiogenesis and prevent apoptosis or fibrosis through the secretion of paracrine mediators. We performed 2 pre-clinical models of osteoarthritis, and showed that a local injection of ASC showed a reduction of synovitis, reduction of osteophytes, joint stabilization, reducing the score of cartilage lesions. This work was completed by toxicology data showing the excellent tolerance of the local injection of ADSC and biodistribution showing the persistence of cells after 6 months in murine models. In addition, quality control and tolerability of the injection of adipose derived mesenchymal cells led to the approval by AFSSAPS in France and in Germany by the PEI to conduct the clinical trial.

The ADIPOA research teams performed successfully the phase 1/2 clinical trial is in France and Germany. A phase 2B controlled trial is ongoing to confirm the clinical benefit of this strategy.

Perioperative and Postoperative Antibiotics

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The rational use of antibiotics is very important, especially in relation to antimicrobial resistance. Guidelines and protocols for antibiotic use should however be evidence-based.

Human health system guidelines are that perioperative antibiotics are not indicated for clean surgeries unless implants are placed. Numerous studies have shown a reduction in infection rates when antibiotics are used during implant surgeries. Veterinary guidelines are similar, although often antibiotics are deemed appropriate for clean procedures lasting longer than 90 minutes. One of the criticisms of these guidelines is that they do not allow for the huge variability of clean, non-implant surgeries. Should a 3-hour procedure in a debilitated or immunocompromised patient be treated the same as a 20-minute procedure in a young healthy patient? The guidelines are also based on evidence largely gathered from developed western healthcare systems, but it has been questioned whether they are equally valid in developing countries, especially those with very different environments. We can also question how appropriate it is to extrapolate these guidelines to our patient populations, who we all know behave very differently to the typical human patient.

Vasseur and others (1988) assessed the impact of perioperative antibiotics in a veterinary teaching hospital. Their data are derived from very variable procedures, including minor procedures such as simple wound closures and neuters. Overall perioperative antibiotic use did reduce infection rates in clean procedures, but when they split clean procedures into different groups, they found that this was not the case if experienced surgeons (i.e. residents and faculty) were operating and surgeries were less than 90 minutes. Interestingly, antibiotics did reduce infection rates when inexperienced surgeons (i.e. students) were operating, regardless of the duration of the procedure. We don't know why experience is a factor, but it could be because inexperienced surgeons create more tissue trauma, or maybe they are more likely to accidently break aseptic technique.

The antibiotic used perioperatively should be relatively narrow-spectrum and appropriate for the likely pathogens encountered. First and second generation cephalosporins are most commonly used. The first dose should be given prior to the first incision such that there are appropriate tissue levels of antibiotic at the time of incision. In human healthcare, checklists such as the WHO's Safe Surgery Checklist have been shown to improve compliance with the appropriate timing of antibiotic dosing, and such checklists have reduced postoperative infection rates. The reduced infection rates are probably not entirely due to antibiotic timing, because the checklist also covers other factors relevant to infection, such as strategies for maintaining normothermia, but timing probably plays a role.

Antibiotics are repeated at an interval of twice the plasma half-life of the chosen antibiotic for at least the duration of surgery. It is not clear how long perioperative antibiotics should be continued for after surgery. If the intention is to give antibiotics only for the potential period of contamination, then they should be stopped once the wound is closed. Human guidelines however generally state that upto 24 hours after surgery is appropriate, and many studies report 'perioperative' antibiotics being used for even 2-3 days after surgery.

There is actually very little information in the human literature on the use of postoperative oral antibiotics for clean surgeries. This is probably because the guidelines are very clear: postoperative oral

antibiotics are never indicated in the absence of infection. Although the guidelines are clear, compliance does seem to be variable, amongst human and veterinary surgeons.

The potential value of postoperative oral antibiotics has been considered recently in human arthroplasty surgery, at least in some patient populations (Inabathula A, et al. J Bone Joint Surg Am. 2018). In a study of arthroplasty patients in a US tertiary referral hospital, some were given postoperative oral antibiotics if they were deemed to be at high risk of infection (high risk being broadly defined as those having one or more comorbidities including diabetes, being a smoker, having a high BMI, chronic renal disease, autoimmune disease or having nasal colonisation of MRSA or MSSA). In this population postoperative oral antibiotics did significantly reduce infection rates. This study has been criticised. It is not prospective nor randomised. The data are from before and after a protocol change in the hospital. The numbers are also relatively low for a human study, with only 2,181 patients, and the follow-up was limited to 90 days. It has been suggested that postoperative antibiotics may have only delayed infections and that longer follow-up would eliminate the difference. This one study therefore does not justify a wide-scale change in protocols, better data would be needed for that, but the potential implications if the findings are genuine are huge. It has been estimated that if this hospital's protocol was rolled-out across the US there would be an additional 50,000 patient years of antibiotic use per annum. How you quantify the potential impact of that on antimicrobial resistance is a burning question.

There are numerous studies which have assessed the value (or not) of postoperative antibiotics after TPLO. The data is of variable quality, and it's mostly retrospective. None of the studies are perfect and the conclusions are variable, but 8 out of the 13 studies do indicate a benefit to postoperative antibiotic use. Ameet Singh and Scott Weese (in Johnston and Tobias) have concluded that despite the quality of the data, the repeated finding of a protective effect of antibiotics after TPLO can not be dismissed. Budsberg et al in their recent systematic review (2021) drew similar conclusions and stated that more research (and clearly also better research) is needed to be able to draw firm conclusions.

There are numerous issues with the current veterinary literature. At a most fundamental level there can be differences in how postoperative infection is defined and reported. Some studies only report deep infections, others deep and superficial infections. Deciding whether a superficial wound issue is an infection or just postoperative inflammation is not always straight-forward. Antibiotic protocols also vary between studies. In some studies perioperative antibiotics may only extend to the end of surgery, in others they may extend to 24 hours after surgery. Postoperative protocols and antibiotic choices can also vary. Perhaps one of the biggest impacts on a study aiming to look at postoperative infection rates is how follow-up data is obtained. Passive follow-up is obtained by combing through medical records looking for cases that are known to have had an infection concern, either because the patient was returned to the hospital or the hospital was informed by the owner or referring vet. Clearly there is huge potential here for infections to go unrecognised, because another vet has managed the infection without informing the practice where the surgery was performed. This is a particular issue with superficial infections which may not warrant return to a referral hospital for treatment. There is an old saying that nothing ruins good results like good follow-up, and that is certainly true of studies evaluating postoperative infection rates. Active follow-up involves taking the time to directly contact owners to find out if there has been an infection, ideally at predetermined time points relatively soon after surgery.

The ideal study should be prospective and it should be randomised. Owner consent is essential and in the UK such studies need an Animal Test Certificate from the Veterinary Medicines Directorate. The team treating the animal need to be blinded to the treatment group, at least until after the surgery is completed. It helps of course if the study population is narrow, and the procedure being studied is repeatable and commonly performed, and TPLO is ideal in this respect. Follow-up must be active and it must be for a sufficient length of time. Three months is a minimum but for an implant surgery such as TPLO 12 months is preferable. And perhaps the biggest challenge, and the reason we do not already have definitive answers to the questions we pose, is that to be able to show a statistical difference in these studies we need hundreds of patients to be enrolled.

Septic arthritis

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The most important cause of septic arthritis is acute bacterial arthritis in humans and other mammalian species including dogs. Bacterial invective arthritis (BIA) is a very rapidly destructive joint disease and irreversible loss of joint function is frequently the consequence. Bacteria introduced into the joint initiate an inflammatory reaction that will lead to cartilage damage and eventual long-term joint pathology. Without early and aggressive treatment the case morbidity and fatality rate is high.

BIA seems to be an uncommon disease in human with a yearly incidence of 2-5 per 100 000 in general population but 28-38 in patients with rheumatoid arthritis and 40-68 in patients with joint prostheses. There is no comparable data in veterinary medicine available.

BIA in native joints is usually secondary to hematogenous seeding of a joint during bacteriaemia and is considered spontaneous BIA. Bacteria enter the joint space and trigger an acute inflammatory synovitis. Bacteria may also be directly introduced during joint surgery, joint aspiration/injection or a penetrating puncture wound. Local spread from adjacent tissues is possible or a focus of osteomyelitis in the metaphysis or epiphysis (seen in children) may spread to the joint. Pre-existing joint diseases (osteoarthritis, joint surgery or prosthetic joints) or concurrent medical conditions (diabetes, urinary tract infection, skin infection, immune-suppression) may predispose a joint to BIA.

Bacterial infection of a joint causes inflammation of the synovium. The synovial membrane reacts with proliferative hyperplasia and the synovial fluid becomes hypercellular with high numbers of polymorphonuclear leucocytes. These cells are a potent source of lysosomal enzymes, cytokines and proteases that result in synovial, cartilage and bone catabolism. Macrophages in the synovium activated by bacterial antigens like lipopolysaccharide release inflammatory cytokines such as TNF-a and IL-1. The catabolic response from synovium and cartilage resulting in proteolysis is leading to eventual irreversible cartilage degradation and subchondral bone loss within a few days. Synovial fluid is free of all factors of the blood clotting system, but in BIA fibrin deposits are formed. Fibrin deposits on the cartilage surface limit normal cartilage metabolism with metabolites and nutrients from synovial fluid contributing to cartilage damage.

The degree of cartilage damage caused by bacterial infection is variable dependent to difference in number, type and virulence of the organism present in the joint, to local and general immunity of the patient and to the duration of the infection.

Staph. aureus and β-*haemolytic streptococci are* the most frequent organisms that cause BIA in humans whereas *staph. pseudintermedius*, *staph. aureus* and β-*haemolytic streptococci* are most common in dogs and *Pasteurella multocida* and *Bacteroides spp.* in cats. BIA can affect any breed of dog but is most frequently seen in large breed dogs. Large joints are more commonly reported than small joints and stifle, elbow and carpus are the most frequently affected joints in dogs. The majority of BIA manifest in one joint (monoarticular) but more than one joint can be affected (oligoarticular). This occurs more likely in immature or immunocompromised patients. Bacterial polyarthritis in puppies can be seen secondary to omphalophlebitis and uterine or mammary infection in the bitch. *Staph. canis* is most commonly isolated in congenital or neonatal bacterial arthritis.

Clinical signs in BIA are acute moderate to severely deteriorating lameness, hot joint swelling and effusion with tenderness of the joint in manipulation and limited range of motion. Mild pyrexia is an inconsistent sign. Radiography shows the underlying joint condition (osteoarthritis, prosthesis) and signs related to soft-tissues (effusion, “fat pad sign”, capsule distension, periarticular swelling). In severe or

delayed cases erosions of subchondral bone show the effect of the catabolic process to articular structures by bacteria and signal significant damage with reserved prognosis for recovery of the joint. Sonography and MRI are more sensitive for detecting effusion but are not mandatory.

Laboratory findings are elevated erythrocyte sedimentation rate and elevated peripheral blood leucocyte count but these signs are not specific.

The diagnosis is confirmed by arthrocentesis and joint fluid cytology and bacteriology. Synovial fluid in BIA is increased in volume and appears turbid and mostly contaminated with blood. Cytologic examination shows a highly cellular fluid on direct cellular smear with a predominantly neutrophil cell population. The neutrophils show degenerative and toxic changes like pyknotic nuclei, degranulation and cell rupture. Cell count is greater than 50 x 10^9 cells/L with greater than 40% neutrophils. In acute BIA cell counts can be 100-250 x 10^9 with >90% neutrophils.

The identification of intracellular bacteria (Gram staining) is pathognomonic for BIA but intracellular bacteria are only observed in about half of culture-positive synovial samples. Bacteriologic culture of synovial fluid has a relatively low sensitivity (30-50%) and can only be used as a diagnostic criterion when positive. Bacteriologic culture of synovial fluid is preferably submitted in a blood culture medium to increase sensitivity (50-80%) and to get an antibiotic susceptibility test (AST) to guide optimized treatment. The reason of the low sensitivity of joint fluid culture is unclear but administration of antibiotics prior to sample collection does not seem to be a significant factor. Purulent exudates exert an inhibitory effect on bacterial growth in culture. Incubating synovial fluid in a blood culture medium dilutes inhibitors of bacterial growth, inactivates aminoglycoside antibiotics and limits in vitro leucocyte phagocytosis of bacteria and this could promote a greater yield of bacterial growth. Samples for blood culture may be indicated in certain cases.

Polymerase chain reaction (PCR) for bacterial DNA was used to identify bacteria in synovial fluid but human and veterinary studies failed to demonstrate improved accuracy compared to traditional synovial fluid culture.

There is little good quality evidence to guide medical and surgical management of BIA other than a few case series in veterinary medicine. Successful management of BIA in all species is based upon early initiation of treatment and later guided by identification of the causative bacteria. Nevertheless early aggressive treatment of patients with a high suspicion of BIA is mandatory regardless of whether a positive bacteriologic culture of synovial fluid was obtained. Treatment of acute BIA requires systemic, preferably intravenous antibiotics and joint drainage. Initial choice of antibiotic should include antimicrobial activity against Gram-negative staphylococci and streptococci. Common protocols entail amoxicillin-clavulanic acid or cephalexin alone or combined with metronidazole. In suspected BIA parenteral broad-spectrum antibiotics should be started immediately and definitive therapy can be adapted based on culture and bacterial susceptibility of synovial fluid or blood culture isolate. The duration of antibiotic treatment should be 28 to 42 days. Synovial fluid analysis at the end of this period should be repeated and cell count and neutrophil percentage should be normalized before stopping treatment. The need for surgical joint drainage is controversial and biased unless penetrating wounds or infected implants are present. Surgical interventions involve joint irrigation by arthrocentesis with large bore needles, arthroscopy or open arthrotomy. The preferred technique is arthroscopy and allows irrigation of all joint recesses combined with direct visualization of articular structures and the possibility to remove debris and foreign material by means of minimal invasiveness. If surgical implants (prosthesis) are present in infected joints the implants need to be explanted to resolve the infection. Local antibiotic delivery may be indicated in instances where the antibiotic of choice based on culture and sensitivity has a toxicity profile that excludes long-term systemic application. Local slow-release preparations include non-biodegradable implantable carriers such as self-made antibiotic-impregnated PMMA beads threaded on a wire. PMMA beads require an additional surgery for removal. Biodegradable carriers are degraded to non-toxic end products and consist of inorganic salts (hydroxyapatite, tricalcium phosphate) or polymeric biomaterials. Natural polymers consist of processed fibers of bovine collagen, gelatin or hyaluronan impregnated with antibiotics and are commercially available.

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Fracture Revision Surgery

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Revisions of osteosyntheses are relatively uncommon complications and are most frequently associated with bone and/or implant failure. Yet the need for revision may also stem from iatrogenic complications such as poor reduction with secondary malalignment or infections. Regardless, the common denominator of failures is technical error on the part of the surgeon. Multiple factors may be involved, eventually leading to post-operative failure requiring revision. Such factors may include inaccurate diagnosis related to poor imaging techniques, cursory pre-operative planning, improper implant selection, failure to adhere to basic surgical principles, inaccurate post-operative evaluation or misevaluation of post-operative compliance.

Pre-operative imaging and planning
Radiographs and/or advanced imaging that includes CT scans or MRI are the primary tools employed for fracture repair planning. High quality orthogonal and on occasion special projections of both the operated limb and contralateral limb should be performed. Inclusion of a calibration marker in every radiograph is paramount to adequate planning with dedicated orthopaedic software (i.e. OrthoView, Mimics, etc.). These powerful tools can then be used to assist the surgeon with the best implant choice and revision strategy. It is important to keep in mind that the benefits of prevention outweigh the costs of revision, not only to the patient biologically and owner/hospital financially, but to our reputation as surgeons. With appropriate preoperative planning strategies and knowledge, revisions can be avoided. *“He who fails to plan is planning to fail” – Sir Winston Churchill*

Implant selection
Improper implant selection may come from inadequate planning, misunderstanding of fracture and implant biomechanics, lack of diverse implant availability. The net result is often the inability of the implant to effectively counteract disruptive forces at the fracture site. Of these, shear forces are the most deleterious to bone healing while cyclic bending moments affect the fatigue life of the implant itself. In the current competitive market, one should keep in mind that the quality of an implant in terms of both design and material greatly affects its mechanical performance. Extensively tested implants offer reliable results when used appropriately. Suitable implant selection should allow for immediately stable osteosynthesis, which in turn should promote early functional recovery without the need for additional external splinting.

Adherence to basic and advanced surgical principles
Such principles include 1) comprehensive knowledge of loco-regional anatomy as well as least invasive surgical approaches, 2) in depth understanding of the benefits and limitations of time tested (Open Reduction and Internal Fixation [ORIF] and Open But Do Not Touch [OBDNT]) as well as new surgical techniques such as Minimally Invasive Osteosynthesis (MIO), 3) gentle manipulation of the soft tissue envelope (including the fracture hematoma) surrounding the fracture site and 4) strict adherence to the Halstead Principles. Similarly, an inclusive command of the rules of applications of specific implants is of paramount importance to the success of any osteosynthesis.

Postoperative evaluation
The ability to critically evaluate postoperative radiographs and patient limb function can reduce chances for failure. Radiographs should be assessed for implant positioning and fixation, limb alignment (in sagittal and transverse planes), and fracture reconstruction (particularly with articular fractures). If any of these are deemed unacceptable, immediate revision should be considered. Objective evaluation is also essential to self-improvement and honing one’s surgical skills as well as accurate assessment of

biomechanical principles that may help anticipate repair (implant and/or bone) failure. In most cases, the potential cause of failure can be seen during thorough and critical evaluation of postoperative radiographs. Failure to identify surgical mistakes on these radiographs may lead to failure particularly if the surgeon is unable to adjust postoperative recommendations accordingly.

Determining the cause of the failure

Whether failure results from mechanical or biological factors, identifying its origin is also essential to revision planning. As with any surgical procedure, both primary and secondary revision options should be considered. Planning strategies can be reinforced with knowledge gained from continuing education courses sponsored by private companies and/or CE entities such as the AO Foundation. As an example, from a mechanical standpoint, fatigue implant failure due to cyclic loading may be addressed with replacement of a fractured plate by an interlocking nail or choice of a larger plate. Conversely, repair failure via screw pullout from a weak, immature bone suggests that the implant is excessively stiff. In such a case, revision using a more compliant plate, a technique known as elastic plate osteosynthesis (EPO) is warranted. From a biological perspective, the surgeon must keep in mind that a revision almost invariably carries higher soft tissue morbidity than a well-planned and performed primary osteosynthesis. Iatrogenic soft tissue injuries generated during revision surgery (e.g. soft tissue dissection with ORIF) create a poor environment for healing, which in turn may increase the risk of implant fatigue failure due to delayed union. With this in mind, following MIO principles is advisable during revisions.

The impetus behind the development of MIO principles and techniques is in large part due to the recognition and identification of the shortcomings of ORIF with anatomical reconstruction and rigid fixation using conventional plating. As with any evolutionary step in medicine however, the critical evaluation of a new standard of care will inevitably lead to the documentation of different boundaries intrinsic to this novel approach. Our incentive to continue to progress is the hope that these new limits will be associated with lower morbidity, better functional outcomes and complications easier to manage when they do occur.

Suggested readings

1. Books from Atul Gawande: The Checklist Manifesto – Complications – Better
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Dealing with complications after ulna osteotomy

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Ulna osteotomies are widely used in small animal orthopaedics for the treatment of various stages of developmental elbow disease (formerly elbow dysplasia) as well as antebrachial limb deformities. The latter usually require a combination of radial and ulna osteotomy. Because complication and functional outcome typically depend on the radial corrective osteotomy, concomitant ulna osteotomy in this context will not be covered further.

Primary ulna osteotomies are either segmental ostectomies or single cut transvers or oblique osteotomies. Distal ostectomies are primarily used in very early stages of antebrachial limb deformities to uncouple longitudinal growth of radius and ulna, without osteotomy of the radius. Premature bony union of the ostectomy with subsequent recurrent limb deformity requires repeated ostectomy and can be prevented by placing a fat graft, taken from the flank or the gluteal region, into the ostectomy. Furthermore, the ostectomy should be long enough; typically, 1.5 times the diameter of the ulna in the area of the ostectomy is recommended. In contrast, non-union of a distal ostectomy usually does not require any intervention as it is asymptomatic in most of the cases. Another application of distal ulna ostectomy are dogs with early radiographic sings of medial coronoid disease (about 5-6 months of age), hoping for some pressure relieve within the medial joint compartment following ostectomy. No matter, which is the indication, care, should be taken to not damage the periosteum of the radius during ostectomy of the ulna. Otherwise synostosis could develop, which might lead to chronic pain. Release of synostosis requires meticulous surgical technique, as any unnecessary trauma during separation of radius und ulna increases the surgical trauma and therefore the risk of recurrent synostosis. In addition, an autologous fat graft placed between radius and ulna has been shown to reduce the incidence of recurrent synostosis. In human medicine, prolonged adjuvant non-steroidal anti-inflammatory medication or/and low-dose radiation as prophylaxis against heterotopic ossification are also recommended.

Complete distal ulna ostectomy (ulnectomy), including the styloid, has been evaluated ex vivo, demonstrating some carpal varus deformity during weight bearing. Resection of the styloid with a varying portion of the distal ulna may be indicated during oncological resection. Personal clinical experience suggest that this procedure is well tolerated and that carpal instability is not an anticipated complication. In case with instability as a complication, panarthrodesis will have to be considered as a salvage procedure.

Most of the complications encountered with ulna osteotomies are in relation to proximal osteotomies, either in a dynamic way or with some form of internal fixation, such as the proximal abducting ulna (PAUL) osteotomy. Such osteotomies are mainly performed to correct for some form of radio-ulnar incongruence in dogs with developmental elbow dysplasia or in elbow joint with advanced “end-stage” medial coronoid disease, hoping for some pressure relieve within the medial joint compartment. Most commonly reported complications arising from such intervention are delay or failure in bone healing, infection, excessive caudal tipping of the proximal ulna in case of dynamic osteotomy (especially in chondrodystrophic dogs) associated with joint instability in severe cases, varus deformity, hardware associated problems and absence of functional improvement of elbow lameness, despite proper healing of the osteotomy.

Excessive caudal tilting of the proximal segment as well as varus deformity are both prevented by performing a bi-oblique osteotomy, centred between the proximal and middle third of the radius (not the ulna!). In the early days, proximal ulna osteotomy was performed much closer to the elbow joint, limiting the ability of the interosseous membrane to provide stability to the osteotomy. It appears that the risk of excessive tilting is higher in chondrodystrophic breeds and therefore dynamic proximal ulna osteotomy should not be performed in those. In case of excessive tilting, non-union and/or joint instability open reduction and internal fixation, preferably with cancellous bone grafting, is recommended. Unfortunately, significant atrophy of the distal ulna segment is common, limiting the ability to achieve bony union, despite rigid fixation and grafting. Alternatively, synthetic reconstruction of the interosseous membrane, attaching the proximal ulna segment to the radius, similar to the reconstruction of a Monteggia fracture, might provide a functional solution. As a salvage procedure, bony fusion between the proximal ulna and radius will have to be performed.

Anecdotally, excessive dissection between the radius and the ulna during proximal ulna osteotomy may lead to significant bleeding and/or secondary ischemia of the radius, similar to radioulnar ischemic necrosis and will have to be treated accordingly.

It is important to note, that incomplete healing of a proximal ulna osteotomy is not associated with clinical symptoms per se and therefore other sources of pain should always be considered as a differential diagnosis, before attempting surgical revision of the non-union. Failure to improve lameness associated with medial compartment disease following proximal ulna osteotomy without obvious cause, including those with internal fixation, warrants repeated intraarticular investigation of medial compartment disease and in case of persistent or progressive cartilage disease, some other form of treatment, such as CUE or partial/complete joint prosthesis, respectively, should be considered.

Olecranon osteotomy is another form of ulna osteotomy, primarily used as part of a caudal approach to the humeral condyle, for example for repair of a T- or Y-fracture. Refixation is traditionally done using a K-wires and cerclage in the configuration of a tension bend. Unfortunately olecranon osteotomy repaired this way has been associated with a high complication rate (>30%) including osteomyelitis, loss of reduction, and improper placement and migration of the K-wires. Since a long time it is the author’s preference to repair such osteotomies with two lag screws instead of a tension band, with good success. To be fair, the author tries to avoid tension bend in any indication, and prefers lag screws if ever possible.

Dealing with complications after patellar luxation surgery

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Patellar luxation (PL) is a frequent condition in dogs with an increasing importance also in cats, which has the potential to significantly affect the animal's quality of life. There are numerous treatment options available with a risk of also serious complications, requiring further surgery.

Definition
Sokol and Wilson (2008) defined a surgical complication as "any undesirable, unintended, and direct result of an operation affecting the patient, which would not have occurred had the operation gone as well as could reasonably be hoped […] a surgical complication is not a fixed reality […] it is dependent on the level of surgical skill and the facilities available". Managing surgical complications is often technically challenging, and revision surgeries tend to carry a less favourable prognosis than initial procedures. In recent years the categories, as suggested by Cook et al (2010), have become the reporting standard of complications in clinical studies: catastrophic (complication or associated morbidity causing permanent unacceptable function, directly related to death, or cause for euthanasia), major (complication or associated morbidity requiring further treatment based on current standards of care; subdivided into major medical or major surgical), and minor (not requiring additional, medical or surgical, treatment to resolve). Nonetheless, it can be difficult to directly compare study results, as there is often a variety of breeds and sizes included, undergoing a variety of surgical techniques, with different length of follow-up and using different and often subjective and unvalidated outcome measures.

What predisposes patellar luxation surgery for complications?
The aetiopathogenesis of PL is complex. Most PL's are medial patellar luxations (MPL) and developmental in aetiology, but they can be traumatic or a complication of previous surgery. Several, also complex, anatomic abnormalities contribute to the malalignment of the quadriceps mechanism, which is the centrally underlying reason for PL. Patients with clinical signs associated with PL can be treated surgically with the aim to realign the quadriceps mechanism and to stabilise the patella within the trochlear groove. In most cases a combination of corrective osteotomy, or osteotomies, and soft tissues stabilising techniques is used. Significant anatomic differences exist between dogs and cats, which require an adjusted approach when treating affected animals in order to tailor the treatment to the individual patient.

Possible complications after patellar luxation surgery
Although the reported complication rates after patellar luxation surgery vary the numbers tend to be quite high. In dogs with medial patellar luxation overall complication rates of 13-45% have been reported including all the surgical correction for different medial patellar luxation grades. For cats with medial patellar luxation overall complication rates of 20-25% have been reported with a 20% rate of major complications.

- Intra-operative complications
    - Intraoperative complications include iatrogenic fractures, such as wedge or block fractures, tibial tuberosity fracture or insufficient alignment of the quadriceps mechanism.
- Infection
    - The risk of infection is as for other orthopaedic surgery. Superficial surgical site infection or septic arthritis requiring the usual work-up and treatment as

required.

- Implant related complications
    - Implant related complications are frequently observed after patellar luxation surgery. They can be classified as severe, i.e. implant failure requiring revision surgery, or less severe, i.e. other implant related problems, such as discomfort or seroma formation.
- Patella reluxation
    - Patellar reluxation is, together with implant related complications, the most frequently reported complication. Inadequate degree of tibial tuberosity transposition (TTT), concurrent femoral or tibial angular limb deformities or a postsurgical inadequate trochlear groove depth are frequent reasons for an inadequate alignment of the quadriceps mechanism. Not in all cases this requires further treatment, however, if clinical signs persist or re-occur, revision surgery is indicated and requires accurate analysis of the contributing factors in order to adequately address them.
- Tibial tuberosity avulsion
    - Inadequate stabilisation can contribute to avulsion of the tibial tuberosity. Treatment can be conservative or surgical, depending on the level of instability of the tibial tuberosity and associated patellar tendon.
- Patella ligament rupture
    - A rare, but serious complication, usually associated with suboptimal surgical technique and/or implant placement, requiring revision surgery including, in most cases, temporary extension of the stifle joint.
- Recession wedge/block displacement
    - Very rarely reported complication, can be addressed by adding a small K-wire as fixation.
- Bone fracture
    - Femoral, tibial and lateral ridge fractures have been reported, usually requiring revision surgery.
- Progression of OA
    - Is to be expected to some degree in most cases, also with the potential to clinically affect the outcome.

The benefits of specific procedures to address PL in dogs and cats have been investigated by several authors and important differences between the species were highlighted by Rutherford et al (2014). Both, sulcoplasty and TTT demonstrated to prevent major complications and reluxation effectively, when comparing dogs with and without these procedures. In cats, although the number of cats with reluxation after sulcoplasty and/or TTT was slightly lower compared to cats without sulcoplasty and/or TTT, the numbers of the cats affected did not differ significantly. In cats, performing TTT, previous ipsilateral femoral fracture and grade 4 PL were significantly more likely to result in complications.

Available outcome data after PL surgery has been mainly based on subjective veterinary assessment, often analysed retrospectively. Current data suggests that the overall outcome after PL surgery can be good despite the occurrence of complications.

Summary

The reported risk of complications after PL surgery in dogs and cats is high. A thorough and complete assessment of the patient is required to help to avoid complications in the first instance and to support the decision-making processes when dealing with complications.

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Dealing with complications after total hip replacement

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Using clinical cases, this proceeding will summarize complications of total hip replacement (THR) surgeries related to acetabular cup issues, with an emphasis on wear of the ultrahigh molecular weight polyethylene (UHMWPE) liner. Due to the longevity and success of current hip prostheses, surgeons do not hesitate to treat dogs as young as a year of age affected with hip dysplasia. Considering that a life expectancy of approximately 12-15 years is not uncommon, surgeons need to be aware that wear of UHMWPE liners represents a potential long-term complication for which revision options may be required.

UHMWPE liner replacement
Case #1

Initial surgeries
A 1-year old, spayed female, mixed breed, weighing ~27 kg was treated for right hip dysplasia via THR with a BioMedtrix BFX CoCr prosthesis – Cup 24 mm / Head 17 mm / Neck +0 / Stem #8. Mild stem subsidence with slight retroversion was diagnosed at 7 weeks post operatively. In the absence of clinical signs, no revision was recommended. A year after the first THR the dog received a second prosthesis (Cup 24 mm / Head 17 mm / Neck +0 / Stem #9) to treat the left hip. Intraoperative femoral fissure during impaction prompted the used of 4 double loop cerclage wires from the calcar to the mid diaphysis (Fig. 1). As documented during yearly clinical and radiographic evaluations, both prostheses remained static over the ensuing 4 years, at which point, right UHMPE liner thinning was diagnosed radiographically. Liner replacement was recommended and performed 5 years following the initial THR surgery (Fig. 2).

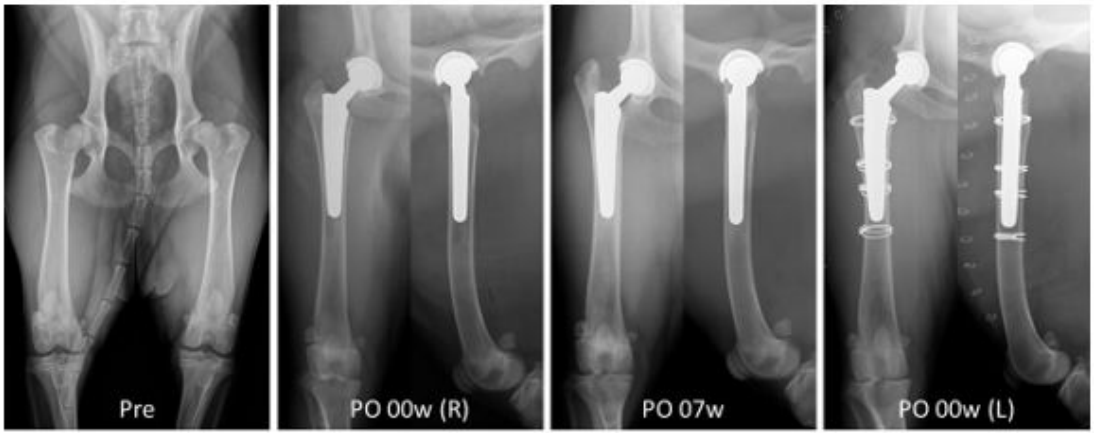

Figure 1 – Pre-operative radiographic view of the pelvis showing bilateral hip dysplasia as well as post-operative views of the right then left THR.

Revision surgery
The right hip was exposed via a routine craniolateral approach. Following luxation of the hip, stability of the acetabular cup and femoral stem was ascertained. The femoral head was removed using a dedicated extractor designed to preserve stem stability. The remnants of the UHMWPE were removed and the inside of the cup metal shell was inspected for potential structural damage. The liner was then replaced. Because of the early stem subsidence, the femoral neck was extended from +0 to +6 to improve hip stability.

Figure 2 – Radiographic view at 5 years showing thinning of the UHMWPE liner. Note the persistence of a thin radiolucent interface between the head and the cup suggesting that metal-on-metal contact had not occurred. Also note that thinning is not apparent on all views. Post-operative views show successful revision consisting of UHMWPE replacement and neck lengthening to improve stability. The case was lost to follow up before the 24 weeks recheck.

Case summary
This case demonstrates that UHMWPE liner replacement can be performed and result in a positive outcome. The original subsidence was likely due to the implantation of an undersized stem and the use of a low neck ostectomy. These techniques were not uncommon in the early development of the BFX system and have been corrected since. Current recommendations include greater canal fill by the stem and higher neck ostectomy. Over the past ~ 10 years, titanium collared or lateral bolt stems have been introduced to further reduce the risk of subsidence via increased frictional stability at impaction and additional primary fixation at the calcar or lateral subtrochanteric region.

More recently, highly crosslinked (via radiation) Vitamin E (anti-oxidative properties) impregnated UHMWPE liners, which have been shown to have an increased longevity, have started to replace traditional liners. Because of slight iterations of cup and stem designs over the years since the introduction of the BFX system, it is essential to keep track of the implant serial numbers in the patient's medical record. Only then can the manufacturer provide the surgeon with the appropriate replacement liner. Because UHMWPE wear is a slow, insidious process, without overt clinical signs, it is highly recommended that regular (yearly) clinical and radiographic evaluations be performed. Only then can liner replacement be planed effectively. Considering that the shelf life of the UHMWPE liners is ~ 5 years, most replacements will require that a custom liner be manufactured based on the serial number of the original implant. This process, which maybe time consuming, can be started once early UHMWPE wear is identified during yearly evaluation. The revision procedure is, as described in this case, relatively straight forward. Conversely, late diagnosis of advanced wear with metal-on-metal contact, structural damage to the inner surface of the cup, or in severe undiagnosed cases, protrusion of the femoral head through the cup (acetabular protrusio) will prevent simple liner substitution and require a more challenging full cup replacement.

Cup replacement
Case #2

History
A 5-year old, spayed female, Labrador, weighing ~30 kg was presented to our practice 4 years following a right THR using a hybrid BioMedtrix prosthesis consisting of a BFX cup / CFX stem – Cup 22 mm / Head 14 mm / Neck +5 / Stem #5. The dog had a history of ~ one-year intermittent lameness with reduction of the right hip range of motion (ROM).

Diagnosis
Upon presentation, the dog had a pain free reduced ROM in extension and adduction characterized by "abrupt" stops and a distinct metallic "feel". This finding was suggestive of impingement secondary to acetabular protrusio. Moderate lameness was attributed to the limited stride of the right hind limb.

Radiographs confirmed the tentative diagnosis of protrusio and revealed the formation of a neo-acetabulum dorsal and medial to its normal anatomical location. The inner diameter of this neo-acetabulum matched that of the outer diameter of the femoral head. Additional radiographic findings included periprosthetic metallosis, a metallic fragment of the acetabular cup and formation of a thick sclerotic wall around the neo-acetabulum (Fig. 3). There was no evidence of stem loosening and the remnant of the cup appeared well osteointegrated.

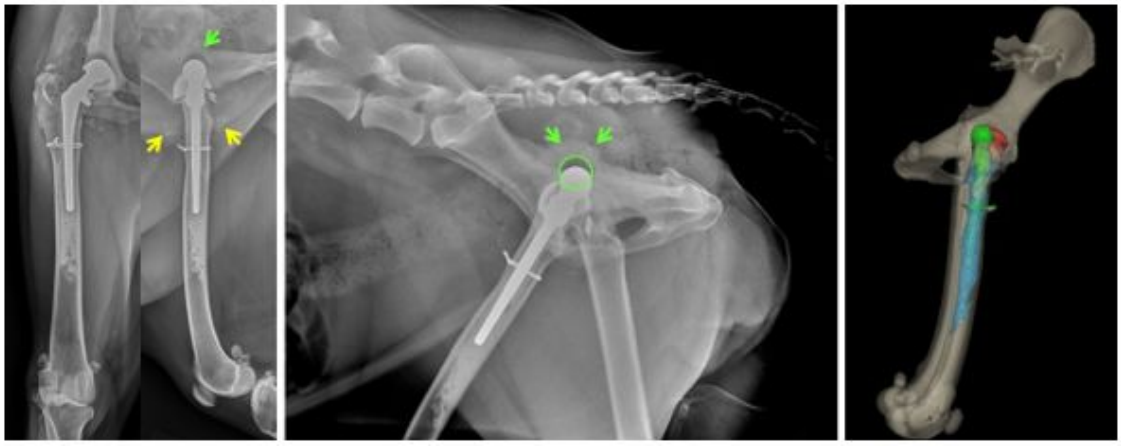

Figure 3 – Radiographic views 4 years after implantation of a hybrid BioMedtrix THR showing protrusion of the femoral head thought the BFX acetabular cup. Findings include formation of a new acetabulum in a dorso-medial location (green circle) surrounded by a thick wall (green arrow) as well as metallosis (yellow arrows). Advanced imaging was used to ascertain the direction of the protrusio.

Revision surgery

Advanced imaging including CT, segmentation and 3D reconstruction was performed as part of the surgical planning (Fig. 3). Images revealed loss of caudo-dorsal acetabular cup wall integrity with partial circumferential defect. Based on this finding the revision included 1) extraction of the UHMWPE remnants and cup fragment, 2) conservative debridement of the metallosis and 3) evaluation of the stem stability. Next, extraction of the failed 22 mm cup was performed by progressively collapsing the outer edge along a cranio-caudal diameter while breaking down the bone implant interface. A new acetabulum, centered on the edges of the original cup, was reamed to receive a 26 mm BFX cup with a 17 mm head with a +3 neck length (Fig. 4). Because excessive laxity resulted in peri-operative luxation, the neck length was increased to +9 and a prosthetic joint capsule augmentation was immediately performed. This last procedure was achieved using a dorsal approach to the acetabulum via osteotomy of the greater trochanter. Four double strands of polyfluorocarbon sutures were passed through two tunnels in the greater trochanter and secured to four suture anchors evenly placed around the acetabulum (Fig. 4).

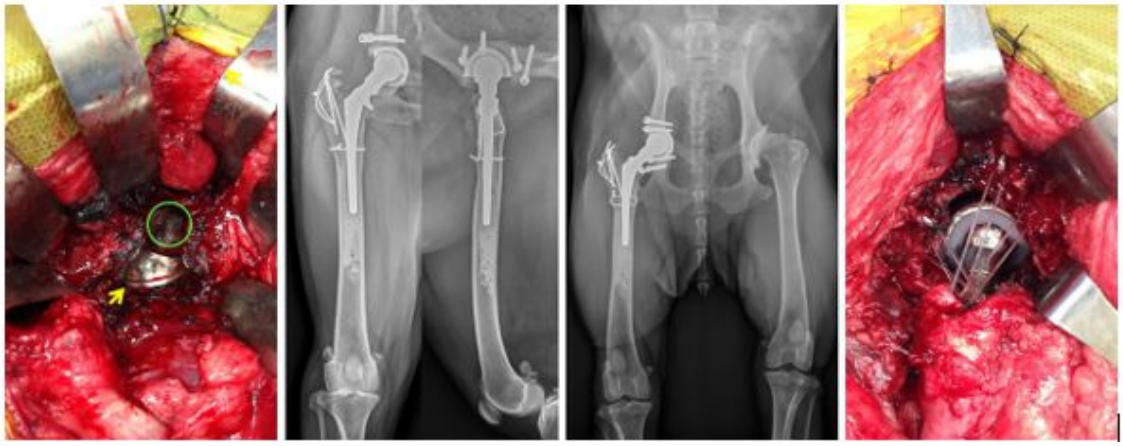

Figure 4 – Intraoperative photographs showing (Left) the structural damage to the original cup (yellow arrow) and the neo-acetabulum (green circle) as well as the new BFX cup with the prosthetic joint capsule augmentation (Right). Post-operative radiographs at 3 months (center) show stable reduction of the revised hip prosthesis.

Clinical outcome

Clinical and radiographic evaluation 12 weeks after revision surgery revealed excellent functional recovery without lameness, pain free near normal hip ROM and no implant failure. Although no further follow up was performed at our institution, phone interview confirmed functional recovery one year after revision.

Case summary

Unlike the first case, the diagnosis of UHMPE wear was not made until acetabular protrusio had occurred. This again emphasizes the importance of yearly radiographic evaluation in order to anticipate revision prior to catastrophic failure. By then, the only valid revision option was full cup extraction and replacement by a larger implant. This revision was possible because the initial cup (22 mm) was undersized. Had a larger cup been used initially, cup replacement might not have been possible due to the limited acetabular bone stock. Wear of the UHMWPE liner occurred quite early in this case likely because an undersized cup with a small 14 mm head were selected in a young

active Labrador. In our experience, most UHMWPE liner wear cases requiring replacement occur at later dates around 9 to 10 years after initial surgery.

Recommended reading:

Nesser VE, Kowaleski KP, Boudrieau RJ: Severe Polyethylene Wear Requiring Revision Total Hip Arthroplasty in Three Dogs, Vet Surg (45)-664-671, 2016

Dealing with complications after cruciate surgery

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Injury to the cranial cruciate ligament (CrCL) is without doubt the most common orthopedic problem in dogs and has a considerably high economic impact. Surgical treatment of CrCL injury has proven to have better short and long-term outcome than conservative treatment. Numerous techniques intracapsular, extracapsular and osteotomies to stabilize the CrCL-impaired stifle evolved over time with considerable debate of which technique is superior to the other. Success rates with CrCL surgery are reported to be >90% regardless the technique but there is consensus emerging shown in recent studies that osteotomies (TPLO, TTA, CBLO) perform superior to extracapsular procedures. Newer reports show evidence that TPLO is the only technique to be able to return dogs to normal function in the walk and trot.

Complications may occur after any surgical procedure and do occur following all types of cruciate repair techniques. Many different factors can lead to surgical complications and understanding the most common causes of complications and there clinical signs will help to deal with these problems.

Complications with cruciate surgery can be described as intraoperative, short-term postoperative and long-term postoperative. Minor complications are considered problems that resolve with time or with medical intervention alone whereas major complications need an additional surgical intervention to resolve.

Some complications seen in cruciate surgery are unrelated to the procedure but some issues are inherently related to the specific technique performed. Osteotomies are the most common performed surgical procedures in CrCL rupture worldwide but complication rates reported are relatively high according to different reports.

Intraoperative complications described in TPLO (9.7-34% include hemorrhage with laceration of the a. poplitea, fibular head fracture and intraarticular screw position. Short term postop complication are swelling, edema, incision line inflammation and tibia fracture. Long-term complications are subsequent meniscal injury, incision site infection, deep infection, patellar tendonitis, tibial tuberosity fracture and patella fracture.

Complications with TTA (13.4-31.5%) are similar to the ones with TPLO with implant failure being specific to the implants used.

Reported complications with extracapsular suture techniques (17.4%) include rupture or failure of the suture material with recurrent instability, subsequent meniscal injury, rapid progression of osteoarthritis and infected suture material with draining tracts.

Meniscal injury is present in 20-77% of cases with cruciate insufficiency. A meniscal injury can occur simultaneously with the injury of the CrCL but more frequently is a consequence of stifle instability over time. Depending on the time when cruciate surgery is performed since initial clinical signs occur more or less meniscal injuries can be expected. For successful cruciate surgery of any technique it is important to diagnose and effectively treat a meniscal injury. Arthroscopy when used by experienced surgeons is more accurate than (mini-)arthrotomy. Understanding meniscal anatomy and using appropriate instrumentation is essential for accurate evaluation and treatment of meniscal injuries. The medial meniscal caudal horn is most frequently injured due to anatomic and kinematic difference to the lateral

meniscus. The medial meniscus is firmly attached to the tibial plateau whereas the lateral meniscus is also fixed to the femur by the meniscofemoral ligament and is slightly sliding on the tibial plateau and follows the femoral condyle in flexion/extension. Meniscal injuries are painful but this pain is indistinguishable from cruciate rupture pain initially. Persistent pain after cruciate surgery is frequently due to undiagnosed and untreated meniscal injury (late meniscal injury). Recurrent pain after cruciate surgery is frequently the cause of unresolved cranial tibial thrust and weight bearing results in femorotibial subluxation with increased compressive and shear forces concentrating on the caudal horn of the medial meniscus eventually fraying the fibrous tissue (subsequent meniscal injury). Incomplete resolved cranial tibial thrust is a common problem in extracapsular techniques. With osteotomies TTA results more frequently with persistent stifle instability than TPLO. The incidence of late/subsequent meniscal injury in the literature is 8.5-27.8% after TTA, 3-12% after TPLO and up to 16.9% after extracapsular repair. At the university of Bern we have seen 6.4% in a series of 774 TPLO cases. Meniscal release procedure has not shown evidence to be able to prevent subsequent meniscal injury but promotes inevitably progression of osteoarthritis by the lost stabilizing function of the meniscus and is therefore not recommended. A “second look” arthroscopy is the preferred approach to treat late/subsequent meniscal injury and partial meniscectomy (removal of only the injured part of the meniscus) is preferred to total meniscectomy.

Surgical site infection (SSI) is a complication of any surgical procedure and has an incidence of 3-12 % in all veterinary procedures and of 1.6-4.8% in clean procedures. The reported incidence of SSI after TPLO considered a clean surgical procedure is higher than expected with a wide range (3-26%) and different risk factors were identified in dogs: German Shepard breed, intact male status, increased body weight, preoperative colonization with methicillin-resistant *Staph. pseudintermedius* (MRSP), anesthesia time, implant type, surgeons experience, meniscectomy and lack of postoperative antibiotic treatment. SSI is a complication that adds significant morbidity to patients and substantial economic cost for treatment. The US Center for Disease Control definition for SSI divides superficial SSI, deep SSI and organ/space SSI. Superficial SSI might resolve with antibiotic treatment and wound management alone but formation of a biofilm by bacteria on surgical implants frequently renders antibiotic medication unsuccessful. Deep SSI needs implant removal as soon as osteotomy healing allows it and debridement of contaminated tissues to eradicate infection. Space SSI by this definition would be an infective bacterial arthritis and is hardly ever seen with TPLO combined with arthroscopy and rarely with arthrotomy.

Incisional site dehiscence and draining tracts are treated by open wound management and bandaging or negative pressure wound treatment until implant removal is possible (6-8 weeks post TPLO). Low-grade implant infection may be the reason for persistent or recurring lameness after TPLO when all other causes for lameness are excluded. Implant removal is indicated although no obvious infection signs or draining tracts are apparent. In most of these cases the lameness resolves and positive bacteriologic culture of an implant screw proves the presumed diagnosis postoperatively. Antibiotic treatment in these cases is normally not indicated, even when a positive culture result follows. SSI can significantly be reduced by adapting preoperative, intraoperative and postoperative aseptic protocols and postoperative TPLO infection rate dropped in one study from 7.4% to 0.94% and implant removal rate decreased from 8.3% to 1.3% after implementing preventive measures. Factors included in our setting were strict use of sterile clipper blades, wearing single-use gloves by all nurses involved in patient handling, strict protocol for alternating alcohol-based solution, chlorhexidine scrub preparation in the prep room and a last wash/spray in the surgery room after positioning, watertight surgical draping with disposable adhesive drapes and an adhesive Ioban (3M) iodophore-impregnated drape, wearing colored double glove technique by the surgeons, perioperative antibiotic protocol i.v. repeated every 90 minutes intraop and continued every 4 hours until 12 hours post op, covering the incision site with sterile adhesive and coaptation 24h; trying to keep anesthesia time as low as possible and postop Elizabethan collar for 10 days.

Use of prophylactic postoperative antibiotics beyond the perioperative time frame to reduce the risk of SSI after TPLO is controversial. A recent review of the literature found little evidence to support the use of extended postoperative antibiotic use after TPLO although some studies claimed less SSI. This is mainly due to the lack of high quality prospective studies and the inconsistent treatment protocols in the evaluated studies.

Implant related complications are seen in TPLO and TTA. In TPLO initially un-contoured standard steel implants with cortical screws and plate holes for interfragmentary compression were used. With the implementation of anatomically contoured locking compression plate systems decreased SSI rates could be shown at least in heavier dogs. Implant failure/fracture of the tibia is a rare complication in

TPLO and TTA and revision surgery can be challenging. Fracture of the tibial tuberosity and patella are rare postoperative complications with TPLO and are minimized with improved position of the osteotomy centered to the tibial plateau, leaving enough tuberosity width cranial to the osteotomy. Position of the anti-rotational K-wire at the level of the patellar ligament insertion is another factor. Most of these fractures are minimally displaced and no specific treatment is indicated. Activity restriction of 6-8 weeks resolves the problem. When using a jig with TPLO the proximal pin is positioned close to the joint surface and care must be taken to avoid directing the pin intraarticular. The distal pin is only driven through one cortex to minimize the stress rising effect for tibial fracture. In very large breeds care must be taken to avoid placing the distal pin mid shaft of the tibia as this will increase the stress rising effect and a tibia fracture may occur with physiologic loading. Fibular fractures with TPLO procedures are rare events and can occur intraoperative with tibia segment rotation and early postoperative. Risk factor for postoperative fibula fracture have been described as heavier body wight and open fibular drill hole. Transient increase in lameness during TPLO recovery may be due to postoperative fibula fracture with no long-term effect to recovery rate. Osteosarcoma after TPLO procedure is very uncommon and was published to occur in 10-30 per 10’000 dog years at risk (DYAR). Causative relationship of TPLO and neoplasia formation was discussed to be metal composition and characteristics of the initially exclusively available original Slocum TPLO plate. With different manufacturers providing implants today incidence density rate of osteosarcoma should even decrease but the overlap population of CrCL disease and periarticular sarcoma is large.

Soft tissue related complications as swelling, seroma and hematoma formation are similar to all orthopedic procedures. Excessive intraoperative bleeding occurs with laceration of branches of the popliteal artery caudal to the tibia with instruments or most frequently with the saw blade. Protection of soft tissues with surgical swabs behind the tibia before application of the oscillating saw was initially recommended but not releasing the caudal soft tissues with carefully guiding the saw blade only to the very caudal edge of the tibia prevents injury to the popliteal artery as reliably. Patella tendon thickening post-surgery can be observed radiographically with all osteotomy techniques in up to 80% with increased presentation in TPLO compared to TTA. This discrepancy is explained in some studies with increased moment arm of the extensor mechanism with TTA decreasing the force through the patella tendon and decreased moment arm in TPLO increasing the force through the patella tendon. Lameness/pain is not diagnosed in most cases explaining the thickening more frequently with paratendinous and fat pad fibrosis over true patella tendinopathy. Clinical patella tendon thickening cases resolve with rest, anti-inflammatory and physical treatment.

Pivot shift phenomenon is rarely seen after TPLO procedure in cases of unstable total CrCL rupture and medial hemimeniscectomy. At the walk during weight-bearing the stifle fails to control internal rotation resulting in cranial subluxation of the proximal tibia combined with a sudden lateral change in direction of the stifle joint. This snap movement can also be triggered in passive flexion/extension manipulation of the leg. Most animals do not seem to reveal discomfort in manipulation or weight-bearing and the phenomenon disappears usually with rest and physical therapy. Cases that do not resolve need an extracapsular stabilization technique. The Arthrex® TPLO plate provides the option for a knotless anti-rotation lateral stabilization technique with *Internal*Brace™ ligament augmentation in a very instable stifle to prevent pivot shift.

In conclusion even though published complication rates after cruciate ligament surgery seem to be very high, rates of true major complications making a second surgical intervention necessary are acceptable but increased morbidity and risk of second surgery for the patient and increased cost and frustration for owners have to be considered. An acceptable algorithm for cases with persistent or recurring lameness after cruciate surgery is clinical examination for signs of inflammation, SSI or instability, radiographs to evaluate for signs of fractures, implant related issues, infection, septic arthropathy or neoplasia followed by joint tap to evaluate synovia. If diagnosis is not established then proceed to arthroscopy to evaluate the medial meniscus and eventually preserved cruciate fibers during the first surgery. If status of the meniscus and intraarticular exploration does not explain the clinical signs removal of the implants (plates and screws or extracapsular suture material) and culture is indicated. For TTA removal of the implants can be a challenge but arguing that the cage is of titanium alloy implant related infection may be less likely.

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3D kinematic evaluation of lateral suture stabilization in an in vitro canine cranial cruciate deficient stifle model

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Introduction
The impact of surgical correction of cranial cruciate ligament rupture (CCLR) on 3D kinematics of the canine stifle joint has not been thoroughly evaluated. While various techniques aim to restore normal limb function following CCLR, their success remains limited, as illustrated by suboptimal weightbearing and the progression of osteoarthritis. The inability to restore the stifle's 3D kinematics might be a key element to a successful outcome. Our objective was to evaluate one of the most frequently used techniques, lateral suture stabilization (LSS), in order to determine if it could restore baseline 3D kinematics. Our hypothesis was that 3D kinematics of the stifle joint would not be restored by LSS in our model.

Materials/methods
Ten pelvic limbs collected from euthanized large dogs (25-40 kg) were tested with a previously validated apparatus that simulates gait. Three experimental conditions were compared: (a) intact stifle; (b) unstable stifle following cranial cruciate ligament transection (CCLt) and (c) CCLt stabilized with LSS. For each condition, 3D kinematic data were recorded over 5 gait cycles. Curves were analyzed using a Wilcoxon signed-rank test.

Results
LSS restored baseline kinematics during the entire stance phase for cranial and lateromedial translation, sagittal flexion, and abduction. It restored distraction over 90% of the stance phase. Internal rotation was limited, but not restored.

Discussion/Conclusion
These results report that LSS can restore 3D kinematics largely comparable to those of healthy stifles. Progression of osteoarthritis and suboptimal weightbearing following CCLR stabilization by LSS therefore may result from causes other than abnormal 3D kinematics.

Evaluation of hindlimb deformity in dogs with grade 2 medial patellar luxation by naturally standing computed tomography imaging

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Introduction
Dogs with grade 2 medial patellar luxation (G2 MPL) showed no significant bone deformities in our previous study using static computed tomography (CT) (VCOT, 29:29-31, 2016); however, abnormal posture such as genu varum are also often observed in the clinical situation. The purpose of this study is to quantify hindlimb deformity in the naturally standing position using innovative high speed 320 slice CT imaging in dogs with G2 MPL.

Materials and Methods
Four limbs of dogs with G2 MPL and 6 limbs of dogs without any orthopaedic disorders (control) were imaged, using CT, in the naturally standing position, without any sedation/anesthesia. In G2 MPL limbs, images were obtained when the patella was luxated (G2-L) and reduced (non-luxation, G2-NL). Bone morphology was evaluated by the same methods as in our previous study. In addition, standing posture was evaluated by objectively measuring hindlimb deformity including femoral rotation and abduction angles, tibial rotation angle, tarsal rotation angle, stifle joint line convergence angle (JLCA), angle between the femoral anatomical axis and the load line of hindlimb, and the plantar rotation angle.

Results
There were no significant differences in bone morphology among the three groups. In the G2-NL group, there was no significant hindlimb deformity compared to the control group. In contrast in the G2-L group, significant hind limb deformities (e.g. external rotation of femur and tarsal, internal rotation of tibia, large JLCA), genu varum, and toe-in posture were observed.

Discussion/Conclusions
Dogs in this study with G2 MPL had no bone deformities, but showed abnormal posture with significant hindlimb deformity during luxation in the standing position.

Mechanical evaluation of two hybrid locking plate designs for canine pancarpal arthrodesis

Zderic I[1], Varga P[1], Styger U[1], Drenchev L[2], Gueorguiev B[1], Asimus E[3], Saunders B*[4], Kowaleski M*[5], Boudrieau R*[5], Déjardin L*[6]*

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Introduction
Hybrid locking pancarpal arthrodesis (PCA) plates were designed with either a round or oval radiocarpal (RC)-screw hole (RH vs. OH), the latter permitting varied screw positioning. Potential decreased structural properties of the OH design was a concern. Our aim was to mechanically compare the structural properties of the contrasting PCA plates.

Materials and Methods
RH and OH PCA plates were bent 20° and fixed to a simulated forelimb model (radius, RC-bone and 3rd metacarpus). OH-plates were evaluated with RC-screw position either most proximal (OH-P) or distal (OH-D). Constructs (N=6) were loaded axially (300N/10 cycles/0.5Hz). Plate strains (µm/m) were measured at areas of highest deformations predicted by Finite Element Analysis (FEA). Outcome measures: construct compliance (CC[□/N]), angular deformation (AD[□]). Statistics: Normal distribution (Shapiro-Wilk) and homogeneity of variance (Levene's test); differences OH-P vs RH-P (ANOVA with Bonferroni post-hoc correction); OH-P vs. OH-D (paired t tests). Significance set to $p<0.05$.

Results
FEA predicted highest strains adjacent to the RC-screw and plate bending point. Mean±SD peak RC-screw hole strains (µm/m) were not influenced by RC-screw position (3329±443 [OH-P], 3222±467 [OH-D]; $p=0.550$), but were lower in the RH group (2123±154; $p<0.001$). Peak strains at the bending point were significantly lower for OH-P (1792±174) and OH-D (1806±194) than in RH plates (2158±114) ($p\leq0.006$). CC and maximum AD were not different between constructs ($p\geq0.123$). FEA findings agreed with these experimental results.

Discussion/Conclusions
OH-Plate higher peak strains adjacent to the RC-screw hole and more heterogenous plate strain distribution compared to RH-Plate warrants further evaluation using fatigue testing.

Mechanical evaluation of two hybrid locking plate designs for canine pancarpal arthrodesis under fatigue loading

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Introduction
Mechanical comparison of two hybrid locking pancarpal arthrodesis (PCA) plates featuring either a round or oval radiocarpal (RC)-screw hole (RH vs. OH) revealed higher peak strain adjacent to the RC-screw hole and more heterogenous plate strain distribution in the OH than RH plates. Due to concern about potential decrease in structural properties of the OH design, our aim was to mechanically compare the fatigue life of the contrasting PCA plates.

Materials and Methods
RH and OH PCA bent (20°) plates were fixed to a forelimb model (radius, RC-bone and 3rd metacarpus). RH and OH-plates instrumented with RC-screw position either most proximal (OH-P) or distal (OH-D) were cyclically loaded (320N, 8Hz, N=10) until construct failure. Fatigue life outcome measures were cycles to failure and failure mode. Differences between groups were analyzed using ANOVA and Bonferroni post-hoc correction ($p<0.05$).

Results
Cycles to failure were significantly ($p=0.028$) higher for RH (695,264±344,023) compared to OH-P (447,900±176,208) and OH-D plates (391,822±165,116).There was no difference between OH-P and OH-D plates cycles to failure ($p\geq0.092$). All constructs predominantly failed by the plate fracturing at the 4th radial screw hole with concomitant 4th radial screw fracturing at the shaft-head interface.

Discussion/Conclusions
Ovalization of the RC-screw hole was meant to improve the surgical application versatility of the OH PCA plate. However, the significant decrease in plate fatigue life and increased failure probability of that design, regardless of screw location, mitigates its potential benefits. Based upon these findings, the OH PCA plate is not recommended for clinical use.

Laser lithotripsy of penile urethral stones in toy breed male dogs

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Introduction
The aim of this study was to evaluate clinical results of micro-endoscopic laser lithotripsy (MicroLL) of penile urethral stones in toy breed male dogs weighing less than 6 kg body weight.

Materials and Methods
Medical records (2018-2020) were reviewed for male dogs that had undergone MicroLL of penile urethral stones. MicroLL was performed using a semi-rigid modular micro-endoscope (0.55 mm outer diameter [OD], 70° vision angle, Polydiagnost GmbH, Hallbergmoos, D) with a working shaft (OD = 0.90 mm, working length 9.0 cm). Integrity of urethral mucosa was visually graded 0-III (0 intact, I local irritation or hyperplasia, II circumferential irritation or hyperplasia, III changes obstructing > 50 % of urethral lumen). MicroLL was performed using Holmium laser energy.

Results
There were six toy breed male dogs at the age of 2 – 14 years weighing 3.5 – 5.7 kg. Urethral mucosa was graded 0-I/III (n=5) or II/III (n=1). MicroLL allowed clearance of the urethra from urinary stones by total fragmentation or by partial fragmentation and retropulsion into the urinary bladder. Total micro-endoscopy time was 25 - 40 minutes. After MicroLL, five dogs returned to normal urination. One dog that had urethral mucosa graded II/III needed urethrostomy because of recurrent stranguria.

Discussion/Conclusion
MicroLL permitted clearance of urinary stones from the penile urethra in toy breed male dogs not amenable to treatment via conventional size urethroscopes. Condition of the urethral mucosa seems to be critical for clinical outcome.

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Proximal perineal urethrostomy in 11 cats: technique and short-term outcome

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Introduction
Stricture after perineal urethrostomy (PU) is a life-threatening complication. Revision surgery can be challenging because of the scar tissues and deep location of the urethra. The purpose of this study was to describe a modified technique to address these issues and provide information about the short-term outcome.

Materials and methods
Medical records of cats that underwent proximal perineal urethrostomy (PPU) between 2007 and 2020 were reviewed. PPU was performed in dorsal recumbency, an elliptical incision was realized around the urethral stoma and the urethral remnant was fully mobilized. The caudal ischiatic arch was exposed to perform an ostectomy (10-mm wide; 12-mm long). The urethra was tilted ventrally and a dorsal incision was performed as for PU, but 2-4 mm proximal to the bulbourethral glands, followed by mucocutaneous anastomosis. The portion of the penis distal to the bulbourethral glands was discarded. Complications over a one-month period were recorded.

Results
11 neutered male cats were included. Indication for PPU was stricture of the urethral stoma following PU (performed at a median time of 6.5-months before) in all but one case which had urethral tears. No intraoperative complications occurred. One cat died one week after surgery for unknown reasons. No wound complications nor incontinence occurred. Two cats had lower urinary tract disease, both of which responded to medical therapy.

Discussion/Conclusions
PPU was used successfully as urinary tract diversion following urethral stricture after PU or urethral tears. Compared to transpelvic urethrostomy, urethral location is less deep and urine flow more ventrally orientated that could prevent urine dermatitis.

Long-term and quality of life assessment following treatment of congenital intrahepatic shunts in dogs by percutaneous transcatheter embolization technique

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Objectives
To report the long-term outcome and quality of life (QoL) of dogs with congenital intrahepatic shunts (cIHPSS) following treatment by percutaneous transcatheter embolization technique (PTCE) using qualitative health-related (Hr) assessment methods.

Methods
Dogs undergoing cIHPSS attenuation with PTCE were retrospectively reviewed. Detailed Hr-QoL and congenital portosystemic shunt (CPSS) questionnaires were sent to the owners. Each animal was given a Hr-QoL score from 0 (worst QoL) to 100 (Best QoL) and a CPSS score from 0 (best) to 110 (worst). Information about the nature of the shunt as well as medication / food that the dogs were still receiving at the time of final assessment were also recorded.

Results
Forty dogs were included (33 retrospectively, 7 prospectively) including 14 left, 21 right, 3 central divisional cIHPSS and one multiple. Median follow-up time was 787 days. Median survival time was 2117 days. 17/31 dogs were still on medical treatment and/or special diet at the time of last follow-up Median [interquartile range] CPSS decreased from before PTCE (22 [16.5-46.5]) to after PTCE (7 [4.3-12.5]) ($P<0.001$) and median QoL score increased from premedical treatment to post medical treatment to post-PTCE ($P=0.003$). There was no difference between the post medical and post-PTCE scores ($P=0.141$). The 1- , 2- and 5-year survival rate were 87.5%, 76.8%, and 59.5% respectively.

Conclusions
This study showed that treatment of cIHPSS with PTCE in dogs was associated with a long-term survival and significant improvement of the QoL similar to that obtained following open surgical treatment.

Outcome and postoperative complications in 73 dogs with thyroid carcinoma with gross vascular invasion managed with thyroidectomy

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Introduction
Outcomes for thyroid carcinomas with gross vascular invasion are poorly described. Our objective was to describe the clinical outcomes and complications in dogs with gross vascular invasive thyroid carcinomas undergoing thyroidectomy.

Materials and methods
Medical records of dogs that underwent thyroidectomy between January 1st 2010 and December 31st 2019 were reviewed at 10 hospitals. Signalment, diagnostic data, primary and adjuvant treatments performed, and outcome data were abstracted. Survival data were calculated using Kaplan-Meier analysis. Multiple logistic regression was used to identify variables associated with disease-specific survival (DSS).

Results
Seventy-three dogs were included, of which 58 underwent unilateral thyroidectomy and 15 underwent bilateral thyroidectomy. Complications were seen in five dogs (6.8%) intraoperatively and 12 dogs (16.4%) postoperatively. Seven dogs (9.6%) developed locoregional recurrence at a median of 238 days postoperatively (range: 15-730 days). Distant metastasis was suspected or confirmed in nine dogs (12.3%) at a median of 375 days postoperatively (range: 50-890 days). Thirty-nine dogs were euthanised or died (20 deaths related to disease or of unknown cause, 19 due to unrelated causes, and 9 dogs lost to follow-up). Median overall survival time was 621 days and median disease-specific survival time was not reached. The one-year DSS rate was 82.5%. No variables were associated with DSS.

Discussion/Conclusions
Survival times were often long following thyroidectomy for tumours with gross vascular invasion. Surgery should still be considered for loco-regional therapy in dogs with thyroid carcinoma with gross vascular invasion. Further work is needed to assess the impact of vascular invasion on prognosis.

Feline salivary mucocele: clinical presentation, treatment and outcome in 23 cases

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Introduction
Feline salivary mucocele is rare and information in veterinary literature is scant. The aim of this retrospective observational study was to describe the clinical presentation, treatment, and outcome in cats with sialocele.

Materials and methods
Clinical records from 7 referral hospitals were retrospectively searched to identify cats with salivary mucocele between 2007 and 2020.

Results
Twenty-three cats were identified. The median age was 7 years (range, 1-15). Domestic shorthair (17) and domestic long hair (6) were the represented breeds. The most common clinical signs were ptyalism, dysphagia and anorexia. Localization of the sialocele was cervical (12), sublingual (9), parotid (3), pharyngeal (1) and zygomatic (1). The affected salivary glands were mandibular-sublingual (19), parotid (3) and zygomatic (1).
The aetiology of the sialocele was traumatic or neoplastic in 3 cats respectively, whilst was unknown in 17 cats.
Sialoadenectomy was performed in 16 cats: the mandibular-sublingual salivary gland-duct complex was removed in 12 cats, whilst the parotid and zygomatic gland was removed in 3 and 1 cat respectively. Post-operative seroma was the only complication and was observed in one cat.
Other treatments included: ranula marsupialization (3), needle drainage (2) or single stab incision (2).
The median follow up time was 485 days (range, 28-1080). No relapse was reported.

Conclusions
Feline salivary mucocele is rare and can be managed succesfully conservatively or surgically with appropriate case selection. Cats undergoing sialoadenectomy for sialocele have a good prognosis with low morbidity and low risk of recurrence.

Owner assisted recovery after surgical treatment of canine brachycephalic obstructive airway syndrome (BOAS)

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Introduction
This study aims to report outcomes and short-term complications after surgical treatment of BOAS in dogs recovered from anaesthesia with the owner´s assistance (OAR: recuperation from anaesthesia in a calm, noise-free ward accompanied by the owners until discharge) and with dogs that had standard anaesthesia recovery and hospitalization (SR).

Materials and methods
Medical records of dogs that underwent BOAS surgery over two consecutive years with SR or OAR were reviewed. Signalment, clinical signs, diagnostic findings, treatment, perioperative complications and hospitalization time were reviewed.

Results
21 and 42 animals were incuded in the SR group and OAR, respectively. 18/21 SR dogs were discharged 24 hours after surgery. Three dogs required sedation and oxygen supplementation during hospitalization. Three animals presented major complications requiring temporary tracheostomy tube placement. Two of these were discharged after 3 and 6 days of hospitalization and the other one suffered severe respiratory arrest and was euthanized.
42/42 OAR dogs were discharged within 4 hours after extubation. 1/42 developed palatal haemorrhage during recovery that required surgical intervention. None required sedation whilst hospitalized. At the time of discharge, most of the OAR dogs had already drunk and eaten.

Discussion and conclusion
Recovery from anaesthesia is critical in animals following airway surgery. Excitement promotes airway inflammation, increased respiratory effort and myocardial work, compromising respiration and increasing complications. The results from this study suggest that calm and stress-free recovery assisted by the owner is possible and safe. It may be useful to reduce morbidity and hospitalization duration following BOAS surgery.

Submucosal resection via a transanal approach for treatment of rectal tumors - a multicentric study

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Introduction
Several surgical techniques are described to treat canine rectal masses. Recent recommendations suggest that submucosal resection via a transanal approach should be reserved for benign masses, with limited published data on submucosal resection for malignant masses. The aim of this study was to evaluate complications and long-term outcome after submucosal resection of benign and malignant epithelial rectal masses.

Materials and methods
The database of 7 referral hospitals were reviewed for dogs that underwent submucosal resection between 2006 and 2019. For survival analysis dog tumors were categorized as benign, carcinoma in situ (Cis) and carcinoma. The Kaplan–Meier method and Cox proportional hazards analysis were used to determine the association of a range of variables with recurrence and survival time.

Results
Ninety-three dogs were enrolled (49 benign, 23 Cis, 21 carcinomas). Twenty-seven developed complications (transient in all but 1 dog with persistent dyschezia). Recurrence was identified in 20/93, with 12/20 recurrent masses undergoing repeat submucosal resection. Median survival was not reached in any group. Carcinomas had a significantly shorter survival than benign tumors (P= .001), but not Cis. The 1-,2-, 5-year survival rates for carcinomas were 95%, 89% and 73% respectively. Developing a complication (P = .032) or incomplete margins (P = .023) were associated with an increased risk of recurrence; developing a recurrence was associated with an increased risk of death (P = .046).

Conclusions
Submucosal resection of both benign and malignant rectal masses is associated with a low complication rate and prolonged survival.

Clinical waste audit in a specialist small animal veterinary operating room: what is the environmental impact?

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Introduction
A prospective study audited operating room clinical waste (CW) in the QMHA.

Materials and Methods
CW weight was recorded (n=82; categorised as soft tissue, orthopaedics, ophthalmology, neurology). Detailed categorisation of CW was performed (n=21) ; material composition and plastic waste percentage recorded. Estimated carbon emissions (CO_2e) generated by CW incineration (presented as mean +/- SD) was analysed by service, patient weight and American Society of Anaesthesiologists (ASA) score.

Results
Soft tissue (n=37) and orthopaedics (n=43) produced higher CW (2.81 kg +/-1.54 and 3.00 kg +/-1.27, respectively) than ophthalmology (n=11) (1.85 kg +/-1.07; $p<0.0001$). ASA score ($r=0.394$; $p<0.002$) and patient weight ($r=0.290$; $p<0.0001$) were correlated to overall CW weight. Estimated average carbon emissions generated per CW bag was 2.90 kg CO_2e in ophthalmology; 3.60 kg CO_2e in neurology; 4.40 kg CO_2e in soft tissue; and 4.73 kg CO_2e in orthopaedics.
On detailed analysis (n=21), true CW was the top waste category (36.6%-47%) followed by gowns (14.8%-25.1%) and drapes (9.5%-20%). On average 52.8% (39.5-63.1%) of waste was plastic. Instrument tray wrap was produced more by orthopaedics ($p<0.05$; 0.23 kg; IQR=0.13 kg).

Discussion/Conclusions
Operating rooms have a significant environmental impact. Clinical waste audit improves waste segregation, increases recycling and reduces the environmental impact and costs of waste incineration. Rational use of reusable surgical textiles could be considered to reduce environmental impact, where appropriate. Sterilisation tins can avoid use of instrument tray wrap, with the greatest impact in orthopaedics. Rigorous consideration of environmental sustainability is necessary for future operational resilience and social responsibility.

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Use of Radiofrequency Volumetric Tissue Reduction for the Treatment of Nasal Turbinate Hypertrophy in Brachycephalic Dogs.

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Introduction
In brachycephalic dogs nasal turbinate hypertrophy results in obliteration of nasal airways leading to dyspnoea and loss of turbinate function. Radiofrequency volumetric tissue reduction (RFVTR) is a turbinate-preserving procedure that increases nasal airway.

Materials and Methods
Dyspnoeic, brachycephalic dogs with hypertrophic turbinates were treated with RFVTR as part of a multi-level upper airway surgery approach. The nasal airway (NA) was measured, and the amount of mucosal contact planes (MCP) were evaluated based on computed tomography (CT) and rhinoscopy prior to and 6 months after RFVTR. The follow-up examination was completed by questionnaires and scored semi-quantitatively.

Results
A total of 140 patients met inclusion criteria with a follow-up period of 30 months. In addition 33 patients could be analysed with a CT and rhinoscopy follow-up. NA increased significantly after six months (p= <0.005). MCP were significantly reduced after six months (p=<0.000). Exercise intolerance and ability to cool down, improved significantly in all dogs (p=<0.000). RFVTR-associated complications were mild and consisted of intermittent serous nasal discharge in all dogs during the first week postoperatively and signs of mild nasal congestion 3-8 weeks after RFVTR in 24.3% of the patients (34/140).

Discussion/Conclusions
Following laser assisted partial turbinectomy (LATE) regrowth and recurrence of clinical signs appears as early as 6 months post operatively, whereas RFVTR shows significant improvement over a long-term period and appears to be a viable turbinate-preserving treatment for intranasal obstruction in brachycephalic dogs.

Comparing near infrared fluorescent image guided sentinel lymph node dissection to unguided locoregional lymph node resections for the treatment of dogs with mast cell tumors: a retrospective study

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Introduction
Near infrared fluorescent (NIRF) imaging has been described for intraoperative sentinel lymph node (SLN) mapping in human cancer and in healthy dogs. In dogs with cancer, the value of NIRF-SLN imaging has not been compared to locoregional lymphadenectomy alone. The aim of this study was to retrospectively compare the lymph node resection (LNR) results in dogs with mast cell tumors (MCT) undergoing intraoperative NIRF image guided SLN resection (NIRF-R) to unguided locoregional lymphadenectomy (CON-R).

Materials and Methods
Medical records between 2012 and 2020 were reviewed for dogs that presented for surgical resection of MCTs with concurrent LNR. Patients were grouped based on resection technique. Thirty-five patients (69 planned LNR) were in the NIRF-R group, and 43 patients (64 planned LNR) were in the CON-R group.

Results
The number and location of resected nodes, presence of metastases, and incidence of perioperative complications were recorded. LNR were significantly ($p=0.043$) more often successful (node identified in pathology) in NIRF-R resections with 59/69 (86%) nodes, compared to 46/64 (72%) nodes in the CON-R group. The metastatic rate in NIRF-R lymph nodes was (49%, 29/59 nodes) compared to CON-R (35%, 16/46 nodes, $p=0.057$). With respect to patients affected, NIRF-R identified metastatic disease significantly ($p=0.013$) more frequently (22/30; 73% of patients affected) compared to CON-R (14/33; 42% of patients affected). No complications were reported related to NIRF imaging.

Discussion/Conclusions
Based on our results, we recommend combined locoregional and NIRF guided lymphadenectomy in dogs affected by MCTs.

Sensitivity and specificity of different blood tests to assess absence of portosystemic shunting in dogs surgically treated for an extrahepatic portosystemic shunt

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Introduction
Medical imaging is required to assess shunt closure after surgical attenuation of extrahepatic portosystemic shunts (EHPSS). Several blood tests have been evaluated in their potential to assess shunt closure. The aim of this study was to determine sensitivity and specificity of blood tests to evaluate absence of portosystemic shunting after gradual attenuation of EHPSS in dogs.

Materials and methods
Twenty dogs with EHPSS were prospectively enrolled. Fasting ammonia (FA), preprandial, postprandial and paired serum bile acid (SBA) and serum hyaluronic acid (SHA) concentrations and the lidocaine/monoethylglycylxylidide (MEGX) test were assessed at diagnosis, one, three and six months postoperatively. Three months postoperatively a transsplenic portal scintigraphy was performed to assess shunt closure.

Results
When performing a single blood test, FA had the highest specificity (100%) combined with a good sensitivity (81.5%). Both SHA and MEGX 15 minutes after lidocaine injection had the highest sensitivity (96.9% and 96.2%, respectively) and at the same time a good specificity (81.8% and 82.8%, respectively). By combining the lidocaine/MEGX test with either FA, postprandial SBA or SHA, 100% sensitivity was obtained to assess shunt closure.

Discussion/Conclusions
Both SHA and the lidocaine/MEGX test are promising tests to evaluate absence of postoperative portosystemic shunting in dogs. By combining two tests 100% sensitivity can be reached, so persistent shunting can be ruled out without the need for medical imaging. If blood tests suggest persistent portosystemic shunting, additional imaging is always advised to differentiate multiple acquired portosystemic shunts from persistent shunting through the original EHPSS.

Should clean but close margins be considered as tumor free in dogs with cutaneous soft-tissue sarcomas?

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Introduction
Adjuvant treatments are recommended in dogs with incompletely excised cutaneous STS (cSTS) to reduce the risk of local recurrence (LR), although guidelines are lacking on how to manage clean but close margins (CbCm). This retrospective study investigates the impact of CbCm on LR of STS.

Methods
We included 92 dogs with STS at first presentation, treated with curative-intent surgery with or without adjuvant chemotherapy. Tissue samples were routinely trimmed and analyzed. Cumulative incidence of LR was estimated for each category of margins (tumor-free, infiltrated, CbCm) and for two dichotomic classifications that included CbCm in the tumor-free and infiltrated category, respectively. The prognostic impact of the two classifications on LR was then adjusted for histotype and grade. Significance level was set at 5%.

Results
Incidence of LR was statistically different among the three margins categories (p=0.016), occurring in 42% dogs with infiltrated margins, 23% with CbCm and in 7% with tumor-free margins. When dichotomic classifications were applied, there was a significant difference both when grouping CbCm with infiltrated margins (p=0.01; HR=5.05) and with tumor-free margins (p=0.008; HR=3.13). The latter classification was independently prognostic in multivariate analysis, while histotype and grade lost their significance. Conversely, when considering CmCm as infiltrated, only grade remained prognostic.

Discussion
Although STS excised with infiltrated margins had the greater risk of LR, the rate of LR with CbCm did not overlap with the low recurrence rate reported for tumor-free margins. Based on our results, the category CbCm should be considered prognostically apart at the moment.

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A retrospective review of dogs and cats undergoing total lung lobectomy using circumferential ligatures

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Introduction
In a previous study pre-tied ligating loops (PLL) reliably withstood supraphysiological airway pressures following total lung lobectomy in a healthy canine cadaveric model. The objective of this study was to retrospectively assess outcomes and complications in dogs and cats with clinical disease undergoing total lung lobectomy using a circumferential suture.

Materials and Methods
A retrospective international multi-centre clinical study including dogs and cats undergoing total lung lobectomy with either commercially available PLL or a hand-tied circumferential ligature (HCL). Intra-operative, short term and long-term complications were assessed.

Results
Sixty-two lung lobectomies were performed in 52 animals (PLL n=28, HCL n=24). Eleven cats (mean bodyweight 4.55kg, range 3 to 8.1kg) and 41 dogs (mean bodyweight 17.7kg, range 3.4 to 45.1kg) were included. HCL included sliding (n=7), Miller's (n=15) and Roeder's knot (n=2). Intraoperative haemorrhage occurred with PLL (n=1 dog, weight 45.1kg) and HCL (n=1 dog, weight 11.5kg, n=1 cat, weight 3.5kg). This was controlled using an additional PLL in the former case and vascular clips in the latter. No air leakage was observed in either group. No short-term or long-term postoperative complications were reported.

Discussion/Conclusions
Lung lobectomy using circumferential sutures is reported in 52 animals with no postoperative complications. Intraoperative haemorrhage (n=3/62, 4.8%) was readily managed. Intraoperative air leak or postoperative pneumothorax were not reported as a complication. Complete hilar lobectomy using circumferential suture was safe and cost-effective in this group of dogs and cats. The use of circumferential suture hilar lung lobectomy should continue to be evaluated.

Acute Traumatic Wound Management - is this evidence based medicine?

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Evidence Based Medicine
Evidence Based Medicine (EBM) is the gold standard for practical application of clinical knowledge in the treatment of surgical patients and this has been defined as “the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients” (Sackett et al 1996). However, this relies on the accurate interpretation of published studies which make conclusions based on a population of patients which may or may not, be representative of the patient you are looking at today. In veterinary medicine sometimes the standard of the evidence is flawed – often due to large variability in the study populations, measurement of objective or subjective outcomes, or in biased conclusions from the evidence. In many circumstances in veterinary surgery, we find ourselves increasingly relying on the subjective evidence of personal experience, which we try to blend with the available data – which leads to affirmation bias (Brown 2012). Personal experience is inherently biased – you may only remember the successful cases, distort your perception of timeframes to recovery, or only remember the cases that returned for further treatment on multiple occasions and you may remember publications that affirm your own experience more than those that do not. Sometimes data is not available at all, and anecdotal evidence is all you have to go on. This does not mean that you should not continue to actively seek evidence based medicine!

In the terms of assessing our treatment of acute traumatic wounds, the most significant problem is determining what is a “consistent, valid, reliable and clinically relevant outcome assessment” (Brown 2012). Wounds and the patients they arrive on, are endlessly variable, patient breed, signalment, comorbidities and location of the wound will all affect outcomes and responses to treatment, and that is not including the incredibly varied origin and age of the wound at the time of presentation (burns, penetrating injuries, ballistic, chronic, infected, contaminated, abrasive, avulsive, bite wounds, vasculitis, pressure etc). These factors will all be variables, which means that for meaningful assessments and grouping of wounds and management, many thousands of patients would have to be enrolled in any study.

The other confounding factor is that if a few case reports, or short series of cases are published, there is immediately an impact on clinical judgement, so there is evolution of wound management without any clear stepwise change thus any retrospective studies are further flawed (Brown 2012). Clinical management is often modified due of positive reporting of case studies where there is incomplete data to indicate that patients benefit specifically from the new technique. Negative pressure wound therapy is an excellent example of this where small veterinary studies and personal experience seem to be very positive, but a Cochrane review (albeit looking at human studies, including from 40 to 586 participants) found no clear evidence of benefit the conclusion being “It is uncertain whether there is a difference in risk of wound infection, adverse events, time to closure or coverage surgery, pain or health-related qualify of life between NPWT and standard care for any type of open traumatic wound” (Pitt 2018, Stanley 2011, Nolff 2015 and Nolff 2018 Iheozor-Ejiofor 2018).

Acute trauma wound management
The primary goal of wound management is to facilitate an environment in which normal wound healing can proceed unimpeded without the development of wound infection. Immediate wound management is aimed at reducing the microbial burden, preventing further contamination and preventing perpetuation of inflammation. (Hosgood 2018)

Stages of acute wound management include:

- Inspection of the wound
- Irrigation and lavage
- Antimicrobial treatment
- Wound dressing
- Debridement

Inspection of the wound
The wound is cleaned of dirt or other foreign material, the fur is clipped to allow inspection of the wound and the surrounding skin and blood or debris is cleaned off the skin. This allows the surgeon to establish the nature of the wound, propose an aetiology for the wound and this will determine the likely characteristics of the wound and how they might affect the development of a normal healing process – or the likely risk of infection. This is part of a full clinical examination and surely requires no EBVM to back up this process.

Irrigation and lavage – solutions and pressures
Historically, we have always recommended lavage with isotonic solutions such as 0.9% saline or Hartmanns solution. However systematic reviews of management of open wounds in humans has shown no difference in the development of wound infection or wound healing in wounds treated with potable tap water or sterile saline (Fernandez 2012, Moscati 2006, Whaley 2004). Studies in the 1990s showed that use of antiseptics in lavage solutions are more likely to harm healthy cells and are no longer recommended.

Pressure of irrigation of open wounds is another controversy – fuelled by the promotion of devices that pulse and irrigate open wounds at specific pressures. Traditionally we have recommended low pressure high volume lavage (<5psi), but many of the commercially available devices create pressures of 6-8psi and jet pressure devices create 70psi. The use of an 18g needle and a 35ml syringe produces surprisingly high pressure 17psi – interestingly, needle size made little difference (Gall and Monnet 2010). There is however, no data indicating whether one pressure is better than another (Chatterjee 2005) – intuitively it would seem higher pressures might drive fluid and debris into the wound tissues and create more harm. However one old study with experimental data showed that bacteria were filtered out by surface tissues and despite oedema around the wound, there was no increased incidence of infection – but these were not naturally occurring wounds (Wheeler 1976).

Antimicrobials and wound infection
At the time of the initial presentation, acute wounds are most likely to be contaminated by a broad range of commensal organisms. A gram stain might be useful to determine the likely spectrum required, but for emergency use, if systemic infection is suspected then a narrow spectrum agent would be appropriate as indicated by a deep tissue culture (Hosgood 2018). Other options are topical antiseptic agents that are not harmful to healthy cells (specifically white cells and fibroblasts) such as silver, honey or hyperosmotic agents (20% saline, honey or sugar solutions). Evidence for the use of honey or silver for management of wound infection is not established. However, the definition of infection (which would be an indication for antimicrobials) in an open traumatic wound is also not clear – the data describing the definition of wound infection as being $>10^5$/g tissue dates from 1970 (Robson 1970). The ‘golden period’ when it is assumed that a wound is more likely to become infected if it is >6 hours old is no longer supported (Zehtabchi 2012). A review of the 10^5/g and >6 hours rule of infection has led us to think of wound infections as a balance of the host-bacteria bioburden. Successful wound healing occurs in the face of a *manageable* bacterial burden and differentiating between heavily colonised versus infected wounds is important in understanding the requirements for bacterial elimination. There are broader issues regarding the local conditions, the wound environment, and host resistance that all collectively influence the impact of a specified number of colonising organisms and there is no evidence that 10^5/g tissue is a key determinant in outcome (Bowler 2003)

Debridement
Surprisingly there is little robust evidence for debridement. One study in 1999 tried to review the data available to support debridement of chronic wounds and concluded that there was no evidence to support debridement of chronic wounds (Bradley 1999). There is data to suggest that debridement using gauze dressings is associated with longer healing times than topical hydrogels (Smith 2013). However experimental data, surgical texts and clinical experience all support the logical conclusion that debridement of necrotic, contaminated or non viable tissue should improve the progression of healing

and reduce the risk of infection. Options include using wound contact layers with debriding properties, surgical layered debridement, hydrosurgery, enzymatic, myiasis or osmotic debridement.

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A review of strategies and innovations to improve skin flap survival

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Skin flaps are used to reconstruct large skin deficits where healing by second intention might be too prolonged or disadvantageous to the patient. The skin is elevated from a donor site and repositioned over the recipient wound bed and the donor site is usually closed primarily during the same surgical event.

There are three types of skin flaps described:

1. Subdermal plexus flaps. Simple flaps generated from adjacent skin that are elevated and moved into position, with a wide base allowing the blood supply to nourish the skin flap via the subdermal plexus of arteries. Basic anatomic knowledge is required and the flaps are limited by the extent to which the blood flow can travel to the distal end of the flap via the anastomoses in the plexus. These flaps are described as local or direct and indirect distant flaps.

2. Axial pattern flaps. These are flaps of skin that can be much larger than the subdermal plexus flaps as they are defined by a single artery and vein that provide the subdermal plexus of that area of skin. Detailed knowledge of the relevant anatomy is important.

3. Microvascular skin flaps.

Axial pattern and sub dermal plexus flaps are the techniques most commonly used in small animal surgery. The survival of the skin flap in the new location relies on the maintenance of adequate blood supply to all parts of the skin flap while it heals in the new location. Axial pattern flaps can be longer and should be more reliable than sub dermal plexus flaps.

Skin flaps are carefully planned in advance of surgery with regard to knowledge of the dermal vascular plexus, local anatomy, local injuries/wounds, planned surgical excision of tissues and other comorbidities.

Veterinary data is limited, but most publications suggest a fairly high complication rate of 15 – 90% following the use of skin flaps to reconstruct elective or traumatic wounds. Complications include partial or total dehiscence, flap necrosis (from 10-100%), seroma/haematoma formation, oedema, wound drainage and infection. The most common reported complications are swelling of the flap, incisional dehiscence and post operative wound drainage. Publications are difficult to compare as some do not report minor complications or only measure outcome by the final healing of the flap (79-100% flap healing) and in any case all are retrospective studies including relatively small numbers of cases (10-92) with a high range of variables. (Aper 2003 & 2005, Emmerson 2019, Field, 2015 Jones 2019, Montinaro 2015, Proot 2019, Trevor 1992). The commonest skin flap used in human surgery is used for breast reconstruction and this has a reported incidence of wound breakdown and tissue necrosis of 3-33%, with partial thickness necrosis reported in up to 40% of cases, so there is considerable interest in ways to reduce this complication (Khavanin 2018).

There are two groups of causes of failure.

1. Inexperience of the use of skin flaps can result in the following extrinsic causes:

Technical errors.

- poor understanding of the anatomy and patient positioning during planning
- poor flap handling/ haemostasis/tissue damage/surgical technique
- poor sterile technique leading to infection

Poor flap design and planning.

- poor recipient site preparation (prolonged surgery, dried out tissue, residual infection)
- poor flap design and elevation
- flap under tension due to poor planning
- flap twisted during repositioning

Other factors

- breed variations
- individual anatomic variations
- post-operative management (drains, analgesia, compressive bandages, patient interference, patient recumbency)
- poor post-operative management of patient comorbidities or other factors leading to infection

However, clinics that are regularly managing patients with skin flaps are unlikely to be caught out by these issues. An experienced surgeon should be able to plan a flap that will work and understand how to manage the patient in the post-operative period. On this basis, it seems surprising that flap complications and failure remain relatively common even in experienced hands.

2. More complex causes of skin flap failure include intrinsic causes:

Failure of blood flow to the flap

- reduced perfusion of the vascular plexus
- increased vascular resistance

Vasoactive cytokines

- hypercoagulability
- infection, inflammation causing vasospasm and poor healing
- seroma/haematoma formation causing pressure points or an inflammatory environment
- interstitial oedema secondary to cytokine release causing tissue hypoxia

Infection

- primary infection related to wound factors
- secondary infection due to patient factors

In experienced hands, reduced intrinsic perfusion of the skin flap or reperfusion injury may be key causes of flap failure, and this could be caused by any vaso-endocrine response that will affect cutaneous blood flow. Potential causes of cutaneous vasoconstriction in a peri-operative patient would include: hypotension (and the use of peripheral vasoconstrictors such as ephedrine; noradrenalin and dobutamine that may be used perioperatively to treat this); hypovolaemia (reflex peripheral vasoconstriction compensates blood pressure and hypovolaemia causing poor peripheral perfusion may go undetected); hypothermia; stress and anxiety in recovery; pain; direct pressure on the skin (eg the use of post operative bandages); drug induced vasoconstriction (such as alpha-2 agonists used for sedation or analgesia). Veterinary studies do not report monitoring of vascular perfusion of skin or other factors that might affect perfusion (such as temperament, pain scores, perceived stress of hospitalisation, inflammatory conditions or peri operative events such as hypotension, hypovolaemia or hypothermia), so it is impossible to know how these factors affect flap outcome in our patients.

Vascular perfusion of the flap may be affected by additional issues that are not just related to vasoconstriction, such as damage to tissues (from trauma or surgery), tension on the flap (seroma, haematoma, surgical design), inflammation and infection may cause the formation of micro thrombi, self trauma or epidermal reaction to skin preparation (eg clipper rash) may cause oedema of the skin and release of inflammatory cytokines that causes microthrombi, and finally direct thromboembolic disease

due to other co morbidities (eg hyperadrenocorticism, protein losing nephropathy or enteropathy). There is limited evidence to suggest that it may be possible to improve flap perfusion in the post operative period with warm packing to cause vasodilation, however it is not known or reported whether this would overcome centrally imposed vasoconstrictive effects secondary to stress, pain, hypothermia, hypotension etc. (Awwad 1983). Heparin has been shown to improve flap survival in an experimental study, but the dose caused a 4.5x increase in APTT and while peri operative thrombosis is a significant risk in human patients, it is less likely to be an issue in companion animals and thus may not justify the risk of the coagulopathy (Torkvist 2004)

Detection of reduced perfusion and confirmation of adequate blood supply at the time of flap elevation is important. Creation and elevation of a flap results in a 10-40% immediate decrease in perfusion (Hunt 2018). When decisions on flap viability are based on clinical assessment alone, necrosis rates can be as high as 30% and early excision of devitalised skin is important to improve survival. In human mastectomy reconstruction, perfusion of skin flaps is variable due to the anatomic considerations of the mastectomy (and in part due to the different blood supply to human skin). Intraoperative techniques have been developed over and above the surgeon's clinical experience and objective means of assessment of flap blood supply include doppler ultrasound, CT angiography, ICG near-red fluorescence and thermography (DIRT) (Khavanin 2019, Unverdi 2020).

Fluorescein and indocyanine green (ICG)
Fluorescein assessment of perfusion of skin flaps has largely been superceded by other techniques as it has a high false negative rate, (resulting in unnecessary debridement) and the fact that the concurrent use of vasoconstrictors such as epinephrine (which may often be used in small animal surgery to maintain blood pressure), limits dye uptake. ICG is used together with a near-infrared fluorescence imaging (NIRF) camera to detect cutaneous blood flow and arterial anatomy. There is a 95% correlation between intraoperative imaging and complications, with 100% sensitivity and 95% specificity (Khavanin 2018). In one veterinary publication, this technique was used successfully in two cats to identify the axial artery and define flap margins as well as confirm perfusion intraoperatively (Quinlan 2021)

Thermography
Dynamic infra red thermography (DIRT) is a non invasive thermal imaging technique that has been shown to be specific even in the presence of inflamed skin and can be used to detect changes in blood flow both post op and peri operatively, allowing early detection of flap failure in the clinical setting. Thermographic skin measurements decrease in response to stress or pain confirming the concern that these issues might have on flap survival during hospitalisation. It is also able to detect congestion secondary to venous occlusion faster than clinical observation. In a prospective study in human thoracodorsal flaps, thermography was successfully used to not only detect the appropriate perforator arteries for the flap but also to document flap perfusion in the post operative period. DIRT was compared to handheld unidirectional Doppler ultrasound and CT angiography and was found to be more sensitive in the post operative period to detect changes (de Weerd 2006, Tenorio 2009, de Sjoberg 2020)

Drug induced vasoconstriction in skin may be important. Alpha-2-adrenergic agonists (eg medetomidine), are popular in veterinary anaesthesia for peri operative analgesia and premedication to reduce the requirements for anaesthetic agents during surgery. However, these drugs cause vasoconstriction mediated via post-synaptic alpha-2-adrenoceptors located in vascular smooth muscle, resulting in increased systemic vascular resistance. Thermography has been used to measure the effect on skin following dexmedetomidine administration. The study demonstrated that cutaneous vasoconstriction occurred following use of the alpha-2-adrenergic agonist and the effect was blocked when the dexmedetomidine was given with a selective peripheral alpha-2-adrenoceptor blocker. This suggests that alpha-2-adrenergic agonists do have an adverse effect on perfusion of skin and that might have an impact both during surgery as well as post operatively if it is part of a post op analgesic plan or for sedation during hospitalisation. (Vainionpaa 2013)

Tissue oximetry
An experimental and clinical report found that transcutaneous pulse oximetry measurements was able to predict skin flap viability and flap survival. Non surgical sites were used for control measurements. (Serafin 1981)

Colour flow Doppler ultrasound
Colour flow doppler has been used successfully to identify suitable perforator arteries for flap elevation

(Gunarrsson 2016) and has been reported in the veterinary literature, but to date, there are no studies demonstrating its use in veterinary surgery to detect or prevent flap complications (Hunt 2018)

Strategies to improve skin flap survival in spite of all the extrinsic and intrinsic influences, have been the subject of many experimental and clinical studies and well established data indicate the most effective technique to improve flap survival is to use the delay phenomenon. However, there are few studies specifically relating to the field of companion animals.

The delay phenomenon
The delay phenomenon, describes the observation that a tissue rendered partially ischemic will undergo neovascularization and enhance its vascularity. This phenomenon was reported in the 1960s when it was shown that raising a flap surgically, then suturing it back down on its bed for 7-14 days before elevating it and moving it to the desired location was associated with a 100% improvement on flap survival (Myers and Cherry 1969, Hamilton 2014). Surgical delay techniques remain the most popular and most reliable method to improve flap survival, but this involves an extra surgical procedure and other studies have sought to find a better way to precondition skin flaps. (Khavanin 2019)

Ischemic preconditioning
Based on the data from cardiovascular surgery that pre conditioning myocardium to ischemia improved survival, a study was carried out to see if this also worked on skin flaps (Zahir 1998). Experimental data showed that myocutaneous and skin flap necrosis was decreased when they were preconditioned by ischemic challenges and the authors propose this as an alternative to the surgical delay technique. The technique, however, is counter intuitive. The flap is raised and the artery/vein are clamped for 10 minutes following by 10 minutes of reperfusion repeated three times over one hour. It would be difficult to do this in a clinical setting, both due to the time involved and the other potential consequences of the longer anaesthetic, reperfusion injury or damage to the artery and vein at the base of the flap.

Microneedling
VEGF is released from endothelial cells , smooth muscle cells and fibroblasts, in ischemic tissues to increase angiogenesis and vasodilation and this is thought to be in part how the delay phenomenon works. Microneedling by roller creates hundreds of tiny wounds into the dermis and kicks off the normal process of wound healing and cytokine release including VEGF. (250 holes/cm^2). An experimental study looked at pre treating skin with microneedling prior to flap elevation. The study showed that 14 days microneedling had the same effect as a surgical flap delay – in veterinary surgery we would have to think about the thickness of the skin (length of the needles) and also how we would apply the microneedling to the dog – would it be practical to do this daily for 7-14 days with sedation? Another study showed improvement of flap survival following a protocol of daily microneedling for 3 days pre op immediately pre surgery and at days 3 and 6 post op. (Unverdi 2020, Baris 2013)

Gamma low dose irradiation
In an experimental study, a low dose of gamma irradiation was used to try and stimulate VEGF release in skin flaps and trigger increased vascularity of skin flaps. While there was evidence of improved flap vascularity, increased numbers of blood vessels and higher VEGF in irradiation skin flaps, this seems like a dangerous technique to use – unless there is a clear indication for irradiation (Karimpour 2017)

Topical lidocaine/prilocaine (EMLA cream) or lidocaine
Local anaesthetic causes relaxation of vascular smooth muscle and produces local vasodilation, improving blood flow in skin. Topical EMLA causes a biphasic vascular response with initial vasoconstriction up to 1.5 hours after application followed by late erythema and vasodilation for >3 hours. EMLA was applied to flaps and covered with opsite for 7 days and the EMLA treated flaps had a significant improvement in survival. There are practical difficulties with applying this to large areas, but small fragile flaps might benefit? Injection of lidocaine has also been shown to reduce the inflammatory response and survival of skin flaps in rats – could wound catheters or lidocaine CRI for analgesia in the post operative period improve flap outcomes? (Karacal 2005, Cao 2015)

Negative pressure wound therapy
A single veterinary case report of the use of a VAC for a skin flap that showed signs of wound dehiscence, fluid accumulation under the flap and poor perfusion (cold, hard and discoloured). The application of a VAC was successful in restoring perfusion and preventing ongoing wound dehiscence and loss of flap coverage was minimal. The likely physiology behind this success is reduction of oedema and interstitial fluid production, improved sterile wound conditions, increasing skin perfusion and improving adherence of the flap to the underlying tissue. However, there is also data suggesting that

this technique should not be used in the presence of infection and we do not know how well this would work for other causes of flap failure. Decompression of small blood vessels underneath a VAC may be important to maintain perfusion but where the negative pressure is too high, perfusion may be reduced (-100mmHg seems to improve perfusion, but above that, perfusion may decrease). It is uncertain whether this could be a useful tool for less reliable skin flaps to improve outcomes and protect them in the early stages of healing. (Bristow 2013)

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Tissue expansion in reconstructive surgery – why, how, and when?

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The learning objectives of this session are:

- To understand the physiology of tissue expansion (with emphasis to skin expansion)
- To appreciate where tissue expansion can help
- To discuss the techniques and devices available and how to use them
- To identify how the process of using tissue expansion works in practice

Tissue expansion is a process that results in the formation of *de novo* tissue similar to the original expanded tissue. This process is different from tissue stretching, in which new tissue is not formed but existing tissue is elongated. The latter relies on elastic properties of the tissue. Tissue expansion is routinely used in veterinary surgery when for e.g., distraction osteogenesis is performed to correct angular limb deformities and/ or limb shortening. The very important common feature recognised in any tissue expansion is the ability for the tissue under expansion to grow (biological creep) as opposed to simply stretch (mechanical creep) (Wilhemi, 1998). This can be also used at the level of the soft tissues like muscles but also skin. Tissue expansion was first described for soft tissues in the 1950s (Neuman, 1957) and is a well utilised tool in the field of human reconstructive surgery. The same idea can be harnessed in veterinary reconstructive surgery for areas that naturally lack skin such as the distal limb, tail, head and nose or if a large skin defect is present. Expanders are used to pre-stretch and develop new skin adjacent to defect or potential defect and the excess skin created is used in reconstruction to achieve primary closure.

The molecular mechanisms which underpin tissue expansion include mechanical strain-induced increase in DNA synthesis (increased local mitotic index) at the level of the initially stretched skin. This is due to local release of several growth factors (including Epidermal Growth Factor, Transforming Growth Factor ,…) responsible for signal transduction from the cytosol to the nucleus (Takei, 1998). The effect of the expander differs between the different layers it interacts with. There is an increase in epidermal thickness and decrease in dermal thickness during the process of expansion. There is also a high recruitment of neo-vessels (see infra delay phenomenon) in the subcutaneous space and the formation of a fibrous capsule.

Key points on vascularization of expanded tissues

- Expanded tissues are highly vascularized
- Angiogenesis due to ischemia of the expanded tissues.
- VGF expressing cells
- Flaps elevated in expanded tissue have significantly greater survival areas than acutely raised and delayed flaps

Several types of skin expanders are described. The most common and widely available form of skin expander is a silicone bag of various forms (rectangle, square , semi-circular….) attached to or with a multi-punction port embedded in. The bag is slowly and gradually inflated with saline until the total volume has been reached or there is sufficient skin expansion. Self-inflating, anisotropic, hydrogel tissue expanders (SIE) (Swan, 2007), which consist of a hydrogel core coated in medical grade silicone have also been developed in veterinary surgery (*As far the author is aware, these SIEs are no longer available*).

Pre (left) and post (right) expansion self-inflating, anisotropic, hydrogel tissue

Types of skin expanders

- Expanders with distal ports
- Expanders with integrated ports
- Self-inflating expanders

The expanders are implanted subcutaneously under general anaesthetic in healthy skin, outside the margins to be resected, in the area that required extra skin. When implanted on a limb, care is taken to ensure that the proximal blood supply to the skin is maintained in all cases and not disrupted by incisions or previous scarring. Animals should be monitored as outpatients throughout the expansion process and administration of pain relief and antibiosis should be at the surgeon's discretion. The initial tension generated by the expander inflation diminished very rapidly due to the visco-elastic nature of the skin and to the multiplication of cutaneous cells. Once sufficient skin had been created, the expander(s) is (are) removed, again under general anaesthetic. The expanded skin is then used for reconstruction as an aid to primary closure or to help create a local flap.

It is interesting to note that skin/ flap expansion has also been advocated as a method to increase the perfusion and overall robustness of axial (insular and peninsular) pattern flaps (Saxby , 1988). The mechanism involved is this case very similar to the delay phenomenon (DP) or ischemic preconditioning (IP) which occurs when a focal and timely ischemia is induced at the level of an angiosome by either targeting the axial artery (IP) or by severing the choke anastomosis (DP). This induces the reorientation of the choke vessels as well as the development of local neovascularisation.

Complications of tissue expander placement include hematoma or seroma formation, infection, dehiscence of the wound, migration of the tissue expander. Furthermore, it is possible that the silicone bag becomes perforated during the inflation.

Historical veterinary studies / information on skin expanders were sparse and limited to experimental data (Spodnik, 1993 ; Keller, 1994). Dogs had skin expanders fitted in distal extremities and underwent inflation of devices every other day. Inflation was well tolerated and volume up to 100 mLs of saline were injected over 7 days. Rotational, advancement and transposition flaps were raised from expanded tissue and survived with minimal complications.

Clinical implications

- The increased area of skin = normal skin recruited from adjacent areas + new skin generated by increased mitosis
- There is an increase in epidermal thickness and decrease in dermal thickness during the process of expansion
- Within 4–6 weeks, epidermal thickness generally returns to initial levels, but some increase in thickness persists for many months

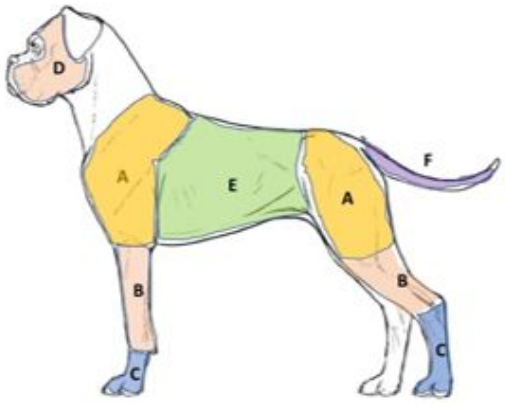
The author's personal main experience includes the management (direct or indirect) of 55 cases treated with SIE , in addition to anecdotical management of more standard expanders.

The analysis of the initial 12 cases of SEI placement (DeLorenzi, 2018) included 3 groups of dogs: Group A (n=4): on, or proximal to the elbow and stifle Group B (n=4): distal to the elbow or stifle and proximal to the carpus or tarsus and Group C (n=4): distal to the carpus or tarsus. Primary closure was achieved in 8/11 cases including all cases from Group A, and 75% and 33% of cases from Group B and C respectively.

It therefore revealed that **defects below the carpus and tarsus were more challenging to treat** with this method.

In addition to these cases, the result of 43 additional dogs were collected (*unpublished data*)– with the addition of cases involving the head, tail and trunk.

These dogs were classified into 6 groups based on anatomical positioning of the expanders. Group A included 11 dogs, group B: 15 dogs, group C: 11 dogs, group D (head) had two dogs and groups E (trunk) and F (tail) had one and three dogs respectively.



Anatomical positioning of the expanders

Complications were classed as minor if they were easily managed and did not affect the reconstructive effort and classed as major if the expanders had to be removed prematurely or if the complications encountered adversely affected the viability of the tissue created.

Three different sizes or expanders were used:

Diameter	Starting height	Expanded height
27mm	9mm	25mm
27mm	5mm	18mm
22mm	4mm	12mm

Different types of pathology were treated:

Mast cell tumour	Soft Tissue sarcoma	Non-neoplastic mass	Non-healing wound	Cyst	Other mass type	Scar Resection	Elbow hygroma	Lick granuloma	Unknown
14	9	1	2	3	1	1	3	3	6

The mean number of expanders used in all of these cases was 4.42 with a median of 4 (range 1-10) and a mean implant duration of 13.35 days (range 3-10 days), the majority having been in situ for 14 days. Primary closure was achieved in 86% of cases with groups A, D and E having 100% primary closure rate (Table 1).

Group	A	B	C	D	E	F
No. of dogs	11	15	11	2	1	3
No. achieving primary closure	11	11	10	2	1	2
% closure	100%	73%	91%	100%	100%	66%

For the 43 dogs there were six dogs that exhibited minor complications and 5 that encountered major complications. There was an overall complication rate of 25% (11/43) for all the groups combined and of

this 14% minor complication rate and 11% major complication rate (Table 2).Table 1- The number of cases in each group achieving primary closure

Group	A	B	C	D	E	F
No. of dogs	11	15	11	2	1	3
Minor Complications	1	3	1	1	0	0
Major Complications	1	1	2	0	0	1

Seventy-nine percent of surgeons reported their procedure outcome as ‘excellent’ (15/43) or ‘good’ (19/43), with an overall surgeon satisfaction of 35/43 (82%).Table 2- Complication rates for the individual groups

Outcome was assessed using 4 measures:

- **Ease of use of the devices** graded as **good** (expanders implanted as planned to include location and number of devices), **fair** (expanders not implanted as planned either location and numbers but leading to satisfactory / complete reconstruction) or **poor** (expanders not implanted as planned leading to partial reconstruction).
- **Procedure outcome** was assessed as **excellent** (no complications during implantation or skin expansion and full reconstruction), **good** (minor complications during implantation or expansion - full or partial reconstruction needing no further surgery post reconstruction), **fair** (major complications during implantation or expansion– full or partial reconstruction – no further surgical intervention required post reconstruction) or **poor** (major complications during implantation or expansion requiring further care under sedation or anaesthesia- partial or no reconstruction)
- **Surgeon’s satisfaction** as assessed by the operating surgeons after full healing and categorized as either ‘**satisfied**’ or ‘**not satisfied’**.

Overall, the satisfaction and positive procedure results have shown an encouraging trend from the first 12 cases reported where comparisons are possible. In groups A and B there has been an increase in the rate of primary closure achieved and, in the procedures, rated as ‘excellent’ or ‘good’. This positive trend is especially evident in group C where it was previously reported and that the expanders may not be suitable for this location. The group previously had a major complication rate of 2/3 and a minor complication rate of 1/3 with a primary closure rate of 66%. In this series the primary closure rate has increased dramatically to 91% with a minor complication rate of less than 10%. It is now clear that this technique is suitable for these distal locations with the correct management and product knowledge. This clearly demonstrates the learning curve associated with novel techniques, which lends itself to the thinking that with continued education and experience this could be a viable technique for other difficult anatomical areas.

Follow-up data collection for neoplastic cases reported here is an ongoing process. The author recognises the importance of understanding the long-term outcome of these cases and the implications this has on the ultimate success of the procedure. The seeding of neoplastic cells and thus the spread of the mass when using skin expansion is of concern. It has, however, been shown experimentally in rats that the insertion of skin expanders under a tumor retarded its growth. The authors speculated that this was due to blood flow redistribution towards the expanded skin away from the tumor bed (Ramasastry, 1991). Long-term clinical follow up on the cases reported here have been positive with three surgeons reporting no recurrence of mast cell tumours at 12 (1) and 24 (2) months and three surgeons reporting no recurrence of soft tissue sarcomas after 12 months. While these cases are not sufficient to conclude ultimate success, it is expected that further follow up will reveal similar results. One of the dogs is known to have had metastatic disease at the time of expansion and chemotherapy was planned as part of his treatment after the removal of the primary mass. This is an example of where tissue expansion can form part of the treatment plan for neoplastic masses and is a useful adjunct to traditional mass removal plans to help get wider margins.

Conclusion

The potential application of tissue expanders for reconstruction is an interesting concept but the true indications are sparse in veterinary patients. The concept of self-inflating expanders seems particularly applicable to veterinary patients but necessitates further refinement. It is undoubtedly true that there is still much to learn about the application of tissue expanders but with increased use and education it could form

an extremely useful tool in tackling difficult reconstruction cases not necessarily limited to skin reconstruction.

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Tracheal Stenting - where are we now ?

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Intervention procedures for canine tracheal collapse (either intra-luminal stent placement or extra-luminal ring prosthesis) remain a salvage procedure. Life-style modification (weight loss, avoidance of environmental stimuli etc) and medical management (combination of oral / inhalational anti-inflammatory medication, cough suppressants and bronchodilators) should be attempted first and in the authors, experience is successful in most cases (disclaimer the author does live in the United Kingdom where the cold weather is useful sometimes!).

When medical management has failed or where an emergency intervention is required placement of an intraluminal stent or extraluminal prosthesis should be considered. Both techniques are not without potential complications and should only be attempted by those appropriately trained in the techniques. The placement technique of intraluminal stents will not be discussed in this lecture and delegates are encouraged to attend a training course before undertaking stent placement.

Extra-luminal Prosthesis
Generally, this is considered a higher risk procedure in terms of peri-operative complications. In one study (White et al1994) a perioperative mortality rate secondary to ischaemic necrosis of 27% was reported. While mortality rates in more recent studies are lower the reported complication rates remain high - Bubak et al (1996) reported the need for a permanent tracheostomy tube in around 20% of cases and Chisnell et al (2015) reported laryngeal paralysis in 17% of cases at some point after ring placement (although only 9% of cases occurred within 48 hours of surgery). Performing a laryngeal tie back at the time of extraluminal ring prosthesis should therefore be considered in some cases. While complications associated with extra-luminal prosthesis can be high the main advantage of this procedure is that a high number of cases (65%) may require no long-term medical management following the surgery (Chisnell et al 2015). It was also previously considered that significant intra-thoracic tracheal collapse was a relative contraindication to extra-luminal ring prosthesis however Becker et al (2012) showed no difference in long term survival between cases with or without concurrent intra-thoracic collapse. In the authors experience extra-luminal ring prosthesis can result in significant improvement in clinical signs even in cases with severe intra-thoracic collapse present.

Tracheal stenting
Placement of an intra-luminal tracheal stent has been shown to be a safe and effective method of relieving clinical signs associated with tracheal collapse. The procedure should only be performed by those properly trained in the technique who have access to the appropriate equipment.

Stent placement is best performed under fluoroscopic guidance although reports of placement under digital radiography have also been published. Determination of stent diameter/length is also mostly performed using fluoroscopy however it has also been reported using CT cross sectional imaging may give a more accurate and repeatable measurement (Williams et al 2016 and Scansen 2014)

The largest case series published on canine tracheal stenting (Weisse et al 2019) reported an overall complication rate of 47% indicating that even with vast experience of the technique the complication rate is high and therefore logically would be expected to be even higher in those with less expertise. The major complications associated with stent placement reported by Weisse et al included granulation tissue formation and stent fracture. Overall, there was a significant improvement in clinical signs including goose honking (89%) and dyspnoea (84%). The overall median survival time reported in this paper was > 1000 days.

Recently a variation of traditional tracheal collapse has been reported (tracheal malformation). This results from a ventro-dorsal fixed obstruction of the trachea rather than simply a dorso-ventral collapse of the tracheal membrane. This variation can be associated with a higher complication rate if not identified and addressed at the time of stent placement (Violette et al 2019).

The most common tracheal stent currently placed is a self-expanding nitinol stent however alternative designs and materials have recently been proposed (Lopez-Minguez et al 2019 and Serrano Cassoran et al 2020).

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Ureteral stenting: still relevant?

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Introduction
The Ureteral stents can serve many functions, including decompression of the renal pelvis to bypass ureteral obstruction, passive ureteral dilation to ease urine flow and stone migration, prevention of postoperative urine leakage and oedema, prevention of postoperative stricture, prevention of ureteral obstruction following shockwave lithotripsy and prevention of migration of nephroliths.

After a first description in women at the end of the 19th century, the ureteral stent was developed and improved to provide drainage of the upper urinary tract when obstruction of the ureter is present or anticipated. The evolution will remain similar in cats and dogs.

The increased diagnosis of obstructive calcium oxalate ureterolithiasis in cats over the last two decades has become a real concern in veterinary medicine and some similarities of this pathology in humans have served as a model to the veterinary world.

Situation in Cats
Thus, some techniques well developed in human medicine, such as percutaneous nephroscopy, open surgery, extracorporeal lithotripsy, or more recently the development of per-endoscopic extraction or lithotripsy with the placement of temporary stents have been considered in cats. Some techniques are applicable while others are not mostly due to the small size of our patients.

The first use of ureteral stent for cat ureterolithiasis was described at the end of the 2000's by Alysson Berent and her team. The technique was made possible with the development of a stent's size more adapted to the cat (3 Fr and then 2.5 Fr), allowing us to foresee a possibility to treat ureterolithiasis effectively and safely in cats.

Between 2008 and 2014, the stenting approach has been favoured by most surgical units, despite some significant technical challenges. The stent placement was reported either by conventional open surgery, fluoroscopy, or a combination of the two. The learning curve can be long, leading to excessive operating and anaesthetic times on animals often in acute renal failure with major electrolyte disorders. Despite this, the initial feedback was satisfactory, and advantageous in comparison to the alternatives available (open surgery, nephroscopy, or extracorporeal lithotripsy). Therefore, this technique remained recommended until 2013-2014.(Adams, 2013; Berent, 2011; Bound et al., 2012; Defarges et al., 2013; Nicoli et al., 2012). By then, there was still no large case series publication reported. Several studies were published in 2014 confirming the technical challenges of stents placement and detailing the long-term complications. (Berent et al., 2014; Kulendra et al., 2014; Manassero et al., 2014)The presence of a stent in the urinary tract induces recurrent urinary tract infections, discomfort, dysuria, and can have encrustation with obstruction. These complications have been widely published in human medicine since the 2000s, bearing in mind that double-J catheters are used temporarily and that these complications occur when the stents are forgotten.

Based on this experience, Alysson Berent and her team devised a new implantable prosthesis with the registration of a patent in 2011: the subcutaneous ureteral bypass (SUB).

After presenting our own results on long-term complications on ureteral stents at a congress in 2014 (Boland L et al., 2014), we compared this case series to a series using SUBs. (Deroy et al., 2017) The result is speechless:

- Median durations of surgery and hospitalization were significantly longer in the stent group versus SUB group;
- Perioperative mortality rate was lower in SUB group;
- Stent placement was associated with a greater risk of lower urinary tract–related signs, such as haematuria, pollakiuria or stranguria;
- The risk of device occlusion was also greater in the stent (26% [7/27]) versus SUB (4% [1/23]) group;
- The percentage of cats requiring additional procedures to treat complications was greater in the stent (44%; complications included uroabdomen, stent occlusion, and refractory cystitis) versus SUB (9%; complications included SUB occlusion and urethral obstruction) group.

This study concluded that although stents are beneficial to treat ureteral obstruction in comparison to traditional techniques, cats managed with SUB devices had a lower risk of complications and a longer survival time than those treated with double-pigtail ureteral stents.

This is due to the combination of the ease of placement, the decreased rates of dysuria and re-obstruction, and the low peri-operative mortality. Within a few months the whole veterinary community had adopted the SUB, which is now the main technique proposed. Today, ureteral stents seem to be little used in favour of SUB in the specific treatment of feline ureterolithiasis.

Situation in Dogs
Although the ureteral intraluminal diameter is poorly documented, it is naturally larger in dogs: 0.4 mm for a cat and 2 to 2.5 mm for a dog of 19 to 30 kg for nonobstructed ureter.

This probably opens up different perspectives in the use of stents in dogs, facilitating a minimally invasive approach by endoscopy and interventional fluoroscopy.

Allysson Berent and her team described the use of stents for the treatment of different canine obstructive lesions of the upper urinary tract (malignant ureteral obstruction, congenital bilateral ureteral stenosis, obstructive pyonephrosis and benign ureteral obstruction) with very satisfactory outcomes compared to more traditional surgical approaches.(Berent et al., 2011; Kuntz et al., 2015; Pavia et al., 2018)

Ureteral Stent: Perspectives and Limits
Despite the benefits of ureteral stents, they may also induce adverse events. Ureteral stents are notoriously fraught with relevant patient discomfort and dysuria. The presence of an indwelling foreign body can also lead to biofilm-formation, which may promote development of UTIs or formation of encrustations. Ideal stent should provide excellent drainage, resist migration, encrustation and infection, provoke no reaction or symptoms in the patient, be inexpensive and be easy to insert and remove. The main approaches for prevention and treatment of stent related complications are stent design and drug therapy.

Developments in improving stent characteristics are necessary to adapt stent composition (biopcompatibility, hardness, stent diameter and drainage capacities, stent length, coating).

Conclusion
The prospects for the use of ureteral stents probably remain good, particularly for dogs of sufficient size or for temporary placements, allowing a mini-invasive approach (i.e. endoscopically or fluoroscopically).

Nevertheless, it is important to consider that the placement of this type of material is associated with certain delayed complications, increasing with the longer duration the material is implanted (infection, encrustation, migration, dysuria, etc).

Specific clinical research in dogs and cats is needed to improve the tolerance of stents in these patients and ensure optimal management of stent-related complications.

In view of the necessary learning curve for these new minimally invasive approaches and the more recent description of complications that may be associated with the prolonged presence of a biomaterial in the ureteral position, our role as clinicians is also to assess the benefit/risk and the relevance of the type of management to be proposed for the patient.

Bibliography on demand

Coiling large abnormal vessels (intrahepatic portosystemic shunting); where are we now?

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The delivery of thrombogenic coils to manage intrahepatic portosystemic shunts has become a popular procedure as it avoids certain hazards of open surgery whilst meeting our profession's commitment to minimising surgical morbidity. The continued development of vascular stents and coils in the human surgical field pave the way for the veterinary profession to further refine our interventions.

After jugular or femoral vein vascular access is secured, fluoroscopic contrast venography is performed to characterise the portosystemic shunt-caudal vena cava junction. This allows assessment of the shape and position of the shunt "mouth", where embolisation coils will be delivered, as well as measurement of the (distended) caval diameter during contrast injection. Accurate measurement of caval diameter is important in selecting the correct size of caval stent which should rest securely in place and fully bridge the portosystemic shunt opening into the vena cava. The purpose of the stent is to prevent thrombogenic coils, delivered into the shunt, from migrating to other vascular regions. Steel has given way to nickel-titanum alloy for the majority of available stents. The range and availability of stent designs continues to improve and the evolution of woven/meshed stents to fixed-length laser cut stents now allow accurate prediction of the caval region a stent will occupy once deployed. Open-cell stent designs have fewer of the internal inflection points fused which allows the stent interstices to nest together or spread apart. This feature offers easier passage of vascular catheters through the stent wall during a coil embolisation procedure, compared to previous closed-cell stent designs. Additional improvements in stent strength, flexibility and visibility facilitate interventional radiology procedures.

Thrombogenic coil development has paralleled that of vascular stents. Modern coils often contain platinum as this enhances fluoroscopic visibility and renders these devices compatible with magnetic resonance imaging; a legacy of their chief historical use in treating brain aneurysms in people. Platinum is not a particularly thrombogenic material but the addition of synthetic fibres to embolisation coils enhances their thrombogenicity, helping to further attenuate shunt flow. Wool fibres were used originally but incited marked inflammatory reactions and so coil fibre composition switched progressively to silk, Ivalon (PVA) and now Dacron (polyethylene terephthalate).

Detachable coils offer the clinician the option, after delivery of a coil into the proposed site, of retrieving said coil if untoward sequelae are noted (namely coil malposition or over-attenuation of flow). If the effect of delivery is satisfactory, such a coil can be detached from the pusher wire. Originally, designs such as the Guglielmi coil, employed electrolytic detachment and modern versions of this method are available. Mechanical mechanisms of detachment include screw release and interlock options. Mechanical-release coils are faster, cheaper and easier to push through a vascular catheter of given diameter, compared with electrolytically-detachable coils, however the detachment mechanism may be more prone to inadvertent detachment and occasionally a coil will fail to detach.

Recanalisation of a vascular site after coil occlusion is well recognised in human medicine. This can occur after bare coil embolisation or after fibred coil embolisation. A recent study, using a porcine arterial model, examined recanalisation three months post-occlusion. The authors documented the percentage cross sectional vessel area recanalised to be 6.2 (+/- 7.6)% in fibred coils and 10.1

(+/-9.2%) in unfibred coils. If this phenomenon occurs similarly in canines, this represents a significant cause for persistent or recurrent primary shunting in dogs treated with transvenous coil embolisation. (1)

Hydrogel coated coils are now available in the human field of brain aneurysm occlusion. These coils include a platinum core coated with a polymer which, in contact with saline or bodily fluids, unravels and absorbs water. The coil axial diameter increases four-fold over a time frame of 20 minutes (2). Occlusion is then due to space occupancy rather than thrombosis. Such a feature, with a significantly slower rate of swelling, would allow veterinary surgeons to deliberately under-attenuate shunt flow, during a transvenous coil embolisation procedure, with the confident expectation of subsequent full shunt occlusion over a physiologically safe time-frame; namely without the risk of inducing acute perioperative portal hypertension. An additional benefit may be the lower risk of recanalisation of the occluded site compared with using traditional thrombogenic coils. Intriguingly, the use of these hydrocoils in managing high flow portosystemic shunting (hepatic encephalopathy-portal hypertension balancing after TIPS procedure) is cited in the same publication.

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