Evaluation of the transarticular external skeletal fixator for the treatment of tarsocrural instability in 32 cats

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Summary
The medical records of all cats with tarsocural joint instability that were treated between June 2002 and December 2008 at the Royal Veterinary College were retrospectively reviewed. A total of 32 cats were identified. Information gathered included signalment, type of injury (subluxation or luxation), concurrent fractures, presence of soft tissue wounds, transarticular external skeletal fixation (TESF) type, configuration of TESF (number of pins proximal and distal to the joint), duration of hospitalisation, duration of TESF prior to removal, complications and cost. A significant association was identified between the length of hospitalisation and the presence of wounds. Similarly a significant association was present between wounds and final cost of treatment. Additionally, the authors found that a high number of implant related complications were present when only two pins were used proximal and distal to the tarsocural joint, but this association was not significant.

Material and methods
The medical records of all cats with tarsocural joint instability treated with TESF at The Royal Veterinary College between June 2002 and December 2008 were reviewed retrospectively. Tarsocural instability was defined as cases which had either tarsocural luxation or subluxation. Tarsocural subluxation was defined as partial articulation of the tibia and talus. Tarsocural luxation was defined as complete loss of articulation between the talus and the tibia. A standard medial, lateral or bilateral surgical

Introduction
The tarsocural joint is defined as the joint between the tibia and fibula and the talus and calcaneus (1). Tarsocural instability is commonly seen in distal limb injuries in cats and occurs as a result of fractures, disruption of ligamentous structures, or a combination of both types of injury (2, 3). The talocural joint is particularly prone to shear injuries and fractures due to the paucity of soft tissue protection in this area (4). The complex anatomy of the tarsus often makes diagnosis and management challenging and the outcome unpredictable.

Once a diagnosis of tarsocural instability has been made, the aims of management are to limit further damage to the supporting structures and articular surface, restore anatomic joint alignment and normal stability to the joint, and maintain normal range of motion (5). Treatment modalities include combinations of primary ligamentous repair, prosthetic ligament reconstruction, external coaptation, external skeletal fixation, arthrodesis and amputation (2, 4). Primary ligament repair or prosthetic ligament placement may be unfeasible when there is significant soft tissue loss or extensive damage, and furthermore, it can be challenging in the cat due to its small size. Wound management is inconvenient with external coaptation; it is usually poorly tolerated in feline patients and it can lead to significant morbidity in the form of pressure sores (6, 7). Arthrodesis is used as a salvage procedure once other methods of stabilisation have failed (8). As a result, the use of external skeletal fixators would appear to be a good method to stabilise tarsocural joint instability in cats (2). Transarticular external skeletal fixation (TESF) provides a simple and cost-effective method of stabilising the joint as well as allowing for concurrent wound care (9).

To date, there have been limited studies that solely assess injuries to the tarsocural joint in cats (3). The purpose of this study was to retrospectively evaluate tarsocural subluxations and luxations treated with TESF. In addition, the study aimed to assess factors associated with increased complication rates and whether there was an association between accuracy of joint reduction and the functional outcome as assessed by client questionnaire.
approach to the tarsus had been performed, depending on the nature of the injury. The luxations and fractures were reduced. Where appropriate, malleolar fractures were stabilised with Kirschner wires. Primary ligamentous repair was not undertaken in any of these cases. A TESF was subsequently applied and the tarsus was stabilised at an angle of approximately 115–125 degrees of extension. Standard postoperative care for cases included the administration of opioids and non-steroidal anti-inflammatory drugs. The type of opioid used was dependent on clinician preference.

The following information was gathered from each of the case files: signalment, type of injury (subluxation or luxation), concurrent fractures, presence of soft tissue wounds, TESF type, configuration of TESF (number of pins proximal and distal to the joint), duration of hospitalisation, length of time until TESF removal, complications, and cost of treatment. Complications were divided into either minor or major complications. Minor complications were defined as those which resolved following implant removal and the administration of antibiotic drugs. Major complications were those that required an additional surgery as well as those that resulted in loss of the limb, persistent lameness or death.

Soft tissue wounds were divided into minor and major soft tissue wounds. Minor wounds included superficial abrasions and puncture wounds. Major wounds included all wounds other than superficial abrasions and puncture wounds.

Dorsoplantar and mediolateral postoperative radiographic images of each case were reviewed. The widest part of the joint space between the talus and the tibia along the length of the tarsocural joint was measured on both orthogonal views (Fig. 1 and 2). The measurements of each radiograph were placed into one of three categories: <1 mm = good reduction; 1–2 mm = satisfactory reduction; >2 mm = poor reduction (Fig. 3 and 4). Measurements were taken in any of these cases. A TESF was subsequently applied and the tarsus was stabilised at an angle of approximately 115–125 degrees of extension. Standard postoperative care for cases included the administration of opioids and non-steroidal anti-inflammatory drugs. The type of opioid used was dependent on clinician preference.

Statistical analysis

A commercially available statistical software programme was used to perform all statistical analyses. Data were assessed for normality using the Kolmogorov-Smirnov test. Non-parametric tests were used to assess data that were not normally distributed. Descriptive statistics were used to report medians and ranges.

Final outcome of each case was assessed by a client questionnaire (Appendix 1, available online at www.vcot-online.com). The questionnaire was divided into four categories: surgical success, limb function, the presence of signs of long-term pain, and owner satisfaction. Owners were asked to make assessments using a semiquantitative scale. Each of the four categories was weighted equally so that a maximum score of 20 was possible. The maximum score for each category was 5. If an amputation or an arthrodesis was performed a score of 0 was automatically assigned to that individual case.

Associations between implant breakage or loosening and the TESF configuration, the presence of wounds and the complication rate, complications and non-responders of the questionnaire, and finally the degree of dorsoplantar reduction and whether a tarsocural luxation or subluxation had occurred were all assessed using the Fisher’s exact test.

Associations between the presence of wounds and final cost of treatment, the presence of wounds and the duration of hospitalisation, and finally the duration of TESF application and complications were assessed using the Mann Whitney U tests. Correlations between functional outcome and the degree of postoperative tarsocural joint reduction and the duration of TESF application and functional outcome were assessed using Spearman Rank tests.

Fig. 1 Postoperative dorsoplantar radiograph of the tarsocural joint with less than 1 mm tarsocural joint reduction.

Fig. 2 Postoperative mediolateral radiograph of the tarsocural joint with less than 1 mm tarsocural joint reduction.

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Results

One hundred and forty-six cases of tarsocrural instability were identified by reviewing the surgical theatre records and electronic patient records. Thirty-six cases of tarsocrural joint instability were managed with TESF. Medical records were available for 32 cases; radiographic images were available for 31 of these cases.

The age of the cats at the time of presentation ranged from seven months to 15 years (median 2 years 9 months). Weight was normally distributed and ranged from 2.6 kilograms to 6.2 kilograms (mean 4.3 kilograms). Ten cats were female neutered, 19 cats were male neutered, two cats were female entire, and one cat was male entire. There were 25 Domestic Shorthaired cats (DSH), two Domestic Longhaired cats (DLH) and five purebreds. Concurrent injuries were present in 15/32 cases (47%). These injuries included superficial soft tissue wounds, diaphragmatic rupture, pelvic fractures, olecranon fractures, distal physeal femoral fractures, severe crushing injuries requiring forequarter amputation, coxofemoral luxations and grade 4 open fractures (10).

The tarsocrural joints of the cats were stabilised with 29 Type I TESF, three Type II TESF and one free form TESF in which the connecting bar is made of epoxy putty. Fourteen of the Type I TESF had an additional connecting bar, which connected the most proximal and distal aspect of the connecting bar (‘A-frame’). The number of fixation pins inserted proximally and distally to the tarsocrural joint respectively was $2 + 2 (n = 10), 2 + 3 (n = 3), 3 + 2 (n = 1), 2 + 4 (n = 1), 3 + 3 (n = 10), 3 + 4 (n = 4), 4 + 3 (n = 5), 3 + 5 (n = 1), 4 + 5 (n = 1), and 5 + 5 (n = 1). Four different TESF systems were used: IMEX SK system$^b$ (n = 23), Kirschner-Ehmer$^c$ (n = 4), epoxy putty$^d$ TESF (n = 4), and IMEX SK combined with epoxy putty TESF (n = 1). The mini SK system was used in all 23 cats. Twenty-eight cats had associated malleolar fractures, three cats had no concurrent crural or tarsal fractures, and one cat had a talar fracture. Twenty-two of the 28 cases had their malleolar fractures stabilised with Kirschner wires and the tarsocrural joints of the remaining six cases were only stabilised with a TESF.

Complications were experienced in 13/32 cases (41%). Eight of the cases were classified as minor complications and resolved following implant removal and antibiotic drug administration. Five of the 13 cases experienced major complications. Major complications included severe osteoarthritis and subsequent pantarsal arthrodesis, persistent tarsocrural instability resulting in amputation, osteomyelitis resulting in amputation, malunion resulting in persistent lameness, and death following sepsis. Two cats had amputations, one cat had a pantarsal arthrodesis following severe osteoarthritis as a result of a methicillin resistant staphylococcus aureus infection in the tarsocrural joint, one cat had persistent instability, and one cat died due to an infection of an associated wound and septicaemia. Five cats experienced implant loosening or failure, and four of these cats had frames involving either two pins proximal or distal to the tarsocrural joint. Twenty-one cats (65.6%) had soft tissue wounds associated with their tarsocrural instability. Fourteen cats had major soft tissue injuries (43.8%) and included open fractures, degloving injuries, and shear injuries.

Duration of TESF application ranged from 20 to 133 days (median 46 days). The TESF remained on one cat for 133 days as a result of lack of owner compliance and failure to return for an examination appointment. Length of hospitalisation ranged from four to 43 days (median 7 days).

Twenty out of 32 owners provided responses to the telephone questionnaire (63%). From the responders of the questionnaire, owner satisfaction of the surgery was excellent in 17/20 of cases, good in 2/20 and satisfactory in 1/20. Only 2/20 of cats were being treated with long-term anti-inflammatory drugs for their lameness. Eight out of the twenty cats did not exhibit any signs of lameness following surgery, seven had a mild lameness, four had a moderate lameness and two had a severe lameness. Ten owners noted that their cats would hold their affected limb differently when compared to the contralateral limb, and five of these cats were reported to hold their affected leg out when sitting down. Thirty-one sets of radiographic images were available for review. It was possible to assess the tarsocrual joint on the dorsoplantar view in all cases. However, it was only possible to assess the tarsocrural joint in 23/31 cases on the mediolateral radiographic view as the...
connecting bar obscured the tarsocural joint in eight cases (Fig. 5). From the thirty-one cats that had dorsoplantar radiographic images available for review, twenty-one of these cases also had owner questionnaires available. From the 23 cases where it was possible to assess the tarsocural joint on the mediolateral radiographic images, 15 also had concurrent owner questionnaires available. In all 23 cases, superimposition of the connecting clamps over the tarsus was avoided.

There was no significant association between functional outcome and the degree of tarsocural joint reduction on the mediolateral (p = 0.26) or dorsoplantar (p = 0.29) radiographic images. There was no significant association between TESF configuration and pin loosening or breakage (p = 0.14). There was no significant association between the presence of a wound and complications (p = 0.47), or between the ratio of responder to non-responders and complications (p = 1.0). Twenty-one cats had tarsocural luxations, and 12 cats had tarsocural subluxations. There was no significant association between tarsocural luxation or subluxation and the degree of tarsocural joint reduction on the postoperative dorsoplantar radiographic image (p = 1.00).

A significant association was noted between the length of hospitalisation and the presence of wounds (p = 0.002). Similarly, a significant association was identified between the presence of wounds and final cost of treatment (p = 0.005); those cats with wounds had significantly more expensive cost of treatment. Cats with soft tissue wounds associated with tarsocural instability were hospitalised between five to 43 days (median 11 days). However, no significant association was detected between duration of TESF and complications (p = 0.39).

**Discussion**

Successful use of external skeletal fixation to stabilise tarsal injuries in dogs and cats has previously been reported (2, 3, 11). However, there have been few reports to date that solely assess the management of tarsocural luxations in cats (3). This study found that both the length of hospitalisation and the presence of concurrent wounds would significantly increase costs of treatment. Owner satisfaction was almost identical to those that were reported before (3). Roch et al. reported excellent owner satisfaction in 17/21 cases of tibial or fibular malleolar fractures; this is comparable to the 17/20 cases that had excellent owner satisfaction in our study. The signalment of cats was similar to those observed in previous studies with younger animals and males being more commonly involved in road traffic accidents. The higher proportion of males may be due to the fact that males have a wide home range and roam in search of females in oestrus (12).

Tarsal injuries are highly variable and frequently complex, which is likely to reflect the complex anatomy of this region. In approximately half of the cases, there were concurrent injuries present, emphasising the importance of performing a thorough physical examination and treatment of other life-threatening injuries prior to tarsocural fracture repair and stabilisation.

Four different types of ESF were used during the study period. The type Ia SK ESF was the most commonly used frame in this study. The traditional Kirschner-Ehmer system was used in the authors’ centre, The Queen Mother Hospital for Small Animals, until 2004. Following 2004 the Kirschner-Ehmer system was superseded by the SK system and epoxy putty due to its greater mechanical stability (13). However, a more recent study has shown that the SK clamps were more subject to degradation than the Kirschner-Ehmer clamps (14). Unfortunately, due to the retrospective nature of the study, we do not know how many times the clamps were used, and hence whether this contributed to implant failure. The majority of TESF systems used were type I; although type II TESF provide more stability, they are bulky, cause more soft tissue irritation proximally, and are heavy for cats. The type Ia ‘A-frame’ configurations with an additional connecting bar placed from the most proximal and the most distal clamps were used to increase fixator stiffness (9).

Joint reduction did not significantly affect clinical outcome as assessed by our owner questionnaire. Certain limitations are present with the use of a client based questionnaire. It has been shown that there is a poor correlation between feline osteoarthritis and clinically significant mo-
bility problems (15). Approximately one-third of cats with radiographic signs of appendicular joint osteoarthritis exhibited mobility problems that could be attributed to that joint (16). This may be due to the excellent ability of cats to conceal their pain. Other limitations may include the poor correlation between a successful outcome for an owner or veterinarian compared to objective gait analysis. It has previously been shown that assessment of gait lameness using a visual analogue scale between owners and veterinarians are of limited use in measuring unilateral lameness due to fragmented medial coronoid process in dogs when compared to objective gait analysis (17). Nonetheless, owner based questionnaires have still been shown to have value in follow-up assessment (18). The overall complication rate was 13/32 (41%), with 5/13 (16%) cases classified as serious complications. The most serious complication was death following sepsis. The complication rate in this study was comparable to previous reports (3, 5, 11). Arguably the death of one cat was the result of another underlying disease and not the surgery. External skeletal fixator pin loosening and pin tract infection is a commonly encountered complication (19). The TESF configuration did not have a significance association with implant loosening or breakage. However, the p-value approached significance (p = 0.14), and a power calculation revealed that insufficient numbers were present to identify a significant association. A minimum of 36 cats in the group with two pins, and 46 cats in the group with three or more pins would have been required to detect a significant difference (α 0.05, β 80%). Hence, there is a possibility that a ‘Type II error may have been made. It is the authors’ opinion that a minimum of three pins proximal and distal to the tarsocurcal joint should be used to reduce the incidence of implant-related problems. Alternatively, use of the type II TESF might avoid the problems associated with premature pin loosening seen with type I TESF (19).

The median time that the TESF was left on in the current study (46 days) seems to be comparable to that reported for the median time to external skeletal fixator removal of long-bone fractures of cats, and to the length of time reported in other studies (4 and 8 weeks [28 to 56 days] (3, 5, 21). Long-term immobilisation of the joint causes a decrease in synovial fluid production, cartilage stiffness and thickness and range of movement (5). In the current study, there did not appear to be any long-term deleterious effects that were noted by the owner between cats that had TESF on for longer durations. Joint reduction did not significantly affect clinical outcome as assessed by the owner questionnaire.

However, the small number of cases in this study might have failed to identify any differences in outcome when compared to accuracy of joint reduction. Each section was weighted equally in an attempt to give an outcome score which was a true reflection of overall success. Postoperative radiographs are used to assess joint reduction and placement of implants, and adjustments can be made if necessary to optimize outcome (2, 22). However, in nearly one-third of cases, it was not possible to assess the degree of tarsocurcal joint reduction on the mediolateral radiograph postoperatively due to superimposition of the TESF. A carbon fibre connecting bar is currently not available for the mini SK system, and therefore a stainless steel connecting bar had to be used. However, the authors believe that this problem can be overcome by positioning the pins in the tibia caudally and avoiding superimposition of the connecting clamps over the tarsus (▶Fig. 6). This would result in the curve of the connecting bar lying caudal to the hock without any superimposition. The small numbers in this study precludes over-interpretation of the findings between outcome and joint reduction.

The study identified that there was a significant association between those cats that had wounds and length of hospitalisation. Cats which had wounds associated with their tarsocurcal injuries were hospitalised for longer. A significant association was also identified between wounds and higher treatment costs. These findings are intuitive and can be explained by the longer hospitalisation necessary to manage the wounds, and the higher complication rates associated with open fractures. The healing of open fractures is known to be slower because of the greater disruption of the vascular supply (10).

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Conflict of interest
None declared.

References


