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Outcome and complications of pantarsal arthrodesis in dogs

Title:

Long-term outcomes after pantarsal arthrodesis by medial plate fixation without external coaptation in 30 dogs.

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Abstract

Objective: To report long-term outcomes of dogs treated with pantarsal arthrodesis (PTA) by medial plate fixation without external coaptation.

Study Design: Retrospective case series.

Animals: Client-owned dogs (n=30).

Methods: Medical records of dogs that had undergone a PTA with a medially applied plate without adjunctive rigid external coaptation were reviewed. Data collected included signalment, complications, and assessment of function at last physical examination. Follow-up information was obtained by phone conversations with owners. Complications were classified as minor, major II, major I and catastrophic as defined by Cook et al.[1]

Results: Thirty-six PTA were performed in 30 dogs. Recorded complications included 8 (22.2%) minor complications, 11 major II complications (30.6%) and 11 major I complications (30.6%). One dog required amputation due to catastrophic complication (2.8%). Owners provided follow-up in 26 dogs, at a median duration of 1215 days (Range: 325 days to 3495 days) after surgery. The outcome was reported as full function in 12 dogs and acceptable function in 14 dogs with no owners reporting unacceptable function. The owner of the amputated dog was not contacted. Incorrect contact details prevented owner's follow-up in the other 3 dogs, but all had acceptable function at last veterinary follow up.

Conclusions: Dogs treated with pantarsal arthrodesis by medially applied plate had a high incidence of complications requiring surgical or medical management, although full or acceptable function was achieved in 29/30 dogs.

Clinical Relevance:

Pantarsal arthrodesis offers a predictably good medium to long-term outcome in spite of a high risk of complications.

Introduction

Pantarsal arthrodesis (PTA) is a salvage surgical procedure, which aims to restore limb function by creating an osseous fusion and abolishing movement of the tarsal joints. Historically arthrodesis of the tarsus would involve the fusion of the talocrural joint only, stabilized with pins, screws, orthopedic wire and bone plates[2] augmented by external coaptation. However, these constructs were subject to high levels of stress and the overall reported success rate in the long term follow-up was 49%.[3] Reported complications included failure to achieve arthrodesis and intertarsal or tarsometatarsal osteoarthritis. Pantarsal arthrodesis involves arthrodesis of the talocrural, intertarsal and tarsometatarsal joints and has been proposed to allow more robust internal fixation and reduce the overload of the intertarsal and tarsometatarsal joints.[4]

Pantarsal arthrodesis can be achieved by dorsal, lateral, medial or plantar plate fixation. Dorsal plates are applied to the compression aspect of the joint and may be prone to failure due to cyclic loading and implant loosening or plate failure.[5,6] Dorsal plating is still preferred by some surgeons and the use of a commercially available, pre-bent, hybrid plate, has been described in 11 cats.[7] To the authors' knowledge there are no published case series reporting the use of these implants in dogs. Application of a plantar plate on the tension aspect of the joint has been reported,[8] though has not gained popularity due to the challenging surgical approach. Pantarsal arthrodesis using a custom-made bone plate for application on either the medial or lateral aspect of the talocrural joint has been described in 13 dogs with a good to excellent outcome reported in 12 dogs. External support was used in all dogs: 12 had a cranial half cast placed while 1 had an external fixator. Complications were reported in 30% (4/13) of dogs, 2 suffered plate failure and 2

suffered osteomyelitis.[4] Roch et al. reported 40 tarsal arthrodeses, 9 of which were pantarsal arthrodesis by medial plate. Complications affected 88.9% (8/9) of procedures, with 4 dogs suffering multiple complications. These included 2 plantar necrosis, 2 screw migration, 3 pressure sores, 2 swellings of the paw, 2 sepsis and 1 gastrocnemius tendinopathy. All dogs had external coaptation applied. Immediately postoperatively this was with a Robert-Jones bandage, which was subsequently replaced with more rigid external coaptation, either a bi-valve cast or a cranial splinted dressing, which was maintained until radiographic union was demonstrated.[9] In recent years, the benefit of external coaptation in the initial postoperative period following arthrodesis has been questioned; any perceived mechanical benefit must be considered against the postoperative morbidity associated with its use. Roch et al reported external coaptation related complications in 40% of tarsal arthrodesis,[9] whilst Meeson et al reported that 63% of patients who had external coaptation applied to the distal limb, developed soft tissue injury associated with its use; 20% were considered severe causing increased morbidity and treatment cost.[10] Whilst an *ex-vivo* mechanical study of pancarpal arthrodesis (PCA) constructs provided evidence that the use of a cast significantly reduced plate strain, the strain magnitude was low and considered unlikely to be clinically significant.[11] This ex-vivo finding would appear to be supported by a retrospective study on PCA, which concluded that external coaptation had no measurable benefit.[12] From a mechanical perspective in PTA, medial plating allows “edge” loading of the implant, and, compared to dorsal plating, increases the dorsoplantar bending stiffness of the construct.[13] Furthermore, the distal screws engage multiple metatarsal bones due to their mediolateral orientation offering a theoretical mechanical advantage compared to dorsal plating. Such

a mechanical advantage may reduce/remove the perceived requirement for application of external coaptation; either prolonged bandaging or more rigid external coaptation such as that achieved with a cast or splint in the initial postoperative period.

To the authors' knowledge, there are no published case series reporting complications and follow-up outcome of pantarsal arthrodesis performed with a medially applied plate, without the use of rigid (cast or splint) external coaptation. This study aims to describe the follow-up and complications following pantarsal arthrodesis in dogs using a medially applied PTA plate, without the aid of rigid external coaptation.

Materials and methods

Inclusion Criteria

The medical records of Willows Veterinary Centre and Referral Service (2007-2016) were searched and all dogs that underwent a PTA were identified and reviewed retrospectively. Inclusion criteria were dogs that had undergone a PTA with a medially applied plate without adjunctive rigid external coaptation, had complete clinical case details, a minimum of six months' follow-up, preoperative radiographs and immediate post-operative radiographs. Data retrieved included species, breed, sex, weight, age at surgery, operated limb, presence of other concurrent orthopedic conditions, lameness duration, the reason for arthrodesis and implants selection. Surgical site infection (SSI) was defined as an infection occurring at the surgical site within a year of surgery following the criteria described by the US Centers for Disease Control and Prevention.[14]

The definition and criteria for reporting complications and outcome proposed by Cook et al were adopted.[1] This to use recognized and validated criteria to facilitate comparison

with any future studies. Briefly, full function dogs had to be able to exercise at a pre-disease level without being on medication. Dogs where restoration or maintenance of the intended activities and performance from pre-injury or pre-disease status was achieved, but this was limited in level or duration and/or required medication to achieve, were classified as having an acceptable function. All other outcomes were classified as unacceptable. The short-term outcome was assessed by veterinary follow-up and mid to long-term outcome by owner telephone follow-up. Complications were classified as minor, major I (surgical treatment required), major II (medical treatment required) and catastrophic.[1]

Owners were interviewed by telephone and asked to:

- Report complications that may have happened following the last veterinary follow-up.
- Classify subjectively clinical outcome as Full, Acceptable or Unacceptable function, after having the classification system explained.[1]
- Report any on-going medical treatment with nonsteroidal anti-inflammatory drugs (NSAIDs) or any other analgesic drug.

Results

Thirty-three dogs underwent PTA between 2007 and 2016. Of these, 30 met the inclusion criteria, of which 6 had bilateral surgery and thus a total of 36 procedures were reported. Of the 3 dogs that did not meet the inclusion criteria, 2 were excluded due to insufficient follow-up period and one was excluded because PTA was performed using a laterally applied plate.

Signalment

The population included 6 Labrador Retrievers, 5 Crossbreeds, 2 Springer Spaniels, 2 Lurchers and one each of Old English Sheepdog, German Pointer, Alaskan Malamute, Staffordshire Bull Terrier, Shar-Pei, Rhodesian Ridgeback, English Pointer, Mastiff, Labradoodle, Italian Spinone, Irish Setter, Greyhound, Golden Retriever, Doberman Pinscher and Border Collie. Fourteen were neutered females, 8 were neutered males, 5 were entire males, 3 were entire females. Median age at the time of surgery was 6 years (range: 7 months to 11 years). Median bodyweight was 29.9Kg (range: 14Kg to 64Kg). The median duration of the lameness at the time of surgery was 150 days (range: 3 days to 1825 days).

Reason for arthrodesis

Reasons for arthrodesis included talocrural osteochondritis dissecans in 7 dogs, degenerative Achilles tendinopathy in 12 dogs (5 having bilateral surgery, for a total of 17 procedures), tarsal fracture in 9 dogs, limb deformity in one dog (bilateral procedure) and traumatic injury of the Achilles mechanism in 1 dog.

Main implant

Commercially available implants were used (Veterinary Instrumentation Limited, Sheffield, UK). The appropriate size was chosen at the discretion of the clinician. A 2.7/3.5/4.5mm medial pantarsal arthrodesis plate was used in 6 procedures, a 2.7/3.5mm

medial pantarsal arthrodesis plate was used in 30 procedures (11 procedures had a short version placed, while 19 had the standard version).

Surgical procedure

Surgeries were performed by diplomates or by residents under direct supervision. After induction of general anesthesia and aseptic preparation of the affected hind-limb, a plantaromedial approach to the tarsus was performed.[15] The medial malleolus was removed either with a high-speed burr or with an oscillating saw at the surgeon's discretion. Bone was removed from the medial aspect of the talus, central tarsal bone and base of the metatarsal II using a high-speed burr. An appropriately sized PTA plate was contoured and applied to the medial aspect of the tibia, tarsus and metatarsal II. The plate and screws were removed and the cartilage of talocrural joint was thoroughly debrided with a high-speed burr. A drill bit was used to forage the distal tibial and proximal talar articular surfaces. A high-speed burr or drill was used to debride the intertarsal and tarsometatarsal joints from the medial aspect. After abundant lavage with saline, the talocrural, intertarsal and tarsometatarsal joints were packed with either autogenous bone graft (25/36), demineralized bone matrix (9/36) or a combination of the two (2/36) at the surgeon's discretion.

In 14 procedures, based on the surgeon's preference, the gastrocnemius and common tendons were transected, preserving the superficial digital flexor tendon; a tenectomy was performed in 12 procedures while a tenotomy was performed in 2 procedures.

In each procedure, the surgical wound was closed in layers. Care was taken to achieve tension-free skin closure; if this was not possible, a releasing incision was made on the lateral aspect of the tarsus (2/36).

Additional fixation

Additional internal fixation was placed according to the surgeon's preference. Additional fixation included a calcaneotibial screw in 24 procedures, a talocalcaneal screw in 6 procedures, a dorsal dynamic compression plate (DCP) in 3 procedures, a tibiocalcaneal screw in 2 procedures and a tibiotalar screw in 1 procedure. In 3 procedures, no additional fixation was used, while 3 procedures had more than one additional implant placed (tibiotalar + calcaneotibial screws, talocalcaneal screw + dorsal plate, or calcaneotibial screw + dorsal plate). A dorsal plate was applied in 2 procedures (number 6 and 15) as additional fixation at the time of revision surgery due to insufficient stability of the initial construct. In procedure number 14 a combination of a medial and a dorsal plate was used at the time of the initial surgery. This dog had a pathological talar fracture secondary to suspected immune-mediated arthritis. A more robust construct was chosen because the surgeon expected the joint to take longer to arthrodese.

All dogs received perioperative antibiotic treatment with either amoxicillin-clavulanate 20mg/kg or cefuroxime 20mg/kg administered intravenously (IV) at the time of induction of general anesthesia and then every 90 minutes until the end of the procedure. Orthogonal post-operative radiographs of the tarsus were acquired to confirm satisfactory implant placement. Non-steroidal anti-inflammatory drugs (NSAIDs) were administered

for at least 3 weeks postoperatively. Cephalexin (Rilexine, Virbac), 20mg/kg orally twice daily was prescribed for a week postoperatively, in all dogs. After discharge, clients were instructed to restrict their dog's activity for the first 6 weeks and then allow increasing levels of lead exercise for 4–6 weeks, followed by a gradual return to normal activity levels. Follow-up examination and radiography were obtained after 6-8 weeks. Further follow-ups were booked depending on the dog's progression and client's concerns. Six dogs had a bilateral staged procedure performed. Complications were counted and described in relation to 36 PTA performed; however, outcomes have been described in relation to individual dogs, so 30 in total.

External dressings

External dressings were used based on the surgeon's preference. Thirty-three procedures had a soft padded dressing (modified Robert Jones bandage) applied postoperatively, 3 procedures had only a conformable adhesive dressing (Primapore, Smith and Nephews) applied for 24h postoperatively. The padded dressing was left in place for a median of 5 days (range: 1 day to 60 days).

Five temporary bandage complications were noted: 2 dogs had moderate swelling of the digits and 3 had pressure sores; all resolved after bandage removal.

Other concurrent orthopedic problems and ongoing medications

Concurrent orthopedic conditions at the time of the last follow-up were reported in 11 dogs. Bilateral elbow dysplasia was reported in 5 dogs, bilateral hip dysplasia in 2 dogs, 1 dog had reported lumbar pain, and 1 dog had carpal osteoarthritis. One dog had ipsilateral

cranial cruciate rupture managed with tibial plateau levelling osteotomy and one dog had signs of degeneration of the contralateral Achilles mechanism.

Six dogs were reported to be on on-going analgesic medication at the time of the last follow-up.

Complications

Complications occurred in 21 of 36 procedures (21/36, 58.3%) with more than one complication occurring in 7 procedures. Eight minor complications (8/36, 22.2%) were reported: 6 broken, bent or loose screws, 1 Achilles tendon pain and 1 metatarsal fracture. These were noted at the time of planned re-examinations. Because progression was satisfactory these were not considered clinically significant and no action was taken. There were 11 (11/36, 30.6%) major II complications. Ten were surgical site infections of which 2 were confirmed by culture & sensitivity. The remaining 8 SSI were suspected by the clinician, based on clinical examination and resolved with antimicrobial treatment (median duration of treatment 32 days, range 14 days – ongoing). One metatarsal fracture was diagnosed and managed by the referring veterinary surgeon with external coaptation. Eleven (11/36, 30.6%) major I complications were encountered. One metatarsal screw (procedure 7) was considered to be causing discomfort due to it being too long and was replaced with a shorter one. One loose calcaneotibial screw and 1 broken metatarsal screw (procedures 25 and 20) had to be removed via stab incision. Three dogs (procedures 4, 20 and 25) had a metatarsal fracture where one screw was within the fracture line and was removed. Two dogs (procedures 7 and 29) were diagnosed with Achilles tendon pain and the tendon was surgically transected. One dog (procedure 3)

underwent implant removal 113 days postoperatively due to non-healing of the releasing incision performed at the original surgery, which was believed to be due to skin tension. One dog (procedure 15) underwent revision surgery because the plate broke at the level of the distal tibial screw hole. The plate was replaced and an additional dorsal locking plate was applied. In one dog (procedure 6), the calcaneotibial screw was loose and had to be removed; because on radiographs the arthrodesis was not complete the surgeon decided to place a dorsal plate for additional construct strength. There was one (1/36, 2.8%) catastrophic complication. Pelvic limb amputation was performed due to a severe surgical site infection that led to early implant removal. However, there was unacceptable limb function due to incomplete arthrodesis and surgical revision was declined for financial reasons. Complications are summarized in Table 1 and Table 2.

Outcomes

The median time to final veterinary follow-up was 223 days (range: 1 day to 1544 days). Outcome reported in the medical records at the time of last veterinary follow-up was: full function in 5 dogs (5/30, 16.6%), acceptable function in 19 dogs (19/30, 63.3%) and unacceptable function in 6 dogs (6/30, 20%). The median time to owner follow-up was 1215 days (range, 325 days to 3495 days). Outcome reported during the telephone interview with the owners was full function in 12 dogs (12/26, 46.1%) and acceptable function in 14 dogs (14/26, 53.8%). Although none of the owners contacted reported an unacceptable function, the owner of the dog that underwent amputation (procedure 24) was not contacted. This dog was classed as having unacceptable function at owner follow-up (1/30, 3.3%). It was not possible to contacts the owners of three dogs

(procedures 3, 4 and 6) because of invalid contact details. For these 3 dogs the last veterinary follow-up at, respectively, 841, 357 and 309 days postoperatively reported acceptable function. (Outcomes are summarized in Table 1). Acceptable or full function was reported at final available follow-up in 29 dogs (29/30, 96.6%). These were telephone follow-up from the owners in 26 dogs (26/30, 86%) and last available veterinary follow-up for 3 dogs where owners could not be contacted.

At the last veterinary follow-up, 6 dogs were reported to have unacceptable function. In two of these (procedure 11 & 26) the last veterinary follow-up was only 1 or 2 days after the surgical procedure; therefore, the poor function reflects normal post-operative recovery. One of those two dogs subsequently achieved full function and one achieved acceptable function at owner follow-up. In procedures number 29, 20 and 15 unacceptable function was associated with complications. After treatment one dog recovered full function and two had acceptable function at last available telephone follow-up with the owner. One dog (Procedure 24) had unacceptable function because of severe surgical site infection. Implant removal was attempted but arthrodesis was incomplete. This dog was owned by a charity and the option of placing a new implant was declined on financial grounds. Amputation was performed instead; this is the only dog in this case series not achieving full or acceptable outcome at the last follow-up.

Bilateral procedures:

To the authors' knowledge, this is the first case series describing dogs having bilateral staged PTA performed. In 5 out of 6 dogs reported here, the reason for arthrodesis was bilateral Achilles tendinopathy, while in one dog it was the presence of a bilateral limb

deformity. The median time interval between the two procedures was 60 days (range, 1 day to 1511 days). Four complications (4/6, 66.6%) affected 3 dogs: these consisted in 2 SSI reported in the same dog (resolved with medical treatment) and 2 dogs having a loose metatarsal screw that did not require treatment. Four dogs (4/6, 66.6%) had acceptable function reported at owner follow up, while 2 (2/6, 33.3%) had full function.

Discussion

We report the subjectively assessed outcomes of 30 dogs treated with 36 pantarsal arthrodeses using a medially applied, commercially available, PTA plate without adjunct postoperative rigid external coaptation. In this study, a total of 31 complications were reported, 8 (22.2%) minor, 11 (30.6%) major I, 11 (30.6%) major II and 1 (2.8%) catastrophic. Because we used a different classification system, it is difficult to compare objectively the results of our study with those reported in previous papers. For example, complications that we classified as major II, which were managed medically would have been classified as "minor" complications in other studies.[4,16] Our results seem to compare favorably with a previous study where 12 complications were recorded in 9 pantarsal arthrodeses performed with the same surgical technique,[9], On the other hand, McKee et al. (2004) and reported complications in only 4 in 13 dogs.[4] Although we report a high number of major complications, most of these were easily addressed with either medical treatment or a short surgical procedure. Of the 11 major I complications needing surgical revision, in 8 dogs this consisted of a small incision for removal of one single screw or transection of the Achilles tendon. Only in 3 dogs, more extensive surgical revision was required (Procedures number 3, 6 and 15).

Roch et al. reported 40 tarsal arthrodeses (9 pantarsal, 31 partial tarsal). In their case series, the most common major complication requiring further surgical intervention was plantar necrosis that occurred in 15% of their procedures. They describe that the skin of the plantar metatarsus and the deep tissues of the metatarsal pad became devitalized in all affected dogs while the skin covering digits II and V appeared variably affected. The authors hypothesized that vascular damage to the dorsal pedal or perforating metatarsal arteries could contribute to the development of this major complication.[9] Interestingly none of the dogs we are reporting developed plantar necrosis. None of our dogs had a rigid cast applied, while most of those described in the study of Roch et al.[9] had a rigid splinted dressing or bivalve cast applied. Differences in technique between the study of Roch et al. and the current study may explain the difference in incidence of plantar necrosis. While Roch et al.[9] described that meticulous debridement was performed, in all our procedures this was performed only medially and care was taken not to extend debridement and dissection dorsally. Therefore, it is also possible that plantar necrosis was not observed because a less aggressive debridement reduced the risk of damaging the dorsal pedal or the perforating metatarsal arteries. In our procedures, bony prominences were meticulously debrided from the medial aspect of the tibia, talus, central, and second metatarsal bones to facilitate plate contouring and skin closure, minimizing skin tension and reducing biological tourniquet effect. This could also have contributed to the absence of plantar necrosis as a complication. Three dogs suffered Achilles tendon pain postoperatively, which was treated with surgical transection in 2 dogs (procedures 7 and 29). Clinical signs improved with rest only in one dog (procedure 2). These three dogs were part of 22 dogs that did not have the tendons transected electively at the time of

surgery Although this complication has been reported in the literature,[17] to the authors' knowledge its aetiogenesis has not yet been investigated. A possible explanation is the development of a chronic strain injury due to excessive tension on the Achilles tendon as the dog tries to extend the stifle in the presence of a fused tarsus. To prevent this, one of the authors routinely transect the common and gastrocnemius tendons, leaving the superficial digital flexor tendon intact, at the time of the initial PTA. In the authors' experience transection of the gastrocnemius and common calcaneal tendons (either by tenectomy or tenotomy), in association with PTA, is a rapid and well-tolerated procedure, with minimal associated morbidity. These results suggest that transection of the gastrocnemius and common calcaneal tendons may be effective in preventing postoperative Achilles tendon pain and, following assessment of these data, the authors believe that it is reasonable to perform elective tenectomy or tenotomy during PTA. Further studies are required to provide evidence that transection of the common and gastrocnemius tendons influences the outcome and/or complications. Five dogs experienced metatarsal fracture following surgery (procedures 4, 16, 20, 25 and 28). To the authors' knowledge, metatarsal fracture has not previously been described as a postoperative complication of pantarsal arthrodesis. In procedure 16 the fracture was located in the distal diaphysis of second and third metatarsal bones and was not associated with the implant. In all other procedures metatarsal bones fractured at the level of a screw hole, which the authors believe may act as a stress riser, and in 3 of these procedures, the involved screw was removed. In all procedures, fractures were associated with an initial worsening of lameness, but all dogs subsequently improved and achieved acceptable (4 dogs) or full function (1 dog). It is possible that the metatarsal fracture

prevented these dogs from recovering full function. In addition to the 4 metatarsal fractures through the distal screw hole, 8 dogs experienced loosening or breakage of 1 or more metatarsal screws. These 12 complications would suggest excessive loading at the distal screw-metatarsal interface. It is possible that external coaptation reduces the stresses at the distal aspect of the implant and that we experienced metatarsal fractures and distal screw loosening because we did not use external coaptation.

As additional internal fixation was adopted in the majority of procedures reported in this case series (33/36), it is not possible to correlate its use to the development of complications such as metatarsal fracture, metatarsal screw failure or SSI. Nevertheless, use of additional internal fixation increases surgery time and need for more extensive soft tissue dissection. It cannot therefore be excluded that its use contributed to the development of complications such as surgical site infection. It also not possible to draw conclusions on the impact additional internal fixation had to the outcome of our procedures. We believe that that placement of a calcaneotibial or tibiocalcaneal screw represents a standard procedure during PTA and improves the overall stiffness of the construct by counteracting part of the forces acting on the talocrural joint. This is supported by an ex-vivo study, which provided evidence that placement of a calcaneotibial screw reduces significantly compliance, angular deformity and strain of medial arthrodesis plates.[13] For these reasons, we adopted it in the majority of procedures. Further studies are required to investigate the effect of additional internal fixation on outcome and complications of pantarsal arthrodesis by medial plate fixation, and also to quantify the effect of different types of additional internal fixation on overall construct stiffness.

External coaptation has been advocated to provide adjunctive stability following arthrodesis with internal fixation[18,19] although the effectiveness of coaptation in reducing loading of the implants remains unclear. An ex-vivo study on pancarpal arthrodesis (PCA) provided evidence that, although the application of a cast to the distal portion of the limb significantly reduced strain in a 2.7/3.5 mm hybrid PCA plate, the magnitude of the measured strain was low. This suggested that fatigue damage was unlikely to accumulate as a result of this type of loading and that external coaptation may not be necessary to prevent fatigue failure of the plate.[11] Because this study tested only PCA constructs, it is not possible to know if results can be applied to PTA.

Our results provide evidence that it is possible to achieve a full or acceptable outcome following PTA without the use of postoperative rigid external coaptation and compare favorably with another study that reports the outcome of this technique (Good to Excellent outcome in 12 out of 13 dogs).[4] Further research is necessary to determine whether external coaptation reduces the requirement for additional internal fixation and reduces fixation related complications. Equally the use of rigid postoperative external coaptation has to be weighed against the known and reported complications associated with its use,[10] as well as the additional cost and time commitment for its management. On this basis, the authors currently prefer to apply only a soft padded dressing after PTA, usually for a short time. Thirty-three procedures reported in this study had a soft padded dressing applied for a median time of 5 days (range, 1 day to 60 days). Only one procedure had had a dressing applied for 60 days and this was to facilitate secondary intention healing of the releasing incision, rather than to provide mechanical stability.

Eleven dogs experienced SSI (11/36, 30.5%). This result is higher than has been previously reported (6.6%) for clean orthopedic procedures[20]. Because of the retrospective design of this study, only two infections were confirmed with culture and sensitivity testing. In all other dogs, SSI was suspected based on clinical signs, which included decreased limb function without evidence of implant failure, focal pain, swelling and radiographic signs compatible with osteomyelitis. Our reported SSI rate is similar to the 22% reported by Roch et al. (2007).[9] Possible reasons for a high SSI rate are the limited soft tissue coverage, the duration of surgery and thermal injury from burring. All dogs had perioperative and postoperative antibiotics and it is therefore not possible to evaluate the protective effect of prophylactic antibiotic administration. Implant removal was only required in one procedure (Number 24) while in all other procedures antimicrobial medication was effective in resolving clinical signs. Procedure 28 was still on long-term antibiotic treatment when the owner was contacted to obtain long-term follow-up.

Study limitations

There are several limitations to this study, of which the major one is its retrospective nature and as such, the data reported relies on accurate record keeping in medical notes. It is possible that there was under-reporting of complications although that is deemed unlikely, especially for major complications. Also, we only report subjective, owner assessed outcome measures for the long-term outcome which have been shown previously not to correspond well with orthopedic examination findings.[21] There is a relatively small sample size hence no statistical analysis was performed. In addition, the

heterogeneous population in terms of breed, age, bodyweight, concurrent orthopedic conditions and reason for arthrodesis can make interpretation of the results more challenging.

Conclusions:

Pantarsal arthrodesis by means of a medially applied plate provided a positive and predictable outcome in most of the 30 dogs described in our study. Complications were frequent although most could be addressed medically or with relatively minor surgical procedures.

Disclosure statement (conflicts of interest)

The authors declare no conflicts of interest related to this report.

References:

1. Cook JL, Evans R, Conzemius MG, et al. Proposed Definitions and Criteria for Reporting Time Frame, Outcome, and Complications For Clinical Orthopedic Studies in Veterinary Medicine. *Vet Surg*. 2010;39(8):905-908. doi:10.1111/j.1532-950X.2010.00763.x
2. Piermattei D, Flo G, DeCamp C. *Handbook of Small Animal Orthopedics and Fracture Repair*. 6th ed. St Louis, Missouri: Elsevier Health Science; 2016.
3. Klause SE, Piermattei DL, Schwarz PD. Tarso-crural Arthrodesis : Complications and Recommendations. *Vet Comp Orthop Traumatol*. 1989;3:120-124.
4. McKee WM, May C, Macias C, Lapish JP. Pantarsal arthrodesis with a customised medial or lateral bone plate in 13 dogs. *Vet Rec*. 2004;154(6):165-170. doi:10.1136/vr.154.6.165
5. Gorse MJ, Earley TD, Aron DN. Tarsocrural arthrodesis: Long term functional results. *J Am Anim Hosp Assoc*. 1991;27(March/April):231-235.
6. Decamp CE, Martinez SA, Johnston SA. Pantarsal arthrodesis in 10 dogs and a cat. *J Am Vet Med Assoc*. 1993;203(January):1705-1707.
7. Fitzpatrick N, Sajik D, Farrell M. Feline pantarsal arthrodesis using pre-contoured dorsal plates applied according to the principles of percutaneous plate arthrodesis. *Vet Comp Orthop Traumatol*. 2013;26(5):399-407. doi:10.3415/VCOT-12-05-0063
8. McCartney W, MacDonald B, Comiskey D, Robertson I. Pantarsal arthrodesis using a plantar plate: Finite element analysis of plate position and preliminary

results of four cases. *Int J Appl Res Vet Med*. 2008;8(1):65-72.

9. Roch SP, Clements DN, Mitchell RAS, et al. Complications following tarsal arthrodesis using bone plate fixation in dogs. *J Small Anim Pract*. 2008;49(3):117-126. doi:10.1111/j.1748-5827.2007.00468.x

10. Meeson RL, Davidson C, Arthurs GI. Soft-tissue injuries associated with cast application for distal limb orthopaedic conditions: A retrospective study of sixty dogs and cats. *Vet Comp Orthop Traumatol*. 2011;24(2):126-131. doi:10.3415/VCOT-10-03-0033

11. Woods S, Wallace RJ, Mosley JR. The effect of external coaptation on plate deformation in an ex vivo model of canine pancarpal arthrodesis. *Vet Comp Orthop Traumatol*. 2012;25(6):439-444. doi:10.3415/VCOT-12-01-0002

12. Bristow PC, Meeson RL, Thorne RM, et al. Clinical Comparison of the Hybrid Dynamic Compression Plate and the Castless Plate for Pancarpal Arthrodesis in 219 Dogs. *Vet Surg*. 2015;44(1):70-77. doi:10.1111/j.1532-950X.2014.12183.x

13. Guillou RP, Frank JD, Sinnott MT, Meyer EG, Haut RC, Déjardin LM. In vitro mechanical evaluation of medial plating for pantarsal arthrodesis in dogs. *Am J Vet Res*. 2008;69(11):1406-1412. doi:10.2460/ajvr.69.11.1406

14. Brown DC. Wound infections and antimicrobial use. In: *Tobias KM, Johnson SA, (Eds): Veterinary Surgery Small Animal; Vol. 1*. St Louis, Missouri: Elsevier Ltd; 2013:135-139.

15. Piermattei DL, Johnson KA. *Surgical Approaches to the Bones and Joints of the Dog and Cat*. 4th ed. (Elsevier, ed.). Philadelphia. Pennsylvania; 2004.

16. Barnes DC, Knudsen CS, Gosling M, et al. Complications of lateral plate fixation

compared with tension band wiring and pin or lag screw fixation for calcaneoquartal arthrodesis: Treatment of proximal intertarsal subluxation occurring secondary to non-traumatic plantar tarsal ligament disruption . *Vet Comp Orthop Traumatol*. 2013;26(6):445-452. doi:10.3415/VCOT-12-07-0089

17. Salvatierra DNA, Witte PG, Scott HW, Catchpole C. Pantarsal arthrodesis in cats using orthogonal plating. *J Feline Med Surg*. 2018;20(1):45-54. doi:10.1177/1098612X17698264

18. Dyce J. Arthrodesis in the dog. *In Pract*. 1996;18(6):267-279. doi:10.1136/inpract.18.6.267

19. Dyce J, Whitelock RG, Robinson K V, Forsythe F, Houlton JE. Arthrodesis of the tarsometatarsal joint using a laterally applied plate in 10 dogs. *J Small Anim Pract*. 1998;39:19-22.

20. Fitzpatrick N, Solano MA. Predictive Variables for Complications after TPLO with Stifle Inspection by Arthrotomy in 1000 Consecutive Dogs. *Vet Surg*. 2010;39(4):460-474. doi:10.1111/j.1532-950X.2010.00663.x

21. Priddy NH, Tomlinson JL, Dodam JR, Hornbostel JE. Complications with and owner assessment of the outcome of tibial plateau leveling osteotomy for treatment of cranial cruciate ligament rupture in dogs: 193 cases (1997-2001). *J Am Vet Med Assoc*. 2003;222(12):1726-1732. doi:10.2460/javma.2003.222.1726

513 **Figure legends, and tables**

514 Table 1. Outcomes of 30 dogs undergoing 36 pantarsal procedures.

	Signalment	Laterality	Complications	Function as last veterinary examination	Owner's assessment of function
1	Labradoodle, FE, 19 MO, 33Kg	R	None	(57) Full	(3495) Full
2	Rhodesian Ridgeback, FN, 4 YO, 40Kg	R	(43) MT screw broken. Minor (91) AT pain, resolved with rest. Minor (64) SSI. Major II	(122) Acceptable	(3044) Acceptable
3	Cross Breed, MN, 6 YO, 22Kg	L	(113) Delayed wound healing. Major I	(841) Acceptable	Invalid contact details
4	Border Collie, MN, 9 MO, 23Kg	L	(69) MT fracture, screw in fracture site removed. Major I	(357) Acceptable	Invalid contact details
5	German Pointer, ME, 7 YO, 35Kg	L	(104) SSI. Major II	(1554) Acceptable	(2278) Acceptable
27	German Pointer, ME, 11 YO, 35Kg	R	(327) SSI. Major II		
6	Mastiff, FN, 3 YO, 64Kg	R	(10) SSI. Major II (71) Loose CT screw, removed Additional dorsal plate applied. Major I	(309) Acceptable	Invalid contact details
7	Lurcher, FN, 5 YO, 25Kg	L	(161) SSI. Major II (71) AT pain, surgical transection. Major I (144) MT screw too long, removed. Major I	(361) Acceptable	(2164) Acceptable
8	Greyhound, MN, 7 YO, 35Kg	L	(5) SSI. Major II	(229) Full	(2169) Full
9	Labrador Retriever, FN, 7 YO, 40Kg	R	None	(131) Acceptable	(1965) Acceptable
10	Labrador Retriever, FN, 7 YO, 38Kg	L	None		
11	Shar-Pei, FE, 6 YO, 39Kg	L	None	(1) Unacceptable	(1835) Full
12	Italian Spinone, FN, 6 YO, 39Kg	R	None	(446) Acceptable	(1710) Acceptable
13	Staffordshire Bull Terrier, FN, 5 YO, 19Kg	R	None	(37) Acceptable	(1590) Full
14	English Pointer, FN, 9 YO, 28Kg	L	(52) CT screw bent. Minor	(316) Acceptable	(1582) Acceptable
15	Labrador Retriever, FN, 5 YO, 32Kg	L	(240) broken plate, replaced. Additional dorsal plate applied. Major I	(330) Unacceptable	(1477) Acceptable
16	Lurcher, ME, 5 YO, 32Kg	L	(38) SSI. Major II (662) MT fracture, managed with external coaptation. Major II	(38) Acceptable	(1304) Full
17	Dobermann, MN, 4 YO, 54Kg	L	None	(77) Acceptable	(1217) Full

18	Springer Spaniel, FN, 18 MO, 14Kg	L	None	(61) Acceptable	(1214) Full
19	Labrador Retriever, FN, 7 YO, 21Kg	L	None	(701) Full	(1150) Full
30	Labrador Retriever, FN, 9 YO, 22Kg	R	None		
20	Labrador Retriever, FN, 7 YO, 30Kg	R	(48) SSI. Major II (72) Broken MT screw, removed. Major I (214) MT fracture, screw removed from fracture site. Major I	(217) Unacceptable	(1124) Acceptable
21	Springer Spaniel, FN, 5 YO, 19Kg	L	(42) SSI. Major II	(42) Acceptable	(1043) Acceptable
22	Old English Sheepdog, ME, 7 MO, 17Kg	R	None	(719) Full	(1068) Full
23	Old English Sheepdog, ME, 7 MO, 17Kg	L	(318) MT screw broken. Minor		
24	Cross Breed, MN, 2 YO, 30Kg	L	(458) SSI, failure to arthrodese, amputation. Catastrophic	(457) Unacceptable	Unacceptable
25	Alaskan Malamute, ME, 8 YO, 47Kg	R	(426) Loose CT screw, removed. Major I (923) MT fracture, screw removed from fracture site. Major I	(436) Acceptable	(962) Acceptable
26	Cross Breed, FN, 7 YO, 26Kg	R	None	(2) Unacceptable	(920) Acceptable
28	Golden Retriever, ME, 7 YO, 37Kg	L	(112) MT fracture. Minor (135) SSI. Major II	(478) Acceptable	(655) Acceptable
29	Irish Setter, FE, 19 MO, 29Kg	R	(27) AT pain, surgical transection. Major I	(58) Unacceptable	(541) Full
31	Labrador Retriever, MN, 9 YO, 32Kg	L	(56) MT screw broken. Minor	(117) Acceptable	(480) Acceptable
32	Labrador Retriever, MN, 9 YO, 33Kg	R	None		
33	Cross Breed, MN, 10 MO, 17Kg	R	(76) MT screw loose. Minor	(76) Acceptable	(441) Full
34	Labrador Retriever, MN, 3 YO, 35Kg	L	(49) MT screw loose. Minor	(268) Acceptable	(325) Full
35	Cross Breed, FN, 5 YO, 22Kg	R	None	(118) Full	(327) Acceptable
36	Cross Breed, FN, 6 YO, 22Kg	L	None		

Legend: MT, metatarsal. AT, achilles tendon. SSI: surgical site infection. CT, calcaneotibial. MO, months old. YO, years old. FN, female neutered. FE, female entire. MN, male neutered. ME, male entire.
Number in brackets indicates days after surgery

515 Table 2. Complications recorded in 30 dogs treated with pantarsal arthrodesis

	Total number	Needing surgical intervention
Metatarsal screw related problem	8	2 needing screw removal
Calcaneotibial screw related problem	2	2 loose screws needing removal
Achilles tendon pain	3	2 cases needing Achilles tendon transection
Metatarsal fracture	5	3 needing removal of a metatarsal screw from fracture line
Delayed wound healing	1	1 needing implant removal to allow tension free closure
Plate failure	1	1 needing plate replacement and placement of an additional dorsal plate.
Surgical site infection	11	1 needing implant removal

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