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Risk Factors Associated with Plantar Necrosis following Tarsal Arthrodesis in Dogs

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Abstract

Objectives The aim of this study was to define landmarks of the intermetatarsal channel of the dorsal pedal artery and to assess whether damage to the dorsal pedal artery during metatarsal screw placement in dogs undergoing pan- and partial-tarsal arthrodesis (PanTA/ParTA) could be a mechanism in the development of plantar necrosis.

Study Design This study was divided in to two parts: (1) ex-vivo anatomical study: 19 canine cadavers, (2) retrospective clinical study: 39 dogs. Cadaveric dissection documented the mean intermetatarsal channel position. Metatarsal screw position was evaluated on postoperative radiographs of dogs after PanTA or ParTA. Screw position, arthrodesis type and surgical approach were assessed for their impact on complications, including plantar necrosis.

Results The mean proximal and distal extent of the intermetatarsal channel lies between 4.3% ± 1.9 and 22.8% ± 2.9 the length of metatarsal III (MTIII) respectively. The intermetatarsal channel lies within the most proximal 25% of MTIII in 95% of cases. At least one screw risked damaging the mean intermetatarsal channel position in 92% of dogs; 8% of these dogs went on to develop plantar necrosis. The mean screw position did not differ between ParTA cases with or without plantar necrosis ($p > 0.05$).

Conclusion Violation of the intermetatarsal channel is possible during metatarsal screw placement. Care should be taken when placing screws in the proximal 25% of the metatarsals, specifically avoiding exiting dorsally between MTII and MTIII and across the distal region of the intermetatarsal channel, where the perforating metatarsal artery passes interosseously, as damage may contribute to the aetiology of plantar necrosis.

Keywords
- plantar necrosis
- arthrodesis
- perforating metatarsal artery
- intermetatarsal channel
- pantarsal

Introduction

Tarsal arthrodesis is a salvage procedure to fuse joints of the tarsus. Complication rates range from 58 to 75%, including a 15% incidence of plantar necrosis.[1,2] Plantar necrosis is a potentially catastrophic complication, the aetiology of which is not fully understood. The principal blood supply to the plantar pes is from the dorsal pedal artery, which courses dorsally over the tarsometatarsal joint, and superficially in a sulcus (the intermetatarsal channel) between proximal metatarsals II and III, before passing interosseously in a dorsoplantar direction as the perforating metatarsal artery

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to supply the deep plantar arch.[3,4] The consistent pattern of soft-tissue damage in cases of plantar necrosis, as described by Roch and colleagues, suggests that vascular compromise of the dorsal pedal artery/perforating metatarsal artery, and occlusion of the collateral blood supply is the most likely aetiology.[2] Vascular compromise may occur via peripheral occlusion (e.g. preoperative or postoperative swelling, external coaptation or tight closure) and/or via direct interruption to the principal arterial blood supply, such as metatarsal screws causing compression/laceration or damage during tarsometatarsal joint debridement.[2]

Landmarks of the intermetatarsal channel have not been previously reported; therefore, its vulnerability to damage during metatarsal screw placement is unknown. This study aims to evaluate whether the dorsal pedal artery/perforating metatarsal artery is at risk of damage following metatarsal screw placement and explores the relationship between metatarsal screw position, the anatomy of the intermetatarsal channel and the development of plantar necrosis.

Materials and Methods

Data Collection

Anatomic Study

The anatomy of the intermetatarsal channel of the dorsal pedal artery and perforating metatarsal artery was evaluated in canine cadavers (ethical approval reference 2013/R358). Dogs were euthanatized for reasons unrelated to this study. The proximal and distal extent of the intermetatarsal channel was measured (►**Fig. 1**) and expressed as a percentage of the total length of metatarsal III, to allow comparison between dogs.

Clinical Study

The medical records and postoperative radiographs for dogs that underwent tarsal arthrodesis between 2004 and 2013 at the Royal Veterinary College Queen Mother Hospital for Animals and East Neuk Veterinary Clinic were reviewed retrospectively. Patients were included if they had undergone tarsal arthrodesis with plate fixation and had a minimum of 6 weeks of follow-up. Signalment, surgical indication, concurrent injuries, surgical procedure, arthrodesis type, surgical approach, complications and duration of postoperative coaptation were recorded. Calibrated postoperative radiographs were evaluated for the length of metatarsal III and the distance of the central axis of the metatarsal screws from the proximal articular surface of metatarsal III, using digital callipers. If the screw did not reach metatarsal III (MTIII), the distance from the base of MTIII to the screw tip was measured from a line that originated halfway across the joint line, and perpendicular to MTIII mechanical axis (►**Fig. 2**). Screw position was expressed as a percentage of the length of metatarsal III.

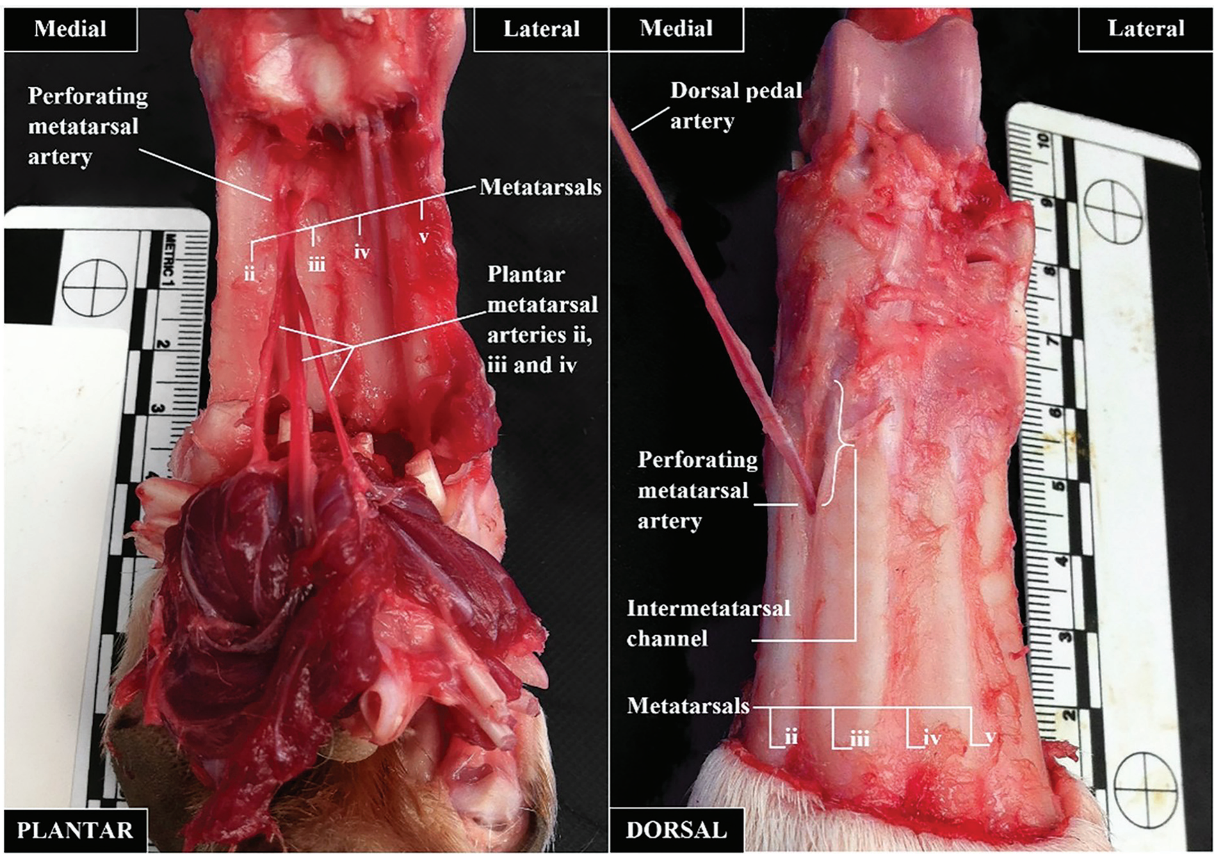

Fig. 1 Dissection photographs of the tarsometatarsal region. Left photograph: Plantar view showing the perforating metatarsal artery exiting the intermetatarsal channel to become the deep plantar arch, before trifurcating into the plantar metatarsal arteries. Right photograph: Dorsal view showing the dorsal pedal artery becoming the perforating metatarsal artery as it enters the distal end of the intermetatarsal channel between metatarsals II and III.

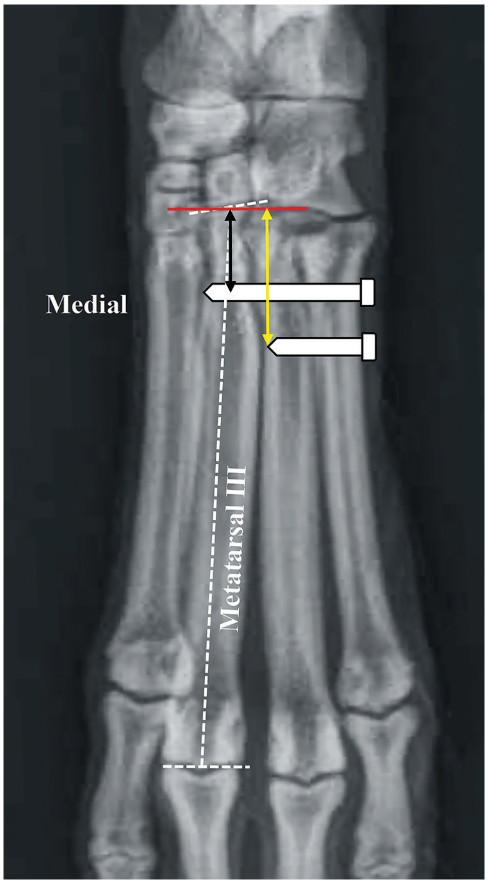

Fig. 2 Illustration showing metatarsal screw measurements on a dorsoplantar tarsal radiograph. Dashed white line indicates the proximal and distal articular surface of metatarsal III (MTIII) and the length of MTIII. The red line originates halfway across the proximal articular surface of MTIII and is perpendicular to MTIII mechanical axis. Screw measurements were taken from the red line to the central axis of the screw (black/yellow arrows).

Postoperative complications were classified according to Cook and colleagues as catastrophic, major and minor.[5] Catastrophic complications were those resulting in permanent unacceptable function, death or euthanasia. Major complications required surgical or medical intervention to resolve, and minor complications resolved without intervention.[5] Postoperative coaptation complications were reviewed separately. The term plantar necrosis was used for cases with a typical distribution of skin necrosis affecting the plantar metatarsus and the deep tissues of the metatarsal pad, as previously defined.[2] In contrast to the superficial lesions over osseous prominences that often develop with coaptation injuries, plantar necrosis lesions were characterized by a deep to superficial progression, initially presenting with skin discoloration without skin abrasions. Soft-tissue complications in other areas were considered coaptation related. In cases undergoing staged bilateral procedures, only data from the first procedure were included.

Surgical Procedure

The surgical technique was consistent with previously reported procedures for pan- and partial-tarsal arthrodesis (PanTA and ParTA).[1,2,6,7] Briefly, an open medial or lateral approach was used for PanTA and ParTA respectively.[8] Articular cartilage was debrided using a high-speed burr. For PanTA, this involved the tarsocrural joint and, depending on the injury, the intertarsal joints, the tarsometatarsal joints or a combination of both. For ParTA, this comprised debridement of the intertarsal joints, the tarsometatarsal joints or a combination of both, based on the surgical indication. Following debridement, demineralized bone matrix or autogenous bone graft was packed into the joint spaces. Premeasured and contoured bone plates were applied and fixed with screws. The proximal metatarsal screws engaged multiple cortices. All plates were placed medially for PanTA and laterally for ParTA. A calcaneotibial screw was used at the discretion of the surgeon in PanTA cases. Routine closure was performed; tension-relieving techniques were utilized where necessary. Postoperative orthogonal radiographs were taken. The East Neuk Veterinary Clinic applied modified Robert-Jones dressings in all cases; these were routinely changed at 48 hours postoperatively and then removed 5 days later. The Queen Mother Hospital for Animals used either a modified Robert-Jones dressing for approximately 6 weeks or a Robert-Jones dressing for the first 48 hours, which was replaced by rigid coaptation once swelling subsided, with a bivalve or half cast for between 6 and 8 weeks.

Data Analysis

The following variables were assessed for their influence on complication rates: metatarsal screw position, plate position, arthrodesis type (PanTa or ParTA), requirement for skin tension-relieving techniques, coaptation, hospital, age and weight. Complications were categorized as wound complications, plantar necrosis, implant loosening/breakage or surgical site infection. Cadaveric intermetatarsal channel data were grouped according to size or breed for comparison.

Normality was assessed on continuous variables using a Shapiro–Wilk test, and data were evaluated using an independent two-tailed *t*-test when testing between two groups, or a one-way analysis of variance when testing between multiple groups. Categorical variables were analysed with a Fisher's exact test. All proportions are expressed with 95% confidence intervals, and normally distributed data were expressed as mean ± standard deviation. Statistical analysis was performed using software (SPSS IBM Statistics version 21), with significance set at p-value less than 0.05.

Results

Anatomic Study

Nineteen cadaveric specimens were examined, including 11 Beagles, five Greyhounds, one Bulldog, one crossbreed and one unknown giant breed. Beagles, greyhounds and the giant breed were grouped by breed, and the similarly sized Bulldog and crossbreed were grouped together.

The most proximal and distal points of the intermetatarsal channel varied between at least two breeds ($p < 0.01$), with the length of the intermetatarsal channel increasing in larger breed dogs, ranging from 8.5mm ± 0.7 in small breeds and up to 18.0 mm in the giant-breed dog. However, the

Table 1 Breed differences in intermetatarsal channel position (expressed as a percentage of the length of metatarsal III)

		Breed					
		Crossbreed/ Bulldog	Beagle	Greyhound	Giant breed	Mean	*p*-Value
Intermetatarsal channel position (as % length of MTIII)	Proximal extent	8.7 ± 0.8	3.4 ± 0.8	4.3 ± 1.6	5.0	4.3 ± 1.9	0.000
	Distal extent	28.3 ± 5.9	22.8 ± 1.3	20.6 ± 1.9	23.0	22.8 ± 2.9	0.006
Intermetatarsal channel length (as % length of MTIII)		19.6 ± 6.7	19.4 ± 1.5	16.4 ± 3.1	18.0	18.6 ± 2.8	0.220
Intermetatarsal channel length (mm)		8.5 ± 0.7	10.8 ± 0.8	12.4 ± 1.7	18.0	11.4 ± 2.2	0.000

Abbreviation: MTIII, metatarsal III.

intermetatarsal channel length expressed as a percentage of metatarsal III did not vary between breeds, with a mean of 18.6% ± 2.8 ($p > 0.05$). The mean proximal and distal extent of the intermetatarsal channel was between 4.3% ± 1.9 (range: 1.8–9.3) and 22.8% ± 2.9 (range: 18.0–32.4) the length of metatarsal III respectively; however, this varied between breeds ($p < 0.01$; ►**Table 1**). The intermetatarsal channel lies within the most proximal 25% of MTIII in 95% of cases ($n = 18$; 95% confidence interval [CI] = 91–96).

Clinical Study

Thirty-nine dogs met the inclusion criteria for the clinical study; 15 dogs underwent a PanTA, and 24 dogs underwent a ParTA. Breeds included Labradors ($n = 7$), Border Collies ($n = 7$), crossbreeds ($n = 4$), Rough Collies ($n = 3$), Shetland Sheepdogs ($n = 3$), Springer Spaniels ($n = 2$), Greyhounds ($n = 2$), Golden Retrievers ($n = 2$) and nine dogs from breeds represented by only one dog. The median age at presentation was 6.2 years (range: 1.0–11.8) and the median weight was 23.5kg (range: 4.5–37.2); 22 were female and 17 were male. Cases are summarized in ►**Appendix 1** (available in online version only).

Indications for Arthrodesis

Indications for arthrodesis included luxation or subluxation of one or more of the tarsal joints ($n = 26$), degenerative Achilles tendinopathy ($n = 5$), tarsal osteochondritis dissecans ($n = 3$), unspecified osteoarthritis ($n = 2$), Achilles laceration ($n = 2$) and tarsal fractures ($n = 1$). Eleven dogs had concurrent fractures of the affected hock involving the tarsal bones, metatarsals, or distal tibia. Two cases had bilateral proximal intertarsal luxation and staged procedures, only the first procedure was included in the study.

Implants

Commercially available implants were used from a single manufacturer (Veterinary Instrumentation, Sheffield, United Kingdom). A hybrid PanTA plate was used most for PanTA ($n = 13$), followed by a customized hybrid medial PanTA plate ($n = 2$). A hybrid plate was mostly used for ParTA ($n = 20$), followed by a dynamic compression plate ($n = 3$) and a locking compression plate ($n = 1$). Plates were placed medially for PanTA and laterally for ParTA. Adjunctive fixation with a calcaneotibial screw was used in two PanTA cases.

Postoperative Complications

There was no difference in complication rate or Cook Scheme classification between PanTA and ParTA ($p > 0.05$). ►**Table 2** details the complication types and rates unrelated to coaptation. The overall complication rate was 36% ($n = 14$; 95% CI = 21–53). Minor complications occurred in 8% of cases ($n = 3$; 95% CI = 2–21), with two cases of metatarsal screws loosening without the need for further surgery and one minor wound complication. Major complications occurred in 26% ($n = 10$; 95% CI = 13–42) of cases, with the most common major complication being surgical site infection ($n = 6$) followed by plantar necrosis ($n = 3$). There was one

Table 2 A summary of complication types and frequencies, excluding those related to external coaptation

Complication	Catastrophic	Major	Minor	Total
Implant loosening or screw breakage	0	1	2	3
Plantar necrosis	0	3	0	3
Surgical site infection	1	5	0	6
Wound complications	0	1	1	2
Total	1	10	3	14
Percentage total of all cases ($n = 39$)	3% (95% CI = 0–13)	26% (95% CI = 13–42)	8% (95% CI = 2–21)	36% (95% CI = 21–53)

Abbreviation: CI, confidence interval.

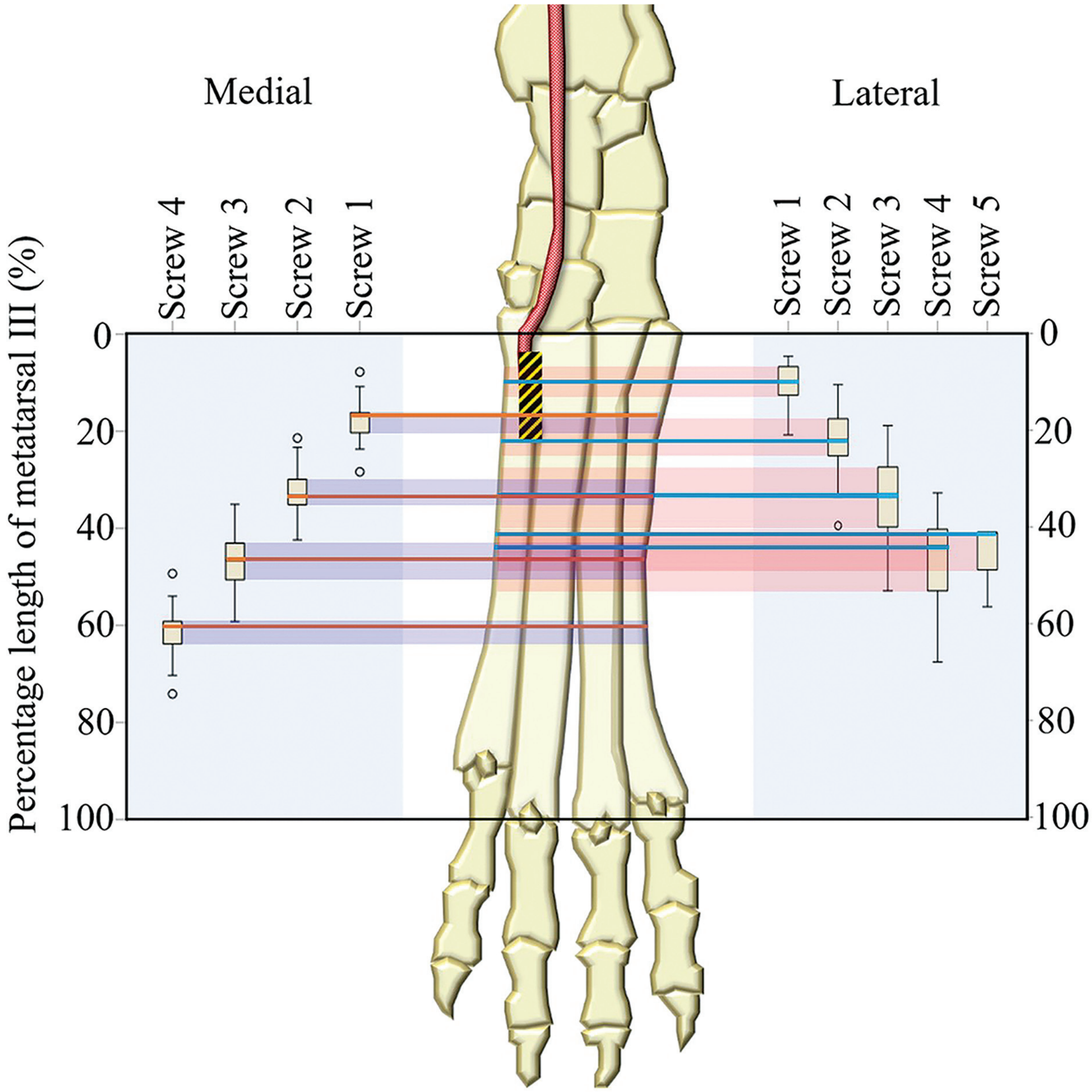

Fig. 3 Box and whisker plot showing proximodistal screw position data superimposed on an illustration of the canine pes. Image is to scale. Yellow stripes = mean intermetatarsal channel position. Red tube= dorsal pedal artery.

catastrophic complication in a dog who had undergone a ParTA and suffered a recurrence of tarsal instability following plate removal for infection 1 year postoperatively; the owner opted for amputation rather than revision surgery. There was no difference in the age and weight of dogs that experienced complications, or whether tension-relieving techniques were used ($p > 0.05$). External coaptation was used in all 39 dogs, of which seven had a bivalve cast or half cast placed and 32 had a modified Robert-Jones dressing. Coaptation type or duration had no impact on post-surgical complication rates. However, the coaptation injury rate was 21% ($n = 8$; 95% CI = 9–36).

Screw Position

Appropriate radiographs were available for review in all cases, and 156 screw positions were measured. The mean screw position, when grouped as PanTA and ParTA, was not different between cases with or without complications. This also applied to major/catastrophic complications compared with minor or no complications ($p > 0.05$).

►**Fig. 3** demonstrates the proximodistal screw position. Our data identified 34% ($n = 53$; 95% CI = 27–42) of all screws risked damaging the mean intermetatarsal channel, and 96% ($n = 51$; 95% CI = 87–100) of these screws were metatarsal screws 1 and 2. Metatarsal screw 1 was placed at the level of the mean intermetatarsal channel in 92% of cases ($n = 36$; 95% CI = 79–98), and metatarsal screw 2 was placed at the level of the mean intermetatarsal channel in 38% of cases ($n = 15$; 95% CI = 23–55). Metatarsal screw 3 was placed at the level of the mean intermetatarsal channel in 5% of cases ($n = 2$; 95% CI = 1–17), and screws 4 and 5 did not impinge on the intermetatarsal channel in any cases. It was found that

36/39 dogs (92% [95% CI = 79–98]) had at least one screw placed at the level of the mean intermetatarsal channel.

Due to the difference in plate types used for ParTA and PanTA, screws were positioned more proximally for ParTA than they were for PanTA ($p < 0.01$), with the mean screw position being within the mean intermetatarsal channel location for the most proximal two ParTA screws. PanTA screws were more distal, with only the mean position of screw 1 being within the intermetatarsal channel. The mean positions of screws 1 to 5, when grouped as ParTA and PanTA, are summarized in ►**Appendix 2** (available in online version only).

Plantar Necrosis

The overall incidence of plantar necrosis was 8% ($n = 3$; 95% CI = 2–21). Plantar necrosis occurred in 13% of lateral ParTA cases ($n = 3$; 95% CI = 3–32) and no medial PanTA cases. All cases of plantar necrosis had screw 1 positioned at the level of the mean intermetatarsal channel. Additionally, one case had the second screw placed at the level of the mean intermetatarsal channel, and another case had the second and third. However, the mean screw position did not differ between ParTA cases without plantar necrosis and those with plantar necrosis ($p > 0.05$) (see ►**Fig. 4**). Of the 36 cases with a screw positioned at the level of the intermetatarsal channel, 8% ($n = 3$; 95% CI = 2–22) went on to develop plantar necrosis. Two cases of plantar necrosis had a modified Robert-Jones dressing applied for 7 days, and the third case had a modified Robert-Jones dressing applied for 6 weeks. None of the cases had a calcaneotibial screw placed. All three cases had traumatic tarsometatarsal joint subluxation as the indication for arthrodesis. Of 11 cases with tarsometatarsal joint subluxation or luxation, three went on to develop plantar necrosis (27% [95% CI = 6–61]). Tension-relieving incisions were needed in 7/39 cases (18% [95% CI = 8–34]); of these 7 cases, 43% developed plantar necrosis ($n = 3$; 95% CI = 10–82).

Discussion

The study aimed to clarify the clinical anatomy of the intermetatarsal channel, dorsal pedal artery, and perforating metatarsal artery; evaluate whether screws were placed at the level of the mean intermetatarsal channel during PanTA and ParTA; and assess the subsequent incidence of plantar necrosis. The principal blood supply to the plantar tissues of the canine pes is from the perforating metatarsal artery which supplies the deep plantar arch.[3,4] It has been hypothesized that this may be interrupted by direct drill or screw impingement during plate application.[2] Through cadaveric dissection, this study revealed the landmarks of the intermetatarsal channel, and demonstrated that it is highly vulnerable to damage during tarsal arthrodesis, with 92% of dogs studied having at least the first metatarsal screw violating the mean intermetatarsal channel position (100% of ParTA and 80% of PanTA cases).

Despite the vulnerability of the intermetatarsal channel to screw damage during arthrodesis, this study found that 92% of cases that had a screw placed at the level of the intermetatarsal channel did not develop plantar necrosis. The anatomy of the intermetatarsal channel in a shallow dorsal sulcus between metatarsals II and III is such that it is only at risk when a screw either exits dorsally in this region or traverses at the level of the perforating metatarsal artery. From radiographs, it is not possible to plot the course of the screws in all planes; this study used the proximodistal screw position as a predictor of risk to the intermetatarsal channel. Based on this information, the placement of screws 1 and 2

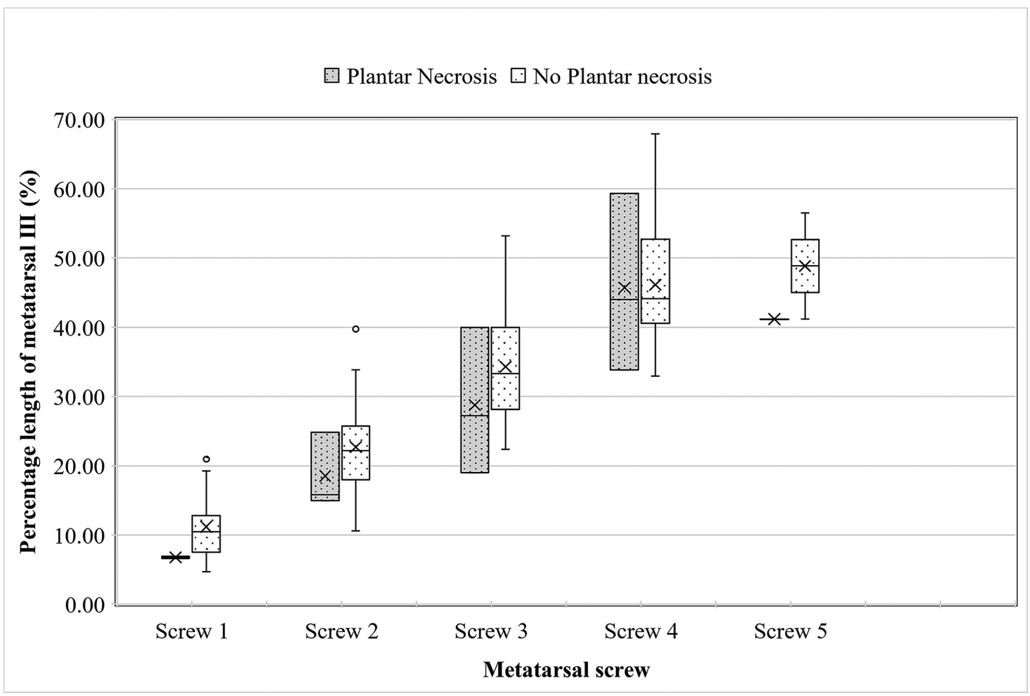

Fig. 4 Box and whisker plot showing no difference in metatarsal screw position between cases with and without plantar necrosis ($p < 0.05$). X= mean. Horizontal line= median.

poses the greatest risk of encroaching on the intermetatarsal channel; whether this occurs or not will be influenced by screw angle, plate selection and screw length. ►**Figs. 5** and **6** demonstrate how it is possible to avoid damaging the arterial blood supply and may explain the low incidence of plantar necrosis despite almost universal screw placement in this region. It is also feasible that the low incidence of plantar necrosis is due to sustained collateral blood supply in the majority of cases; damage to the dorsal pedal artery or perforating metatarsal artery may therefore be possible without subsequent development of plantar necrosis. Anecdotally, the authors have subsequently observed damage to the perforating metatarsal artery during elective ParTA for non-traumatic calcaneoquartal instability, without development of plantar necrosis. However, minimal swelling occurred, and collateral circulation appeared uninterrupted. Conversely, the authors have also observed ischaemia necessitating pelvic limb amputation following ParTA for traumatic calcaneoquartal/tarsometatarsal luxation; the case required tension-relieving incisions, and postoperative dissection revealed thrombosis of the dorsal pedal artery secondary to screw impingement.

Plantar necrosis has previously been associated with medial plating; however, in our study, plantar necrosis occurred only in lateral ParTA cases, with 13% of laterally plated cases developing plantar necrosis.[2] In a previous study, plantar necrosis was reported to occur in 33% of medial plates and 4% of lateral plates.[2] There is therefore no consistent evidence that plantar necrosis is associated with plate laterality. Tarsometatarsal joint debridement and tight closures have also been previously postulated as risk factors for plantar necrosis.[1,2] Interestingly, all three cases that developed plantar necrosis in this study had tension-relieving incisions and traumatic tarsometatarsal joint injuries. Tarsometatarsal joint luxation presents an opportunity for shearing injuries to occur to the dorsal pedal artery at the time of injury, and damage may also occur during tarsometatarsal joint debridement. A recent study of 30 dogs undergoing PanTA reported no cases of plantar necrosis.[1] Anesi and colleagues postulated that this was due to the care they took with tarsometatarsal joint debridement, debriding only medially and ventrally, and burring osseous prominences to reduce skin tension.[1] It is notable, however, that none of the dogs in that study underwent arthrodesis due to tarsometatarsal joint injury. Conversely, all of the plantar necrosis cases in this study and 67% of cases in Roch's study had subluxation of the tarsometatarsal joint.[2] Anecdotally, the tarsometatarsal joint region is often the tightest region to close; therefore, swelling in this region may increase skin tension and the risk of a postoperative biological tourniquet effect. The number of tarsometatarsal joint luxation cases was too small to perform statistics on; however, based on our preliminary data, the authors postulate that damage to the tarsometatarsal joint may be a risk factor in the aetiopathogenesis of plantar necrosis, and future studies should look to investigate this.

Further studies are needed to identify all the contributory factors leading to plantar necrosis, but the authors theorize

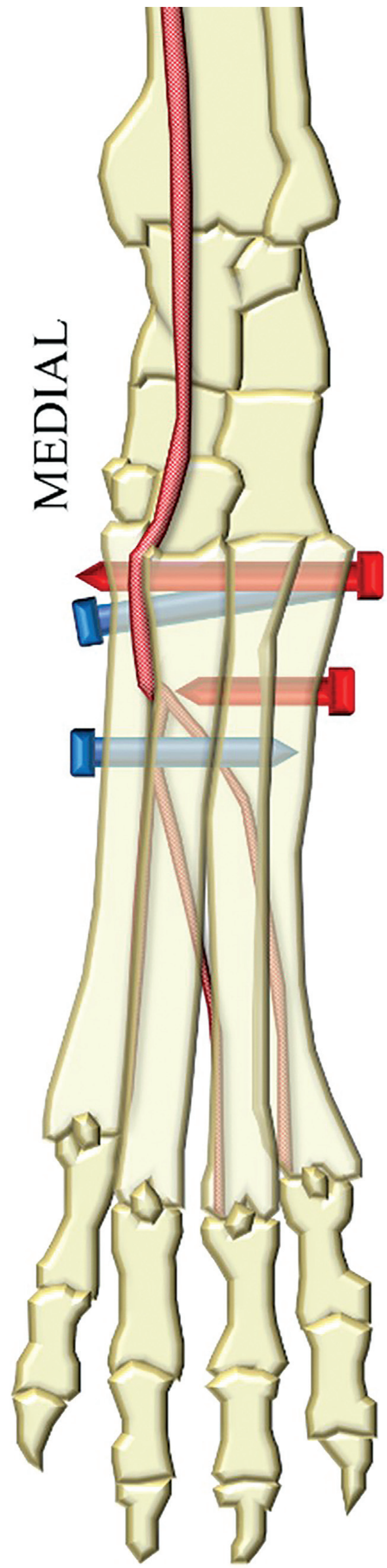

Fig. 5 Dorsoplantar illustration of the distal pelvic limb showing a proposed safe corridor approach for the proximal two medial and lateral metatarsal screws, avoiding the intermetatarsal channel and the perforating metatarsal artery.

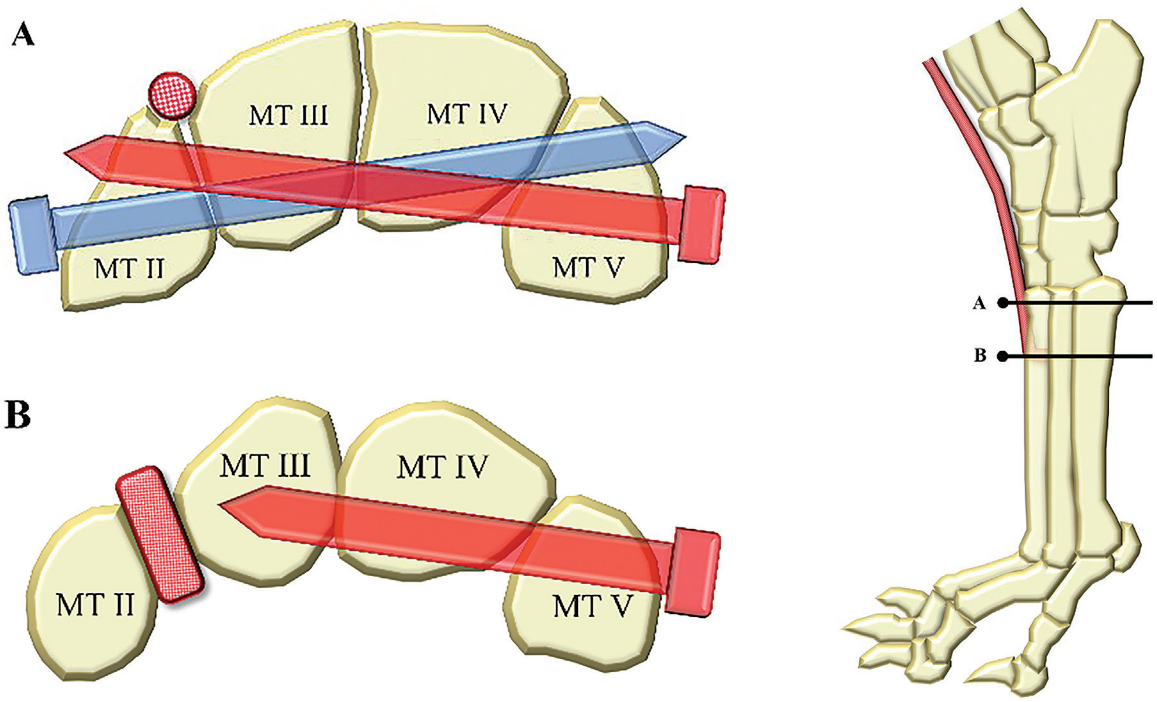

Fig. 6 Illustration showing transverse sections (**A** and **B**) through the metatarsals (MT) at levels indicated by the accompanying diagram of the distal pelvic limb, demonstrating the safe corridor to the proximal MT region, avoiding the intermetatarsal channel and the perforating MT artery. (**A**) Proximal extent of the intermetatarsal channel. (**B**) Interosseous segment of the perforating MT artery. Red circle= dorsal pedal artery within the intermetatarsal channel. Red rectangle= perforating metatarsal artery.

that plantar necrosis is unlikely to occur due to isolated damage to the perforating metatarsal artery. However, until further angiographic studies can clarify this, it appears prudent to take particular care with placement of screws 1 and 2 when performing a ParTA with a lateral plate and with screw 1 when performing a PanTA with a medial plate. This study shows that the intermetatarsal channel is expected to lie in the most proximal 25% of metatarsal III in 95% of cases. Using the dimensions recorded in this study and a calibrated radiograph, the surgeon can calculate the expected length and position of the intermetatarsal channel in their patient. Intraoperatively, the dorsal pedal pulse can also be palpated between metatarsals II and III to aid in confirming the location of the intermetatarsal channel. ►**Figs. 5** and **6** outline the proposed safe corridor to the metatarsal region to reduce the probability of damaging the interosseous part of the perforating metatarsal artery. The distal extent of the intermetatarsal channel is where the perforating metatarsal artery passes between the metatarsals and is most at risk of screw perforation, being relatively immobile and therefore vulnerable to damage as it passes interosseously. Therefore, with a lateral approach, surgeons are advised to place screw 1 proximally and plantarly, away from the dorsally situated intermetatarsal channel and the perforating metatarsal artery. Furthermore, when placing screw 2, the transcortex of metatarsal III should not be perforated with either the drill bit or the screw because the perforating metatarsal artery will be in this region. Further screws can be placed routinely, below 25% of the length of MTIII. For a medial approach, particular attention should be paid to the placement of the first metatarsal screw, angling it proximally and plantarly to avoid traversing the distal interosseous perforating metatarsal artery position and to keep it below the intermetatarsal channel dorsally. The 2nd, 3rd and 4th metatarsal screws can be placed routinely below 25% of the length of MTIII. However, angled approaches are only achievable for non-locking or polyaxial screws.

There are several limitations to this study. Due to the retrospective nature of the study, the author's ability to evaluate surgical decision-making or which joints were debrided was constrained by the accuracy of clinical records. In addition, the intermetatarsal channel position was found to lie in the proximal 25% of MTIII in 95% of cases; however, there was one outlier at 32.4%. In the clinical setting, there may therefore be a low risk of interrupting the intermetatarsal channel beyond the proximal 25%. Furthermore, the sample population was heterogenous, and the reasons for arthrodesis varied. Tarsal arthrodesis is an uncommon surgery and therefore the sample size is relatively small; it should therefore be noted that type II statistical errors are possible.

Additional studies investigating the timing between injury and surgery are recommended. Swelling caused by the primary injury could be a factor in the constriction of the collateral vessels. In human medicine, current recommendations regarding timing of surgery vary widely, although there is little argument that oedema impairs tissue microcirculation and perfusion, which are critical to the cellular processes of healing.[9–11] Therefore, until further research is available, the authors recommend postponing surgery until swelling subsides. The use of negative pressure wound therapy in the prevention and treatment of plantar necrosis should also be explored, as it has been shown to promote wound contraction with diminished tensile forces, decrease oedema, remove excess fluid and stimulate blood flow.[12–15]

In conclusion, the vulnerability of the dorsal pedal artery and perforating metatarsal artery during tarsal arthrodesis is highlighted. Although it is not possible to confirm that damage to the dorsal pedal artery and perforating metatarsal artery is the primary cause of plantar necrosis, these data support the notion that damage to this region could, in conjunction with collateral circulation occlusion, contribute to the aetiopathogenesis of plantar necrosis. The low incidence of plantar necrosis, despite this vulnerability, reinforces the theory that plantar necrosis is unlikely to result from isolated damage to the dorsal pedal artery or perforating metatarsal artery. Therefore, the authors propose that disruption of both the principal and collateral blood supply is required for plantar necrosis to occur. Consequently, until prospective angiographic studies in cases of plantar necrosis are available to more accurately clarify the potential for damage during screw placement, it is advisable to be cautious with screw angulation in the region of the intermetatarsal channel and perforating metatarsal artery.

Authors' Contribution

K.L.H contributed substantially to study design, drafting, revisions and final approval. R.L.M and E.K contributed to study concept, design, revisions and final approval. M.J.P helped in data collection, study concept, design, revisions and final approval. L.M and J.F.F helped in data collection, study concept, design, revisions and final approval.

Animal Care

This research was conducted following approval from the RVC Clinical Research Ethical Review Board and with informed owner consent. Ethical approval reference 2013/R358.

Funding

None.

Conflict of Interest

None declared.

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