The use of an external skeletal traction device for distal fractures in the dog

A clinical case series of 11 patients

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Summary

Metacarpal and metatarsal fractures in 11 patients were treated ‘closed’ with a specially designed External Skeletal Fixation (ESF) frame with a walking bar and traction applied to the digits. Mediolateral angulation had improved postoperatively in 10 of the 11 patients. Cranio-caudal angulation had improved in eight patients and could not be evaluated in three due to ESF frame superimposition. At follow-up, eight patients had a good clinical function, whereas three patients were still slightly lame. Only minor ESF-related complications were seen (pin loosening, pin tract infection, cerclage wire breakage and bending of the frame), which resolved without intervention after frame removal.

Keywords

Fractures, external skeletal fixation, dogs

Introduction

The currently described methods for multiple or displaced metacarpal and metatarsal fractures include several types of internal fixation. External coaptation is usually reserved for single, closed, non-displaced fractures (1–4). In proximal and distal fractures, only a very limited amount of bone is available for fixation. This can create problems in obtaining and maintaining reduction, as well as in providing stability, especially in comminuted fractures. Additionally, the incidence of open metatarsal and metacarpal fractures was high in the present study, presumably due to limited soft tissue coverage. This adds to the risk of postoperative complications if internal fixation is used, while also making external coaptation less desirable. External fixation would therefore be indicated in these cases. Traction devices are commonly used in fracture treatment in human medicine. However, this usually involves bed rest, which is not feasible in veterinary medicine. Our goal was to design, describe and evaluate an external skeletal fixation device that would make it possible to apply and maintain traction to distal appendicular fractures in dogs.

Materials and methods

Medical records of clinical patients with metacarpal or metatarsal fractures, treated with a traction External Skeletal Fixation (traction-ESF) device, were assessed. Only patients with a complete follow-up were included. Follow-up consisted of clinical, orthopaedic and radiographic examinations every two to three weeks.

All of the patients were treated with a type II ESF with a distal ‘walking’ bar connected to the frame. Briefly, two to three pins were placed in the tibia or radius, either with a chuck or a power drill. Smooth pins were introduced under a 30° angle to the bone surface to prevent frame displacement due to pin loosening. Centrally threaded pins were placed perpendicular to the bone, parallel to one another and to the joint surfaces, after predrilling with a smooth pin with the same diameter as the non-threaded part. The pin through the digit was placed using a chuck, while digitally stabilizing the phalanx. The cerclage wire was placed after predrilling with a larger size pin. Bilateral bars were used in a size that was appropriate for the weight of the dog, and Meynard Clamps (Veterinary Instrumentation, Sheffield, UK) were used to connect the pins to the bars. The bilateral bars were bent to accommodate for the joint (tarsus or carpus) angle and connected distally using a horizontal bar and two Meynard clamps to create a ‘walking bar’. In order to augment frame strength in cases with bent frames, a second straight bar was placed bilaterally, connected both proximally and distally to the same bar. Cerclage wire was used to apply traction between the distal limb and the walking bar. The method of applying the cerclage wire differed slightly among the patients. In four patients, traction was applied using a cerclage wire directly applied to the proximal phalanx of one or two digits: ‘direct traction-ESF’ (Fig. 1A). A modified, indirect traction-ESF system was used consistently in the remaining seven patients: ‘indirect traction-ESF’. In the modification, a small diameter pin was placed through the proximal phalanx of the two middle digits and
Fig. 1  A) A schematic line drawing of the direct traction-ESF. Traction is applied directly to a digit using cerclage wire. B) A schematic line drawing of the single cerclage wire indirect traction-ESF. The traction is generated by a cerclage wire between a pin and the ESF frame, placed inbetween the middle digits, and is therefore applied indirectly. C) A schematic line drawing of the double cerclage wire indirect traction-ESF. The traction is generated by two cerclage wires between a pin and the ESF frame, placed abaxial from the middle digits, and is therefore applied indirectly.

Fig. 2  Immediate postoperative radiographs of a direct traction-ESF applied to the P1 of D4 to stabilize a comminuted distal fourth metatarsal shaft fracture (Case #3). Good alignment was obtained.

Table 1  Summary of the fractures, their management and additional injuries. In the direct traction-ESF, cerclage wires were attached directly to the proximal phalanx (P1) or distal phalanx (P3) of one or more weightbearing digits (D3 and/or D4). In the indirect traction-ESF a pin was placed transversely through the proximal phalanx of the third and fourth digit and was attached to the walking bar with either one or two cerclage wires (number of wires between brackets).

<table>
<thead>
<tr>
<th>No.</th>
<th>Bones</th>
<th>Fracture</th>
<th>Traction type</th>
<th>Associated injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MT2–5</td>
<td>Open, comminuted, shaft</td>
<td>Direct to D3 &amp; D4 (P3)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>MT2–5</td>
<td>Closed, transverse, distal</td>
<td>Indirect to D3 &amp; D4 (P1)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>MT4</td>
<td>Closed, comminuted, distal</td>
<td>Direct to D4 (P1)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>MC2–5</td>
<td>Open, transverse (MT2–4),</td>
<td>Direct to D3 &amp; D4 (P1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>comminuted (MT5) shaft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>MT2–5</td>
<td>Closed, comminuted, distal</td>
<td>Direct to D3 &amp; D4 (P1)</td>
<td>Ipsilateral tibial fracture</td>
</tr>
<tr>
<td>6</td>
<td>MT2–5</td>
<td>Closed, transverse, proximal</td>
<td>Indirect to D3 &amp; D4 (P2)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>MT2–5</td>
<td>Open, oblique, distal</td>
<td>Indirect to D3 &amp; D4 (P1)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>MT2–5</td>
<td>Closed, transverse, distal</td>
<td>Indirect to D3 &amp; D4 (P1)</td>
<td>Ipsilateral ilial fracture</td>
</tr>
<tr>
<td>9</td>
<td>MT2–5</td>
<td>Open, transverse, distal</td>
<td>Indirect to D3 &amp; D4 (P1)</td>
<td>Luxation MT5-D5</td>
</tr>
<tr>
<td>10</td>
<td>MT4.5</td>
<td>Closed, transverse, shaft</td>
<td>Indirect to D3 &amp; D4 (P1)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>MC2–5</td>
<td>Open, comminuted, shaft</td>
<td>Indirect to D3 &amp; D4 (P1)</td>
<td></td>
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</tbody>
</table>
either one cerclage wire was looped around the pin, between the two digits (Fig. 1B), or two cerclage wires were used, one placed medially and the second placed laterally to the two digits (Fig. 1C). At this point, the pin was placed through Meynard Clamps, but without tightening the clamps. Traction was applied by tightening the cerclage wire to the walking bar of the external fixator, after which the Meynard Clamps holding the pin were tightened. All frames were designed by the second author.

The case records and radiographs (orthogonal views) were evaluated by three observers, each in one separate session for initial displacement, postoperative displacement, complications, apposition postoperatively, final mediolateral angulation, as assessed on the dorsoplantar or dorsopalmar (DP) views, final cranio-caudal angulation on the mediolateral views and functional outcome as assessed by the orthopaedic clinician performing the clinical and orthopaedic examination during the follow-up. The total follow-up periods ranged from one month to eight years (mean 13 months, median three months).

### Results

Eleven patients (all dogs) were included (seven female, four male). Body weights ranged from three to 35 kg (mean 19, median 21 kg). Their ages ranged from six to 53 months (mean 22, median 23 months). Nine dogs had metatarsal fractures, two had metacarpal fractures. Four bones were fractured in nine patients, one bone in one patient and two in one patient. Therefore, a total of 39 fractures were included (13 comminuted and 26 simple). Five patients had open fractures, whereas the fractures were closed in six patients, therefore the incidence of open fractures was 45%. Aetiologies ranged from gunshot [1], bite wound [1], road traffic accident [4], a fall from the stairs [1], a vase falling on the leg [1], being kicked by a horse [1], while in two cases the cause was unknown. The duration between the incident and admission at our clinic ranged from one to 15 days (mean 3.4 and median one day).

Angulation preoperatively ranged from 3–45° on the DP radiographs and from 3–28° on the lateral view. Postoperative mediolateral angulation (DP radiographs) had improved in 10 of 11 patients and had worsened in one patient. Postoperative cranio-caudal angulation on the lateral radiographs had improved in eight patients and, due to superimposition of the ESF could not be evaluated in three patients. The angulation on the final follow-up radiographs was less than 5° for both views in nine cases. In one case, the final angulation was 10° on the lateral view, although it had improved from 18° preoperatively (angulation on the DP view was 0°). The second case had a postoperative angulation of 16° on the DP view (preoperative 6°) without any angulation on the lateral view.

Apposition, as measured by percentage bone contact, and as judged from individual radiographs, had improved postoperatively in all of the cases. In 10 cases the apposition had improved on both views, whereas in one case, the angulation worsened on the lateral view, whereas the ESF was improved.

### Table 2  
Summarized radiographic results. The radiographic angulations preoperatively (preop.) and at the final examination (Final) were measured. Pre- and postoperative apposition was judged on individual radiographs. DP = Dorsoplantar or dorsopalmar projection; lat = mediolateral projection; np = measurement not possible (ESF superposition); m = missing, MT = metatarsal, MC = metacarpal. Le = left, Ri = right.

<table>
<thead>
<tr>
<th>No. bones</th>
<th>DP</th>
<th>lat</th>
<th>Postop.</th>
<th>Final</th>
<th>Preoperative</th>
<th>Postoperative</th>
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<tr>
<td>MT2–5</td>
<td>10</td>
<td>5</td>
<td>0</td>
<td>4</td>
<td>25–50</td>
<td>75–100</td>
</tr>
<tr>
<td>MT2–5</td>
<td>23</td>
<td>5</td>
<td>np</td>
<td>0</td>
<td>75–100</td>
<td>near 100</td>
</tr>
<tr>
<td>MT4</td>
<td>3</td>
<td>3</td>
<td>np</td>
<td>0</td>
<td>75–100</td>
<td>near 100</td>
</tr>
<tr>
<td>MC2–5</td>
<td>15</td>
<td>15</td>
<td>1</td>
<td>0</td>
<td>0–25</td>
<td>75–100</td>
</tr>
<tr>
<td>MT2–5</td>
<td>10</td>
<td>28</td>
<td>3</td>
<td>np</td>
<td>25–50</td>
<td>75–100</td>
</tr>
<tr>
<td>MT2–5</td>
<td>34</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>25–50</td>
<td>75–100</td>
</tr>
<tr>
<td>MT2–5</td>
<td>20</td>
<td>28</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>75–100</td>
</tr>
<tr>
<td>MT2–5</td>
<td>12</td>
<td>m</td>
<td>5</td>
<td>np</td>
<td>50–75</td>
<td>75–100</td>
</tr>
<tr>
<td>MT2–5</td>
<td>30</td>
<td>6</td>
<td>0</td>
<td>5</td>
<td>25–50</td>
<td>50–75</td>
</tr>
<tr>
<td>MT2–5</td>
<td>45</td>
<td>18</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>75–100</td>
</tr>
<tr>
<td>MC2–5</td>
<td>6</td>
<td>10</td>
<td>0</td>
<td>16</td>
<td>75–100</td>
<td>75–100</td>
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</tbody>
</table>

![Fig. 3](image-url)  
Immediate postoperative radiographs of an indirect traction-ESF applied to P1 of the third and fourth digits to stabilize simple distal shaft fractures of the second, third, fourth and fifth metatarsal bones. Slight angulation is present in the second metatarsal bone and rotation in the fourth metatarsal bone. Overall angulation was estimated at 5°.
patient improvement was seen on one view without any significant increase or decrease in bone contact on the second (DP) view. This case had also deteriorated in angulation postoperatively on the same view. The fractures treated with direct traction (Fig. 2) had better alignment than those treated with indirect traction (Fig. 3). Loss of alignment was seen in two cases, both treated by indirect traction.

Only minor complications were noted during follow-up: premature pin loosening was seen in three cases. The ESF frame was removed at the time when the pin loosening was seen. Pin tract infections were seen in two cases, but were resolved without any intervention after the fixator had been removed. Slight bending and breakage of the cerclage wire were seen in one case, respectively. The bending did not require any intervention, and the wire breakage was noted at the time when the fixator could be removed, thus making replacement unnecessary.

Healing and fixator removal was at a mean of 45 days postoperatively (median 50 days; range 19–77 days). Subjectively, eight patients had a good functional outcome as assessed at final follow-up at our clinic, whereas three patients were still lame. Two of these three patients did not have full radiographical bone union at that time. Radiographically, nine out of 11 patients had full union at the time of fixator removal.

Discussion

The incidence of patients with fractures of four metacarpal or metatarsal bones was higher (80%) than in previously reported studies. In one previously reported retrospective study, an incidence of 41% was found in 37 patients (5), while in a second study, in a comparison of surgical versus conservative treatment, a 59% incidence was found in animals with four fractures (6). A possible explanation for the higher number in our study might be a bias towards more severe cases, as only surgically managed fractures were included.

We found a high percentage of metatarsal fractures (81%), whereas the reported percentage was 37% in both previously published studies (5, 6). We hypothesized that the selection of surgically managed fractures might have contributed to this high percentage, but when we looked at all metacarpal and metatarsal fractures treated in our clinic, the percentage was only slightly lower (77%).

The current literature states that shaft fractures of the metacarpal and metatarsal bones can be treated with external coaptation. However, internal fixation is advisable if two or more bones are involved, especially if they are the middle bones (1–4).

The outcome after surgical versus conservative management has been compared in recent studies and surprisingly those authors did not find any statistical difference between the two methods (5, 6). This led Kapatkin et al. to conclude that the published criteria for internal fixation may not be accurate (6). Although conservative therapy was not found to improve alignment, this was not related to the outcome (5).

Several surgical techniques are described for treating metacarpal and metatarsal shaft fractures, most of which use small plates or IM pins (1–4). However, in comminuted or very proximal or distal fractures, the practical application of these techniques might be difficult. For fractures of the base (proximal) or the head (distal) of metacarpal and metatarsal bones, a tension band wire technique or lag screw placement have been advocated, although external coaptation can be used if the fractures are non-displaced (1).

Kapatkin et al. found a difference in the recovery time between conservative therapy (median seven weeks) and surgical therapy (median 12 weeks) (6). In the current study, recovery time was 6.3 weeks, which compares favourably with the recovery time after internal surgical therapy that was found in the article by Kapatkin et al.

Surgical salvage of comminuted metatarsal fractures was previously described using intramedullary pins and epoxy resin putty, applied distally together with a fibre-glass cast (7). Those authors felt that the fractures were too comminuted distally to use external fixation therapy, while external coaptation was not an option because of the comminution and displacement. The fractures healed with minor malalignment and slight osteoarthritic changes in the ipsilateral hock. Although this method was successful in the case described, it might prove difficult to apply that technique to proximal metatarsal or metacarpal fractures and in smaller breeds, making it less versatile than the traction-ESF device described in the current article.

All but one of the surgically treated dogs in the study by Kapatkin et al. had a postoperative splint (6), which is also advised in the current literature to augment the internal fixation (1). One of the benefits of an ESF is the accessibility for wound care, if necessary.
The novelty in the ESF frame described in the current study is obtaining and maintaining alignment of the fractures by applying traction on the digits. Several traction systems have been described in the human orthopaedic literature for distal extremities, among which a ‘pins & rubbers’ device (Suzuki device, Fig. 4) is the most commonly used (8–11). This device uses rubber bands to exert traction for comminuted fractures or fracture-dislocations of the hand; the rubber bands are connected bilaterally to transversely placed Kirschner-wires. This system would not have been sufficiently strong for use in animals and in addition, the rubber bands allow for flexion and extension exercises, which is not necessary in metatarsal and metacarpal fractures in small animals. Therefore, a more rigid and stronger system was used in our cases, although the principle of traction was maintained.

The majority of the fractures had an improvement in both alignment and apposition postoperatively. Those treated with direct traction maintained the improved alignment better than those with indirect traction.

In multiple metatarsal or metacarpal fractures, that are not amenable to internal fixation or external coaptation, the traction-ESF device can provide a valuable alternative in fracture management. This is especially beneficial if the wounds are infected and require frequent attention and dressing. Direct traction to the fractured digit is more beneficial for obtaining and maintaining alignment than indirect traction, but both types of traction lead to a functional outcome.

Addendum

In recent cases, a second, more distal horizontal bar has been added to protect the twisted ends of the cerclage wires. A photograph, preoperative and postoperative radiographs of this case are shown in Fig. 5.

References


Fig. 5  A direct traction-ESF. A) A photograph, immediately postoperatively of a direct traction-ESF applied to the left front limb. Traction is applied to P1 of the fourth and fifth digit. A second walking bar has been placed to protect the twisted ends of the cerclage wires. An open fracture of the fifth metatarsal bone is present and a loose bone fragment had been removed while the wound was debrided. B) Preoperative DP radiographs of the left metatarsus. Comminuted distal fractures with medial butterfly fragments of the fourth and fifth metatarsal bones are visible, with additionally chip fractures of the head of the fourth metatarsal bone. Displacement and lateral angulation of the distal bone ends are evident. C) Immediate postoperative radiographs of the same dog, showing improved alignment of the fourth and fifth metatarsal bone. The butterfly fragment of the fourth metatarsal bone is not apposed and is slightly displaced medially. The butterfly fragment of the fifth metatarsal bone has been removed and a gap is present between the proximal and distal bone ends. A cerclage wire through the heads of the first phalanx of the fourth and fifth digit is present and is attached to a horizontal bar of the ESF frame.

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