

# Long-term prognosis of metacarpal and metatarsal fractures in dogs

## A retrospective analysis of medical histories in 100 re-evaluated patients

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### Keywords

Dog, fracture, metacarpus, metatarsus, conservative treatment, surgical treatment, prognosis

### Summary

**Objectives:** Lameness after metacarpal and metatarsal fractures in dogs is reported to occur with an incidence of 18% to 70%. On the basis of long-term results, the prognosis of these injuries was re-evaluated retrospectively.

**Methods:** Medical records of 100 dogs with complete clinical and radiographic follow-up examinations after an average of four years (4 months – 14 years) were evaluated. According to their treatment, patients were allocated to three groups (Group 1 = conservative, Group 2 = surgical, Group 3 = combined). Assessment included complications during the healing period and the final radiographic and functional outcome, which was statistically compared for differences between groups (Fisher exact test, exact Wilcoxon-Mann-Whitney test). Further, risk factors for each bone were analyzed (stepwise, multiple logistic regression model). In 15 dogs, kinetic data (relative stance phase, peak vertical force and impulse) were investigated by computed gait analysis.

**Results:** Complications were observed in 11 of 67 (16%) conservatively, in three of 25 (12%) surgically, and in three of eight (37%) conservatively and surgically treated dogs. Overall frequency of lameness evaluated by visual clinical assessment was three percent. Frequency of osteoarthritis and nonunion was also low, accounting for three percent and one percent respectively, although healing of mainly single-bone fractures resulted in malunions in 14% radiographically. Synostoses were found in 19% of patients, and significantly more frequent in surgically treated dogs. A higher risk of complications was identified for metatarsal compared to metacarpal fractures. Further, an increased risk for complications was detected for a higher degree of displacement and instability.

**Clinical significance:** According to the long-term results found in this study, the prognosis for metacarpal and metatarsal fractures is better than reported in the literature to date. With the reservation that more severe injuries are generally treated surgically, and these fractures more frequently developed synostosis, no significant difference could be detected between conservative and surgical treatment.

## Introduction

Metacarpal and metatarsal fractures in dogs are reported to occur with an incidence of up to 11.9% of all fractures (1, 2). They are diagnosed in dogs of all ages but are most frequent in young and male dogs. The most common causes are motor vehicle accidents and falls, except in the case of racing greyhounds, in which stress fractures of single bones (left metacarpal 5, right metacarpal 2, right metatarsal 3) typically occur (2–7). Concurrently, severe soft tissue injuries of the paw and fractures of the phalanges, the pelvis, and the long bones are reported (3, 4). Metacarpal and metatarsal fractures are classified according to their anatomical location as fractures of the base, the body, the head, and the physis (3). There is an almost equal distribution of fractures of the metacarpus and metatarsus, although a tendency towards a greater frequency of fractures of the metacarpus has been reported (4, 8). Most metacarpal and metatarsal fractures are closed, transverse, or oblique fractures (3, 4).

Treatment options for metacarpal and metatarsal fractures include external coaptation using a variety of splint types and various surgical methods such as intramedullary pinning and their modifications (3, 4, 8–17). In addition, the use of tension bands, lag screws, bone plates, and external skeletal fixation has been described (3, 5, 11, 18–23). Indications for the treatment of these fractures that have been described in the literature are conflicting (24). However, there is agreement on the conservative management of mildly displaced, single-bone fractures (3, 4, 8, 10, 11, 18). Surgical

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therapy is recommended for cases with more than two fractured bones, and when the main weight-bearing third and fourth metacarpal and metatarsal bones are affected. Furthermore, surgical therapy is also recommended in articular fractures, avulsion fractures of the base, in severely displaced or open fractures, and in large breeds and working dogs (3, 4, 8, 10, 11).

A high incidence of lameness (18–73%) after conservative and surgical treatment of metacarpal and metatarsal fractures is reported in the literature (► Table 1). Kapatkin and colleagues therefore questioned the validity of these veterinary guidelines and hypothesized that they are extrapolated from the human literature and are not accurate for dogs – in particular, their conclusions were proposed because a significant difference between conservative and surgical treatment was not noted (9). Long-term studies that compare the different results obtained with conservative and surgical therapy for the treatment of metacarpal and metatarsal fractures are lacking (24).

This study therefore aimed to assess the long-term results of, and the validity of indications for, the conservative and surgical treatment of metacarpal and metatarsal fractures in dogs.

## Materials and methods

### Study design

The medical records and radiographs of all dogs with metacarpal and metatarsal fractures that were presented to the Clinic for Small Animal Surgery and Reproduction at the Ludwig-Maximilians-University in

Munich from 1990 to 2007 were retrieved from the medical record database. Complete medical records and radiographs with a minimum of four months follow-up met the inclusion criteria of this retrospective study.

### Fracture data

The information regarding age and body weight of the dogs as well as the cause of trauma was extracted from the medical records. After reviewing orthogonal radiographs, the fractures were classified by one veterinarian (MK) according to the affected bones (metacarpals 1–5, metatarsals 1–5), localization (base, body, physis, head), fracture type (fissure or greenstick fracture, transverse, oblique, butterfly fragment, comminuted, articular) and the degree of displacement (grade 1 = < 50% of the diameter of the bone; grade 2 = 50–100%; grade 3 = >100%).

### Fracture treatment

The fractures of each case were further classified into three groups, according to the method of treatment: Group 1 = conservative, Group 2 = surgical, Group 3 = combined treatment. Outcome was evaluated at an average of four years (minimum 4 months, maximum 14 years) post-trauma. The dogs had been re-examined several times at the same clinic; therefore, early complications, which were seen during the healing period could also be detected. Final assessment was based on the last radiographic and functional results available.

## Complications and radiographic outcome

Early complications were categorized as delayed union, osteomyelitis and implant failure. Two radiographic views of both forelimbs or hindlimbs were available for comparison. Radiographs from the last follow-up examination were interpreted by two investigators (MK, KZ\*). Fracture healing was assessed for signs of malunion, osteoarthritis, nonunion and synostosis.

## Functional outcome

### Clinical assessment

Lameness was graded as present or absent. In 16 dogs (11 dogs of Group 1, 3 dogs of Group 2, and 2 dogs of Group 3), clinical examination had been performed by various veterinarians and the information was extracted from the medical records, whereas 84 dogs were assessed by one investigator (MK).

### Computed gait analysis

Fifteen dogs were evaluated by computed gait analysis owing to patient or client compliance (► Appendix Tables 1–3: available online at [www.vcot-online.com](http://www.vcot-online.com)). Vertical ground reaction forces were measured on a treadmill with four integrated force plates<sup>a</sup> (25). Measurements were performed with a mean treadmill velocity of 0.6 m/s. Only gaits in which each paw was placed on one force plate and which had a minimum of

a Kistler\*, Winterthur, Switzerland

**Table 1** Overview of the outcome after conservative and surgical treatment of metacarpal and metatarsal fractures of dogs in the literature.

Author	Time period	Number patients	Patients available for follow-up	Number conservative / surgical	Observation time	Outcome (Number that were lame)			
						Conservative treatment	%	Surgical Treatment	%
Lösslein (3)	1975–81	178	96	69 / 27	2–72 months	15	22	12	44
Manley*(8)	1978–80	35	31	21 / 10	4–26 months	10	48	7	70
Kapatkin (9)	1986–96	25	19	10 (16) / 9	9–68 months	7	44	2	22
Muir (4)	1987–96	37	25	14 / 11	NR	NR	NR	2	18
Total	1975–96	275	171	114 / 57	2–72 months	32	28	23	40

**AUTHORS:** \*From this study we included combinations of metacarpal/metatarsal and phalangeal fractures, and excluded phalangeal fractures. NR = not reported

**Figure 1**

Dorso-palmar and medio-lateral radiographic views in a four-year-old German Shepherd dog from Group 1 (dog 34) taken before (A), immediately after (B), and approximately 10 years after (C, D) external coaptation of diaphyseal fractures of the second to fifth metacarpal bones. The dog was not lame.



five valid trials were used for analysis. Relative stance phase (% total step), peak vertical force (% body weight), and impulse (% BW\*s) were derived using motion analysis software<sup>b</sup> and normalized by the mass of each dog. Data were analyzed for lameness using the symmetry index and a cut-off value of 10 was determined based on healthy dogs at our institution (unpublished data, 26). Examinations were performed by one veterinarian (MK) and interpreted independently by two clinicians (MK, SS\*)

### Data analysis

In dogs with fractures of three or four bones ( $n = 49$ ), the groups were compared for the frequency of complications during the healing period as well as the radiographic and functional results by means of the generalized Fisher exact test (Fisher – Freeman – Halton – test). The Pearson chi-square test could not be used because the minimum estimated expected values were too small. For ordinal scaled variables, the group comparison was done by the exact Wilcoxon-Mann-Whitney test. For the identification of risk factors for compli-

cations, several influencing factors (treatment group, body mass, age, cause of injury, open or closed fracture, concurrent injury of the same limb or paw, number of affected bones, fracture type, fracture location, degree of displacement, therapy, complications [bandage associated, delayed union, nonunion, osteomyelitis, implant loosening]) in relation to several target variables (complications, radiographic outcome, lameness) were analyzed for their possible association for each bone (first to fifth) using a stepwise, multiple logistic regression model. Due to the high number of possible influencing factors, the stepwise version of the procedure was chosen.

Subsequently, to increase the chance of identifying possible associations, the central (third and fourth) and peripheral (second and fifth) bones were considered together to increase the fraction of positive events.

A commercially available statistical software package<sup>c</sup> was used for the analyses (27).

A significance value of  $\alpha = 0.05$  was used. Because this was a retrospective study with a high number of variables, the

results were assessed as an exploratory data analysis implicating no exact control of the global significance level.

## Results

From 1990–2007, a total of 175 dogs with metacarpal or metatarsal fractures were presented to our clinic. From these cases, 100 dogs satisfied the inclusion criteria by means of having available complete clinical and radiographic follow-up examinations for a minimum of four months. Thirty-six animals had already died or were euthanatized because of other reasons, 29 were lost to follow-up, and 10 had incomplete medical records.

### Fracture data

The most common histories of the dogs included in the study were motor vehicle accidents (33%), followed by jumps or falls (21%), unknown trauma (21%), falling objects (11%), dog interactions (6%), being stepped on by a horse or owner (5%), and bites (3%).

Thirty-seven percent of the animals were less than one-year-old and 41% were younger than two years at the time of presentation. Age ranged from one month to 18

<sup>b</sup> SIMI©, Unterschleissheim, Germany

<sup>c</sup> BMDP / Dynamic, Release 8.1: Statistical Solutions Ltd, Boston, MA, USA

years (mean: 2.6 years). Body mass varied between 2.5 and 58.3 kg (mean: 18.7 kg). Small dogs (<10 kg) were slightly more common (39%) than medium-sized (10–30 kg) (34%) and large breeds (>30 kg) (27%).

Of the patients, 51 (51%) had injured forelimbs, 48 (48%) had injured hindlimbs, and in one dog (1%) both hindlimbs were affected. The metacarpus was more frequently affected in small breed dogs (54%) and in large breed dogs (59%). In medium-sized dogs, the metatarsus (59%) was more commonly involved. In total, 246 fractured bones were counted, of which 119 were metacarpal and 127 were metatarsal fractures. Fractures of one or two bones (57%) dominated in the metacarpus, and fractures of three or four bones (54%) were slightly more frequent in the metatarsus. The third metacarpal and metatarsal bones were the most commonly fractured. The first metacarpal and metatarsal bones, in contrast, were fractured in just three dogs. Most fractures affected the body (metacarpus 86%, metatarsus 84%), followed by the base (metacarpus 6%, metatarsus 14%) and the physis (metacarpus 7%, metatarsus 2%). Fractures of the head were rare (metacarpus 1%). More than 80% (metacarpus 81%, metatarsus 87%) were transverse and oblique fractures. Butterfly fragments and comminuted fractures were present in 16% of metacarpal and in nine percent of meta-

tarsal fractures. Fifty-five percent of the fractures were displaced grade 1 (<50% of the diameter of the bone), 31% were displaced grade 3 (>100% of the diameter of the bone), and 14% were displaced grade 2 (50–100% of the diameter of the bone).

Closed fractures (84%) were predominantly observed. Concurrent injuries, mainly caused by car accidents, were common (47%). Soft tissue injuries and phalangeal fractures of the same paw were most frequent.

### Fracture treatment

According to treatment, the dogs were allocated to three groups:

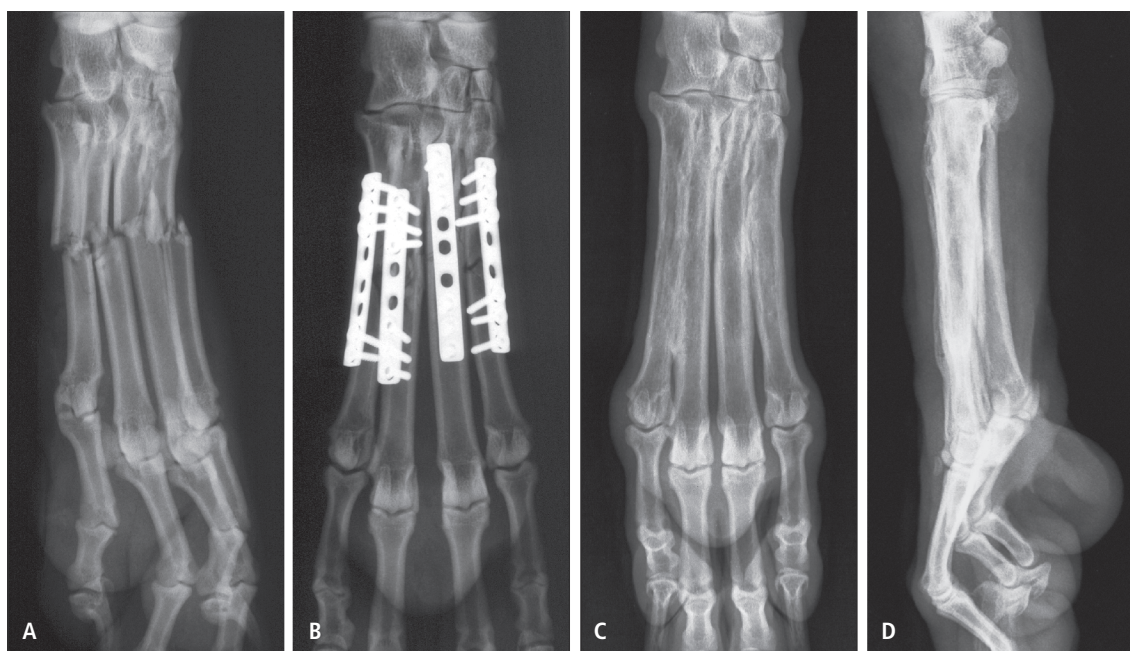
#### Group 1: Conservative treatment

Sixty-seven dogs (68 limbs) with single, mildly displaced or non-reconstructable multiple bone fractures, as well as dogs with fractures of the physis and with multiple bone fractures which could be reduced under general anaesthesia and stabilized by external coaptation, were treated conservatively (► Appendix Table 1 – available online at [www.vcot-online.com](http://www.vcot-online.com)). Success was documented radiographically (► Figure 1). In open fractures, wounds were debrided, and secondary wound healing was achieved if closure was not possi-

ble. For an average of six weeks (range: 4–12 weeks) a synthetic splint was applied for immobilization. Bandages were changed weekly.

#### Group 2: Surgical treatment

Internal fixation was performed in 25 dogs (25 limbs) with severely displaced fractures of single bones, in reconstructable articular fractures, and in multiple bone fractures, especially when the third and fourth bones were affected (► Table 3). Transverse and oblique fractures of the body were mainly treated by dowel pinning, as described in cats, or using standard bone plates (► Figure 2) (12, 15). Other, less frequently used techniques were lag screws in long oblique fractures and lag screws or tension band wires in fractures of the base. Furthermore, an external skeletal fixator was used in two patients with multiple, open fractures. In one patient with multiple fractures at the metatarsal base and involvement of the tarsometatarsal joints, crossed pins were used for fixation. Finally, in two patients, proximal metacarpal fractures were stabilized with a medial or lateral bone plate. A modified Robert-Jones bandage, which was additionally stabilized with crepe paper, was applied for an average of six weeks (range: 4–8 weeks) postoperatively. Bandages were changed weekly.



**Figure 2**  
Dorso-plantar radiographic views in a two-year-old German Shepherd dog from Group 2 (dog 24) with fractures of the second to fifth metatarsal bones preoperatively (A) and one year after treatment with standard bone plates (B). The dorso-plantar and medio-lateral radiographic views taken nine years after treatment (C, D) revealed synostosis between the second and third metatarsal bones. The dog was not lame.

**Figure 3**

Dorso-plantar views in a two-year-old German Shepherd dog of Group 3 (dog 8) with fractures of the second to fifth metatarsal bones and a lateral wound preoperatively (A) and postoperatively (B) after dowel pinning of the second to fourth metatarsal bones. The fifth metatarsal was immobilized by external coaptation. The dorso-plantar and medio-lateral views taken eight months later (C,D) show synostosis between the second to fifth metatarsal bones and malunion of the fifth metatarsal. The dog was not lame.



External skeletal fixators and the majority of bone-plates were removed when healing was radiographically diagnosed. In the other cases, implants were removed only when there was implant loosening or soft tissue reaction.

### Group 3: Combined surgical and conservative treatment

In eight dogs (8 limbs) with multiple fractures, not all of the fractured bones were surgically stabilized, because of comminution, too-short fragments, or skin wounds (► Figure 3). In these cases, additional support of the non-repaired fractured bones was provided by external coaptation similar to patients in Group 1.

All owners were advised to restrict their dog's activity to confinement indoors and leash walking for six weeks or until healing was radiographically completed.

Patient and relevant fracture data, complications, radiographic and functional outcome are provided in detail in ► Appendix Tables 1-3 (Available online at: [www.vcot-online.com](http://www.vcot-online.com)).

### Complications and radiographic outcome

#### Group 1

Two out of 67 dogs showed radiographic signs of delayed unions (metatarsal 4 and metatarsals 2–5). Furthermore, 10 dogs had bandage-associated problems such as dermatitis, erythema, and rub sores which required treatment but did not impair the final results.

#### Group 2

Three out of 25 dogs developed early complications. Two dogs developed osteomyelitis and implant loosening. One of these had open shaft fractures of the second to fifth metatarsal bones that were treated with dowel pinning. The other patient had fractures of the bases of the the second to fifth metatarsal bones that were stabilized with crossed pins. The fractures healed, but malunion occurred and resulted in permanent lameness. In the third dog, open fractures of the second to fifth metatarsals had been treated by an external skeletal fixator. In this case, radiographic signs of delayed

union were noted without functional impairment at the latest follow-up.

#### Group 3

Three out of eight dogs exhibited complications. In two dogs, implant loosening was observed without affecting fracture healing. In both these patients, the second metacarpal was treated with a bone plate, and the third bone was treated conservatively. In the third dog, delayed union occurred after open fractures of the second to fifth metatarsal bones. Over-sized bone plates were used for fracture repair in the second to fourth metatarsals. To avoid nonunion, additional surgery was required, and implants of adequate size and cancellous bone autograft were used.

Malunions were seen in nine dogs of Group 1 (► Figure 4), in three dogs of Group 2, and in two dogs of Group 3. In Group 1, malunion occurred in two-thirds of the fractures with four bones and in three cases with a single bone affected. In Groups 2 and 3, malunions were identified after early complications ( $n = 3$ ) and in untreated fractures of the second and fifth

metatarsals. Osteoarthritis was seen in two dogs of Group 1 (open fracture of metacarpal 2, fracture of the base of metacarpal 2/3) and in one dog of Group 3 (fracture of the base 2/3) and was considered rare (3%). Nonunion was present in just one dog (1%) of Group 1, with fractures of the third to fifth metatarsal bones, and affected only one bone, which did not affect weight bearing and remained untreated. However, synostosis was a frequent finding. It was seen in five cases of Group 1, three dogs in Group 2, and three of eight dogs in Group 3. Synostoses occurred more frequently in the proximal half of the metacarpus and metatarsus and in combination with butterfly fragments and comminuted fractures.

## Functional outcome

### Clinical assessment

At the last recheck, 65 dogs of Group 1, 24 dogs of Group 2, and all dogs of Group 3 were free of lameness.

Lameness in Group 1 was caused by malunion in one dog, in which the distal fragment of the third metatarsal bone was too short for internal fixation. In another patient (dog 12), severe injury of the soft tissue envelope resulted in extensive osteoarthritis. In a dog of Group 2 with open fractures, implant loosening occurred and

premature implant removal was necessary. Fractures healed, but malunion of the third bone had occurred.

### Computed gait analysis

Kinetic data revealed differences in vertical ground reaction forces between the affected and the contralateral limb rated as lame in three dogs of Group 1 and in one dog of Group 2 (► Appendix Table 4). In dog 12 (Group 1, see clinical assessment), osteoarthritis was most likely responsible for the functional impairment. In dog 46 (Group 1) with an open fracture of the second metatarsal and phalangeal fractures, osteoarthritis of the ipsilateral hip joint had developed. The dog progressed to visually apparent lameness one year after follow-up; it was treated with total hip replacement, and became clinically unimpaired. Dog 57 (Group 1) with fractures of the third to fifth metatarsal had been rated clinically normal but computed gait analysis revealed lameness in the hindlimbs and also mild changes in the forelimbs. Radiographs other than those of the metatarsus were not available because the owner declined further radiographic examination. The reason for this dog's gait abnormalities therefore could not be identified. In dog 16 of Group 2 with the second metatarsal fractured, which was stabilized using tension

band wire fixation, tarsal subluxation was also present and treated with crossed pins, lag screws and tension band wire. In this case, concomitant tarsal trauma may have caused subtle lameness. As a result, computed gait analysis confirmed the visual clinical assessment in 12 unimpaired dogs and revealed lameness in three dogs that did not have any visually apparent lameness.

### Statistical results

A significantly higher incidence of synostoses was seen after surgery ( $p < 0.0001$ ) (► Table 2), when comparing the treatment groups 1–3 in terms of fractures of three or four metacarpal or metatarsal bones. Significant differences between the three groups could not be identified for complications ( $p = 0.2913$ ), radiographic changes other than synostoses ( $p = 0.2443$ ), and the functional outcome ( $p = 0.5185$ ). The same results were found by comparing the treatment groups for the metacarpus and the metatarsus separately.

Looking at influencing factors and command variables, obviously more significant correlations for the second to fifth metatarsal bones were observed. According to the frequency of correlations, open, oblique and comminuted fractures, fractures of the base, moderate and severely displaced frac-



**Figure 4** Dorso-plantar radiographic views in a six-year-old mixed breed of Group 1 (dog 66) with proximal fractures of the second to fifth metatarsal bones before (A) and immediately after external coaptation (B). The follow-up radiographs in both views taken approximately two years later (C, D) show a valgus deformity of the second to fifth metatarsal bones. The dog was not lame.

tures (►Table 3), and surgical therapy in general held an increased risk for complications, osteoarthritis, malunion, and synostosis.

Comparison of complications with command variables revealed that complications resulted in an increase of synostoses in all metatarsal bones and of malunion in the fifth metatarsal bone.

Combined analysis of the central (third and fourth) and peripheral (second and fifth) bones confirmed that open fractures and surgical intervention increase the risk for complications and that complications increase the risk for synostosis, osteoarthritis, malunion and nonunion. This again was more obvious for the metatarsus.

No correlation between potential influencing factors and lameness was detected because lameness was rarely diagnosed.

## Discussion

Our findings that metacarpal and metatarsal fractures are mainly caused by motor vehicle accidents and occur predominately in young animals are in agreement with the findings of other investigations (3, 4). These fractures in dogs were almost equally distributed on forelimbs and hindlimbs, were single bone fractures in one-third of the patients, and were predominantly closed, mildly displaced, transverse, or oblique fractures of the body. In addition, in 49% of our patients, three and four bones were affected, being moderately or severely displaced (and therefore unstable) and in part associated with concurrent injuries of the paw.

The fact that fractures in this region show a great heterogeneity — in that different numbers of fractured bones, and with large variation within single-bone fractures regarding localization, fracture type, and degree of displacement — makes it difficult for retrospective studies to define significant guidelines for their treatment. At the same time, controlled, prospective, and randomized studies revealing evidence-based data are lacking. Therefore, retrospective studies may be still valuable.

Despite the large number of patients in our analysis compared with earlier studies,

**Table 3** Demonstration of significant associations between the degree of displacement (influencing factor) as a risk factor for complications (target variable) given as a result of a stepwise logistic regression procedure.

A				
	Displacement	Complication		Total
		None	Yes	
Metatarsal bone 2	No fracture	21	1	22
	Grade 1	16	1	17
	Grade 2	2	0	2
	Grade 3	5	4	9
	<b>Total</b>	<b>44</b>	<b>6</b>	<b>50</b>
	p-value	0.0272		
Metatarsal bone 4	No fracture	16	0	16
	Grade 1	16	2	18
	Grade 2	4	0	4
	Grade 3	8	4	12
	<b>Total</b>	<b>44</b>	<b>6</b>	<b>50</b>
	p-value	0.0485		

Displacement of fracture: grade 1 = <50%, grade 2 = 50–100%, grade 3 = >100% (preoperatively).

B						
	Displacement	Complication				Total
		None	Delayed union	Nonunion	Osteomyelitis	
Metatarsal bone 5	No fracture	21	0	0	0	21
	Grade 1	12	0	0	0	12
	Grade 2	5	1	0	0	6
	Grade 3	8	0	1	2	11
	<b>Total</b>	<b>46</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>50</b>
	p-value	0.0101				

Displacement of fracture: grade 1 = <50%, grade 2 = 50–100%, grade 3 = >100% (preoperatively).

and the higher incidence of synostosis in surgically and combined treated patients, there were no significant differences between conservative and surgical treatment detected.

In one previous study, in which 16 conservatively and nine surgically treated dogs were rechecked nine to 68 months after treatment, it was also found that there was no difference in the outcome (9). In addition, there was no significant influence regarding the number of affected bones, soft tissue injuries, location, type, and displacement of fractures. Only in terms of convalescence, which was reported to be seven weeks for conservative and 12 weeks for

surgically treated dogs, could a clear difference be noted.

Because of variable re-evaluation periods, healing time could not be analyzed in our investigation. In contrast, we identified a higher risk for complications, osteoarthritis and synostosis in metatarsal bones and in open, comminuted and severely displaced fractures, which were more often treated by surgery. Although the statistical associations detected in this retrospective study should be considered as a result of an exploratory data analysis, they reflect our clinical experience.

Overall, the majority of metacarpal and metatarsal fractures can be treated success-

**Table 2** Demonstration of comparison of treatment groups 1 – 3 in 49 dogs with fractures of three and four bones for the frequency of synostosis by means of the generalized Fisher exact test (Fisher – Freeman – Halton – test).

		No synostosis	Synostosis	Total	p-value
Metacarpus	Group 1	14	1	15	Not significant
	Group 2	3	4	7	
	Group 3	0	0	0	
Metatarsus	Group 1	12	1	13	0.0007
	Group 2	5	4	9	
	Group 3	0	5	5	
Metacarpus / metatarsus combined	Group 1	26	2	28	0.0001
	Group 2	8	8	16	
	Group 3	0	5	5	

Treatment groups: Group 1 = conservative treatment, Group 2 = surgical treatment, Group 3 = combined treatment.

fully without the selected therapy significantly influencing the outcome. However, there are criteria making special treatment options more preferable.

Thus, conservative therapy using external coaptation is commonly favoured in the following situations:

- in minimally displaced fractures
- when only one or two bones are fractured
- when one of the two main weight-bearing central bones is intact.

On the other hand, surgical intervention is usually preferred in the following situations:

- when displacement of fragments exceeds 50% of the bone diameter
- when more than two bones or both central bones are fractured
- when the articular surface is affected
- in fractures of the base in the second and fifth metacarpal and metatarsal bones, which tend to valgus or varus displacement because of ligamentous insertion. In cases of concurrent carpal hyperextension injury, arthrodesis may be indicated in the carpus.

According to the present study, these empirical and often repeated recommendations cannot be confirmed or refuted statistically (3, 4, 8, 18). These guidelines have been crucial for the decision on treat-

ment in our patients, albeit varying in some individual cases in response to a client's request.

Because the fractures in Groups 2 and 3 were more displaced and unstable, the similar outcome with Group 1 may be interpreted as an advantage for internal fixation. On the other hand, in surgically treated patients, there were more complications and these tended to be more severe, which occurred during healing (Group 1 = 11/67; Group 2 = 3/25; Group 3 = 3/8), although this did not influence overall outcome. With an incidence of one percent for nonunion (1 dog of Group 1), three percent for osteoarthritis (2 dogs of Group 1 and 1 dog of Group 3), and three percent for lameness graded by visual assessment (2 dogs of Group 1, 1 dog of Group 2), the outcome was considerably better than previously reported in the literature, albeit 14% of our dogs developed malunions (9 dogs of Group 1, 3 dogs of Group 2, and 2 dogs of Group 3) and synostoses were diagnosed in 19% (5 dogs of Group 1, 9 dogs of Group 2 and 5 dogs of Group 3) (3, 4, 8, 9). Therefore, lameness and osteoarthritis are not inevitable consequences of malunions. Accordingly, and consistent with the findings of others, surgery may not be imperatively indicated in fractures which cannot be reduced completely (► Figure 4) (9). The presence of synostoses in multiple bone fractures and after surgical therapy may be related to

the more severe initial trauma with soft tissue injury by displaced fracture ends and to periosteal irritation during surgical intervention. However, this radiographic finding was not clinically relevant, which is consistent with other reports (3, 12, 15).

In summary, according to our long-term results, metacarpal and metatarsal fractures in dogs reveal a good long-term prognosis. The discrepancies with earlier studies may in part be related to the subjective nature of visual assessment. This supposition is supported by the findings in the 15 dogs which were additionally evaluated by computed gait analysis in our investigation. In three dogs, computed gait analysis revealed mild differences in vertical ground reaction forces between the affected and the contralateral limb which were not detected visually. Discrepancies between visual and computed assessment of lameness are common, which confirms the requirement of objective data to support clinical studies (28, 29). The contralateral limb may be of limited value as a reference, because forces may be shifted to the other limbs in cases of lameness. However, in sound dogs the contralateral limb may serve as a reference (30, 31).

Because studies comparing conservative and surgical therapy are under-represented, and long-term results for fracture management in a higher number of patients are still missing in the literature, this analysis was provided with the best possible transparency. Nevertheless, owing to the heterogeneity of groups regarding the number of patients and their injuries, and the retrospective, non-randomized assignment of patients to groups, detailed conclusions about specific methods of treatment cannot be drawn from our data.

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## Conflict of interest

None declared.



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