Post-traumatic complications in the distal limb of a Spitz dog. Evaluation and outcome of a physiatric approach

Metacarpal fractures in canine forelimbs generally occur as a consequence of trauma. Conservative or surgical approaches can be used to manage these fractures. Rehabilitation is used in Veterinary Medicine to promote the recovery of the musculoskeletal system, addressing both neurological and orthopaedic lesions. In this case report, we discuss the physiatric approach used to regain weight-bearing and mobility of the left forelimb in a 3 years old female Spitz dog with a delayed skin and bone union of multiple exposed fractures of metacarpal bones occurred as surgical complication after a road accident.

KEY WORDS
Metacarpus - Fracture - Physiotherapy - Laser therapy - Rehabilitation - Dog

Lopedote Mirella[1]
DVM, CCRP

Bolzoni Jenny[1]
DVM, Department of Veterinary Medical Sciences

Valentini Simona[1]
DVM, Associate Professor

Spinella Giuseppe[1]
DVM, PhD, Dipl. ACVSMR, Dipl. ECVSMR, Researcher

INTRODUCTION

In dogs there are 5 metacarpal bones (MC), each anatomically defined and conventionally numbered MC 1, 2, 3, 4 and 5, from medial to lateral direction. MC1 is the shortest, while MC3 and MC4 are longer bones that support most of the load of the thoracic limbs.[1] In the dog, metacarpal bone fractures are frequent forelimb fractures and are often of traumatic origin, as reported by several authors.[2,3,4,5,6,7] Fractures of the metacarpals are generally unexposed, often with a transverse or oblique fracture line orientation and usually involve 3 or more bone segments.[2,6,7] In the greyhound, given the different limb loads during track racing a higher frequency of left MC5 and right limb MC2 stress fractures are reported.[9] Pancarpal arthrodesis is also reported in the literature among the potential predisposing causes of metacarpal fractures: a higher risk of metacarpal fractures is reported if the length of the fixation device used does not cover at least 53% of the bonelength.[2,10] The therapeutic approach for metacarpal fractures can be conservative or surgical: the indications for choosing one option over the other have not yet been fully clarified.[2,3,11,12,13,14] In principle, surgical correction is indicated when: 1) more than two metacarpals of the same limb are fractured; 2) fractures involve both MC3 and MC4; 3) joint fractures are present; 4) dislocation of bone fragments is greater than 50%; 5) fractures involve the base of MC2 or MC5; 6) the dog is either of large size

The surgical reduction of exposed metacarpal fractures and implant stability issues may be the cause of difficult-to-manage complications that can hinder the patient's physiological locomotor activity. A targeted physiotherapeutic approach may allow partial or total recovery of the limb's locomotor function.

[1]Ambulatorio Veterinario Associato Therapy Pet, Monopoli (BA)
[2]Department of Veterinary Medical Sciences, University of Bologna, Ozzano dell'Emilia (BO)

*Corresponding Author (simona.valentini@unibo.it)

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or an athlete dog.[2,15]

Regardless of conservative or surgical therapy, it is believed that limb function recovery can be facilitated by the implementation of targeted physiotherapy treatment. This must include periodic and scheduled physiatric examinations of the patient in order to allow monitoring of the progress of the chosen protocol. For this purpose, qualitative and quantitative measures are used, such as: degree of lameness, articular range of motion (ROM), muscle circumference, body condition score and pain assessment.[16,17]

Laser Therapy (LT) is often integrated with manual therapy due to its beneficial effect on pain and inflammation control.[18,19,20] In fact, laser therapy modulates the inflammatory response via the reduction of inflammatory cytokines (COX2), tumor necrosis factor (TNF) and interleukins 1 and 6 (IL1 and IL6); it also facilitates collagen synthesis, the release of growth factors and, by stimulating the maturation of fibroblasts, it promotes tissue repair.[18,19,20,21,22] LT also acts on the muscles, reducing fatigue and increasing contractile strength.[18]

The physiotherapeutic protocol must be established after a thorough physiatric examination and must include specific aims and ongoing evaluation criteria.

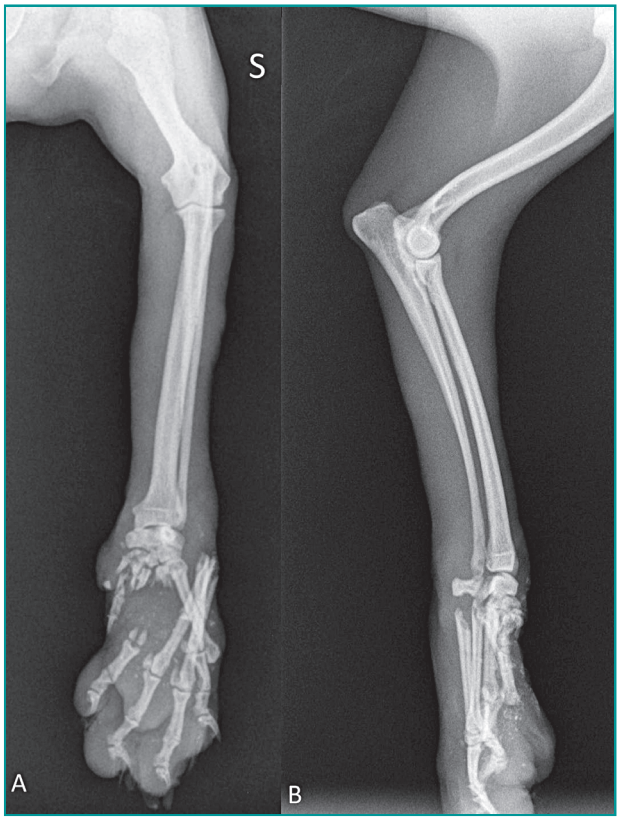

Figure 1 - Three-year old, spayed female Spitz dog. Dorsopalmar (**A**) and mediolateral (**B**) X-ray of the left forelimb after the trauma. Multiple fractures of all metacarpal bones.

At the end of each physiotherapy stage it is always important to re-evaluate the patient. Articular ROM and muscle circumference measurements are useful tools in order to monitor the results obtained.

CLINICAL CASE PRESENTATION

A 3-year old, spayed female Spitz dog, weighing 3.7 kg, was referred following a car accident. At physical examination the patient was in post-traumatic hypovolemic shock and with a severe 6-7 cm skin wound in continuity with subcutaneous and muscular layers, allowing complete visualization of the exposed bone tissue. The radiographic examination confirmed the clinical suspicion of complete comminuted fracture of all the metacarpal bones of the left forelimb (Fig. 1).

A bilateral monoplanar external fixator was first applied in order to stabilize the fracture. The post-surgical protocol included 20 days of antibiotic therapy with amoxicillin/clavulanic acid (Konclav, Fatro Spa, Ozzano dell'Emilia, Bologna) at the dose of 12.5 mg/Kg *per os,* every 12 hours. Medication and bendage were changed daily, after sedation (only in the first week) with medetomidine hydrochloride (Sedator, ATI srl, Ozzano dell'Emilia, Bologna) at 10 mcg/kg IM and methadone hydrochloride (Semfortan, Dechra Veterinary Products Srl, Turin) at 1 mg/kg IM, as the patient showed pain during manual procedures. During the following 10 days the limb showed large necrotic skin areas with sero-haemorrhagic and purulent exudate (Fig. 2). Surgical curettage was performed and the necrotic nails of the first and second digits were excised. At 25 days after the curettage the granulation tissue started to regress, exposing the underlying bones. The radiographic examination showed non-union of the fracture stumps and the owner decided to ask for a second medical surgical opinion. The consulted surgeon removed the external fixator and stabilized the MC3 and MC4 fractures using intramedullary pins (one per metacarpal bone). Two days later, the pin inserted in MC3 was removed, as it had exited from the insertion site. Ten days after the second operation the wound granulation tissue was still scarce and uneven, despite daily replacement of the bendage. To facilitate the healing process, LT was started. At this stage the dog was submitted to a physiatric examination for the first time. The patient presented a grade 5/5 lameness (where 0 = normal and 5 = no weight bearing), left forelimb pain 7/10 (Visual Analog Scale - VAS) and contracture of the contralateral shoul-

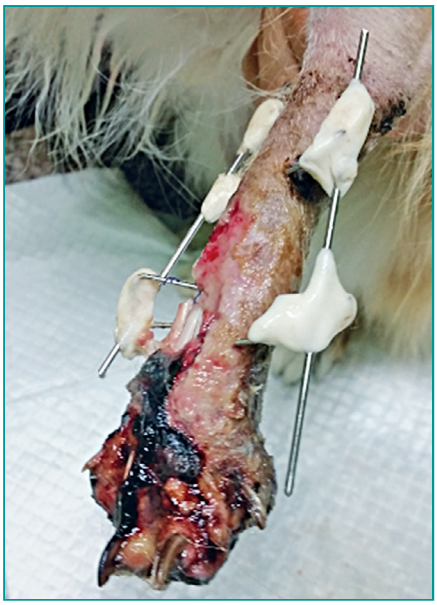

Figura 2 - Three-year old, spayed female Spitz dog. Appearance of the lesion 30 days after the first intervention. Note soft tissue necrosis and exposed bone stumps.

Surgery alone does not always allow complete functional limb recovery, especially in small size patients; a rehabilitation approach can instead be highly indicated and effective.

der and neck muscles.[17] The affected limb showed moderate atrophy of the extensor and flexor compartment of the shoulder muscles and of the anatomical region of the left arm. The physical examination at 30 days after insertion of the intramedullary pins continued to show bone instability and the radiographic examination confirmed breakage of the MC4 intramedullary pin. The owner excluded any additional surgery, including the removal of the second pin; consequently, a targeted physiotherapy protocol was implemented. Aims of the treatment were muscle strengthening, pain management and gradual recovery of ambulation. To achieve these goals the rehabilitation plan was divided into 5 steps. Each step included re-educational exercises, modalities and the evaluation of clinical improvement via measurement of forelimb muscle circumference (Table 1) and the degree of lameness.[17]

Aim of the first step was pain control and treatment of disuse atrophy. The patient was treated three times a week with sessions of about 1 hour each; each session included muscle massage, shoulder and elbow Passive Range of Motion (PROM) exercises and distal part of the left forelimb and LT (4 J/cm^2) for 370 seconds to decontract muscle tissue (MLS Multiwave Locked System - Cutting Edge Laser Technologies, Rochester, NY 14623 USA). Due to of the instability of the fracture stumps during this first stage it was not possible to perform passive exercises of the distal part of the left forelimb or to assign specific exercises at home; only rest in cage and massage of bilateral neck and shoulder muscles were prescribed (Table 2). In order to stimulate healing and reduce pain in the affected area during each session, LT (4 J/cm^2) was performed on the lesion for 150 seconds during bandage replacement.

The second phase of the physiotherapy protocol, with 2 sessions per week (1 hour each) for 4 weeks, aimed at increasing muscle tone and the progressive stimulation of continuous weight bearing of the left limb with the animal standing on the proprioceptive tablet and walking (Table 2). Assisted swimming with an operator inside the underwater treadmill tank (UWTM) was also introduced for muscle strengthening, setting the water level so as not to allow weight bearing. To ensure better stability a carpal splint was used during the day (Anterior splint, Medicvet, Italy). Walks on a short leash for a maximum of 15 minutes were allowed at home (Table 2). After three sessions of assisted swimming the patient autonomously started limb weight bearing. The left forelimb circumference had increased by 0.5 centimeters since the beginning of physiotherapy (Table 1). As proposed by Millis and Levine, muscle circumference of the forelimb was measured with a Gullick type II tape measure

Table 1 - Monitoring of circumference of the left forelimb from presentation to the end of physiotherapy by means of a Gullick II tape measure at a point that is 20% of the limb length as measured from the proximal aspect of the lateral epicondyle of the humerus (forelimb length is measured from the proximal aspect of the olecranon to the distal aspect of the lateral styloid process). At the end of the first step the limb circumference did not increase as it was not possible to perform loading exercises on the limb itself; a gradual circumference increase was observed in the second step, due to a gradual increase in muscle tone and trophism

	Pre physiotherapy	Step 1	Step 2	Step 3	Step 4	End physiotherapy
Circumference of left forelimb (cm)	6,5	6,5	7	7	7,5	9,5

at a point representing 20% of the limb length from the proximal aspect of the olecranon to the distal aspect of the lateral styloid process.[17] Given the healing of the skin wound, during this phase the laser for wound healing was discontinued.

Aim of the third step was to promote constant limb weight bearing while standing and walking, with the addition of assisted slalom as a therapeutic exercise following rectilinear movement, and to further strengthen limb muscles (Table 2). At the end of this phase the goals were partially reached, with constant limb weight bearing while standing and intermittently while walking.

Aim of the fourth step was to promote constant use of the limb while walking, a target not achieved in the previous phase. Laser use as a decontracting and pain-relieving therapy was suspended as the VAS showed absence of pain (0 out of 10). During each session the manual therapy started during the third phase (massage, PROM and stretching) remained unchanged, while the following therapeutic exercises were added: standing on the physioroll (diameter 30 cm), wheelbarrow exercises and proprioceptive training with cavaletti rails (Table 2). Assisted walking in the UWTM with immersion up to the elbow was performed with progressively increasing

Table 2 - Physiotherapy protocol used in the clinical case described. The protocol was divided into 5 steps based on the physiatric evaluation of the patient; the sessions were performed 2 or 3 times a week. Each step lasted for a period of about one month. Manual, physical and electromedical therapies were carried out during each step - Laser Therapy (LT).

	Duration	Physical therapy	Laser therapy	Home exercises
STEP 1	3 sessions per week of 1 hour for 4 weeks	Muscle massage (effleurage and petrissage) for 5 min per zone (forelimbs, neck and paravertebral muscles) PROM shoulder and elbow 10 reps	LT for decontracting shoulder and elbow muscles (4 J/cm^2 continuous mode) and for soft tissue healing and pain therapy (4 J/cm^2 pulsed mode)	Controlled diet + chondroprotectors Massage (effleurage and petrissage) for neck and forelimb muscles
STEP 2	2 sessions per week of 1 hour for 4 weeks	~ STEP 1 + Forelimb stretching for 5 min (anteroposterior and laterolateral) + Balance for 5 min (proprioceptive reinforcement) + Walk on a leash + Assisted swimming for 10 min	~ STEP 1 Suspension of soft tissue healing therapy	~ STEP 1 + Walks on a short leash with carpal splint for 15 min
STEP 3	2 sessions per week of 1 hour for 4 weeks	~ STEP 2 + Assisted slalom + Assisted swimming for 15/20 min	~ STEP 2	~ STEP 2 + Up/down small steps for 5 min
STEP 4	3 sessions per week of 1 hour for 4 weeks	~ STEP 3 + Standing on Physioroll (diameter 30 cm) for 5 up to 10 min + Wheelbarrow + Proprioceptive training with Cavaletti rails from ground level up to carpus height + Walking in water at elbow height for 20 min with speed from 0.6 to 1.1 Km/h		~ STEP 3 + High five repeats (15 times for 3 successive repetitions) + Lie/stand (15 times for 3 successive repetitions) + Walk on a leash on wet sand for 10 min
STEP 5	3 sessions per week of 1 hour for 4 weeks	~ STEP 4 + Walking/running in water at elbow height for 20 min with speed from 1,1 to 2 Km/h + Walk on inclined planes for 10 min		~ STEP 4 + Walk on sand for 10 min

times until reaching a total of 20 minutes per session. The speed was gradually increased from 0.6 km/h to 1.1 km/h (Table 2). At home, the owners led the dog to daily walks on wet sand in order to promote muscle strengthening (Table 2). At the end of this phase, limb weight bearing was constant (Fig. 3) and the limb circumference was slightly increased (0.5 cm) compared to the previous phase (Table 1).

Finally, the fifth step allowed to reach full limb weight bearing during both walking and trotting without the support of the carpal splint. In the clinic, walking uphill and downhill on inclined planes (about 15% inclination) was added and both the time and speed of UWTM therapy were increased, as reported in Table 2. At home, daily walks on dry sand for about 10 minutes without the carpal splint were prescribed. Physiotherapy, 2-3 sessions per week as shown in Table 2, ended after 5 months, with the resumption of normal walking and trotting. Only at faster gaits mild intermittent lameness was observed; the forelimb circumference was considerably increased compared to the first session (Table 1).

Figura 3 - Three-year old, spayed female Spitz dog. Patient after the fourth step of physiotherapy: note the healing and recovery of left forelimb weight bearing.

DISCUSSION

The therapeutic approach for metacarpal fractures can be either conservative or surgical.[2,3,11,12,13,14] In both approaches, the physiatry, as shown by the specialist literature - although limited and not particularly detailed - underlines the need to preserve the ROM of the proximal joints during rehabilitation.[23] The failure of previous therapies and the owner's wish to continue with physiotherapy alone, made this case quite unique and not comparable to other cases reported in the literature.

The synergism between manual and instrumental therapies and the prescription of exercises at home, associated with controlled physical activity, facilitates the recovery of normal locomotor function in cases of complex presentation and surgical management such as open multiple metacarpal bone fractures in a small-size dog. Frequent complications associated with the healing of this type of fractures are reported in the veterinary literature: nonunion, implant loosening and migration, degenerative joint disease, residual lameness and disuse muscular atrophy.[2,6,11] Experimental studies report clinical healing and resumption of walking following the implementation of focused physiotherapy protocols.[15] In 2011, De Souza and collaborators demonstrated that muscle massage, PROM, neuromuscular electrical stimulation (NMES) and UWTM therapy are physiotherapy techniques that can accelerate clinical recovery in case of disuse muscle atrophy in the dog.[24] The effectiveness of the treatment is greater when performed following appropriate surgical therapy. When implant failure or surgical complications occur, as in our clinical case, a multimodal rehabilitation approach associated with correct animal management by the owner is crucial for a good clinical outcome.

Based on the specific needs of the patient we opted for a physiotherapy protocol divided into 5 steps in order to gradually and progressively achieve the different objectives, aimed at the functional recovery of the limb. In the described clinical case, the transition to each subsequent phase was initially planned based on the patient's general condition and modulated in relation to the achievement, in whole or in part, of the set objectives. Patient compliance was initially poor, but progressively improved thanks to pain management with LT and the use of positive reinforcement with food. The owners were very cooperative from the start, feeling involved in the rehabilitation of their pet. In these cases, owner compliance is extremely important, because of the duration of treatment, the number of sessions needed and the gradual development of any improvement. From the beginning, therefore, an active owner collaboration was required for the daily execution of massages - after appropriate training to ensure a correct execution of the therapeutic manual skills - and for the subsequent walks on a leash on surfaces of different texture: wet sand to work muscles and joints without overloading them and dry sand to strengthen and increase muscle tissue endurance. There were no complications throughout the

entire physiotherapic approach as the proposed activities were carefully monitored and carried out with all the necessary precautions.

The patient progressively became more cooperative both in the clinic and at home, presumably due to the gradual reduction of pain, and the physiotherapy sessions were concluded after about 5 months of constant work.

It is authors' opinion that, considering the severity of initial injury, the timing of the rehabilitation protocol was a good compromise between therapeutic needs and owner compliance and allowed to achieve the desired outcome within an appropriate timeframe.

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KEY POINTS

- In the dog, metacarpal bone fractures are usually traumatic.
- The treatment for metacarpal bone fractures may be conservative or surgical, depending on the specific guidelines reported in the literature.
- One of the main consequences of metacarpal bone fractures is muscle disuse atrophy and loss of limb function.
- Physiotherapy is a branch of Veterinary Medicine to be considered in the conservative management and/or in association with surgical treatment in order to limit secondary muscle complications and promote function recovery.