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Total removal of the fourth metacarpal bone in an Icelandic horse

Vollständige Extirpation des lateralen Griffelbeins an einer Vordergliedmaße bei einem Islandpferd

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ABSTRACT

Fractures of the splint bones are the most common fractures in horses. Various treatment options for splint bone fractures (MC/MT II and IV), including conservative and surgical management, have been described. This report describes an acute splint bone fracture due to external trauma in a 17-year-old Icelandic mare. The fracture was diagnosed as an open multi-fragment fracture of the proximal third of the fourth metacarpal bone (MCIV) in the right front limb. Surgery was performed with the horse under general anaesthesia. The distal fragments were removed, and the distal part of the proximal remnant splint bone was cut with an osteotome. During the postoperative period, a routine x-ray-control two days after surgery showed a dislocated fracture of the remaining proximal part of the fourth metacarpal bone. In a second surgery, the proximal part of MCIV was entirely removed. After a reconvalescence period of 5 month, the horse reached her previous level of performance as a leisure horse. The mare is still free of lameness 6 years after the incident.

ZUSAMMENFASSUNG

Griffelbeinfrakturen gehören zu den häufigsten Frakturen des Pferdes. In der Literatur sind verschiedenste Behandlungsmöglichkeiten, sowohl konservativ als auch chirurgisch, beschrieben. Der vorliegende Bericht beschreibt eine akute Griffelbeinfraktur durch ein externes Trauma bei einer 17-jährigen Isländerstute. Es handelte sich um eine offene Mehrfragmentfraktur im proximalen Drittel des Os metacarpale quartum (MCIV) der rechten Vordergliedmaße. In Allgemeinanästhesie wurden alle Fragmente distal der Fraktur entfernt. Das distale Ende des verbliebenen proximalen Griffelbeinanteils wurde mit Hilfe eines Osteotoms glatt abgetrennt. Das postoperative Routineröntgen, welches 2 Tage später erfolgte, zeigte eine stark dislozierte Fraktur des verbleibenden Griffelbeinanteils. Daraus resultierte die Indikation für einen erneuten chirurgischen Eingriff. Im Rahmen der zweiten Operation wurde das komplette Os metacarpale quartum (MCIV) entfernt. Nach einer 5-monatigen Rekonvaleszenzphase erreichte die Stute ihr vorheriges Leistungsniveau als Freizeitpferd wieder. Im Rahmen eines Klinikbesuchs 6 Jahre nach erfolgter Operation wurde die Stute orthopädisch untersucht und präsentierte sich lahmfrei.

Introduction

Splint bone fractures are a common injury in horses, regardless of their breed, age, and type of usage [1, 2]. Due to their anatomic structure and localization, the splint bones (MC/MT II and IV) are predisposed to external trauma [1–4]. There are different aspects to consider for proper fracture classification such as localization, joint involvement, fracture pattern and geometry, displacement, and grade of contamination. Fractures of the splint bone can occur

anywhere along the length of the bone. Depending on the location, fractures are classified as proximal, middle, or distal [1–3]. Fractures of the proximal aspect and midbody are often the result of external trauma such as a kick injury or limb entrapment for example in a fence or doorway [1–3]. Additionally, splint bone fractures are classified as either closed or open. Lastly, splint fractures can be classified as two-fragment or multifragment fracture [1–3]. Selecting an appropriate therapy for a splint bone fracture can be challenging and should be based on the type and location of the fracture or the involvement of surrounding structures like the suspensory ligament.

Therapy can be performed either conservatively or with various surgical techniques. The surgical techniques include removal of the distal fragment, a segmental ostectomy, or an internal fixation with plates in fractures of the proximal aspect of the splint bone after removing the distal fragments [1–7].

In cases where more than 3/4 of the lateral or 2/3 of the medial splint bone is removed, internal fixation of the remaining proximal fragment is recommended to provide axial support of the carpal or tarsal joint [1, 2, 4, 5]. However, in cases of proximal comminuted fractures, achieving adequate stabilization via internal fixation can be difficult. Open fractures have a higher risk of implant infection, which depends on the level contamination, size, and age of the wound [1, 4–6, 8, 9]. In cases where the lateral splint bone is affected, it may be considered to remove the entire bone. This has been described for the fourth metatarsal bone (MTIV) [1–3, 9], but not for the fourth metacarpal bone. The present case report describes the complete removal of a fourth metacarpal bone.

Case description

Patient and history

A 17-year-old Icelandic mare was presented due to severe lameness in the right front limb and a skin injury located palmarolateral in the proximal part of the metacarpal region. The mare had not received any preliminary treatments before admission to the equine clinic.

Diagnostics

Upon arrival at the clinic, the horse underwent a general examination and a lameness examination. The horse was in a good general condition and was equally weight-bearing on all limbs. Its body condition score was 5/9 and cardiovascular as well as respiratory parameters were within normal range. The rectal temperature was 37,9 °C. The blood values were as follows: haematocrit 0,38 l/l, total plasma protein 7,0 g/dl and white blood cell count 7000×10^6/l.

The patient presented with a perforating skin injury located laterally in the proximal third of the fourth metacarpal bone, measuring approximately 2 cm, and with a moderately swollen and contaminated wound. The horse exhibited severe tenderness to pressure in the vicinity of the injury. Based on the AAEP lameness scale [10], the lameness was categorized as a grade 4/5. Radiographic and ultrasonographic diagnostics were conducted to further assess the injured right front limb.

Radiographs were taken in the 4 standard views (dorsopalmar, dorsolateral-palmaromedial oblique, lateral, dorsomedial-palma-

rolateral oblique). In addition to the previously described findings, radiographs revealed a proximal multifragment fracture of the fourth metacarpal bone (▶ Fig. 1). The dorsopalmar radiograph (▶ Fig. 1a) showed a proximal comminated displaced fracture of the fourth metacarpal bone as well as swelling of soft tissue and radiolucencies extending from the skin surface to the bone spreading from proximal to distal. The dorsomedial-palmarolateral oblique view showed a multifragment fracture of the MCIV overlaying the third metacarpal bone. However, the dorsolateral-palmaromedial oblique view did not show the entire dimension of the fracture due to the displacement and overlaying of bony fragments (▶ Fig. 1b). Additionally, several hyperechoic spots were found in the area of the suspensory ligament and the accessory ligament of the deep digital flexor tendon during ultrasonographic evaluation, which could indicate either bone fragments or calcifications. We diagnosed an open dislocated multifragment fracture of the proximal aspect of the fourth metacarpal bone of the right front limb, with moderate contamination and mild trauma of the surrounding tissue. Additionally, the accessory ligament of the deep digital flexor tendon showed a mild lesion with loss of fibre alignment and hyperechoic spots.

▶ **Fig. 1** Radiographs taken on the day of arrival at the clinic. The dorsopalmar radiographic projection of the metacarpal region (**a**) shows a multifragment fracture of MCIV and radiolucencies in the soft tissue. The dorsolateral-palmaromedial oblique (**b**) view shows many radiolucent areas in the soft tissue, a small radiolucent line in the proximal aspect of MCIV, and an isolated radiopaque fragment distal to this line. Source: A. Vidović.

▶ **Abb. 1** Röntgenbilder, am Tag der Ankunft in der Klinik aufgenommen. Die dorsopalmare Röntgenaufnahme (**a**) der Metakarpalregion zeigt eine dislozierte Mehrfragmentfraktur des MCIV und mehrere Aufhellungen im Weichteilgewebe. Die dorsolaterale-palmaromediale schräge (**b**) Aufnahme zeigt mehrere Aufhellungsbereiche im Weichteilgewebe, eine kleine Aufhellungslinie im proximalen Anteil des MCIV und eine röntgendichte isolierte Verschattung distal dieser Linie. Quelle: A. Vidović.

► Fig. 2 Dorsolateral-palmaromedial oblique radiograph taken 2 days after initial surgery. The proximal remaining splint bone part is fractured longitudinally with a large palmar fragment being dislocated with its distal end proximolaterally. Source: A. Vidović.

► Abb. 2 Dorsolaterale-palmaromediale schräge Röntgenaufnahme, 2 Tage nach der ersten Operation. Der proximale, verbliebene Griffelbeinanteil ist in longitudinaler Richtung frakturiert und ein großes palmares Fragment ist mit dem distalen Ende proximolateral disloziert. Source: A. Vidović.

Initial treatment

The skin was clipped and scrubbed with chlorhexidine gluconate (HIBISCRUB® 4%, Mölnlycke Health Care AB, Gothenburg, Sweden). The wound was cleaned and flushed with hypochlorous acid (Vetericyn® VF + plus, Ecuphar GmbH, Greifswald, Germany) and a single layer pressure bandage was applied. Initially, the patient was treated with the systemic antibiotics gentamicin (6,6 mg/kg IV SID, Genta 100®, CP-Pharma, Burgdorf, Germany) and procaine benzylpenicillin (25000 IU/kg IM BID, Procain-Penicillin-G 300 mg/ml®, aniMedica GmbH, Senden-Bösensell, Germany). As analgetic and antiphlogistic medication flunixin meglumine was administered (1,1 mg/kg IV SID, Flunidol RPS 50 mg/ml®, CP-Pharma, Burgdorf, Germany). To reduce the risk of general anesthesia, surgery was scheduled for the following day.

First surgery

The horse was anesthetized, placed in left lateral recumbency and the left front limb was straightened and placed horizontally. A tourniquet was applied, and the leg was aseptically prepared and covered with sterile drapes for the orthopedic surgery. A fifteen-centimeter incision was made lateral to the fourth metacarpal bone using a 23 blade. The fourth metacarpal bone was bluntly dissected from the interosseus ligament, and the distal end of the fracture identified. The distal part of the MCIV was separated with an osteotome proximal to the fracture and removed. Loose bone frag-

ments were removed, and the wound was flushed with 0,9% saline. About 80% of the MCIV's total length was removed. Due to the contamination and age of the wound the surgeon chose not to use internal fixation on the proximal end. After taking control radiographs, the wound was closed in 3 layers, and a single layer bandage was applied. The recovery period went smoothly without any complications.

Follow up

The medical treatment involved the antibiotic agent gentamicin (6,6 mg/kg IV, Genta 100®, CP-Pharma, Burgdorf, Germany) which the patient received once a day for 5 days starting at the day of arrival at the clinic and procaine benzylpenicillin (25000 IU/kg IM, Procain-Penicillin-G 300 mg/ml®, aniMedica GmbH, Senden-Bösensell, Germany), which the patient received twice daily over the same time frame. For analgesic and antiinflammatory purposes, flunixin meglumine (1,1 mg/kg IV, Flunidol RPS 50 mg/ml®, CP-Pharma, Burgdorf, Germany) was administered once a day. To minimize the risk of thrombophlebitis, the central catheter was removed, and flunixin meglumine was given orally at the same dose.

One day after surgery, the lameness in the right front improved from grade 4/5 to a grade 3/5 on the AAEP lameness scale, but the horse developed clinical symptoms of acute laminitis on the left front leg. The horse had an increased temperature of the left front hoof, increased digital pulses, and a painful response to a hoof tester. To stabilize the left digit, the heels were elevated, and a hoof cast was applied. The left front was cooled with ice packs for 48 hours. Due to this complication the drug management was adjusted, and the horse received heparin (40 IU/kg SC, Heparin-Natrium 25000 IU/5 ml ®, Braun Melsungen AG, Melsungen) twice daily over 3 days, followed by acetylsalicylic acid (20 mg/kg PO, 1000 mg/g ®, aniMedica GmbH, Senden-Bösensell, Germany) once daily for 10 days. The symptoms of laminitis improved after 48 hours. The routine bandage change and control radiography were performed 2 days after surgery.

The wound was closed and did not show any exudation, swelling or tenderness upon pressure. However, the postoperative radiographic images revealed a longitudinal fracture in the remaining proximal splint bone, with a large fragment dislocated towards the carpometacarpal joint (► **Fig. 2**). As a result of this complication, a second surgery was necessary.

Second Surgery

The patient was anesthetized and placed in left lateral recumbency and aseptically prepared as was done during the initial surgery. The staples were removed, and the wound was reopened. The remaining parts of MCIV were carefully dissected and completely removed. The dislocated fragment, which was part of the carpometacarpal joint, was excised, resulting in an opening of the joint. The joint was distended and fluid was observed draining through the wound. In order to reduce the risk of joint infection, the carpometacarpal joint was flushed with saline during the surgery and treated with 150 mg of gentamicin (Genta 100®, CP-Pharma, Burgdorf, Germany) intra-articularly after the surgery.

► **Fig. 3** Dorsopalmar (**a**) and dorsolateral-palmaromedial oblique (**b**) radiograph of the metacarpal region 2 days after complete removal of the fourth metacarpal bone. Source: A. Vidović.
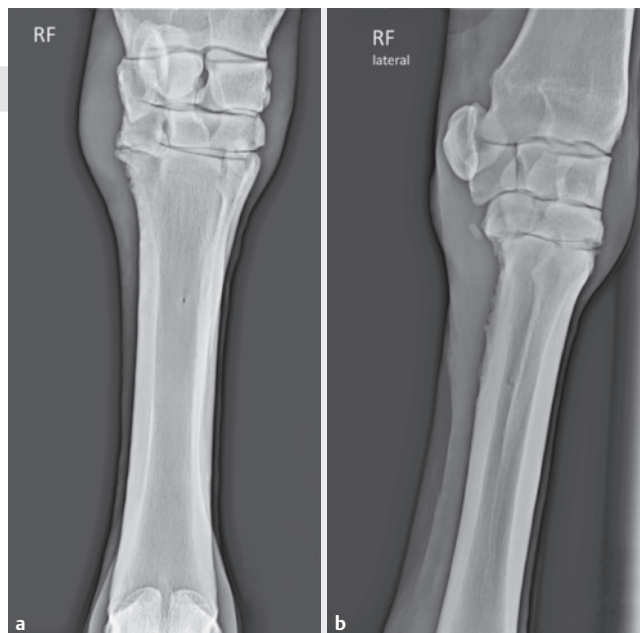
► **Abb. 3** Dorsopalmare Röntgenaufnahme (**a**) und dorsolaterale-palmaromediale schräge Röntgenaufnahme (**b**) der Metakarpalregion 2 Tage nach der vollständigen chirurgischen Entfernung des lateralen Griffelbeins. Source: A. Vidović.

► **Fig. 4** Radiographs taken 10 months after second surgery. Dorsopalmar view (**a**) shows moderate periosteal reaction and new bone formation along the proximolateral aspect of the third metacarpal bone (MCIII) and the distolateral aspect of the os carpale quartum. Dorsolateral to palmaromedial oblique (**b**) shows an isolated radio-opacity palmarolateral to the os carpale quartum and irregular contour of cortex in the proximal third of MCIII. Source: A. Vidović.

► **Abb. 4** Röntgenaufnahmen 10 Monate nach der zweiten Operation. Die dorsopalmare Röntgenaufnahme (**a**) zeigt mittelgradige periostale Reaktionen und knöcherne Zubildungen entlang des proximolateralen dritten Metakarpalknochens und am laterodistalen Anteil des Os carpale quartum. Die dorsolaterale-palmaromediale schräge (**b**) Röntgenaufnahme zeigt eine deutliche isolierte Verschattung lateropalmar des Os carpale quartum und mittelgradige periostale Reaktionen im proximalen Drittel des MCIII. Source: A. Vidović.

Follow up after second surgery

In addition to flunixin meglumine, the selective COX-2 inhibitor firocoxib (0,1 mg/kg PO, Equioxx®, Boehringer Ingelheim, Ingelheim, Germany) was administered orally once a day for 7 days after the second surgery. Local antibiotic treatment was given to the carpometacarpal joint 3 days after surgery in the form of a second gentamicin injection. A radiographic control image was taken 2 days after the second surgery during a routine bandage change (► **Fig. 3**).

No further complications during the mare's hospitalization occurred. The weight-bearing of the right front limb continuously improved, and after 2 weeks, she did not show any signs of lameness when walking. The convalescence period after leaving the clinic involved 6 weeks of box rest, followed by a 6-week program of controlled exercise at walk. The program started with 5 minutes twice a day and increased by 5 minutes weekly. The training was gradually intensified and after 5 month she was trained to full extent.

Ten months after surgery, a clinical and radiographic control were performed. The horse was free of lameness when walking and trotting, and the wound healed with mild formation of scar tissue. The radiographic image showed periosteal reaction and new bone formation along the proximolateral aspect of the third metacarpal bone (MCIII) and the distolateral aspect of the os carpale quartum (► **Fig. 4a**). Additionally, the dorsolateral to plamaromedial oblique view showed an isolated radio-opaque area palmarolateral to the os carpale quartum (► **Fig. 4b**). After completing the convalescence period, the mare was used again as a leisure horse. Six years later, she is still free of lameness and without complications.

Discussion

There are different treatment options for a proximal splint bone fracture, including conservative therapy with standing wound debridement or various surgical techniques. These surgical techniques may involve removing the distal fragments with or without internal fixation of the proximal remaining part of the splint bone. Additionally, a segmental ostectomy or resection of the entire MTIV are mentioned in the literature as surgical treatment for splint bone fractures [1–3, 5–8]. The most suitable treatment option is determined based on the individual case.

Conservative therapy has some advantages over surgery, such as avoiding the risks associated with general anesthesia [7]. Several studies have demonstrated successful outcomes with conservative treatment for proximal open comminated splint bone fractures

[1, 7, 11]. However, in our case, we chose not to pursue conservative treatment due to the increased risk of excessive callus formation and the involvement of the suspensory ligament.

In cases where there is instability of the proximal fragment or when 3/4 or more of the lateral and 2/3 or more of the medial splint bones are removed, internal fixation with plates is recommended [1–3, 5, 6, 9, 10, 12, 13]. However, the main disadvantage of using a metal implant is the increased risk of infection, which can lead to chronic lameness and require later removal of the implant. This risk is particularly high in cases of open multifragment fractures [6, 7]. During the first surgery approximately 20 % of the proximal MCIV was left in place, as the remaining fragment was stable and showed no visible bone injury either macroscopically or radiographically. Taking into account all the findings, we decided against internal fixation due to the high risk of infection in an open, contaminated fracture.

A postoperative complication occurred after the first surgery which involved a longitudinal fracture in the proximal part of the splint bone along with the dislocation of a fragment. The fracture may have occurred due to hidden fracture lines in the proximal fragment or due to the tension of the palmar metacarpal fascia that is attached to the proximal part of the splint bones.

During the second surgery, the remaining part of the fractured MCIV was completely removed because of the high level of dislocation, making internal fixation more challenging, and due to the reasons mentioned above.

Currently, complete resection of a splint bone has only been described for the fourth metatarsal bone (MTIV) [1–3, 9]. In a study conducted by Baxter et al. [9], 5 out of 8 horses regained their previous performance level after the complete removal of MTIV. Different authors recommend removing the entire MTIV rather than attempting internal fixation in cases of infection and sequestration formation after conservative therapy, due to the high risk of implant infection [9].

In the postoperative course after a complete removal of MTIV, there is an increased risk for instability in the tarsometatarsal joint [2]. Because of the minimal weight on the fourth tarsal bone (TIV) to the head of MTIV, the risk to develop osteoarthritis in the tarsometatarsal joint can be regarded as very low [7, 9, 14].

The weight-bearing on the medial splint bone is greater than on the lateral splint bone, particularly in the front limbs. The second carpal bone (CII) transfers even more weight to the medial splint bone (MCII) than to the MCIII. Additionally, the MCII does not only articulate with CII but also with the third carpal bone (CIII) whereas the MCIV only articulates with the fourth carpal bone (CIV) [15, 16]. It has not been recommended in literature to remove more than two third of the MCII without internal fixation. However, a biomechanical study published in 2012, shows that the removal of 80 % of the MCII is possible without further complications [17]. Due to the small articulating surface with the fourth carpal bone and the biomechanical perspective, complete removal of the fourth metacarpal bone seems to be a treatment option for very proximal, multifragment, open, and severely contaminated fractures, similar to the situation after complete removal of MT IV in the hind limb.

In the case of complete splint bone removal, the rehabilitation period should be longer compared to partial resection to provide enough time for the ligamentous reattachment of palmar meta-

carpal fascia, palmar carpal fascia, and the suspensory ligament to MCIII. The radiographs taken 10 months after surgery showed a periosteal reaction and new bone formation in the proximal area where MCIV originally made contact with MCIII. However, this finding does not seem to have any clinical significance to the movement pattern of the patient in this case. Over the course of 6 years of follow-up, no complications arose, and the mare has been used for leisure riding at the same level as before the injury.

CONCLUSION FOR PRACTICE

This report describes a case of a mare with an open multifragment fracture of the splint bone, where complete removal of MCIV led to a positive clinical outcome. It suggests that, due to the high risk of implant infection and exostosis formation in other treatment options, complete removal of the splint bone could be a viable alternative for patients with a proximal multifragment fracture of the fourth metacarpal bone. The case also highlights the importance of diligent follow-up to promptly address any complications that may arise.

Conflict of interest

The authors declare that the manuscript was written in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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