Unusual incomplete frontal plane third metacarpal fracture in a dressage horse

Christoph T. Paschke and Ullrich Walliser

Pferdeklinik in Kirchheim, Kirchheim unter Teck, Germany

Summary: Different types and locations of fractures of the third metacarpal bone have been discussed for decades, especially in regard to treatment and prognosis. There is lack of documentation of frontal plane third metacarpal fractures diagnosed by MRI within the extensive previous literature. The present case report describes an incomplete frontal plane third metacarpal fracture in a dressage horse. The A 6 year-old Hanoverian mare was suddenly lame during side passes within a dressage contest. Physical examination revealed a grade 3/5 lameness of the left forelimb. When standing the horse showed a tendency to leg rest. A discrete oedematous swelling from the medio-proximal metacarpus to the middle third of the flexor tendons was palpable. Rotation of the phalanx resulted in a mild pain response. Initially a basic set of x-ray images was carried out, which did not show an evident fractureline. To further evaluate the cause of local swelling and lameness a standing MRI examination was carried out with a 0.27 Tesla Hallmarq EQ2 dedicated equine MRI system. In consequence, an incomplete frontal plane third metacarpal fracture of the third metacarpal bone was confirmed. The images depict typical features of acute fractures in MR studies. Angle adapted x-ray images were taken and the fracture line initially obscured by the splint bones became visible. No diagnostic block was performed due to the risk to worsen the incomplete fracture. Conservative management was chosen. During the first four weeks immobilisation was applied and exercise was restricted to box rest for another four weeks. During that time the mare was re-evaluated regarding to lameness in the walk, by MRI and by x-ray images. In the present case conservative management led to complete recovery. The last recheck in the stable took place after 46 weeks by the referring veterinarian. Until that time no signs of secondary osteoarthritis had occurred in follow-up radiographs taken by the referring veterinarian.

Keywords: equine, metacarpus, frontal, fracture, cannon bone, mri

Introduction

Metacarpal fractures occur in all parts of the cannon bone from proximal to distal. Short intracortical stress fractures of the dorsal cortices of Metacarpus III known as `saucer fractures can be found in different breeds used for disciplines of racing. The predisposed site of occurrence is the dorsal or dorsolateral diaphysis (*Cervantes* et al. 1992, *Hanie* et al. 1992, *Dallap* et al. 1999, *Jalim* et al. 2010). Cases in which fracture lines spread out from their distal or dorsal original position are well documented (*Spurlock* 1988, *Barr* et al. 1989).

Beside these cortical changes, the diaphysis almost exclusively gets involved in comminuted, short transverse or sometimes short oblique fractures of traumatic origin. Sometimes spiral fractures can be diagnosed. Furthermore, greenstick fractures do occur (*McClure* et al. 1998, *Bischofberger* et al. 2009). Condylar fractures (*Riggs* 2002), distal palmar cortical stress fractures (*O'Sullivan* and *Lumsden* 2002) and the incomplete proximal fractures (dorsal and palmar) (*Lloyd* et al. 1988), are supposed to result from a different pathophysiologic mechanism and to be of stress related nature.

Generally main factors evoking fractures of the long bones involve high bending loads and/or rotational forces (*Selker* and *Carter* 1989). Furthermore, avulsion fractures at the origin of the suspensory ligament (*Bramlage* et al. 1980, *Booth* 2003, *Launois* et al. 2010) and dorsal cortical fatigue fractures do occur. Additionally, in foals fractures with involvement of the growth plates (Salter-Harris-type) have to be considered (*Orsini* 2012).

The incidence of cannon bone fractures in regard to all bone fractures is 17.2−17.7% in racing thoroughbreds (*Mizuno* 1996). In general, complete fractures of the third metacarpal bone have a prevalence of 22.3% of all long bone fractures (*McClure* et al. 1998). Incomplete proximal third metacarpal fractures seem to be comparatively rare (*Lloyd* et al. 1988, *McClure* et al. 1998).

Incomplete proximal third metacarpal fractures result in a mild to severe, but predominantly moderate grade of lameness and rather subtle physical findings (*Ross* et al. 1988, *Pleasant* et al. 1992). Usually the assumption of a fracture can be made based on radiographic images. If no fracture line is visible trabecular hypertrophy and / or medullary sclerosis in a dorsal to palmar radiographic view and in chronic cases intramedullary sclerosis in a latero-lateral view can hint to fracture. Only in a minority of cases the definite diagnosis of an incomplete proximal third metacarpal bone fracture can be made by radiography only (*Lloyd* et al. 1988, *Ross* et al. 1988, *Pleasant* et al. 1992, *Mizuno* 1996, *O'Sullivan* and *Lumsden* 2002). Oftentimes advanced imaging techniques such as ultrasound (*Richardson* 2005), nuclear scintigraphy (*McClure* et al. 1998, *O'Sullivan* and *Lumsden* 2002) or magnetic resonance imaging (MRI) are required to secure the fracture diagnosis and to monitor healing.

Furthermore computed tomography (CT) is well established to precisely distinguish structural bony pathology such as (incomplete) fractures and can aid surgical planning (*Del Chicca* et al. 2008, *Braim* et al. 2010, *O'Brien* et al. 2011, *Brünisholz* et al. 2015). But currently the use of CT is limited as general

anaesthesia is still prerequisite to the use of this modality in diagnostic imaging of equine limbs (*O'Brien* et al. 2011).

Undisrupted and healthy subchondral and cortical bone does not give a MRI signal, which results in a black appearance in all MR sequences. Outline and inner margins are well delineated. Due to its structure cancellous bone has an inhomogeneous appearance. On the one hand the bony component lacks any signal and on the other hand the fatty bone marrow component and soft tissues give in general a high signal thus resulting in somewhat grainy and mixed signal intensity. Only in fat suppressed STIR (short τ inversion recovery) sequences there is no signal resulting from the bone marrow (*Martinelli* et al. 1996, *Tucker* and *Sande* 2001, *Breitenseher* 2005, *Murray* and *Mair* 2005, *Murray* et al. 2009).

In case of (incomplete) bone fracture the appearance changes markedly. The fissure or fracture line produces a high MR signal and thus becomes visible as a bright white line in most sequences but especially in T2 weighted sequences. Furthermore the surrounding bone matter produces reduced signal intensity in T1 weighted images or increased signal intensity in STIR as well as in PD (proton density) sequences. It gives a mixed fluid and fat signal which usually shows up very markedly in T2* GRE weighted sequences by its fat / water phase cancellation artefact in active cases (*Murray* and *Mair* 2005, *Powell* 2012, *Smith* et al. 2012, *Ramzan* et al. 2015).

Conservative management as well as surgical treatment under general anaesthesia or in a standing procedure are described (*Lloyd* et al. 1988, *Ross* et al. 1988, *Platt* et al. 1990, *Pleasant* et al. 1992, *Payne* and *Compston* 2012). Despite usual involvement of the carpometacarpal joint and the origin of the suspensory ligament simple incomplete fractures of the proximal palmar cortex of the third metacarpal bone are correlated
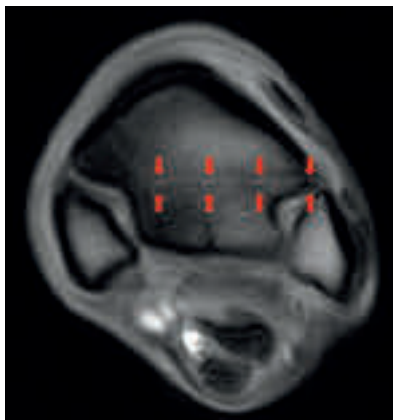

Fig. 1 T1W GRE TRA MI MR image obtained 0.5 cm distal to the carpometacarpal joint (day 4 after onset of lameness). Lateral is to the right. Discrete linear disruption of the lateral cortical bone plate and the cancellous bone within the cannon bone (between arrows). Adjacend cancellous bone with generalized medium degree of reduced signal especiallaly on the medial side. Normally there is mixed signal intensity as present within the unaffected splintbones.
T1W GRE TRA MI MR – Aufnahme gewonnen 0,5 cm distal des Carpometacarpalgelenkes (am 4. Tag nach dem Eintreten der Lahmheitssymptome). Rechts entspricht lateral. Diskrete lineare Unterbrechung der lateralen Corticalis und der spongiösen Knochensubstanz des Röhrbeines (zwischen den Pfeilen). Die umgebende Spongiosa weist eine mittlere, generalisierte Reduktion des Signales besonders der medialen Seite auf. Physiologisch wäre eine gemischte Signalintensität wie diese in den nicht betroffenen Griffelbeinen vorhanden ist.

to a good prognosis for soundness even for athletic purposes (*Lloyd* et al. 1988, *Ross* et al. 1988, *Platt* et al. 1990, *Pleasant* et al. 1992, *Payne* and *Compston* 2012).

For this type of fracture a shortened period of convalescence and return to training earlier than three month after injury resulted in a recurrence of lameness (*Ross* et al. 1988). The mean duration of box rest in horses suffering an incomplete palmar third metacarpal bone fracture is reported to be 6 months and carries a good prognosis with 9 out of 10 horses returning to soundness (*Lloyd* et al. 1988) with a substantial amount of horses (64 %) returning to full athletic function (*Pleasant* et al. 1992).

Complications of surgical treatment of third metacarpal fractures can be rather common (19 %) and involve local problems like fragmentation of drill bits, osteomyelitis, disturbed fracture union, catastrophic failure of the cannon bone or local infections as well as more generalised complications like laminitis and colitis (*McClure* et al. 1998, *Lescun* et al. 2007). Furthermore, recurrence of the fracture at the same site does occur (*Cervantes* et al. 1992). To the author`s knowledge the present case is the first one in this special location diagnosed by MRI, therefore precedence in therapy and prognosis lacked.

Case History

A 6 year-old Hanoverian mare was presented to our clinic four days after a sudden onset of non-weight-baring lameness, which occurred during side passes within a dressage
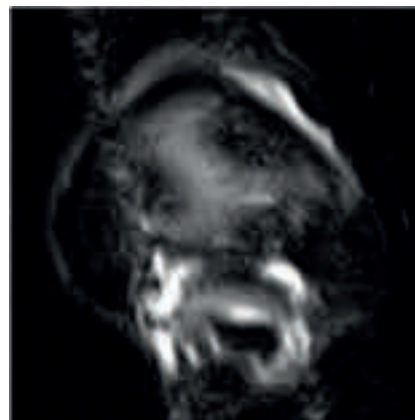

Fig. 2 Short τ inversion recovery (STIR) FSE TRA MI MR image obtained at the same level and day as image 1. Lateral is to the right. Widespreat increased signal in the cancellous bone adjacend to the fracture site indicating the presence of fluid. Normally there is no fluid signal present as visible within the unaffected splintbones. Note: A similar fluid signal can be seen at the dorsolateral section of the soft tissues at the cannon bone due to their inflammatory response close to the site of compacta / periosteal disruption.
Short τ inversion recovery (STIR) FSE TRA MI MR – Aufnahme gewonnen auf der gleichen Höhe und am selben Tag wie bei Abbildung 1. Rechts entspricht lateral. Die weitreichende, verstärkte Signalintensität des spongiösen Knochengewebes, das dem Frakturbereich anliegt, weist auf einen erhöhten Flüssigkeitsgehalt hin. Physiologisch wäre ein signalloses Gewebe wie diese in den nicht betroffenen Griffelbeinen sichtbar ist. Beachte: Ein entsprechendes Flüssigkeitssignal tritt im dorsolateralen Abschnitt des Weichteilgewebes auf dem Röhrbein auf. Es ist eine Folge der Entzündungsreaktion an der Unterbrechung von Compacta bzw. Periost.

contest in which the horse competed according to its age. No history of previous lameness or traumatic incident was known to the owner.

Initial clinical presentation

When arriving at our facility the mare was grade 3/5 lame in the left front leg independent of the underground on which
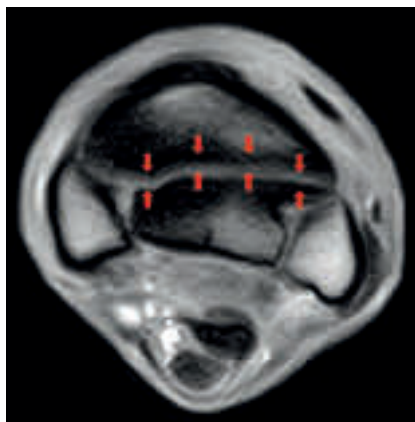

Fig. 3 T1W GRE TRA MI MR image obtained at the same level as image 1 (day 41 after onset of lameness). Lateral is to the right. Marked linear disruption of the lateral cortical bone plate and the cancellous bone wthin the cannon bone (between arrows). Adjacend cancellous bone with more focal reduced signal intensity. Normally there is mixed signal as present within the unaffected splintbones.
T1W GRE TRA MI MR – Aufnahme gewonnen auf der gleichen Höhe wie bei Abbildung 1 (am 41. Tag nach dem Eintreten der Lahmheitssymptome). Rechts entspricht lateral. Deutliche, lineare Unterbrechung der lateralen Corticalis und der spongiösen Knochensubstanz des Röhrbeines (zwischen den Pfeilen). Die umgebende Spongiosa weist einen örtlich begrenzteren Signalverlust auf. Physiologisch wäre eine gemischte Signalintensität wie diese in den nicht betroffenen Griffelbeinen vorhanden ist.

Fig. 4 T1W GRE SAG MI MR image obtained at the same day as image 3. Dorsal is to the left. Marked linear disruption of the subchondral bone plate and the cancellous bone within the proximal cannon bone (arrows). Adjacend cancellous bone with focal reduced signal intensity. Normally there is mixed signal as present within the unaffected third carpal bone.
T1W GRE SAG MI MR – Aufnahme gewonnen am selben Tag wie bei Abbildung 3. Links entspricht dorsal. Deutliche, lineare Unterbrechung der subchondralen Knochenplatte und der spongiösen Knochensubstanz des proximalen Röhrbeines (Pfeile). Die umgebende Spongiosa weist einen örtlich begrenzteren Signalverlust auf. Physiologisch wäre eine gemischte Signalintensität wie diese im nicht betroffenen Os carpale tertium vorhanden ist.

the horse was presented. When standing the horse showed a tendency to leg rest. Closer inspection of the limb revealed discrete oedematous swelling from the medioproximal metacarpus to the middle third of the flexor tendons. Digital pulses, hoof testers and filling of the synovial cavities of the distal limb were within normal limits. Rotation of the phalanx resulted in a mild pain response whereas flexion appeared unremarkable.

Diagnostic imaging

Initially a basic set of x-ray images was carried out, which usually consists of a latero-medial (90°), a frontal (0°) and two oblique views (45°/135°) using a FUJIFILM FCR Profect One system. The acquired images did not show evident pathology but an incomplete fracture was assumed.

To further evaluate the cause of local swelling and lameness a standing MRI examination was carried out. A 0.27 Tesla Hallmarq EQ2 dedicated equine MRI system was used and images were acquired in a standard procedure. The sequences used were described by *Ramzan* and *Powell* (2010) for the fetlock. Due to increasing discomfort during the examination the study was finished with a shortened protocol. T1 weighted gradient echo (TRA, SAG and FRO), T2* weighted gradient echo (TRA) and short τ inversion recovery (STIR) fast spin echo (TRA and SAG) were acquired. In consequence, an incomplete frontal plane fracture of the third metacarpal bone was confirmed (Figures 1 and 2). The images depict typical features of an acute (incomplete) fracture in MR studies. Angle adapted x-ray images were taken and the fracture line initially obscured by the splint bones became visible (Figure 5). Even tough lameness of incomplete fractures of the proximal third metacarpal bone can improve to a high palmar regional nerve block as described by *Lloyd* et al. (1988), no diagnostic block was performed due to the risk to worsen the incomplete fracture.

Fig. 5 Angle-adapted latero-lateral radiograph (80°; day 4 after onset of lameness). Fine fissure fracture advancing from the carpo-mediocarpal joint into the proximal cannon bone.
Winkel-adaptierte Röntgenaufnahme (80°; am 4. Tag nach dem Eintreten der Lahmheitssymptome). Diskrete Fissurlinie, die sich vom Carpometacarpalgelenk in das proximale Röhrbein hinein erstreckt.

Management

Surgical treatment / approach was without clear reference for this specific lesion orientation. Given the mare's character and size the risk of recovery from general anaesthesia in absence of a hydropool seamed high. Thus a conservative approach was chosen. During the first four weeks immobilisation with an splint enforced Robert-Jones dressing up to the elbow joint was applied as recommended for first aid by different authors (*Smith* 1993, *Walmsley* 1993, *Schramme* 2005, *Auer* 2012) until the mare no longer tolerated the bandage. Exercise was restricted to box rest. Due to incompliant behaviour proper cast immobilisation appeared too risky. Whereas splint enforced dressing was tolerated well initially. After treatment a mild focal decubitus was visible. This is a well described complication especially after long term bandaging due to ischemia induced by intense pressure which can result in focal dermal necrosis (*Morlock* et al. 1997, *Payne* and *Compston* 2012). It resolved after removing the bandage without further treatment. During additional four weeks of box rest without bandage the mare was re-evaluated regarding to lameness in the walk, by MRI and by x-ray images. The outline of the bone structure disruption initially became more clearly visible in x-rays after day 14 and was also visible on MR images at day 41 respectively (Figures 3 and 4). This widening of the fracture gap is a typical phase of bone fracture healing, two to three weeks after the formation of a fracture line (*Sande* 1999). Furthermore, the widespread fluid signal resolves over time, which facilitates a clear delineation of the fracture outline.

During the course of healing a marked callus formation was visible. Eight weeks after admission the horse was released into her owner s care. Over a time of 14 weeks a careful controlled exercise program was installed. Starting with five minutes in hand walking without turns. Later ridden work was invented and the workload subsequently increased. By 26 weeks all passes had been reinvented and the training was extended to the lesson necessary for age appropriate dressage contests.

Outcome/Follow-up

After 46 weeks the last recheck in the stable took place for routine purposes by the referring veterinarian. By that time the horse had returned to its intended use and was furthermore used for low level jumping exercises without limitations. Until that time no signs of secondary osteoarthritis had occurred in follow-up radiographs taken by the referring veterinarian.

Discussion

While (incomplete) proximal third metacarpal fractures have been described to occur in a sagittal plain (*Lloyd* et al. 1988, *Ross* et al. 1988, *Pleasant* et al. 1992, *Richardson* 2005) the recent case demonstrates that (incomplete) frontal plane fracture of the third metacarpal bone can arise and can be treated successfully.

The current case was several years older compared to race horses suffering from different bone stress related fractures which are usually diagnosed in early age of mostly under three years (*Cervantes* et al. 1992, *Dallap* et al. 1999, *O'Sullivan* and *Lumsden* 2002, *Jalim* et al. 2010). In general racehorses compete at an early age. In comparison horses used for dressage purposes need to be trained longer for competition, which is reflected in increased age. This age matches other cases of incomplete proximal third metacarpal fractures in non-racehorses in sagittal orientation (*Lloyd* et al. 1988). Nevertheless, the mare was subsequently undertaking an increasing amount of workload, which might have been inappropriate in regard to the adaptation of her developing bone matter. Typically horses diagnosed with incomplete proximal third metacarpal fractures had a history of altered work type or load (*Pleasant* et al. 1992).

The proximal third metacarpal bone has an almost oval shape with the cortical bone being thicker in dorsal and palmar components. The areas of contact to the splint bones on either side of the cannon bone have only a thin layer of cortical bone at the very proximal end, resulting in an almost pentagonal shape immediately distal to the carpometacarpal joint (*Les* et al. 1997, *Murray* 2007, *Sampson* and *Tucker* 2007). The dorsal half of the subchondral bone plate of the cannon bone within carpometacarpal joint is very thick compared to its palmar section (*Les* et al. 1997, *Sampson* and *Tucker* 2007, *Nagy* and *Dyson* 2011).

During the horses motion the bones are known to physiologically be exposed to three types of force: axial loading / compression, bending and torsion (*Selker* and *Carter* 1989). Furthermore, lateral impact due to trauma must be considered which can result in cannon bone fractures (*Bischofberger* et al. 2009). Ex vivo cannon bone specimens of thoroughbred race horses predominantly suffer longitudinal bone cracks evolving from one of the ends (*Cheney* et al. 1973). Generally, main factors evoking fatigue fractures of the long bones involve high bending loads and / or rotational forces (*Selker* and *Carter* 1989). Due to its oval shape the cannon bone of the horse represents a structure optimised for dorsal bending and thus is naturally less well prepared to cope with sagittal bending (*Les* et al. 1997). The fact of side passes entailing a high degree of dynamic sagittal bending in addition to the other forces affecting the long bones during competitions might have contributed to pathogenesis in the present case albeit this kind of lesion seems to be very rare.

Furthermore, in vitro examinations in isolated bone loading models have proven a significant individual variation of biological resistance to fracture resulting from cyclic overload (*Danova* et al. 2003). It remains unclear whether the incomplete proximal third metacarpal fracture in a frontal plain is an under diagnosed lesion. The supposed underlying pathogenesis of ill fitted workload in regard to structural adaptation of different loaded structures like bones is a long known problem in racing animals but might become a growing problem in riding populations as well. Increasing rideability and more accentuated gates are clearly goals of horse breeding societies, which allow earlier participation in higher-level competitions. Thus time for adaptation of the musculoskeletal system might get shorter. Nevertheless, third metacarpal fissures and fractures have been reported predominantly in racehorses (standardbred trotters and thoroughbreds) (*Cervantes* et al. 1992, *Pleasant* et al. 1992, *Ross* and *Martin* 1992, *Mizuno* 1996, *Dallap* et al. 1999, *Zekas* et al. 1999, *O'Sullivan* and

Lumsden 2002, *Parkin* et al. 2004, *Parkin* et al. 2006, *Jalim* et al. 2010) even if some reports document a wider range of breeds and uses (*Lloyd* et al. 1988).

The possible fatal outcome demands an early diagnosis. While x-ray is still valuable as a first line diagnostic tool and for recheck examinations for example to monitor for callous formation or signs of osteoarthritis it has its limitations. As once more demonstrated in the recent case in anatomically complex areas tomographic techniques are superior to plain radiographs. This special occurrence of proximal third metacarpal fractures carries the risk of being obscured by the splint bones in latero-lateral radiographic views. Furthermore, the high variation of bone thickness might result in the optical illusion of Mach bands in that very area (*Daffner* 1989, *Nielsen* 2001, *Reeves* 2004). Due to increasing awareness of radiation safety issues and comprehensive availability of standing MRI, early MR evaluation should be considered. Nevertheless, standing MRI of the proximal metatarsal area has its challenges in painful horses, resulting in increased levels of patient motion and thus motion related artefacts.

In the present case early fracture diagnosis was possible. Despite her unpleasant temperament, the mare recovered during conservative management and was able to go back to her intended use. This observation fits an overall positive prognosis and results from the fact that intraarticular fractures are supposed to be more forgiving in joints with a low range of motion (*Lloyd* et al. 1988, *Ross* et al. 1988, *Pleasant* et al. 1992). The present case was even favourable compared to sagital incomplete fractures of palmaro-proximal metacarpus due to lack of suspensory ligament involvement at its attachment.

Manufacturer s addresses

FUJIFILM Europe GmbH, Düsseldorf, Germany
Hallmarq Veterinary Imaging, Guilford, Surrey, UK.

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Erweiterte Zusammenfassung

Eine ungewöhnliche Röhrbeinfraktur an der Vordergliedmaße eines Dressurpferdes

Eine 6-jährige Hannoveraner Stute zeigte während der Traversale in einem Dressurwettbewerb plötzlich eine hochgradige Lahmheit einer Vordergliedmaße. Es waren weder ein vorangegangenes Trauma noch eine frühere Lahmheit bekannt. Die Befunde der klinischen Untersuchung beim Eintreffen in der Pferdeklinik umfassten eine Lahmheit Grad 3/5 der linken Vordergliedmaße und die Entlastung des Beines im Stand. Weiterhin war eine diskrete, ödematöse Schwellung vom medioproximalen Röhrbein bis zum mittleren Drittel des Beugesehnenpaketes tastbar. Die Rotation der distalen Gliedmaße resultierte in einer Schmerzreaktion. Auf den initial angefertigten Röntgenaufnahmen in Standardprojektionen war ein Fissurspalt zunächst nicht klar darstellbar, sodass eine Kernspintomographie im Stehen durchgeführt wurde. Dazu wurde ein 0,27 Tesla Hallmarq-EQ2-System verwendet, welches zur Untersuchung der Gliedmaßen am stehenden Pferd entwickelt wurde. Es war so möglich eine eine inkomplette Fraktur des Metacarpus III zu bestätigen, deren Verlauf das proximale Röhrbein in frontaler Ausrichtung durchmaß.

Die Behandlung erfolgte konservativ mittels Ruhigstellung über vier Wochen und im Anschluss weiterer vier Wochen vollständiger Boxenruhe. Während dieses Zeitraumes erfolgten neben den klinischen Verlaufsuntersuchungen, auch eine Kontrolle mittels Magnetresonanztomographie und wiederholten Röntgenaufnahmen. Dabei war zunächst nach dem 14. (Röntgen) bzw. 41. Tag (Magnetresonanzomographie) eine klarer begrenzte Unterbrechung der Knochenstruktur darstellbar. Weiterhin bildete sich das ausgedehnte Flüssigeitssignal im Laufe der Zeit zurück, sodass die Abgrenzbarkeit der Fissurlinie deutlicher wurde. Mit fortschreitendem Heilungsverlauf war eine deutliche Kallusbildung sichtbar. Acht Wochen nach der Einlieferung in die Pferdeklinik wurde das Pferd in Betreuung des Pferdebesitzers entlassen. Mittels eines kontrollieren Bewegungsprogrammes wurde die Stute über 14 Wochen systematisch aufgebaut. In der 26. Woche nach dem Auftreten der Fraktur war die Genesung soweit fortgeschritten, dass die in einer altergemäßen Dressurprüfung erforderlichen Lektionen wieder trainiert werden konnten. Die letzte Nachuntersuchung fand nach 46 Wochen im Stall des Pferdes durch den betreuenden Haustierarzt statt. Zu diesem Zeitpunkt war das Pferd wieder im Training und wurde auch über leichte Sprünge geritten. Weiterhin ließen sich auf den zu dieser Gelegenheit angefertigten Kontrollröntgenaufnahmen keine Anzeichen einer sekundären Arthrose darstellen.

Schlüsselwörter: Pferd, Metacarpus, frontal, Fraktur, Röhrbein, MRT