

Surgical treatment including gentamicin-impregnated collagen sponge implantation of a chronic sinus tract of the superficial digital flexor tendon in a Hannoverian mare

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Summary: An 18 months old Hannoverian mare was presented with an approximately 8-week old, non-healing focal wound in the left mid metatarsal region and severe left hind limb lameness at a walk (grade 4/5). Ultrasonography revealed a sinus tract between the skin and the superficial digital flexor tendon (SDFT) and a diffuse chronic tendonitis of the SDFT. Surgical *en bloc* resection of the sinus tract and the affected SDFT tissue was performed, and two collagen sponges (size 5 cm × 5 cm × 0.5 cm) consisting of 70 mg equine tendon collagen impregnated with 50 mg gentamicin sulfate (GENTA-COLLresorb®, Resorba Medical GmbH, Nürnberg, Germany) were implanted into the wound prior to closure in 3 layers. A half limb cast was applied for 14 days followed by 4 days of a splint bandage. The wound healed by primary intention and the horse was discharged 4 weeks post operatively. Follow up examinations 6 and 24 month after discharge revealed excellent wound healing and soundness. Seven and 14 years after surgery the horse was still successfully used as pleasure riding horse as intended.

Keywords: Tendon, trauma, laceration, septic tendonitis, fistula, collagen sponge, antibiotic, immobilisation

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Introduction

Septic tendonitis in horses has been rarely reported compared to septic tenosynovitis.^[1] Although primary septic tendonitis^[1] or septic tendonitis secondary to systemic infectious diseases has been described,^[2] it is more common, that septic processes are the result of a percutaneous injury with subsequent infection of the underlying structures.^[3]

This case report describes the diagnosis, treatment, and long-term outcome of a partial laceration and septic tendonitis of the superficial digital flexor tendon (SDFT) with subsequent formation of a sinus tract between the SDFT and the skin as a late complication of the percutaneous trauma.

Case details

History and clinical findings

The mare was presented with a history of a non-healing wound at the mid metatarsal region. According to the owner, the mare had injured herself with a metal object on the trailer approximately 8 weeks previously. Since then, the mare had shown lameness at a walk and intermittently mild fever. The

treatment of the referring veterinarian consisted of cleaning, curettage and bandaging of the wound.

On presentation, the horse was bright and alert and vital parameters were within normal limits. Complete blood count revealed a moderate leucocytosis of 15.8 G/l (reference range 5 to 10 G/l). A moderate diffuse swelling of the left metatarsus and a focal exudative wound with a diameter of 2 cm and perifocal granulation tissue at the latero-plantar aspect of the mid metatarsal region was noticed (Fig. 1a). The swollen area was warm and painful on palpation.

While standing, the horse constantly rested its left hind limb and showed severe left hind limb lameness (grade 4/5) at walk. A focal chronic and exudative wound and cellulitis of the distal metatarsal region were diagnosed.

Further examinations

Ultrasonographic examination was performed in the transverse and longitudinal plane including panoramic imaging using a 6–15 MHz linear ultrasound probe (Logiq E9, General Electric [GE] HealthCare) and a standoff pad (Figs. 2a and 3a). A sinus tract between the skin surface and the SDFT was visible

as a hypoechoic area reaching the SDFT on the level of zone 2B to 3A. Adjacent to this area the SDFT was heteroechoic with hyperechoic spots (Fig. 3a) and disorganized fiber-bundle alignment (Fig. 2a). The adjacent latero-plantar parts of the deep digital flexor tendon (DDFT) showed more aligned fiber bundles but also a heteroechoic texture and could not be clearly differentiated from the SDFT (Figs. 2a, 3a). A pre-

sumably chronic sinus tract caused by a partial laceration of the SDFT with signs of a diffuse, septic tendonitis (zone 3A to 4A) and a partial, diffuse tendonitis of the DDFT (zone 3A to 4A) with fibrous adhesions between the latero-plantar aspect of the SDFT and the DDFT were diagnosed. Ultrasonography of the common digital flexor tendon sheath (DFTS) showed mild effusion with anechoic fluid. A swab sample from the



Fig. 1 Lateral aspect of the distal left hindlimb over time. (a) Prior to, (b) 2 weeks after and (c) 2 years after en bloc resection of a chronic sinus tract from the superficial digital flexor tendon. Yellow arrow: opening of the sinus tract; White arrows depict the approximate segment of the plantar metatarsus shown ultrasonographically in figure 2. | Laterale Ansicht der hinteren linken Mittelfußregion im zeitlichen Verlauf. (a) Vor, (b) 2 Wochen nach und (c) 24 Monate nach chirurgischer en bloc Resektion einer chronischen Sehnenfistel der oberflächlichen Beugesehne. Gelber Pfeil: Fistelöffnung; Weiße Pfeile markieren näherungsweise den in Abb. 2 ultrasonographisch dargestellten Anteil des plantaren Metatarsus,

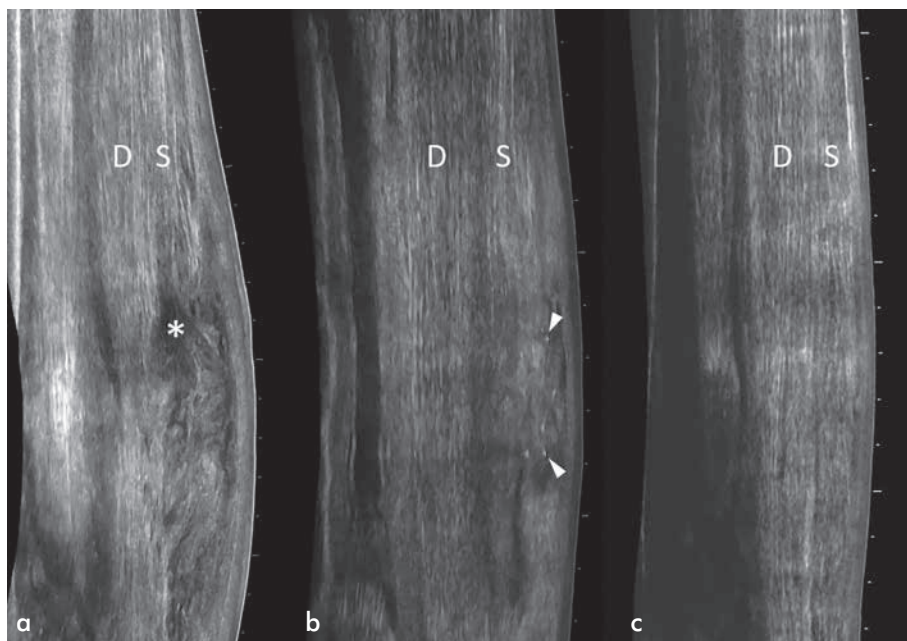


Fig. 2 Consecutive longitudinal panoramic ultrasonographic images of the left plantar metatarsus. (a) Prior to, (b) 2 weeks after and (c) 2 years after en bloc resection of a chronic sinus tract from the superficial digital flexor tendon (SDFT). D: deep digital flexor tendon, S: SDFT, asterisk: channel of sinus tract; Arrowheads indicate cross sections of suture material. | Longitudinale Panorama-Ultraschallbilder des linken plantaren Metatarsus im zeitlichen Verlauf. (a) Vor dem, (b) 2 Wochen nach und (c) 2 Jahre nach chirurgischer en bloc Resektion einer chronischen Sehnenfistel der oberflächlichen Beugesehne (OBS). D: Tiefe Beugesehne, S: OBS, Stern: Fistelgang; Pfeilspitzen weisen auf Anschnitte von Nahtmaterial hin.

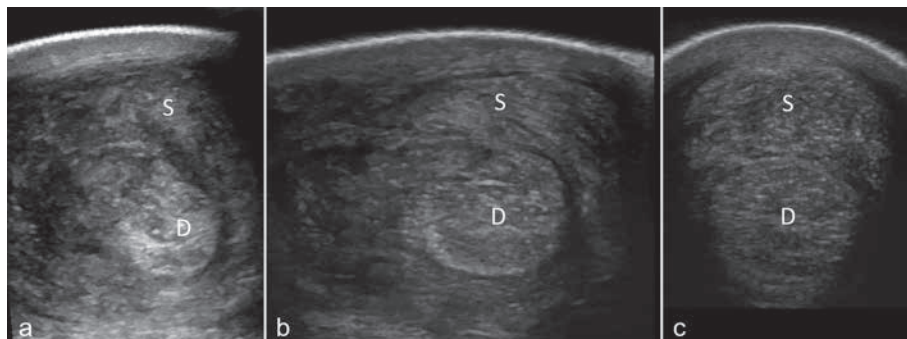


Fig. 3 Consecutive transverse ultrasonographic images of the left plantar metatarsus at the level of the greatest extent of the original tendon lesion. (a) Prior to, (b) 2 weeks after and (c) 2 years after en bloc resection of a chronic sinus tract from the superficial digital flexor tendon (SDFT). D: deep digital flexor tendon, S: SDFT. | Transversale Ultraschallbilder des linken plantaren Metatarsus im zeitlichen Verlauf auf Höhe der größten Ausdehnung der ursprünglichen Sehnenläsionen. (a) Vor, (b) 2 Wochen nach und (c) 2 Jahre chirurgischer

en bloc Resektion einer chronischen Sehnenfistel der oberflächlichen Beugesehne (OBS). D: Tiefe Beugesehne, S: OBS.

sinus tract revealed infection with *Streptococcus equi* subsp. *zooepidemicus* (*S. zooepidemicus*), which was demonstrated to be sensitive to several antimicrobials amongst these cefquinome and gentamicin.

Radiographic examination of the left metatarsus revealed a small area of radiolucency (1 × 1 cm) in the middle of the fourth metatarsal bone (Mt IV) at the same level as the soft tissue wound. In this area, the diameter of the Mt IV was increased, and the bone contour was irregular. These findings were indicative of an old fracture of the lateral splint bone in the process of healing with callus formation.

Treatment

Surgical treatment of the wound and resection of the affected tissue including the sinus tract was recommended. After 3 days of consideration, the owners agreed to the procedure. During this time, the horse was treated medically with 1 mg/kg cefquinome IM (Cobactan 4.5% 1 Intervet GmbH, Unterschleissheim, Germany) once daily. The left hind limb was bandaged and wooden wedges for heel elevation were applied on both hind limbs. Prior to surgery the horse received 1.1 mg/kg flunixin-meglumine IV (Flunidol RP; 2 CP Pharma, Burgdorf, Germany).

The horse was anesthetized and positioned in right lateral recumbency. To confirm that the DFTS was not affected, synovial fluid was sampled and analysed. The results of the analyses indicated mild aseptic synovitis with a total cell count of 1000 cells/ μ l (reference range < 1500/ μ l), with 9% neutrophils (reference range < 20%) and a total protein concentration of 2.8 g/l (reference range < 1.5 g/l).

Afterwards, blood flow to the surgical field was reduced using an Esmarch bandage, which was applied just distal to the tarsus. The opening of the sinus tract was closed provisionally with a simple continuous suture and a longitudinal fusiform skin incision of about 7 cm length was performed around it. The fibrous tissue of the sinus tract including all affected tissue of the SDFT was resected *en bloc* (Fig. 4a). Direct involve-

ment of DDFT could not be revealed, and no foreign material was found at the base of the tract (Fig. 4b, c). Two sponges (5 × 5 × 50.5 cm) consisting of equine tendon collagen (70 mg) impregnated with 50 mg gentamicin sulfate (GENTACOLLresorb®, Resorba Medical GmbH, Nürnberg, Germany) were implanted into the wound and kept in place by adapting parts of the SDFT and the surrounding thickened fascia with a simple continuous suture using 4 metric absorbable synthetic monofilament polydioxanone (PDS, Ethicon, Hamburg, Germany). The subcutis was also closed using a simple continuous pattern (4 metric; PDS, Ethicon, Hamburg, Germany). The skin incision was closed with an interrupted vertical mattress suture (Donati-) pattern using a 4 metric absorbable synthetic monofilament suture (Glycolon, Ethicon, Hamburg, Germany) and a half limb cast was applied. Recovery from general anaesthesia was coordinated and uneventful.

Post-operative management

After recovery an epidural catheter was placed aseptically and 80 μ g/kg of morphine (Morphin ratio 20 mg/ml, Ratiopharm, Ulm, Germany) in combination with 5 μ g/kg of detomidine (Cepesedan 10 mg/ml, CP Pharma, Burgdorf, Germany) diluted with physiologic saline to 10 ml were administered epidurally every 8 to 12 hours for 3 days. Further, the horse received 1.1 mg/kg of flunixin-meglumine twice daily for 6 days and once a day for the following 11 days. The horse continuously showed full weightbearing of the left hindlimb. Cefquinome (1 mg/kg, once a day) was administered via regional limb perfusion for the first 4 days after surgery. From day 5 onwards cefquinome was administered systemically via intramuscular injection for the following 11 days. Two weeks after surgery the cast and the skin sutures were removed. The wound healed by primary intention (Fig. 1b) and without complications, except for formation of a small seroma that resolved spontaneously. Ultrasonography revealed no signs of infection and adequate wound healing (Figs. 2b, 3b). A bandage with a plantar splint (Fig. 5a) was applied for 4 days followed by another 4 days of bandaging without a splint. After cast-removal, the horse was hand-walked for up to 3 minutes twice daily and the bandages were changed every

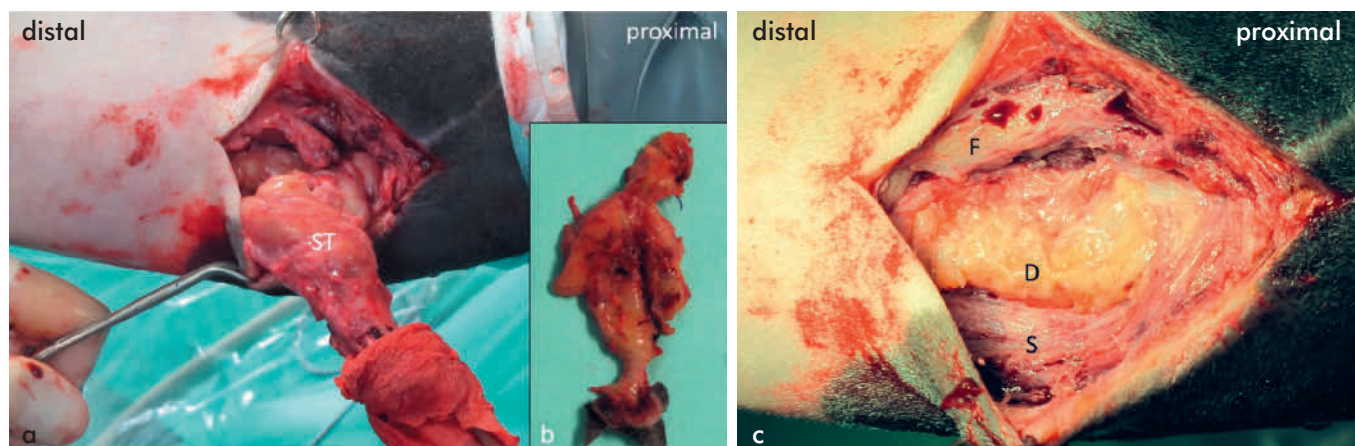


Fig. 4 Sinus tract during resection from the superficial digital flexor tendon, SDFT (a) and with opened channel (b). Wound after resection of the sinus tract and débridement (c). D: deep digital flexor tendon, covered by edematous connective tissue; F: fascia, S: SDFT, ST: sinus tract. | Sehnenfistel während der Resektion aus der oberflächlichen Beugesehne (a) und mit geöffnetem Fistelgang (b). Operationswunde nach Resektion der Sehnenfistel und Débridement (c). D: Tiefe Beugesehne bedeckt von ödematösem Bindegewebe, F: Faszie, S: OBS, ST: Fistelgang.

2 to 3 days. Additionally, the hoof was trimmed and a shoe with palmar extensions and slightly elevated heels was applied (Fig. 5b). The horse was discharged 4 weeks after surgery.

Follow-up

The duration of hand-walking intervals was slowly increased over the following 6 months to up to 1 hour per day. On re-evaluation 6 months after discharge the horse showed a moderate lameness (degree 2/5) and the distal metatarsal area was still slightly swollen, but without signs of acute inflammation. The exercise intensity was slowly increased over the next year, including pasture turnout. During the follow-up examination 24 months after discharge the horse was sound at a walk and trot and swelling of the metatarsal area had further decreased (Fig. 1c). Conventional ultrasonography (Fig. 2c, 3c) and computed Ultrasound Tissue Characterisation (UTC) revealed healing of the SDFT and DDFT lesions with



Fig. 5 Palmar splint (a) and metal horseshoe with palmar extensions and bar for moderate heel elevation (b). | *Palmare Schiene (a) und Hufeisen mit verlängerten Hufeisenschenkeln und geringgradiger Trachtenerhöhung durch untergeschweißten Steg (b).*

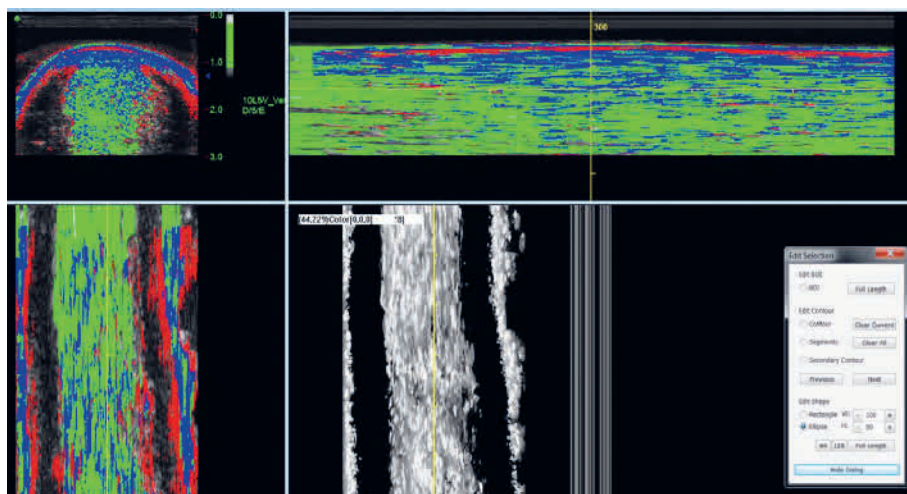


Fig. 6 Ultrasound Tissue Characterization (UTC). Colour coded transverse (top left), sagittal (top right) and frontal (bottom left) ultrasonographic images of the superficial digital flexor tendon (SDFT) and parts of the deep digital flexor tendon of the left hindlimb 2 years after resection of a sinus tract from the SDFT. Green echo-type I: intact, aligned fascicles; Blue echo-type II: discontinuous, waving, swollen fascicles; Red echo-type III: fibrillar matrix; Black echo-type IV: amorphous matrix, fluid. | *Ultraschallbild der oberflächlichen Beugesehne (OBS) und von Teilen der tiefen Beugesehne der linken Hintergliedmaße 2 Jahre nach chirurgischer Entfernung einer*

Sehnenfistel der OBS. Grüner Echotyp-I: intakte und parallel ausgerichtete Faszikel; Blauer Echotyp-II: Diskontinuierliche, verdickte, wellige Faszikel; Roter Echotyp-III: Fibrilläre Matrix; Schwarzer Echotyp IV: Amorphe Matrix, Flüssigkeit.

re-alignment of fiber bundles and advanced re-organization of amorphous and fibrillar matrix into discontinuous, waving fascicles (Fig. 6). On telephone follow-up 7 and 14 years after surgical treatment the owners reported that the horse was still sound and used for pleasure riding as intended.

Discussion

In the reported case, the horse was presented with a chronic non-healing wound that included the skin, subcutis as well as parts of the SDFT. *En bloc* resection of the sinus tract, systemic and local antimicrobial treatment including allogenous collagen as well as immobilisation followed by a gradually increasing exercise programme led to an excellent functional, ultrasonographic and cosmetic outcome.

Despite treatment attempts by the referring veterinarian wound healing was incomplete for 8 weeks after the initial trauma in the reported case. The treatment of penetrating wounds with partially lacerated flexor tendons but without involvement of tendon sheaths usually consists of thorough debridement of the affected tendon tissue, limb-immobilisation and systemic application of anti-inflammatories and antimicrobials.^[4-6]

In this current case the lack of sufficient bandaging and immobilisation after the initial trauma might have contributed to the incomplete wound healing. Excessive movement of an injured area can disrupt the healing process by repetitively destroying the new formed tissue components.^[7] Additionally, injury of the collagen-rich tendinous tissue prolongs wound healing because pathophysiological proteolysis of collagen is slow. This can extend the inflammatory and debridement phase during healing of tendinous tissue, while the surrounding soft tissue already enters the next stage of granulation tissue formation.^[8] This might have contributed to partial albeit incomplete healing of the subcutis and skin in the current case leaving a sinus tract connecting the injured tendon tissue and a small opening in the skin.

In the context of this major wound healing complication the terms "sinus tract" and "fistula" and often used interchange-

ably. However, per definition, a passage between two organs (internal fistula) or from an organ, e.g. a synovial cavity, to the skin surface (external fistula) is considered a fistula (“organ fistula”) while a sinus tract is defined as a cavity or channel that allows exudate such as pus to pass through the skin.^[9]

Sinus tract or fistula formation affecting the equine flexor tendons albeit not the DFTS has, to the authors’ knowledge, only been sparsely addressed as a distinct entity in the literature before. Formation of a sinus tract is a typical complication in cases where necrotic tissue, a foreign body and/or wound infection are present^[10] and are often associated with bone sequestration.^[9] In the current case, the exposed collagen of the lacerated tendon could have acted similar as a foreign body with the collagen fibers facilitating the entry and descent of bacteria and, therefore, the development and persistence of wound infection.

In this case, *S. equi ssp. zooepidemicus* was detected in such high quantity in the wound exudate that including clinical findings the wound was considered infected. For optimal choice of an effective antimicrobial, resistance testing was performed and the local application of gentamicin via a collagen sponge and regional limb perfusion with cefquinome were used to reach sufficiently high drug concentrations in the infected tissue. In human medicine gentamicin impregnated collagen sponges are used regularly, for example to improve haemostasis and wound healing on the one hand but also to reduce the risk of wound infection (for review see Gallo et al.^[11]) e.g. after cardiac surgery.^[12] Although experience with this treatment in horses is limited, the available reports suggest that this method of gentamicin application can be a useful addition to conventional therapy. A case series including 8 horses with synovial sepsis revealed promising results with only mild local side effects after intraarticular and subcutaneous implantation of gentamicin impregnated collagen sponges.^[13] Another study looked at the synovial concentrations of gentamicin after implanting impregnated sponges into the tarsocrural joints of horses. Although high gentamicin concentrations were only reached for a few hours, the authors concluded, that this might have been the result of dilution by the synovial fluid. They hypothesized that after implantation in a closed tissue space, like in the presented case, high levels of gentamicin might be reached for a longer time.^[14] This is further supported by a study in human patients in which high gentamicin concentrations in the wound exudate were present for two to three days after gentamicin impregnated collagen sponges had been implanted in infected groin wounds.^[15] In this reported case, excellent wound healing of the formerly infected region might have been promoted by sufficient tissue concentrations of gentamicin and was thereby potentially superior to a surgical treatment alone.

Furthermore, the collagen sponge itself might have had a positive effect on wound- and, more limited, on tendon healing, especially since it consisted of collagen from the same species. Several mechanisms of wound healing such as inhibition of collagen proteases, promotion of vascularization, fibroblast growth and others are mediated by collagen.^[11] A study using injectable collagen to treat non-septic equine tendon lesions revealed a potential positive effect, although this

study did not include a control group.^[16] In rats it was shown that collagen sponges improve biomechanical properties and collagen type I-content after repair of experimental Achilles tendon transections.^[17] In summary, controlled studies on septic lesions caused by external trauma involving tendons in equids are needed to investigate the added value of collagen sponges impregnated with antimicrobials.

In addition to surgical and antimicrobial treatment, immobilisation by a cast and later by a splint bandage was used in this case. Temporary cast application is a common strategy during the (per)acute phase of SDFT lacerations in horses and promotes tendon healing by reducing the strain in the injured tendon.^[4] A study in horses with surgically created SDFT lesions showed that immobilisation of the lower limb for 10 days by cast bandages reduced the degree of the SDFT lesions.^[18] Because surgical resection of the infected parts of the SDFT in the present case resulted in an acute SDFT lesion, cast immobilisation potentially contributed to a limited propagation of the lesion in this case as well. Furthermore, cast immobilisation reduced tension on the surgically closed skin incision and thereby contributed to successful primary healing.

An old fracture of the lateral splint bone was suspected in the left hindlimb. Since the abnormal radiographic findings were located near the chronic wound and tendon laceration, it is possible that the fracture resulted from the same trauma as the soft tissue injury. Surgical treatment of the fracture was not considered necessary, as it was already in the process of healing and no deviation of the splint bone was present.

Although prognosis regarding soundness and structural integrity in this reported case was first considered guarded, extensive surgical debridement of the infected tissue in combination with temporary immobilisation and strategic antimicrobial therapy resulted in an excellent functional long-term outcome. The structural integrity was good as shown by UTC two years after treatment and included advanced transformation of fibrils into fascicles and re-alignment of fibrils.

Conflict of interest statement

The authors declare that there are no conflicts of interest

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