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Retrospective evaluation of septic fetlock arthritis in 61 cattle – short- and long-term outcomes

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Summary

This retrospective study included 61 cattle suffering from septic fetlock arthritis. It aimed to evaluate the aetiology, the severity of joint infection and the efficacy of treatment regimens and to describe treatment outcomes using medical records (2001–2021).

Twenty-nine cattle (47.5 %) were treated, while the other 32 (52.4 %) were euthanized after diagnosis due to a poor prognosis or for economic reasons. The 29 animals were divided into four treatment groups, according to severity of disease. Group 1 included two animals (6.9 %) (septic serous arthritis and septic serous tenosynovitis of the digital flexor tendon sheath (DFTS), treated by puncture and lavage); Group 2 comprised 15 cattle (51.7 %) (septic serofibrinous/fibrinous arthritis, treated by arthrotomy and lavage); Group 3 included five cattle (17.2 %) (septic serofibrinous/fibrinous arthritis and concurrent septic fibrinous/purulent tenosynovitis of the DFTS, treated by arthrotomy, lavage of the joint and resection of the flexor tendons); and Group 4 included seven cattle (24.1 %) (septic serofibrinous/fibrinous arthritis and infection of the joint-forming bones, treated by arthrotomy, lavage and bone curettage).

Postoperative complications occurred in six cattle (20.7 %). Five of them were euthanized, while one cow was discharged after complete recovery. We found neither statistically significant correlations between treatment group (disease severity) and the occurrence of complications, nor between locomotion score on initial

Zusammenfassung

Retrospektive Auswertung der septischen Arthritis des Fesselgelenkes bei 61 Rindern – kurz- und langfristige Ergebnisse

Anhand der Patientendaten von 61 Rindern (2001–2021) wurden der Schweregrad der septischen Fesselgelenksarthritis, die Behandlungsregime sowie die Behandlungsergebnisse ausgewertet. Von den insgesamt 61 Rindern wurden 29 (47,5 %) behandelt, während die anderen 32 (52,4 %) nach Diagnosestellung wegen schlechter Prognose und aus wirtschaftlichen Gründen euthanasiert wurden. Die 29 Patienten wurden je nach Schweregrad der Erkrankung in vier Behandlungsgruppen eingeteilt: Gruppe 1: zwei Tiere (6,9 %) (septische seröse Arthritis und septische seröse Tendovaginitis der Fesselbeugesehnenscheide (FBSS): Behandlung durch Punktion und Gelenkspülung); Gruppe 2 (septische serofibrinöse/fibrinöse Arthritis: Behandlung durch Arthrotomie und Gelenkspülung): 15 Rinder (51,7 %); Gruppe 3 (septische serofibrinöse/fibrinöse Arthritis und septische fibrinöse/eitrige Tendovaginitis der FBSS: Behandlung durch Arthrotomie und Gelenkspülung sowie Resektion der Beugesehnen): fünf Rinder (17,2 %); Gruppe 4 (septische serofibrinöse/fibrinöse Arthritis und Infektion der gelenkbildenden Knochen: Behandlung durch Arthrotomie, Gelenkspülung und Knochenkürettage): sieben Rinder (24,1 %).

Bei sechs Rindern (20,7 %) kam es zu postoperativen Komplikationen; fünf von ihnen wurden euthanasiert,

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examination, treatment group and occurrence of complications. Twenty-four of the 29 treated cattle (82.8 %) were discharged as cured. The mean cumulative postoperative survival time (POST-SURV) in successfully treated animals was 24.4 months (±21.9) in the cows (n=20) and 8.3 months (±2.2) in the males (n=4). The POST-SURV of these 24 patients showed no statistically significant correlations between age and severity of disease (Group 1–4).

Our results show that the severity of septic arthritis in the fetlock joint (excluding cases of purulent arthritis), where the treatment regimen was adapted to the severity of the disease, had no significant effect on postoperative survival time or postoperative complication rate. However, cattle in severity groups 2 to 4 (advanced stages with concurrent tenosynovitis) required more joint lavages and had a success rate approximately 15–20 % lower than that of cattle with an early stage of joint infection (septic serous, serofibrinous).

Abbreviations: DDFT = Deep digital flexor tendon; DFTS = Deep flexor tendon sheath; LCS = Locomotion score; POST-Surv = Postoperative survival time.

während bei einer Kuh eine Abheilung erzielt werden konnte. Weder zwischen dem Schweregrad der Erkrankung und dem Auftreten von postoperativen Komplikationen noch zwischen dem Locomotion-Score bei der Erstuntersuchung und dem Schweregrad der Erkrankung bzw. dem Auftreten postoperativer Komplikationen konnten statistisch signifikante Zusammenhänge nachgewiesen werden.

Vierundzwanzig von 29 behandelten Rindern (82,8 %) wurden als geheilt entlassen. Die 20 erfolgreich behandelten Kühe hatten eine mittlere kumulative postoperative Überlebenszeit von 24,4 Monaten (±21,9). Die vier erfolgreich behandelten Bullen zeigten eine mittlere postoperative Überlebenszeit von 8,3 Monaten (±2,2). Die postoperative Überlebenszeit dieser 24 Patienten zeigte keine statistisch signifikante Korrelation mit dem Alter und der Schweregrad der Erkrankung (Behandlungsgruppe 1–4).

Die Ergebnisse zeigen, dass der Schweregrad der septischen Arthritis des Fesselgelenks (ausgenommen Fälle eitriger Arthritis) keinen signifikanten Einfluss auf die postoperative Überlebenszeit und die postoperative Komplikationsrate hatte. Dabei war das Behandlungsregime jeweils adäquat an den Schweregrad der Erkrankung angepasst worden. Allerdings benötigten Rinder der Behandlungsgruppen 2–4 (fortgeschrittene Stadien mit gleichzeitiger Sehnenscheidenentzündung und/oder Knochen-infektion) eine höhere Anzahl an Gelenkspülungen und wiesen eine um etwa 15–20 % geringere Erfolgsquote auf, als Rinder mit einem frühen Stadium der Gelenkinfektion (septisch serös, serofibrinös).

Introduction

Regardless of the joint affected, septic arthritis in adult cattle is most commonly the result of primary infection through a wound that penetrates the joint capsule or of secondary infection, where the pathogen invades the joint from infected peri-articular tissue. In calves, the haematogenous route of infection is most frequently reported (Meier 1997; Steiner et al. 1999; Mulon et al. 2016).

The fetlock joint is reported to be less frequently infected than the distal interphalangeal joint (Nuss 2000; Nuss 2016). The main symptoms of septic arthritis of the metacarpo-/metatarsophalangeal joint are lameness; circumferential swelling; a flexion posture involving the fetlock joint and increased temperature of the joint region; and a pain reaction to palpation and manipulation of the joint (Desrochers & Francoz 2014; Nuss 2016; Kofler et al. 2019). Diagnostic ultrasound by means of a 5.0–8.0 MHz linear (rectal) and 3.5–5 MHz convex probe, the former commonly used in bovine pregnancy diagnostics, is the preferred method to examine evident soft-tissue swelling over the limb regions (Kofler 2021). However, radiography (Steiner et al. 2010; Kofler et al. 2014; Constant et al. 2018), arthrocentesis of the fetlock joint and macroscopic, cytological and microbiological examination of synovial fluid are important accompanying diagnostic procedures (Nuss 2000; Rohde et al. 2000; Starke et al. 2009).

The efficacy of any evidence-based treatment method depends on the stage of septic arthritis and the involvement of bone or other adjacent structures (Nuss 2000, 2019). There are many therapeutic options, from relatively conservative options such as exclusive systemic antibiotic therapy (Desrochers & Francoz 2014), intra-articular antibiotic application (Geishauser 1997; Starke et al. 2009) and puncture and lavage of the joint (Meier 1997; Desrochers & Francoz 2014; Nuss 2016), to surgical procedures such as arthroscopy (Steiner et al. 1999; Blaser et al. 2015; Watson et al. 2023) and arthrotomy (Starke et al. 2009; Mulon et al. 2016; Nuss 2019). The latter allows the removal of fibrin and pus, as well as infected soft tissue, bone and cartilage (Starke et al. 2009; Desrochers & Francoz 2014; Nuss 2019). Joint resection and arthrodesis can be viewed as ultimate treatment options for severe chronic septic (purulent) arthritis and extensive adjacent bone infection (Geishauser 1997; Starke et al. 2006; Sartelet & Touati 2008; Desrochers & Francoz

2014). The prognosis for septic arthritis depends on its cause, the number of affected joints, the type of joint effusion (septic serous, serofibrinous, fibrinous, purulent), the concurrent presence of osteitis/osteomyelitis of subchondral bone or the adjacent physis in calves, the involvement of other adjacent anatomic structures and concurrent disorders of other organ systems (Meier 1997; Nuss 2000; Mulon et al. 2016). The more chronic the septic arthritis, the more complex and difficult the treatment and the worse the prognosis (Trent & Pumb 1991; Desrochers & Francoz 2014).

There have been no studies of the prevalence of septic arthritis in calves and adult cattle on Austrian farms, either in general or specific to the fetlock joint. Only one case report has been published (Kofler et al. 2019). With this retrospective study, we aim to evaluate the causes and severity of septic arthritis of the fetlock joint in cattle referred to our teaching hospital over the course of 20 years, to present the treatment methods, according to severity of disease, and to assess the short- and long-term outcomes.

Materials and Methods

This retrospective study included cattle that had documented records in the Animal Hospital Information System (TIS) and had been hospitalized at the University Clinic for Ruminants Vienna for septic arthritis of the fetlock joint of one limb during the period from January 2001 to December 2021. We excluded cattle diagnosed with aseptic arthritis of the fetlock joint and cattle with septic polyarthritis where at least one fetlock joint was also infected. The medical records of 61 cattle that satisfied these criteria were available. The data contained all findings (stage of septic inflammation, localization, cause, findings of the clinical, ultrasonographic, radiographic and synovial fluid examinations and presence of concurrent disease), the treatment methods, the duration of hospitalization and the success or otherwise of treatment.

The study was reviewed and endorsed by the Ethics and Animal Welfare Committee of the University of Veterinary Medicine Vienna for compliance with Good Scientific Practice and national legislation (ETK-03/02/2022).

Diagnosis of fetlock arthritis

In all cases, lameness was assessed using the locomotion scoring system of Sprecher et al. (1997), corresponding to the ascending locomotion score (LCS) 1 (not lame) to LCS 5 (severely lame). Subsequently, the lame limb was examined by inspection and palpation. To identify or exclude wounds reliably, the swollen fetlock joint region was generously clipped and washed. Any swelling was examined for location, size, consistency, fluctuation, painfulness and elevated temperature. In addition, the mobility of the fetlock joint during flexion, extension and lateral tilting was determined (Kofler et al. 2019).

Ultrasonography of the fetlock joint region was performed on restrained animals in lateral recumbency on a tilting table with the diseased limb uppermost. After preparing the fetlock joint region, imaging was performed in the longitudinal and transverse views from dorsal, palmar/plantar, medial and lateral views, and from proximal to distal. The position, size, differentiation, echogenicity, echo-pattern, presence of flow phenomena, acoustic enhancement and acoustic shadowing of the structures were evaluated (Kofler 2021). Ultrasonographic depictions of conspicuous changes were stored as frozen images. Radiographs of the affected fetlock joint regions were taken from animals restrained in lateral recumbency in lateromedial, dorsopalmar/-plantar and oblique projections (Steiner et al. 2010).

Arthrocentesis of the fetlock joint was performed after clipping and careful cleansing. The puncture site was aseptically prepared and puncture performed using sterile cannulae (14 gauge and 80 mm or 16 gauge and 40 mm). Preferably, arthrocentesis was performed at the palmar/plantar pouch, located between the palmar/plantar contour of the metacarpal/metatarsal bone and the dorsal contour of the ipsilateral abaxial branch of suspensory ligament. A site approximately 1 cm proximal to the abaxial proximal sesamoid bone was reached by a vertical puncture of approximately 3 cm depth (Desrochers et al. 1997; Nuss et al. 2002). Macroscopically, the joint effusion was classified as serous, serofibrinous, fibrinous or purulent exudate (Geishauser 1997; Nuss 2000). Synovial samples were examined cytologically and bacteriologically and antibiotic resistance tests were performed.

Treatment methods

Depending upon the stage of inflammation and the involvement of bone and/or adjacent synovial structures, septic arthritis of the fetlock requires a stage-oriented treatment regimen adapted to the particular case (Nuss 2000; Starke et al. 2009; Desrochers & Francoz 2014). Cattle were restrained in lateral recumbency on a hydraulic tilt table so that the diseased limb was on top. They were sedated with xylazine (0.05 mg/kg; i.v.; Sedaxylan® 20 mg/ml; Eurovet Animal Health BV; Bladel; The Netherlands) intravenously five minutes before fixation on the tilt table. Cows in the last trimester of pregnancy were given isoxsuprine hydrochloride (200 mg/animal; i.m.; Degraspasmin®; Dr. E Graeub AG, Bern, Switzerland) ten minutes before xylazine application to prevent uterine contractions (Groot et al. 2012). Subsequently, regional intravenous anaesthesia was administered. An elastic rubber tourniquet was placed around the proximal metacarpal/metatarsal region and 20 ml of 2 % procaine hydrochloride

(Procamidor® 20 mg/ml injection solution; Richter Pharma AG, Wels, Austria) administered into one of the three digital veins (Starke et al. 2009; Nuss 2016). Following local anaesthesia, the fetlock joint region was prepared antiseptically for surgical treatment.

Lavage of the fetlock joint and the digital flexor tendon sheath in cases of septic serous arthritis and tenosynovitis

In cases of acute, contaminated and penetrating wounds with septic, serous inflammation of the fetlock joint, thorough wound debridement with surgical removal of all infected tissue was performed. Afterwards the fetlock joint was punctured under aseptic conditions with at least two cannulae (14 gauge and 80 mm or 16 gauge and 40 mm) at the opposing (dorsal lateral or medial and palmar/plantar) pouches and joint lavage was performed according to the "through-and-through system" (Desrochers & Francoz 2014; Mulon et al. 2016). Depending upon the size of the animal, between 3,000 and 5,000 ml of sterile 0.9 % saline solution (Physiologische Kochsalzlösung 0.9 %, Fresenius Kabi, Graz, Austria) containing 0.1 % povidone-iodine (Vet-Sept® Lösung 10 %, aniMedica GmbH, Senden-Bösensell, Germany) was used. The joint was lavaged manually using 20 or 60 ml syringes. To increase the effectiveness of lavage, the joint was repeatedly flexed and extended. Finally, antibiotics (the same as applied systemically) were instilled into the joint. When there was septic, serous inflammation of an adjacent digital flexor tendon sheath (DFTS), two cannulae (16 gauge and 40 mm) were inserted into the diseased DFTS, one proximally and the other in the middle of the pastern region distal to the ipsilateral dew claw. The DFTS was irrigated with between 2,000 and 5,000 ml of sterile 0.9 % saline solution containing 0.1 % povidone-iodine (Hund et al. 2020) and antibiotics were instilled into the DFTS. Depending upon the severity of arthritis, joint (and tendon sheath) lavage was performed daily until the emerging synovial fluid appeared clear and free of small fibrin clots.

Arthrotomy and lavage of the fetlock joint in cases of septic, serofibrinous/fibrinous arthritis

The access sites chosen for arthrotomy of the fetlock joint affected with septic serofibrinous and septic fibrinous arthritis with large adhering fibrin clots usually corresponded to the locations for arthrocentesis. As a rule, three access sites were created to open the fetlock joint pouches and permit complete removal of adherent fibrin and lavage the joint pouches effectively (Starke et al. 2009; Kofler et al. 2019). Three approaches were made: one dorsomedial, one dorsolateral (each precisely centred over the medial and lateral condyles of the metacarpal/metatarsal bone) and one palmar/plantar approach immediately proximal to the abaxial proximal sesamoid bone. The approaches were bounded dorsally by the palmar/plantar contour of the metacarpal/metatarsal bone and palmar/plantar by the abaxial branch of the suspensory ligament. Each joint approach was executed as a longitudinal incision of approximately 4–5 cm. The incision was made immediately palmar to the bone contour of the metacarpal/metatarsal bone, parallel to its axis. It included the skin, subcutaneous tissue (while protecting the neurovascular structures) and the joint capsules dorsal and palmar/plantar (Starke et al. 2009). If an accidental penetrating wound was present, it was used for joint access after careful surgical debridement. Once arthrotomy ports to the fetlock joint were established, infected soft tissue in the wound area was carefully excised with a scalpel blade and fibrin clots/coagulated fibrin masses were completely removed from the fetlock joint pouches using a Volkmann bone curette. The joint was then lavaged with between 3,000 and 5,000 ml of sterile 0.9 % saline solution containing 0.1 % povidone-iodine and the soft tissue, cartilage and bone inspected for inflammatory alterations. Finally, rinsing with 0.9 % saline solution (500 ml) alone was conducted. To permit/improve the drainage of wound exudate/synovial fluid, drains were placed in the three arthrotomy ports using sterile 1 cm thick polyurethane soft foam strips (Ligasano®; Ligamed medical products GmbH, Cadolzburg-Wachendorf, Germany). Afterwards, an antibiotic was instilled intra-articularly. To facilitate lavage of the joint again on subsequent days, the arthrotomy ports were not sutured.

Arthrotomy, lavage of fetlock joint and resection of superficial and deep digital flexor tendons in cases of septic, serofibrinous and fibrinous arthritis & fibrinous and purulent tenosynovitis of the DFTS

The same approaches were made for arthrotomy of the fetlock joint. As five animals also suffered from a fibrinous and purulent tenosynovitis of the DFTS, resection of both the digital flexor tendons of one digit was performed. The affected DFTS was opened with a scalpel blade along its length from approximately 10 cm proximal to the ipsilateral dew claw to distally at the skin-horn boundary at the bulb of the heel. The superficial (SDFT) and the deep digital flexor tendons (DDFT) were removed as described in detail (Hund et al. 2020). This was followed by careful surgical debridement of the entire DFTS wound surface using a scalpel blade to remove adherent fibrin and purulent exudate, followed by lavage of the DFTS with 2,000 ml of sterile 0.9 % saline solution containing 0.1 % povidone-iodine. The DFTS port was not sutured but a polyurethane soft foam (Ligasano®) wound dressing (20 x 17 x 1 cm) was placed in the port as a drain to permit exudate to drain off and allow repetition of the irrigation on subsequent days. In animals that had undergone opening of

the DFTS and resection of both digital flexor tendons, a wooden or hard plastic block was attached to the sound partner claw and remained affixed for six weeks (Nuss 2016; Hund et al. 2020).

Arthrotomy, lavage of the fetlock joint and bone curettage in cases of septic serofibrinous and fibrinous arthritis and bone infection

Seven cattle had a septic fibrinous arthritis of the fetlock joint as well as a circumscribed infection of one of the joint-forming bones, which involved the lateral or medial phalanx I, the lateral or medial condyle of the metacarpal/metatarsal bone, or, in one case, one of the abaxial proximal sesamoid bones. The initial surgical procedure was the same as above. As the osteolytic areas were always the result of penetrating wounds, they could be quickly exposed and visually accessed after surgical debridement of the wound. Thereafter, they were carefully curetted using a sharp surgical spoon, including 2–3 mm of vital-appearing bone tissue beneath. If there were osteolytic foci deeper in the epiphysis or metaphysis, a 4.5 mm drill was used to create access followed by curettage with a sharp spoon (Starke et al. 2006; Mulon et al. 2016; Kofler et al. 2019) and the bone lesion and the fetlock joint pouches were extensively lavaged. Finally, an antibiotic was instilled into the curetted bone lesion and into the fetlock joint. Drains were inserted into the arthrotomy ports, which were not sutured.

Wound dressings and bandages

Following surgical treatment, tetracycline spray (Cyclo Spray® 2.45 %; chlortetracycline hydrochloride; Eurovet Animal Health, Bladel, The Netherlands) was applied to the wounds. A sterile 20 x 17 x 1 cm polyurethane soft foam dressing (Ligasano®) was used as wound dressing, which also served as drainage material for the arthrotomy ports (Hund et al. 2020). Four layers of cotton roll padding were wrapped around the site, beginning at the level of the claw sole to the proximal third of the metacarpal/metatarsal region. They were fixed with tear-resistant bandages (Raucolast®; Lohmann & Rauscher GmbH & Co. KG, Rengsdorf, Germany), resulting in a firm pressure bandage. Proximally, the bandage was covered with an elastic, self-adhesive bandage roll (Vetrap®; 3M Österreich GmbH, Vienna, Austria) and the complete dressing was covered with several layers of water-resistant tape (Tesa Textilband® 5 cm wide; Henry Schein Animal Health, Vienna, Austria). To immobilize fetlock joints with arthrotomy ports during the postoperative period, polyvinyl-chloride half-tubes (PVC-splints) were applied dorsally and palmar/plantar over the bandage (Kofler et al. 2019). Alternatively, a cast was applied over the complete bandage (Cellacast® Longuette 12 cm, Lohmann & Rauscher, Vienna; Austria).

Intra-, peri- and postoperative medication and care

For local instillation of antibiotics into the fetlock joint, between 6 to 10 ml of gentamicin (Gentavan®; 50 mg/ml, Vana GmbH, Vienna, Austria) was used in calves. Alternatively, ampicillin was administered in calves and adult cattle (Ampicillin "Vana"®, 200 mg/ml, Vana GmbH, Vienna, Austria or Ampivet® 10 % ad us. vet., Virbac S.A., Carros, France). Regional intravenous limb perfusion was performed immediately after injection of the local anaesthetic into the digital vein through the same cannula. Calves/heifers up to one year old received 400 mg gentamicin, whereas cows received 500 mg ceftiofur sodium, administered once during initial treatment at the clinic. Peri- and postoperative systemic antibiotic treatments depended upon availability during the 20-year study period and comprised procaine penicillin/dihydrostreptomycin (Peni-Strepto® 200/200mg/ml, 8 mg/kg i.m., Virbac Laboratoires, Carros, France), ampicillin (Ampicillin 'Vana'® 200 mg/ml, 10 mg/kg i.m., Vana GmbH, Vienna, Austria; Ampivet® 10 % ad us vet, Virbac S.A., Carros; France), amoxicillin (Betamox® long acting – 150 mg/ml, 15 mg/kg i.m., Norbrook Laboratories Ltd., Monaghan, Ireland), cefquinome (Cobactan® 2.5 %, 1 mg/kg i.m., Intervet GesmbH, Vienna, Austria) or ceftiofur (Eficur® 50 mg/ml, 1 mg/kg s.c., Laboratorios Hipra S.A., Girona, Spain) for approximately seven to twelve days, depending upon group allocation and their presence of concurrent bone infection. Treatment with nonsteroidal, anti-inflammatory drugs (NSAIDs) generally comprised ketoprofen (Rifen® 100 mg/ml, 3 mg/kg i.m./i.v., Richter Pharma AG, Wels, Austria) for three days and the anti-inflammatory treatment was extended for further days, if necessary, using metamizole (Novasul® – 500 mg/ml, 20–40 mg/kg i.v.; VetViva Richter GmbH, Wels, Austria) twice daily at 12-hour intervals.

All patients were housed postoperatively in deep-bedded loose stall boxes. The first two-to-three changes of bandage and lavages were performed with the patient restrained in lateral recumbency on the tilt table, again under regional intravenous anaesthesia. Each dressing was changed within 24 hours of surgery, allowing repeat lavage of the fetlock joint and the DFTS. Subsequent bandage changes were performed either daily or every other day, with the intervals subsequently extended depending upon clinical findings and the healing of the wounds. During each bandage change, lavage of the fetlock joint and/or the wounds (the latter was solely lavaged during later stages of the healing process) was performed, and intra-articular antibiotics applied.

Patients were discharged as soon as the arthrotomy and the DFTS ports were completely closed by thick, vital granulation tissue. An additional criterion for the time of discharge was a distinct reduction in lameness compared to pre-treatment, to at least LCS 2. The owners were instructed to house the animals

separately from the herd in a recovery box for four weeks after discharge. The local veterinarian removed the bandage approximately seven days after the animal returned to the farm. The owners were instructed to clean the wounds daily with cold water (from a hose pipe) for another three weeks, followed by application of a non-antibiotic wound spray (e.g. Silver® spray; Agrochemika GmbH, Bremen, Germany).

Postoperative survival time (POST-SURV) of the 24 successfully treated patients, their culling data or whether they were still alive at that time were surveyed on 14 June 2023 in the database of Agrar-Markt-Austria (AMA; https://www.ama.at/).

Statistical analysis

The patient data were analysed using SPSS (IBM SPSS Statistics®, SPSS Inc., Chicago, USA) to produce descriptive and inferential statistics. We also calculated mean and median values, standard deviations, minimum and maximum values of patient data and data on septic arthritis of the fetlock joint using the spreadsheet program Excel (Excel 365®, Microsoft Corp., Redmont, USA).

The severity of the disease was classified by treatment group (1 = mildest form; 4 = most severe form of the disease). As there were only two animals in treatment group 1, we combined patients of groups 1 and 2 for statistical calculations. A log rank test (Mantel-Cox) was performed to check whether the severity of the disease (measured by treatment groups 1–4) affected the POST-SURV of cattle. Results were presented graphically using the Kaplan-Meier survival function. As four animals were still alive at the time of analysis, we calculated the cumulative POST-SURV. We used Pearson's chi-square test to determine whether there was a significant correlation between each of the four treatment groups (concurrent infection of the DFTS or bone) and the occurrence of postoperative complications. Spearman rank correlation coefficients were compared to determine whether there were any correlations between LCS on the initial examination or on discharge and the severity of the disease, measured by treatment group. We used the Mann-Whitney test to look for statistically significant differences between the LCS on the initial examination and the severity of the disease, classified according to treatment group, as well as between the LCS on initial examination and the occurrence of postoperative complications. Spearman rank correlation coefficients were used to analyse the relationship between patient age and POST-SURV and between LCS on baseline and on discharge. We applied Wilcoxon tests to investigate whether the LCS on baseline and on discharge differed. All results were considered significant at $p<0.05$.

Results

The 61 cattle with septic fetlock arthritis comprised 44 Austrian Simmental cattle (71.0 %), eight Holstein-Friesian (12.9 %), four Charolais (6.5 %), one Brown-Swiss, one Limousin and three crossbreeds. At the time of admission to the clinic, the cattle had a mean age of 2.8 (±2.4) years (median: 2.3; min: 0.1; max: 11.0). Of the 61 cattle, 17 were calves (up to six months old; 27.9 %), of which six were treated and eleven euthanized after diagnosis. The 61 cattle comprised 47 females (77.0 %) and 14 males (23.0 %). Of the 47 females, 27 were not pregnant (57.4 %) and 20 were pregnant (42.6 %).

Clinical findings

On initial examination at the clinic the cattle had a mean LCS of 4.0 (±1) (median: 4.0; min: 2.0; max: 5.0). The fetlock joint exhibited a characteristic inflammatory circumferential swelling over all aspects of the joint. From the lateral perspective, a characteristic moderate-to-severe flexion of the fetlock joint could be observed. Palpation and manipulation of the region was judged moderately to severely painful and an elevated temperature was palpable on the skin over the swollen joint.

A primary route of infection through penetrating wounds was found in 67.2 % of admissions, followed by a secondary route of infection (periarticular abscess, wounds involving originally periarticular structures only) in 13.1 % of cases. Haematogenous infection occurred in 4.9 % of cases with only mono-arthritis present. In nine cattle, the data gave no information on the cause (Table 1). Septic inflammation of the fetlock joint occurred in 38 cases (62.3 %) in the forelimbs (n=24 left; n=14 right) and in 23 cases (37.7 %) in the hindlimbs (n=12 left; n=11 right). The mean rectal body temperature (RBT) recorded at the initial examination was 39.0 °C (±0.5) in all cattle seven months of age or older, and 39.6 °C (±0.4) in all calves up to six months of age. The mean RBT was 38.9 °C (±0.5) in the 23 older cattle that were treated and 39.4 °C (±0.5) in the

Tab. 1: Pathways of septic arthritis of the fetlock joint in 61 cattle / Ursache der Infektion des Fesselgelenkes bei 61 Rindern.

	All cattle; n=61	%	Treated cattle; n=29	%
Penetrating wound	41	67.2	20	68.9
Secondary infection	8	13.1	1	3.4
Haematogenous infection	3	4.9	1	3.4
Cause unknown	9	14.7	7	24.1

treated calves. The mean RBT was 39.1 °C (±0.6) in older cattle that were euthanized after diagnosis and 39.6 °C (±0.5) in the euthanised calves, which exceeded the physiological range (Baumgartner et al. 2014).

Findings of ultrasonographic and radiographic examinations

Ultrasonographic examination of the affected fetlock joint was performed in 49 of the 61 patients (80.3 %). Table 2 lists the findings. In 36 of the patients (59.0 %), radiological examination of the fetlock joint region was performed at admission; Table 3 presents the findings.

Evaluation of synovial fluid

Assessment of the character of synovial fluid obtained from the fetlock joint was based on macroscopic evaluation of the discharge from joint-perforating or -fistulating wounds, ultrasonographic examination and/or arthrocentesis, with the latter performed either intraoperatively or during necropsy of euthanized animals. Arthrocentesis of the fetlock joint was performed in 21 of the 61 patients (34.4 %). Eight of the synovial fluid samples (38.1 %) were serofibrinous, three (14.3 %) fibrinous and ten (47.6 %) purulent. Table 4 presents an overview of the quality of inflammatory synovial effusion in septic fetlock arthritis of all 61 cattle. Cytologic examination was performed in fourteen synovial samples out of the 29 treated cattle; the white blood cell count ranged from 11,500×10^9 to 98,700×10^9 cells/l, of which ≥78.0 % were neutrophils. The total protein content of the synovial samples ranged from 32 to 80 g/l.

Bacteriological examination and microbiological antibiotic resistance tests on 21 synovial samples detected *Escherichia coli*, *Trueperella pyogenes*, *Staphylococcus* spp. and *Micrococcus* spp., as well as mixed infections caused by these bacteria. The culture test was negative in five (23.8 %) of 21 samples. The five animals had been pre-treated with antibiotics and NSAIDs. The bacteria showed good *in vitro* susceptibility to penicillin, dihydrostreptomycin, ampicillin, amoxicillin, cefquinome and ceftiofur.

Tab. 2: Findings of ultrasonographic examination in 49 cattle with septic arthritis of the fetlock joint; DFTS: digital flexor tendon sheath / Befunde der Ultraschalluntersuchung bei 49 Rindern mit septischer Arthritis des Fesselgelenkes; DFTS: Fesselbeugesehnenscheide.

	Number of cattle	%
Inflammatory effusion in the fetlock joint showing a variety of echogenicity and flow phenomena	49	100
Irregular bone contour, depression of bone contour	12	24.5
Presence of gas bubbles in the joint effusion	5	10.2
Inflammatory effusion in the DFTS showing various echogenicity and flow phenomena	21	42.9

Tab. 3: Radiographic findings in 36 cattle with septic arthritis of the fetlock joint / Befunde der radiologischen Untersuchung bei 36 Rindern mit septischer Arthritis des Fesselgelenkes.

	Number of cattle	%
Soft tissue swelling	21	58.3
Enlarged joint space	23	63.9
Bone without abnormal findings	8	22.2
Periosteal proliferation	4	11.1
Osteolysis	16	44.4
Osteitis/Osteomyelitis	11	30.5
Bone fragments	1	2.8
Presence of gas in the joint pouch	5	13.9

Reasons for euthanasia

In total, 32 (52.4 %) cattle were euthanized after diagnosis and consultation with the owners. The 32 animals had a mean age of 2.7 years (±2.3; median: 2.3; min: 0.1; max: 11). The reasons for deciding against treatment were the severity of the septic fetlock arthritis (purulent) and the concurrent presence of other diseases (n=29): the euthanized animals had a range of co-morbidities, including extensive osteomyelitis of the subchondral bone at the metatarsal/metacarpal condyles or at phalanx I (n=16), fibrinopurulent tenosynovitis of the adjacent lateral and medial DFTS (n=8), fibrinopurulent tenosynovitis exclusively of the lateral adjacent DFTS (n=5), purulent arthritis of the distal and/or proximal interphalangeal joint or both on the same limb caused by wounds (n=8), bronchopneumonia

Tab. 4: Type (quality) of effusion in septic arthritis of the fetlock joint in 61 cattle / Art (Qualität) des Ergusses bei septischer Arthritis des Fesselgelenkes bei 61 Rindern.

	Number	%
Serous	3	4.9
Serofibrinous	15	24.6
Fibrinous (clotted fibrin)	11	18.0
Purulent	27	44.3
No information	5	8.2

(n=3), severe (grade 3) congenital flexural limb deformity (n=1), and large, purulent pre-carpal bursitis (n=1). Cattle with these comorbidities were considered to have a poor prognosis. Additionally, the high cost of treatment was considered prohibitive in some cases.

Pre-treatment by referring veterinarians

The referring veterinarians had initiated treatment of 39 of 61 patients (63.9 %) before admission to the clinic. Thirty-one cattle (79.5 %) received antibiotics and 24 (61.5 %) NSAIDs, with both antibiotics and NSAIDs administered to 19 of the 39 animals (48.7 %). Local treatment by ointment application had commenced in four of the 39 animals (10.2 %). One animal (2.6 %) received a corticosteroid in combination with antibiotics, NSAIDs and local ointment application. These medical pretreatments are generally beneficial, although in no case additional therapy, such as surgical wound debridement and/or joint irrigation, was performed on site for any of the cattle.

Applied treatment methods

Of the 61 patients with septic arthritis of the fetlock joint, 29 (47.5 %) were treated. The treated animals had a mean age of 3.0 (±2.7) years (median: 2.4; min: 0.1; max: 7.3), where six cattle were six months old or younger, nine were one year old or younger and the remainder were older. The cattle were divided into four groups based on the definitive diagnosis and the evidence-based stage-oriented treatment:

Group 1 consisted of two (out of 29; 6.9 %; mean age: 0.7 years; ±0.3) patients diagnosed with septic serous fetlock arthritis (without bone involvement) and septic serous tenosynovitis of an adjacent DFTS. Treatment involved puncture and lavage of the fetlock joint and the DFTS.

Group 2 included 15 (51.7 %; (mean age: 2.7 years; ±2.3) cattle with septic serofibrinous or fibrinous arthritis of the fetlock joint without involvement of the DFTS or bone. They were treated by arthrotomy (Figure 1a, b) and lavage of the fetlock joint.

Group 3 included five (17.2 %; mean age: 2.3 years; ±0.9) cattle with septic serofibrinous or fibrinous arthritis of the fetlock joint, septic fibrinous/purulent tenosynovitis of one of the adjacent DFTS with a fibrinous or purulent tendinitis of the flexor tendons in the affected DFTS. Treatment involved arthrotomy, lavage of the fetlock joint and resection of both digital flexor tendons.

Group 4 included seven (24.1 %; mean age: 4.5 years; ±3.8) cattle with septic serofibrinous or fibrinous arthritis of the fetlock joint and concurrent bone infection (of the metatarsal/metacarpal bone, phalanx I, proximal sesamoid bone) with or without septic fibrinous/purulent tenosynovitis of one of the adjacent DFTS. These cattle were treated by arthrotomy, lavage of the fetlock joint and curettage of the infected bone areas. Two of the seven cattle showing a concurrent septic tenosynovitis of the DFTS were additionally treated with resection of both digital flexor tendons.

Results for cattle with treatment

Table 5 lists the type and duration of medication, the number of lavages of the fetlock joint and the number of intra-articular antibiotic applications in the 23 patients with septic fetlock arthritis where no postoperative complications occurred. Regional limb perfusion was performed once in six young cattle using 400 mg

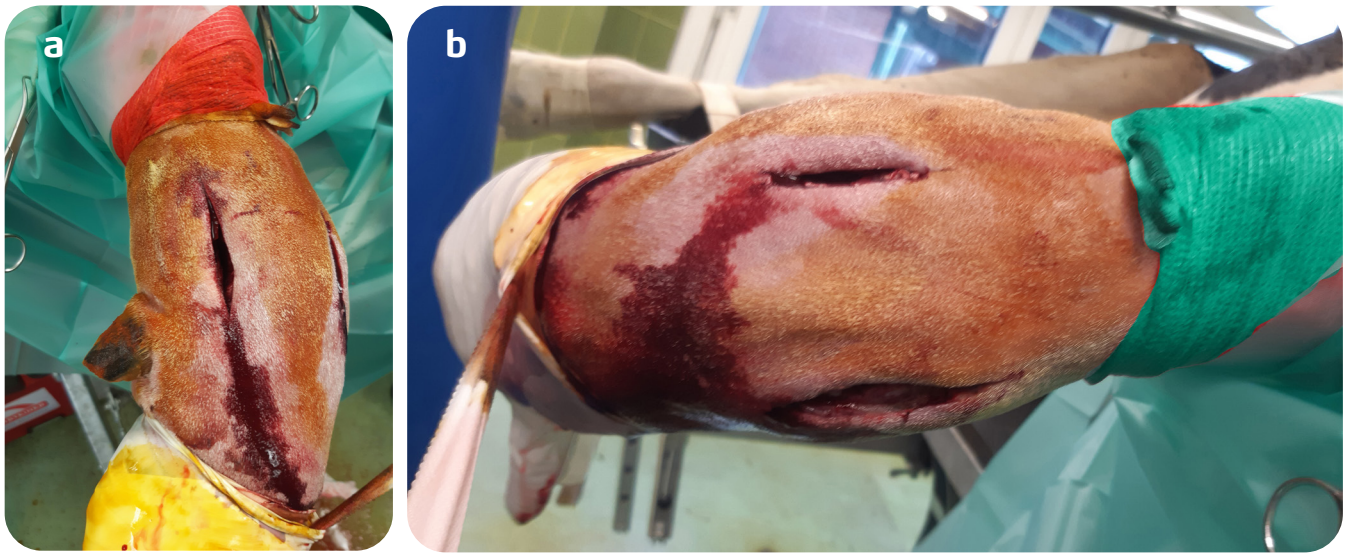


Fig. 1a, b: Intra-operative lateral (a) and dorsal (b) view of the right metacarpophalangeal joint region showing the three longitudinal incisions for approaching the palmar (a) and the lateral and medial dorsal (b) joint pouches to remove large fibrin clots and to irrigate the joint / Intraoperative laterale (a) und dorsale (b) Ansicht der rechten Fesselgelenkregion mit Darstellung der drei chirurgischen Zugänge (Arthrotomie-Inzisionen) zum palmaren (a) und zu den dorsalen (medialen und lateralen) Rezessus (b), um große Fibringerinnsel entfernen zu können und das Gelenk sorgfältig zu spülen.

Tab. 5: Type of peri- and postoperative medication, duration of medication (in days), number of intra-articular antibiotic applications and number of lavages of the fetlock joint in 23 cattle with septic fetlock arthritis (without postoperative complications), broken down by treatment group 1–4; NSAIDs: nonsteroidal anti-inflammatory drugs; SD: standard deviation; min: minimum; max: maximum / Art der peri- und postoperativen Medikation, Dauer der Medikation (in Tagen), Anzahl der intraartikulären Antibiotika-Instillationen und Anzahl der Gelenkspülungen bei 23 Rindern mit septischer Arthritis des Fesselgelenkes (ohne postoperative Komplikationen), entsprechend der Behandlungsgruppen 1–4; NSAIDs: nichtsteroidale Entzündungshemmer; SD: Standardabweichung; min: Minimum; max: maximal.

		Systemic antibiosis	NSAIDs	Intra-articular antibiosis	Number of joint lavages
Group 1	Number of cattle: 2				
	mean	5.5	2.0	1.0	1.0
	SD	0.5	0.0	0.0	0.0
	median	5.5	2.0	1.0	1.0
	min	5.0	2.0	1.0	1.0
	max	6.0	2.0	1.0	1.0
Group 2	Number of cattle: 11				
	mean	11.4	7.0	3.2	3.7
	SD	4.1	3.3	1.2	1.5
	median	11.0	5.0	3.0	4.0
	min	6.0	1.0	2.0	1.0
	max	18.0	10.0	5.0	6.0
Group 3	Number of cattle: 4				
	mean	8.0	2.8	1.8	2.3
	SD	1.9	1.5	0.8	0.8
	median	7.5	2.5	1.5	2.5
	min	6.0	1.0	1.0	1.0
	max	11.0	5.0	3.0	3.0
Group 4	Number of cattle: 6				
	mean	10.8	4.0	2.2	3.3
	SD	3.8	1.8	0.4	1.8
	median	10.5	3.0	2.0	2.5
	min	7.0	2.0	2.0	2.0
	max	18.0	7.0	3.0	7.0

gentamicin and in five adult cattle using 500 mg ceftiofur. Only one animal was successfully treated despite a postoperative complication. The animal received systemic antibiotics for a maximum of 18 days and NSAIDs for a maximum of ten days and there was a maximum of seven lavages of the fetlock joint and five intra-articular antibiotic applications (Table 5). Following the results of antimicrobial resistance testing, the systemic antibiotic had to be changed in four patients and treatment continued with cefquinome instead of ampicillin.

Postoperative complications

Of the 29 cattle treated for septic fetlock arthritis, 23 (79.3 %) were cured without complications, while six (20.7 %) developed complications (Table 6). The complication was successfully treated in one of these six patients. This 3.1-year-old, non-pregnant cow had been diagnosed with septic serofibrinous arthritis of the fetlock caused by a perforating wound and underwent arthrotomy. A fresh suppuration occurred at the plantar arthrotomy port ten days postoperatively, where the original wound was located. Radiographs taken at the time showed the bony structures without pathological findings. The wound was subjected to renewed surgical debridement with resection of the granulation tissue that had since formed. A small abscess near the joint was completely excised and the fetlock joint was again irrigated with 0.9 % saline solution containing 0.1 % polyvidone iodine, local antibiotic instillation and renewed systemic administration of antibiotics and NSAIDs. The joint lavage was repeated on the following two days. The other five cattle (83.3 %) with complications were euthanized without further treatment for

financial reasons (Table 6). These five patients had a mean age of 2.8 years (±2.3; median: 2.4; min: 0.1; max: 7.3).

Tab. 6: Time (days postoperatively) and type of postoperative complications, broken down by treatment group 1–4; LCS: locomotion score / Zeitpunkt des Auftretens postoperativer Komplikationen aufgeteilt auf die Behandlungsgruppen 1–4; LCS: Locomotion-Score.

Patient	Group	Time of occurrence of complication	Type of complication
1	2	9	Increase of LCS from 2/5 to 4/5; purulent discharge from arthrotomy ports; severe swelling around the wound; osteolysis of the lateral, abaxial proximal sesamoid bone; osteolytic area proximally at phalanx I
2	2	6	Increase of LCS from 3/5 to 5/5; periarticular abscess, severe subchondral osteolysis proximal at the lateral phalanx I and at the lateral metatarsal condyle
3	2	5	Increase of LCS from 3.5/5 to 4/5; severe swelling around the fetlock joint; fibrin and purulent discharge from arthrotomy ports
4	3	9	Increase of LCS from 1.5/5 to 3/5; discharge of turbid synovial fluid and fibrin from arthrotomy ports; osteolysis at the metacarpal bone
5	4	6	Purulent discharge from arthrotomy ports, osteolysis at the proximal phalanx I and the metacarpal bone

Duration of hospitalization

The 24 cattle that were successfully treated spent a mean of 19.5 days in the teaching hospital postoperatively (±7.1; median: 16.5; min: 11.0; max: 33.0). The cattle without postoperative complications were hospitalized for a mean of 19.0 days (±6.9; median: 16.0; min: 11.0; max: 33). The animal with a postoperative complication spent 30 days postoperatively at the hospital.

Short-term outcome

Of the 29 cattle, 24 were discharged after treatment and complete closure of the arthrotomy wounds by granulation tissue (Figure 2a, b), corresponding to a success rate of 82.8 %. The 24 cattle had a mean age of 3.0 years at the time of treatment (±2.8; median: 2.1; min: 0.1; max: 7.3). Four of the 24 were male with a mean age of 0.8 years (±0.4; median: 0.7; min: 0.4; max: 1.5); the remaining 20 were female with a mean age of 3.4 years (±2.8; median: 2.5; min: 0.1; max: 7.3).

The success rate in treatment group 1 was 100 % (two of two cattle cured), in group 2 80.0 % (12 of 15 cattle cured), in group 3 also 80.0 % (four of five cattle cured) and in group 4 85.7 % (six of seven cattle cured). At discharge, the 24 successfully treated cattle had a mean LCS of 2.0. On initial examination, the mean LCS of the 24 successfully treated animals was 3.4, so treatment led to a reduction of LCS by a mean of 1.4 (Table 7).

Postoperative survival time

Four of the discharged cattle were still alive at the time of the survey (June 14, 2023) and had a POST-SURV of 20.5 (Group 2),

Fig. 2a, b: Lateral (a) and dorsal (b) view of the right fetlock region 16 days postoperatively showing the three closed surgical incisions into the metacarpophalangeal joint covered by thick vital granulation tissue. At this time, the cows showed a locomotion score of 2 (out of 5) / Seitliche (a) und dorsale (b) Ansicht der rechten Fesselgelenkregion 16 Tage nach der Operation mit den mittlerweile komplett ausgranulierten Arthrotomiewunden. Zu diesem Zeitpunkt zeigten die Kühe einen Locomotion-Score von 2 (aus 5).

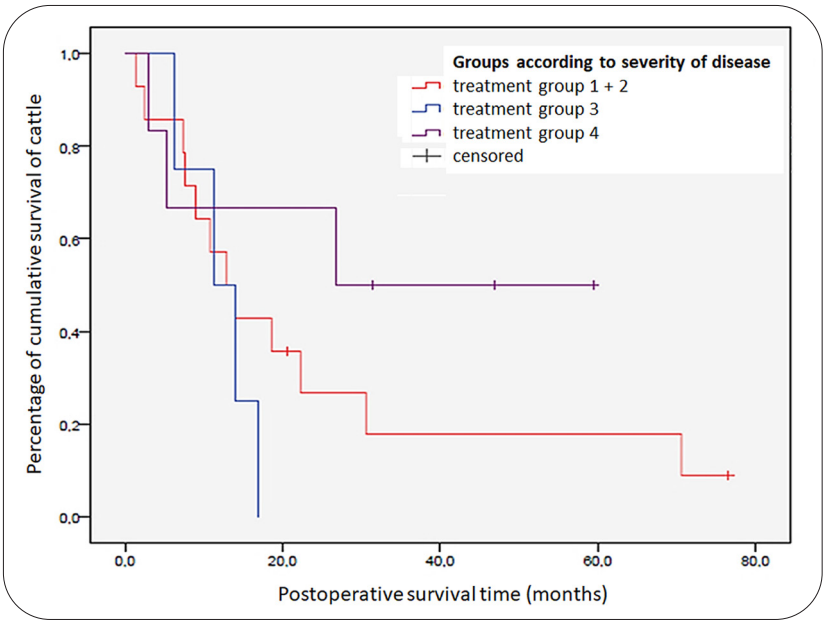
31.5 (Group 4), 46.9 (Group 4) and 59.4 (Group 4) months (mean: 39.6). One cow with a successfully treated postoperative complication had a POST-SURV of 76.6 months. This was the longest POST-SURV of all 24 discharged patients at the time of data evaluation. The mean POST-SURV for all 24 successfully treated cattle was 21.9 months (±20.7; median: 14.0; min: 1.4; max: 76.6). The 20 successfully treated females showed a mean cumulative POST-SURV of 24.4 months (±21.9; median: 17.8; min: 1.4; max: 76.6); the four successfully treated males had a mean POST-SURV of 8.3 months (±2.2; median: 8.3; min: 5.3; max: 11.3) (Table 8).

Tab. 7: Locomotion score (LCS) on first examination and on discharge from the clinic for the 24 successfully treated animals with septic fetlock arthritis in treatment groups 1–4. SD: standard deviation / Locomotion-Score (LCS) zum Zeitpunkt der Erstuntersuchung sowie bei Entlassung aus der Klinik bei den 24 erfolgreich behandelten Rindern mit septischer Arthritis im Fesselgelenk aufgeteilt auf die Behandlungsgruppen 1–4; mean: Mittelwert; SD: Standardabweichung.

		All 24 cattle	Group 1	Group 2	Group 3	Group 4
LCS on first examination	mean	3.4	3.0	3.5	3.8	3.6
	SD	1.1	1.0	1.2	0.8	1.0
	median	3.0	3.0	3.0	3.5	3.5
LCS on discharge from clinic	mean	2.0	1.0	1.9	2.3	2.3
	SD	0.6	0.0	0.5	0.4	0.5
	median	2.0	2.0	2.0	2.0	2.0

Tab. 8: Mean cumulative postoperative survival time (months) of the 24 successfully treated cattle and for cattle in treatment groups 1–4; SD: standard deviation; min: minimum; max: maximum / Mittlere kumulative postoperative Nutzungsdauer (Monate) der 24 erfolgreich behandelten Rinder und der Rinder in den Behandlungsgruppen 1–4; SD: Standardabweichung; min: Minimum; max: Maximum.

	mean	SD	median	min	max
All 24 cattle	21.9	20.7	14.0	1.4	76.6
Group 1 (n=2)	10.8	3.2	10.8	7.6	14.0
Group 2 (n=12)	23.6	23.	15.8	1.4	76.6
Group 3 (n=4)	12.1	4.0	12.7	6.2	17.0
Group 4 (n=6)	28.8	20.4	29.1	3.0	59.4



Results of statistical analysis

As there were only two animals in treatment group 1, we combined the cows in treatment groups 1 and 2 for statistical calculations. At the time of data analysis, four animals were still alive, so we calculated the cumulative POST-SURV. Table 9 summarizes the results of the analysis. No statistically significant correlation or difference was assessed between the individual parameters. The only significant and clear correlation ($r=0.541$; $p=0.006$) was between the severity of the disease (measured by treatment group) and LCS on discharge. While cattle in treatment groups 1 and 2 had mean LCSs at discharge of 1 and 1.9, respectively, cattle in treatment groups 3 and 4 had a mean LCS of 2.3. We also found a statistically significant difference for all 24 cattle between LCS on initial examination and LCS on discharge ($p<0.001$). The difference was exclusively attributed to the decrease in LCS of the cows in group 2 ($p=0.007$). No group had a significantly longer or shorter POST-SURV ($p\geq0.147$) than any other group, even although the Kaplan-Meier survival plot (Figure 3) shows that animals in group 3 had a shorter mean survival time than animals in group 2.

Fig. 3: Kaplan-Meier survival function plots of successfully treated cattle with septic arthritis of the fetlock joint, divided into treatment groups 1–4; patients in the combined treatment groups 1+2 and in group 4 tended to have a longer postoperative survival time than cattle in group 3 but the difference was not statistically significant / Kaplan-Meier-Überlebensfunktions-Diagramm mit den erfolgreich behandelten Rinden mit septischer Arthritis des Fesselgelenks aufgeteilt in die Behandlungsgruppen 1–4; Patienten der zusammengefassten Behandlungsgruppen 1+2 und der Gruppe 4 hatten im Vergleich zu Rindern in der Behandlungsgruppe 3 tendenziell eine längere postoperative Überlebenszeit, jedoch ohne statistische Signifikanz.

Tab. 9: Overview of results of the statistical analysis with the tested correlations differences, the test, p values and correlation coefficients; POST-SURV: postoperative survival time; LCS: Locomotion Score / Auflistung der Ergebnisse der statistischen Analysen mit den überprüften Korrelationen/Differenzen, den verwendeten Tests, und den errechneten p-Werten und Korrelationskoeffizienten.

	Test	p value
Correlation of severity of disease (treatment groups 1–4) and POST-SURV	Log Rank test (Mantel-Cox)	≥0.147
Correlation of severity of disease (treatment groups 1–4) and occurrence of postoperative complications	Chi-Square test (Pearson)	0.878
Correlation of severity of disease (treatment groups 1–4) and LCS on initial examination	Spearman-Rank correlation	r=0.073
Correlation of severity of disease (treatment groups 1–4) and LCS on discharge	Spearman-Rank correlation	r=0.541 0.006
Difference between LCS on initial examination and severity of disease (treatment groups 1–4)	Mann-Whitney test	>0.706
Association of LCS on initial examination and occurrence of post-operative complications	Mann-Whitney test	0.676
Correlation between LCS on initial examination and LCS on discharge	Spearman-Rank correlation	r=0.199 0.350
Difference between LCS on initial examination and LCS on discharge	Wilcoxon test	<0.001
Correlation between age of cattle and POST-SURV	Spearman-Rank correlation	r=0.154 0.473

Discussion

Septic arthritis of the fetlock joint in cattle is much less frequent than septic arthritis of the distal interphalangeal joint (Nuss 2000, 2016). Veterinarians in practice are thus distinctly less familiar with the diagnosis and correct treatment of septic fetlock arthritis. Unfortunately, there have been few studies of treatment regimes, success rates and POST-SURV of cattle with this condition. In an older study of 73 adult cattle with septic arthritis, septic fetlock joint inflammation was diagnosed in 20 animals (27.0 %) (Meier 1997). Another article described the postoperative course of four cattle aged from five weeks to 3.5 years with chronic, purulent arthritis of the fetlock joint, which were treated by radical surgical joint resection. This was the only therapeutic option in such cases of severe joint destruction to save the animals (Geishauser 1997). A retrospective study of the diagnosis, treatment methods and success rates relating to 203 cattle with septic arthritis of various limb joints included 32 cattle (15.8 %) with septic fetlock arthritis. Only ten of them were treated (Nuss 2000). These articles report the treatment of bovines with septic fetlock arthritis by arthrotomy, joint resection and joint lavage, giving success rates, but otherwise there are only case reports of the treatment of individual cattle for septic fetlock arthritis, alone or in combination with septic tenosynovitis of an adjacent DFTS and/or adjacent osteomyelitis of the distal metacarpal growth plate (Kofler & Altenbrunner-Martinek 2005; Lietzau et al. 2015; Kofler et al. 2019; Watson et al. 2023).

The present study included 61 cattle. In two-thirds of the cases (67.2 %), the fetlock joint was directly infected due to penetrating wounds. The other cases showed either a secondary route of joint infection (13.1 %) or a haematogenous route (4.9 %), with the latter resulting in mono-arthritis. This distribution of pathways of infection is consistent with other studies (Meier 1997; Nuss 2000; Mulon et al. 2016).

Calves with polyarthritis resulting from umbilical infection, bronchopneumonia, enteritis or insufficient immune transfer presented frequently during the observation period in the clinic but were not included in the study. Surgical treatment by procedures such as lavage, arthroscopy or arthrotomy of several infected joints is very rarely performed in calves with polyarthritis, due to its poor prognosis, the severity of the primary disease and for financial reasons (Trent & Plumb 1991; Mulon et al. 2016). Farmers in Austria, as elsewhere, are generally not prepared to exceed pre-calculated budgets for treating calves and cows. The expected treatment costs for cows with septic arthritis can reach up to half the value of the animal, and for young cattle can amount to between 50 % and 100 % of the animal's value, depending upon the breed and current market conditions (Babatunde et al. 2019; Kappes et al. 2023).

In approximately two thirds (63.9 %) of the 61 cattle with septic arthritis of the fetlock, the referring veterinarians started treatment on the farm. Antibiotics and NSAIDs were applied to 79.5 % of these animals. However, the exclusive systemic administration of antibiotics to treat septic arthritis is only suitable in cases with very early haematogenous infection if the therapy

is started within the first four days of the onset of joint infection (Desrochers & Francoz 2014). Conspicuously symptomatic animals with joint swellings are very rarely presented to the veterinarian within this period of time, except in experimental studies (Francoz et al. 2005). In practice, this therapeutic option comes too late for most cases of septic arthritis. In the presence of penetrating wounds and when a secondary route of infection leads to septic fetlock arthritis, the exclusive systemic administration of antibiotics and NSAIDs is not an evidence-based, appropriate and promising method of treatment (Nuss 2000; Desrochers & Francoz 2014; Mulon et al. 2016). If careful surgical debridement of the wound and joint lavage is not feasible on the farm, which is often the case in bovine practice in Austria, early referral of patients to a specialized clinic is strongly recommended. This maximises the chance of successful treatment and is far preferable to several days of experimental medication (Desrochers & Francoz 2014; Nuss 2019; Kofler & Altenbrunner-Martinek 2022).

On initial examination, the 61 cattle had a mean LCS of 4.0 (range 2–5), indicating severe lameness (Sprecher et al. 1997). However, we found no statistically significant correlation between the severity of disease (according to treatment group) and LCS at baseline. This has been explained by individual differences in sensitivity to pain (Whay et al. 1998; Ijichi et al. 2014). LCS on initial examination also did not correlate significantly with postoperative complications. LCS on initial examination is thus not a suitable measure of the severity of septic fetlock arthritis, which may be merely a septic serous (early stage) or a purulent (advanced stage) arthritis of the fetlock with or without concurrent septic tenosynovitis of one of the adjacent DFTS and/or an adjacent bone infection. However, we did find a statistically significant difference between the LCS on initial examination and the LCS on discharge. Surgical treatment reduced the LCS significantly but the difference between LCS on baseline and on discharge was significant only in treatment group 2, which included cattle with septic fetlock arthritis without concurrent infection of the DFTS and/or bone. This result could be related to the observation that cattle with more severe disease, in which adjacent bone or/and the adjacent DFTS were also incriminated, took longer to show significant improvement in their LCS. Alternatively, the difference might represent an anomaly resulting from the small number of cattle in the groups.

Calves and adult cattle with septic arthritis of a fetlock joint do not necessarily show an increased RBT, although this was the case in almost 50 % of patients. This finding is consistent with previous reports (Meier 1997; Watson et al. 2023). As the euthanized cattle also had infections of other organs in addition to septic, and very often purulent, arthritis of the fetlock, the animals more frequently had a clearly elevated RBT (Baumgartner et al. 2014).

The diagnosis of septic arthritis of the fetlock is based on careful clinical and orthopaedic examinations and on diagnostic imaging procedures (Desrochers & Francoz 2014; Nuss 2019). Diagnostic ultrasound with the 5–8 MHz linear (rectal) probes commonly used in bovine gynaecology is particularly relevant as it can be performed anywhere and at any time (Kofler 2021). Ultrasonography is highly indicated when soft tissue swelling is evident at the fetlock joint region and visual inspection and palpation alone are insufficient for an exact diagnosis. Ultrasonography allows determination of the degree of joint effusion and its echogenicity, the presence of flow phenomena and the characterization of liquid or semi-solid effusions, which indicate a fibrinous exudate (Kofler 2021). Diagnostic ultrasound permitted the clinically obvious joint swelling to be clearly assigned to the joint pouches of the fetlock joint in all cattle examined. In 21 animals it was also possible to differentiate a concurrent tenosynovitis of the DFTS, which might have been overlooked without ultrasound. Diagnostic ultrasound also enabled the imaging of irregular bone surfaces and/or depression of the bone contour in 12 cattle, frequently indicating an infection (although physiologically the bone surface appeared as a smooth hyperechoic contour), and the presence of gas bubbles in the joint effusion in five cattle, which, with concurrent inhomogeneous joint effusion, always indicates an advanced stage of joint infection (Kofler 2021). Ultrasonography of the fetlock joint region was performed in 80.3 % of patients and gave valuable additional information. A possible explanation for why ultrasonography of the fetlock joint region was not performed on all 61 patients since 2001 is that various operators were active in the clinic during this period, some of whom opted instead for radiography. In addition, the clinical diagnosis was sufficient in some cases, including cases with concomitant severe diseases that prompted euthanasia.

Radiographs are particularly suitable for depicting bony alterations but are very rarely taken in bovine practice because few livestock practitioners are equipped with a portable X-ray unit (Kofler et al. 2014). However, when radiographs are taken, it is important to note that changes to bone density and/or structure resulting from osteitis/osteomyelitis are often seen only 10–14 days after the onset of infection (Constant et al. 2018; Steiner et al. 2010). In the present study, we saw characteristic radiographic findings of joint infection in only 23 (64 %) of cattle, where radiographs showed an enlarged joint space, although osteitis could be depicted radiographically in 16 (44 %) of the cattle and osteolysis and/or osteomyelitis in 11 (30.5 %). These findings are characteristic for an infection that has been present for a longer time (Steiner et al. 2010; Constant et al. 2018). Ultrasonography can yield more information in earlier stages of septic arthritis (Kofler 2021). Radiographs were taken for 36 of the 61 animals (59.0 %) included in the present study, including

all 29 that were treated. Despite the usefulness of careful ultrasonography of the entire fetlock joint region, radiographic examination is necessary when animals are to be treated. Radiographs either ensure that the bony structures of the fetlock joint appear inconspicuous or reveal how deeply the osteolytic areas detected in sonograms extend into the bone (Steiner et al. 2010; Kofler et al. 2014). This additional information facilitates the diagnosis, especially in cases where only one joint is affected, and helps determine the prognosis and the planning of any surgical intervention (Starke et al. 2006; Mulon et al. 2016; Nuss 2019).

In the case that a joint effusion cannot be determined by evaluating discharge from a perforating wound and by ultrasonography, or if it is unclear whether the joint inflammation is septic or aseptic, centesis of a joint pouch and macro- and microscopic evaluation of the synovial fluid is indicated (Nuss 2000; Rohde et al. 2000; Francoz et al. 2005). Arthrocentesis of the fetlock joint was performed in 34.4 % of the 61 cattle. In the remainder, the type of septic fetlock arthritis was determined by other means, e.g. by macroscopic evaluation of a direct discharge from the opened joint and by ultrasonography (Kofler 2021). In 69.0 % of cattle treated, a penetrating wound was the cause of joint infection: there was a discharge from the joint that could be well assessed macroscopically as described (Nuss 2000).

The decisive factor for the choice of treatment of septic arthritis is the character of the condition, which can be serous, serofibrinous, fibrinous or purulent (Nuss 2000; Kofler et al. 2019; Watson et al. 2023). Nuss (2000) introduced the term 'stage-oriented sequential therapy,' which considers an early stage of septic arthritis (a septic serous arthritis), a fibrinous arthritis or a purulent arthritis, for adequate, evidence-based treatment that will not jeopardize the chances of a successful outcome. As part of the diagnostic process, the veterinarian should always type-determine a septic arthritis from a macroscopic evaluation of any leakage from a penetrating wound by ultrasonography or by arthrocentesis and aspiration of synovial fluid (Nuss 2000).

We divided the cattle into four treatment groups depending upon the current form of septic inflammation in the fetlock joint and on the presence of concurrent infections of directly adjoining anatomical structures, such as the DFTS or joint-forming bones. The appropriate therapeutic approach, corresponding to a 'stage-oriented sequence therapy' (Nuss 2000), in the presence of septic arthritis (serous, serofibrinous, fibrinous, purulent) has been described in detail (Geishauser 1997; Starke et al. 2006; Nuss 2019).

The three access ports to the fetlock joint usually necessary for arthrotomy (dorso-medial, dorso-lateral and palmar/plantar/palmar) correspond to the anatomical architecture of the joint pouches, which permit efficient treatment of serofibrinous arthritis with large fibrin clots and, especially, of fibrinous arthritis with adherent coagulated fibrin masses. While the lateral and medial dorsal pouches are separated from each other by a septum, the palmar/plantar/palmar pouch forms a large, contiguous cavity palmar/plantar to the two metacarpal/metatarsal condyles (Desrochers et al. 1997).

As an alternative to arthrotomy in cases of serous and serofibrinous septic arthritis, arthroscopy can be used to lavage the joint (Steiner et al. 1999; Blaser et al. 2015; Watson et al. 2023). This requires two ports, one to the palmar/plantar pouch and one to the dorsal pouch, whereby the septum between the medial and lateral dorsal pouches can be fenestrated so the arthroscope can be introduced into the neighbouring dorsal pouch (Watson et al. 2023). Arthroscopy in cattle is much less effective once septic arthritis becomes chronic and extensive fibrin clots are present. In such cases, arthrotomy is the preferred method (Desrochers & Francoz 2014; Watson et al. 2023). In 14 cases where arthroscopy was used to treat cattle with septic arthritis of fetlock, tarsocrural and antebrachiocarpal joints, refractory to previous treatment, the success rate was 86.0 % (Steiner et al. 1999).

When arthrotomy and joint lavage are necessary to treat septic arthritis, additional systemic and intra-articular antibiotic treatments are essential (Trent & Plumb 1991; Starke et al. 2009; Mulon et al. 2016). In bovine septic arthritis, *Trueperella pyogenes*, haemolytic *Streptococcus* spp., *Escherichia coli*, Pasteurellaceae and other bacteria are frequently detected in culture tests (Francoz et al. 2002; Starke et al. 2009; Desrochers & Francoz 2014). A microbiological antibiotic resistance test should be performed on the first day of treatment as a routine procedure to check the efficacy of the antibiotic. This will only yield results when bacteria can be isolated from the sample (Mulon et al. 2016; Watson et al. 2023). The culture test was negative for 23.8 % of the 21 samples in this study, most likely due to the antibiotic pre-treatment of cattle by the referring veterinarians. In the 23 cattle with fetlock arthritis, systemic broad spectrum and bactericidal antibiotics were administered for a mean of 8.9 days, from a minimum of five days to a maximum of 18 days, using both non-reserve and reserve antibiotics such as cefquinome and ceftiofur in accordance with the literature (Nuss 2000; Mulon et al. 2016; Watson et al. 2023). Since 2018, the use of reserve antibiotics in European Union countries must be critically questioned (Aigner 2018). In cases of septic fetlock arthritis where amputation is not a viable surgical option, reserve antibiotics may be considered, particularly if antibiotic resistance tests indicate their use (Aigner 2018). This contrasts with advanced, severe infections of the interphalangeal joints, where amputation may be an option (Desrochers & Francoz 2014). In addition to joint lavage and/or arthrotomy and systemic antibiosis, regional limb perfusion is a simple and effective technique for the treatment of synovial sepsis in the bovine

distal limb using, e.g., 1.5 g of combined ampicillin–sulbactam, 0.67 mg/kg of marbofloxacin or 500 mg per animal of ceftiofur sodium. Their concentration in the synovial fluid remains above the minimum inhibitory concentration for a mean of 18.9 hours (Depenbrock et al. 2017) or for a mean of 4.0 to 5.2 hours after infusion (Navarre et al. 1999; Celani et al. 2017). We used 400 mg of gentamicin in young cattle and 500 mg ceftiofur sodium in cows for regional limb perfusion.

Our patients also received a mean of 2.0 applications (between one and five) of off-label intra-articular antibiotics after joint irrigation. An experimental study of healthy calves showed that intra-articular application of doxycycline was excellently tolerated, inducing only a mild transient increase of inflammatory mediators in the synovial fluid (Haerdi-Landerer et al. 2007). Studies on intra-articular antibiotic therapy of septic arthritis in cattle are very rare but the combination of intramuscular (5 mg/kg) and intra-articular (100 mg) gentamicin, along with joint lavage, did not show better therapeutic effects than intramuscular administration alone (Moulvi et al. 2002).

Multiple joint lavages are often necessary when septic arthritis is present, dependent upon the stage of joint inflammation. The fetlock joints of the cattle in this study were irrigated up to seven times, with obvious differences between the four treatment groups in the number of irrigations (Tab. 5). A comparably high number of necessary joint lavages has been reported by others, from a minimum of one to a maximum of nine and with a mean of 2.4 (Meier 1997; Desrochers & Francoz 2014; Mulon et al. 2016).

Postoperative complications occurred in 20.7 % of the treated cattle. They were distributed among the four treatment groups in such a way that we found no statistically significant correlation between group membership and the occurrence of postoperative complications. Complications occurred from days five to nine postoperatively in the form of an increase in the degree of lameness, an increase in swelling of the fetlock joint region and a fresh discharge of purulent exudate from one arthrotomy port. The radiographs taken at this time showed osteolytic changes in the condyles of the metacarpal/metatarsal bone or phalanx I in five cattle, so that in addition to the distinctly worsened prognosis, and for economic reasons, no further treatment was undertaken. In comparison, a retrospective study of 203 bovines with septic arthritis of various limb joints showed that only 121 cattle were treated (Nuss 2000). A significantly higher complication rate of 51.2 % (n=62) was registered in these patients and 29 (24.0 %) could not be healed because they showed similarly serious complications to those we describe.

The prognosis for septic fetlock arthritis must always be considered at least guarded to rather unfavourable, especially when primary and secondary infection pathways are involved. As joint structures other than just the joint cavity are frequently involved in these cases, a possible complication can never be completely ruled out, even when arthrotomy, removal of fibrin and debris, repeated joint lavage and systemic medication with antibiotics and NSAIDs are performed (Geishauser 1997; Steiner et al. 1999; Mulon et al. 2016).

In the present study, 24 of 29 cattle were discharged after treatment, corresponding to a success rate of 82.8 %. While we found no statistically significant differences in success between the treatment groups, we assume that the group sizes were too small. Similar success rates of 81 % (Meier 1997) and 89 % (Nuss 2000) have been reported after treatment of septic arthritis in cattle with joint lavage.

Cattle without complications were hospitalized for a mean of 19.0 days postoperatively, and the one cow with the successfully treated complication was discharged 30 days postoperatively. The decision on the time of discharge was made on an individual basis, depending upon clinical findings and owner compliance, e.g. the possibility of follow-up care and the availability of a recovery box. A comparable mean hospitalization time of 22 days (14–36 days) was reported in 13 cattle with septic arthritis of various joints after arthroscopic lavage (Steiner et al. 1999); 17 cattle had a mean hospitalization time of 18.9 days after joint lavage (Meier 1997); and cattle with fibrinous and purulent tenosynovitis had a similar hospitalization period with a median of 16 days after resection of the digital flexor tendons (Hund et al. 2020).

Overall, the 24 cattle with successful outcomes had a mean age of 3.0 years at the time of surgery and a mean cumulative POST-SURV of 21.9 months (1.8 years). Four of the 24 cattle were fattening bulls that were slaughtered at a mean age of 15 months, consistent with the mean slaughter maturity of fattening bulls in Austria (Biedermann 2015). The 20 successfully treated females had a mean cumulative POST-SURV of 24.4 months (2.1 years), corresponding to extended production for two additional lactation periods, so these 20 cows were on average 5.4 years old when they left the farm. The mean age at culling of these 20 cows was about one year less than the mean age of culling of Austrian dairy cows, which is 6.3 years (Egger-Danner et al. 2022). In addition, four cows were still alive at the time of the survey with a current POST-SURV of 39.6 months. The AMA cattle database survey does not contain the data required to assess the specific cause of culling for each animal.

We can draw some relevant conclusions from this study. For example, the LCS recorded on the initial examination proved to be an unsuitable parameter for estimating the severity or extent of septic arthritis of the fetlock joint, or for estimating the likelihood of postoperative complications. Further diagnostic measures, especially ultrasonography of the affected fetlock joint region but also radiography, are indispensable to diagnose the joint infection as accurately as possible at an early stage and thus not to jeopardize the treatment.

Portable ultrasonography using 5–8 MHz linear (rectal) probes is readily accessible to most practising bovine veterinarians (Kofler 2021) and can be applied in practice at any time. Several studies have shown that the rate of success of treatment for septic arthritis is significantly higher when the infection is localized to the fetlock joint than when it is in the tarsocrural, stifle and carpal joints. This is due to the complex anatomical architecture of these proximal joints in comparison to the fetlock joint, which has two dorsal and only one large palmar/plantar pouch (Desrochers et al. 1997; Nuss 2000; Sartelet & Touati 2008).

Our results show that neither the occurrence of postoperative complications nor the POST-SURV of cattle can be deduced from the severity of the septic fetlock arthritis. No animals with purulent arthritis of the fetlock were treated, as extensive subchondral bone areas are always concurrently infected in these cases (Geishauser 1997; Starke et al. 2006; Sartelet & Touati 2008). Cattle with such an advanced stage of infection of the fetlock are euthanized after diagnosis because of the poor prognosis. Radical surgical resection of the fetlock joint, as successfully completed by Geishauser (1997) in three of four cattle after six-to-eight weeks of treatment, and after a 12-month convalescence period (Starke et al. 2006), was not considered in any of these patients for financial reasons and because of the protracted therapeutic measures compounded with an uncertain prognosis. Many of the patients with purulent arthritis of the fetlock also had serious concomitant diseases.

Conclusions for the practice

Of the 29 patients with septic arthritis of the fetlock that received therapy, 24 (82.7 %) were successfully treated. The prognosis for septic arthritis of one single fetlock joint in cattle with serous, serofibrinous and fibrinous infection is good when adequate stage-oriented treatment is applied. However, the rate of success could be significantly improved if cattle with early stages of septic arthritis, when only serous septic inflammation is present, are referred to a specialized clinic. Cattle with freshly developed contaminated wounds in the fetlock joint region should also be identified early by farmers. Veterinarians should increase their efforts to sensitize farmers to wounds in a joint region, which unfortunately often penetrate the joint capsule, as was the case in 69.0 % of cattle in this study. Such animals must be submitted for professional treatment during the first 12-to-24 hours to maximize the chance of healing.

Fazit für die Praxis:
Zusammenfassend lässt sich festhalten, dass die Behandlung bei 24 (82,7 %) von 29 Rindern mit septischer Arthritis des Fesselgelenks erfolgreich war. Die Prognose einer septischen Arthritis eines einzelnen Fesselgelenks bei Rindern mit seröser, serofibrinöser und fibrinöser Gelenkinfektion kann daher bei adäquater stadiengerechter Behandlung als gut eingeschätzt werden. Die Erfolgsquote könnte jedoch erheblich verbessert werden, wenn Rinder mit septischer Arthritis im Frühstadium, wenn nur eine seröse septische Entzündung vorliegt, an eine spezialisierte Klinik überwiesen werden. Auch Rinder mit frisch entstandenen kontaminierten Wunden im Fesselgelenksbereich sollten von Landwirt*innen frühzeitig vorgestellt werden. Daher sollten Tierärzt*innen verstärkt an der Sensibilisierung der Tierhalter*innen arbeiten, damit Wunden im Gelenkbereich, die leider häufig die Gelenkkapsel durchdringen, wie dies bei 69,0 % der Studienrinder der Fall war, in den ersten 12 bis 24 Stunden einer adäquaten chirurgischen Behandlung unterzogen werden, um den Heilungserfolg zu maximieren.

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Conflict of interest
The authors declare no conflict of interest.

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