

# Surgical treatment of septic arthritis of proximal joints and treatment of bone sequestra in cattle

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## Introduction

Septic arthritis is a common cause of severe lameness in cattle, most commonly the distal interphalangeal joint is involved (Starke et al., 2007; Heppelmann et al., 2009). Septic arthritis of proximal joints (fetlock, carpal, tarsal, stifle etc.) in cattle had been reported on a much lower frequency (Munroe & Cauvin, 1994; Adegboye et al., 1996; Kofler 1996, 1997; Hirsbrunner & Steiner, 1998; Grubelnik et al., 2002; Nuss, 2000, 2003; Desrochers & Francoz, 2014). Septic arthritis is caused by direct inoculation of bacteria into the joint (primary infection) or from spread of periarticular infection (secondary infection) or by haematogenous spread (Trent & Plumb, 1991; Desrochers & Francoz, 2014). Traumatic arthritis is not as common as septic arthritis and involves predominantly the larger proximal joints (Kofler, 1996).

## Diagnosis of septic arthritis of proximal joints in cattle

Up to now, the diagnosis of bovine arthritis has been based on careful clinical examination, radiography, arthrocentesis and macroscopic, cytological and microbiological examination of the synovial sample (Rhode et al., 2000; Shearer et al., 2012; Kofler 2014a,b; Kofler et al., 2014, 2016a). However, during the last 20 years, ultrasonography has proved to be of paramount importance for soft tissue differentiation in bovine orthopedics, adding important information to the clinical findings (Kofler 1996, 1997, 2009; King, 2006; Gonçalves et al., 2014; Kofler et al., 2014, 2016a; Borges et al., 2015). Therefore, today, the application of diagnostic ultrasound is a standard procedure for investigation of all cases associated with swelling of a joint region allowing to identify with certainty the incriminated structures, periarticular/articular soft tissues or bone structures (Munroe & Cauvin, 1994; Kofler, 1996, 1997; 2009; Grubelnik et al., 2002; Nuss, 2003; Kofler & Martinek, 2004; Kofler & Altenbrunner-Martinek, 2008; Starke et al., 2008;

Kofler et al., 2014, 2016a; Altenbrunner-Martinek et al., 2017). In contrast to radiography, the presence of synovial effusion can be detected reliably even in very early stages of an arthritis by ultrasonography (Kofler, 1996, 2009). If an ultrasonographic unit is available, even linear rectal probes are very suitable for investigation of swollen joint regions. The diseased synovial cavity (joint pouch, tendon sheath, bursa) appears mildly to severely distended, and the thin echoic capsule is distinctly displaced from the articular surface.

The echogenicity of the inflammatory effusion ranges from anechoic to echoic depending on its nature (serous, sero-fibrinous, fibrinous, purulent) (Kofler, 1996, 1997, 2009). Liquid content can be identified based on flow-phenomena, which are characterized by small and large hypoechoic to echoic particles or clots that are seen floating in anechoic fluid (Kofler & Hittmair, 2006; Kofler, 2009). In long-standing cases of sepsis, the precipitated gelatinous masses of fibrin impair or prevent aspiration of fluid, and these semi-solid masses appear hypoechoic to echoic and show no flow-phenomena (Kofler, 1996, 1997; Kofler 2009). Definitive information about the nature of effusion is provided by puncture of the synovial cavity (Rhode et al., 2000; Shearer et al., 2012; Kofler, 2014b).

An ultrasonographic inspection of the region of interest should always be carried out before puncture (Kofler, 2009; Kofler et al., 2014, 2016a). The position and size of the distended joint cavity and the location of liquid effusion within as well as its distance and direction from a set point on the skin surface can be determined accurately. After assessing the direction and depth of the structure to be punctured the needle may be inserted with or without (free hand) ultrasonographic guidance (Kofler, 2009; Kofler et al., 2014, 2016a). Macroscopic evaluation of the aspirated synovial fluid allows an immediate classification of the inflammatory exudate as serous, sero-fibrinous, fibrinous or purulent, depending on the gross macroscopic appearance (Rhode et al., 2000; Nuss, 2000; Kofler, 2014b). A mild to severely turbid synovial fluid is always a certain indication for the presence of an infection (Rhode et al., 2000; Nuss, 2000; Kofler, 2014b). The exudate in cases of septic arthritis in cattle can be highly fibrinous and

render the aspiration of synovial fluid impossible (Kofler, 1996). Radiography reveals increased width of the intraarticular space and subsequently osteolysis, but it does not allow localization and exact determination of the character of the soft tissue swelling (Bargai et al., 1989; Verschooten et al., 2000; Steiner et al., 2010; Kofler et al., 2014, 2016a).

### **Differential diagnosis to septic arthritis**

Aseptic arthritis (osteochondrosis), osteomyelitis of the physis, epiphyseal growth plate, metaphysis, periarticular abscessation, periarticular tenosynovitis or bursitis, joint luxation, and epiphysitis (in fattening bulls) (Kofler, 2014a).

### **Prognosis**

Prognosis is depending on the primary disease (penetrating wound, secondary infection, hematogenous spread), the number of involved joints (mono- or polyarthritis), the type of effusion (serous, fibrinous or purulent), the involved joint, the presence of a concurrent osteomyelitis and the presence of concurrent disorders of other organs systems (Nuss, 2000; Desrochers & Francoz, 2014). Therefore, in all cases of septic arthritis of (proximal) joints a thorough physical and orthopedic examination have to be carried out (Nuss, 2000; Kofler, 2014a), that should be complemented by an ultrasonographic investigation prior to make a final decision for treatment or for culling (Kofler et al., 2014, 2016; Desrochers & Francoz, 2014).

### **Treatment of septic arthritis of proximal joints in cattle**

An early detection of septic arthritis, in particular of proximal bovine joints, is important for starting an adequate treatment as early as possible and for a favourable outcome (Nuss, 2000; Desrochers & Francoz, 2014). The application of diagnostic ultrasound and the subsequent arthrocentesis of an involved joint allow to classify the type of effusion (serous, sero-fibrinous, fibrinous, purulent), and decision-making based on these important findings

for culling of the animal due to a poor prognosis or for treatment by joint lavage, or arthrotomy/arthroscopy or only very rarely by joint resection (for purulent arthritis of carpal and fetlock joints only) (Nuss, 2000; Starke et al., 2009; Desrochers & Francoz, 2014).

However, in any case of treatment of a septic arthritis of proximal joints in cattle, in addition to the topical therapy a long-term systemic antibiotic and anti-inflammatory treatment has to be combined (Trent & Plumb, 1991; Jackson et al., 1996; Nuss, 2000; Anderson & Muir, 2005; Starke et al., 2008; Shearer et al., 2013; Desrochers & Francoz, 2014).

Joint lavage and arthrotomy can be carried out in the sedated animal (xylazine: 0.05 mg/kg BW) restraint in lateral recumbency on a surgical table (Rizk et al., 2012). For these surgical interventions on the fetlock, carpal and tarsal joints the application of a regional intravenous anesthesia in combination with an intravenous regional limb perfusion (IVRLP) of water soluble antibiotics is highly suitable (Steiner et al., 1990; Stanek, 1994; Navarre et al., 1999; Rodrigues et al., 2010; Shearer et al., 2013). For the lavage and arthrotomy of the stifle or for lavage of the coxofemoral joint an epidural anesthesia is recommended using procaine-hydrochloride or lidocaine 0.4 ml/kg (8 mg/kg) BW or Xylazine 0.1 mg/kg BW, diluted with 0.9% saline to a final volume of 0.4 ml/kg BW (Meyer et al., 2007). However, alternatively in calves a general anesthesia can be administered using xylazine (0.1 mg/kg BW) and ketamine (2 mg/kg BW) intravenously (Meyer et al., 2007).

### **1. Exclusive systemic antibiotic treatment**

It is recommended only for those cases of hematogenous septic arthritis when it can be started within the first 2 to 4 days of joint infection. If there is no obvious improvement after 36 - 48 hours after starting systemical antibiotics, then a topical treatment of the joint should be immediately performed. The treatment is then assessed following performance of an antibiogram and a resistogram. Chemotherapeutics with a proved penetration into synovial cavities and bones are Penicillin, Ampicillin, Cephalosporins, Aminoglycosides, Oxytetracycline,

Fluorquinolones, and Sulfonamides (Trent & Plumb, 1991; Nuss, 2000; Desrochers & Francoz, 2014). However, the duration of application is very important, so for a septic arthritis and/or osteomyelitis caused by hematogenous spread the agent has to be administered for at least 2 weeks, in some cases for up to 4 weeks. The systemic antibiotics can be combined with the application of intravenous regional limb perfusion (IVRLP) of the same antibiotic (Steiner et al., 1990; Stanek, 1994; Navarre et al., 1999; Rodrigues et al., 2010; Shearer et al., 2013).

### **2. Joint lavage and systemic antibiotic treatment**

The application of a joint lavage using at least two cannulas with a lumen diameter of 1.6 to 2 mm is promising in cases of a septic serous and septic sero-fibrinous arthritis with only small fibrin clots. Depending on the joint and the size of the animal about 1000 - 4000 ml of 0.9% saline solution should be used (Jackson et al., 1996; Meier, 1997; Desrochers & Francoz, 2014). Depending on the duration of the joint infection, the joint lavage have to be applied repeatedly, and the macroscopic evaluation of the synovial effusion before the next joint lavage, cytology of the synovial sample and the clinical findings such as improvement of weightbearing and decrease of joint swelling are suitable parameters for monitoring the healing process (Rhode et al., 2000; Nuss, 2000). By joint lavage, and even more effectively by arthrotomy and arthroscopy, a decompression and a drainage of the inflamed joint, a removal (elusion) of inflammatory breakdown products, and a debridement of fibrin can be obtained. Following joint lavage, antibiotics, such as ceftiofur or penicillin, can be injected into the joint (Desrochers & Francoz, 2014).

### **3. Arthrotomy, joint lavage and systemic antibiotic treatment**

The correct approaches for arthrotomy/arthroscopy of each joint correspond to those localisations that are used for arthrotomy (dorsal/cranial and/or plantar/caudal joint recesses) (Nuss, 2000; Kofler & Martinek, 2005; Kofler, 2014b).

Arthrotomy should be undertaken in joints with high synovial clotted fibrin and/or purulent effusion, and in cases of arthritis attributable to a penetrating puncture or laceration wound (Hirsbrunner & Steiner, 1998; Nuss, 2000). In addition to joint lavage and arthroscopy/arthrotomy gentamicin-impregnated collagen sponges can be implanted into the joint (Desrochers & Francoz, 2014).

#### **4. Arthroscopy, joint lavage and systemic antibiotic treatment**

The application of arthroscopy in cattle is restricted on those rather early stages of septic arthritis showing a serous or sero-fibrinous effusion. However, this technique is associated with high equipment requirements and the application of a general anesthesia or an epidural anesthesia, allowing the safe application of the instruments (Munroe & Cauvin, 1994; Steiner et al., 1999; Nuss, 2000; Bertagnoli et al., 2012).

#### **5. Joint resection and arthrodesis, joint lavage and systemic antibiotic treatment**

This surgical method is recognized as „ultima ratio“ in long-term purulent arthritides associated with subchondral bone infection. This technique is frequently applied for the treatment of purulent arthritis of the distal and proximal interphalangeal joint (Starke et al., 2007; Heppelmann et al., 2009; Burgstaller & Kofler, 2015). However, in proximal bovine joints this radical surgical technique can be applied only for the metacarpophalangeal (metatarsophalangeal and the carpal joints using a local intravenous retrograde in combination with sedation or a general anesthesia (Geishauser 1996, 1997; Van Huffel et al., 1998; Riley et al., 1998; Steiner et al., 1999; Kofler & Peterbauer, 2014). This surgical intervention starts with a transverse incision through the skin and joint capsule on the dorsal/cranial aspect of the fetlock joint, the intercarpal- or the carpometacarpal joint, even the medial and lateral collateral ligaments are completely transected. Thereafter, the joint can be completely opened in a flexed position, all the infected tissues (capsule, cartilage, subchondral bone,...) have to be carefully removed using a curette

followed by a joint lavage. The skin is sutured and the limb is immobilized by application of a full limb cast (Geishauser 1996, 1997; Van Huffel et al., 1998; Riley et al., 1998; Steiner et al., 1999; Kofler & Peterbauer, 2014).

#### **6. Removal of a circumscribed osteomyelitic area localized in the physis/metaphysis**

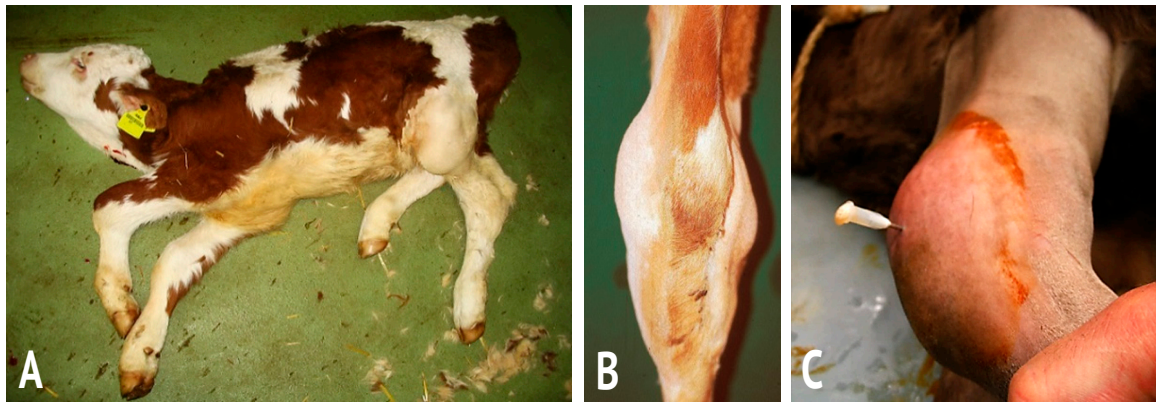
The intention is to create a decompression of the infected bone area, a debridement of the infected bone tissue, a lavage of inflammatory products and a drainage of the lesion. The exact localization of such an osteomyelitic lesion is obtained by radiography using at least two orthogonal projections (Firth et al., 1997; Verschooten et al., 2000; Kofler et al., 2014). A skin incision is made over the identified area, and the bone surface is surgically visualized. If necessary, a hole is drilled into the osteomyelitic lesion, and the infected bone tissue is completely removed using a curette. Finally the lesion is irrigated using 0.9% saline solution, and a drainage is applied. In addition, a systemic antibiotic treatment is administered for 2 to 4 weeks (Trent & Plumb 1991; Steiner et al., 1999; Nuss, 2000; Francoz et al., 2007; Starke et al., 2008; Achard et al., 2012; Desrochers & Francoz, 2014).

#### **7. Antiphlogistic treatment using NSAID's**

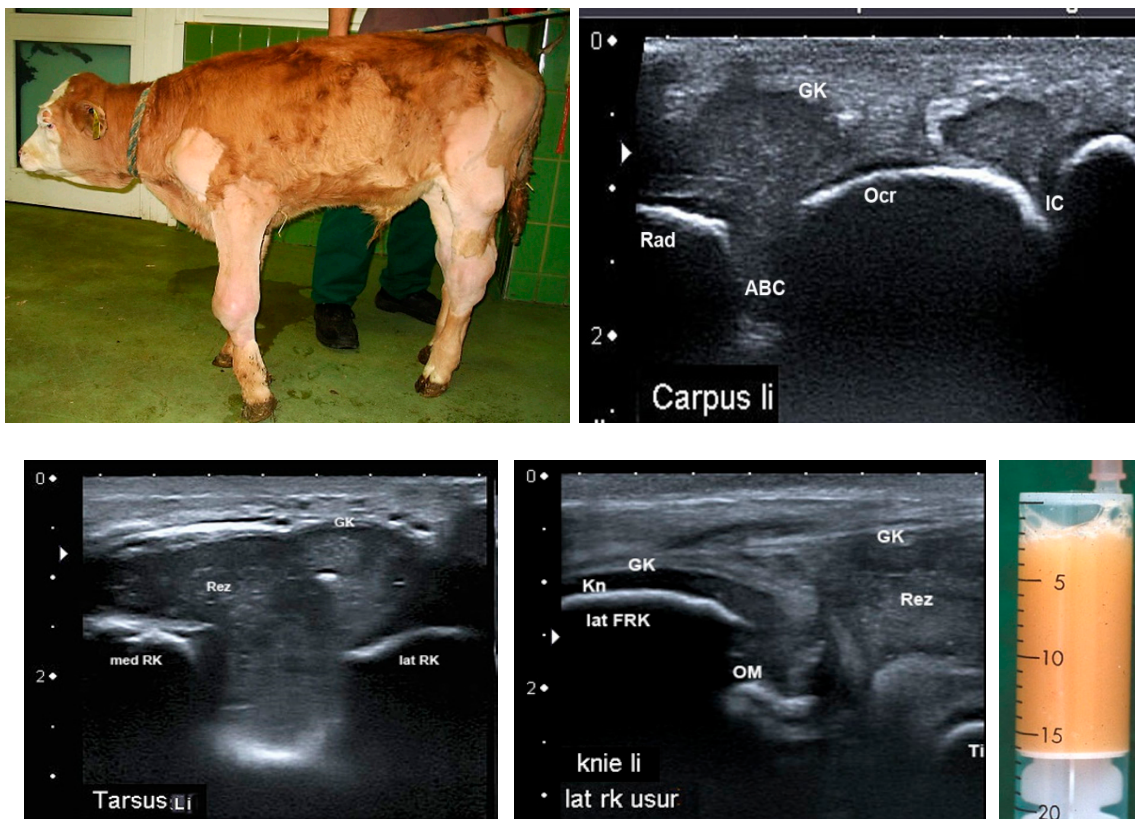
In addition to all the above mentioned surgical techniques, antiinflammatory drugs are administered for 3 days using NSAID's (e.g. flunixin-meglumine, ketoprofen, carprofen, meloxicam) for inhibition of the inflammatory mediators, for reduction of the inflammatory swelling, and for improvement of the feed intake (Barrett et al., 2004; Anderson & Muir, 2005; Shearer et al., 2013; Desrochers & Francoz, 2014).

#### **Prophylaxis**

Sufficient and early application of colostrum in neonates within the first six hours of life, improvement of the postnatal management of calves to avoid lung- and gastrointestinal infections, check-up of the concentration of immunoglobulins in blood, and correct disinfection of the umbilicus (Desrochers & Francoz, 2014).



Examples of **septic polyarthritis in calves**: (A): severe distension of the left carpal, left stifle joint; (B): severe distension of the caudo-lateral and caudo-medial recesses of the tarsocrural joint; (C): severe swelling of the left carpal region in a calf with septic arthritis of all three carpal joints: arthrocentesis of the antebrachioacarpal joint with discharge of a highly turbid synovial fluid.



Simmental calf (4 weeks old) with a **serofibrinous, septic polyarthritis of the left carpal, both tarsal and both stifle joints**: Sonograms of the carpal joint showing a hypochoic effusion in the antebrachioacarpal- (ABC), intercarpal joint (IC), tarsocrural and stifle joints. GK: joint capsule; Rez: the joint recess is highly distended; Rad: radius; Ocr: Os carpi radiale; RK: trochlear ridge of talus; FRK: trochlear ridge of the distal femur; Ti: tibia. At the distal lateral trochlear ridge of the femur a subchondral bone lesion can be identified (osteomyelitis: OM). Arthrocentesis of the tarsocrural joint revealed a highly turbid synovial fluid, that showed complete coagulation 15 minutes later (fibrinous arthritis).



**Joint lavage of a metatarsophalangeal joint** in a Simmental calf with a septic serofibrinous arthritis caused by a large penetrating wound (on the lateral aspect) 5 days before calf: the treatment was carried out after application of a local retrograde intravenous anesthesia (the arrow shows the elastic tourniquet) and sedation of the calf; the wound was carefully debrided and a plantar arthrotomy approach was used for joint lavage; 2500 ml of 0.9% saline solution with added povidine solution 0.1% was used.

## Conclusions

Accurate orthopedic examination, ultrasound, and radiographic imaging and synovial fluid evaluation are common diagnostic tools for septic arthritis (Shearer et al., 2012; Kofler, 2014b; Kofler et al., 2014, 2016a). Commonly affected joints are carpus, stifle, and tarsus. The treatment strategy must include long-term antibiotics, anti-inflammatories, and depending on the stage and duration of joint infection, joint lavage, arthroscopy or arthrotomy (Nuss, 2000; Desrochers & Francoz, 2014). The knowledge of communication and boundaries for commonly affected joints is essential to perform joint lavage and arthrotomy (Jackson et al., 1996; Meier, 1997; Nuss, 2000; Desrochers & Francoz, 2014). Arthrodesis is the final solution when no treatments were efficient or because of the chronicity of the joint infection, joint function will never be restored (Desrochers & Francoz, 2014; Kofler & Peterbauer, 2014). Decision making for arthrodesis of the fetlock and the carpal joint is indicated when capsule fibrosis is extensive and joint motion cannot be restored or there is radiographic evidence of extensive irreversible osteomyelitis lesions. (Desrochers & Francoz, 2014).

## Bone sequestration in cattle – diagnosis and treatment

Bone sequestration is most commonly associated with traumatic injuries that lead to localized cortical ischemia and bacterial invasion

secondary to loss of adjacent periosteal and soft tissue integrity and viability (Firth, 1987; Squire et al., 1990; Hirsbrunner et al., 1995; Valentino et al., 2000; Clerc et al., 2005; Kofler et al., 2016). Most bone sequestra occurred in the proximal half of the third metatarsal bone and the third metacarpal bone (Hirsbrunner et al., 1995; Kofler et al., 2016b).

Medical records of 12 patients from the Clinic of Ruminants, University of Veterinary medicine in Vienna with the diagnosis bone sequestration within the period 2000 to 2015 were evaluated retrospectively. Signalment, clinical and radiographic findings, localization of the bone sequestrum, the treatment regime and the outcome were reviewed (Kofler et al., 2016b).

## Results

Eleven patients were cattle of different breeds, and one a male goat. Nine (75%) were female, and three (25%) were male. The mean age was 41.5 months (range: 3–170 months). All animals with bone sequestra on the limbs were lame on presentation. Wounds of various age and various sizes on the limbs with swelling and fistula formation were assessed. The three animals with mandibular sequestration showed a hard and painful swelling and masticatory problems. All sequestra were identified radiographically either when they were presented to the clinic or on control-radiographs taken two to three weeks after the initial trauma. Six sequestra (50%) were localized on the metatarsus, three (25%) on the mandible, one (8.3%) on the metacarpus, one on the tuber coxae, and another one on the calcaneal tuberosity. The size of the bone

sequestra determined radiographically measured between 1– 10 cm in length.

Sequestrectomy in limbs with partial removal of the surrounding exuberant new bone formation was performed in nine cases using intravenous regional anesthesia and sedation, and general anesthesia for removal of the mandibular sequestrum. Wounds were drained in all these cases, and in some the skin was partially sutured. One animal with a small bone sequestrum of about 1 cm length on the lateral metatarsus was treated conservatively.

Pre- and postoperative medication included systemic administration of antibiotics for 5 to 10 days and of NSAID's for 3 days. A protective bandage was applied in 8 surgically treated cases, and in seven cases of metatarsal/calcaneal sequestration an immobilization cast using synthetic casting tapes or PVC-splints was applied. Two animals, one with a large mandibular and one with a large metacarpal sequestrum, were slaughtered after diagnosis due to poor prognosis and cost considerations. Eight (80%) animals had a successful outcome and were discharged from the clinic after mean hospitalization of 29.3 days. However, two heifers had severe complications three weeks after sequestrectomy developing complete bone fractures despite a cast application (Kofler et al., 2016b).

### Discussion

The prevalence of bone sequestration in ruminants is low, however it represents a serious injury in affected animals (Huber, 2011; Hirsbrunner et al., 1995; Valentino et al., 2000; Kofler et al., 2016b). Cattle between the ages of 6 months and 2 years are considered at a higher risk for sequestrum formation; most likely because adolescent animals are more likely to be involved in traumatic accidents than are adults. Also, periosteal trauma may have a more severe outcome in young animals because the periosteum plays a greater role in cortical circulation in young animals than it does in adults (Firth, 1987; Squire et al., 1990; Clerc et al., 2005; Huber, 2011; Hirsbrunner et al., 1995; Valentino et al., 2000; Kofler et al., 2016b). In collected samples from the drainage tract for bacteriology 84 different organisms were cultured (61 aerobic, 23 anaerobic) from 40 positive cultures (Valentino et al., 2000). Perhaps in cases where a negative culture result

was obtained, the causative agent was not viable after a prolonged immune response.

Medical management using antimicrobials and strict confinement, sometimes on a long-term basis, is indicated prior to surgery. Some small-sized sequestra may resolve completely with medical management and confinement only (Huber, 2011; Hirsbrunner et al., 1995; Valentino et al., 2000; Kofler et al., 2016b). Sequestrectomy is the appropriate treatment method, however proper timing of surgery has to be oriented towards the radiographically verified maturation of the sequestrum being accompanied by clear demarcation by a large radiolucent area from vital bone, or, in the case of a large sequestrum, until a stabilizing callus proliferation is formed around (Huber, 2011; Kofler et al., 2014; 2016a). Surgical management has a favourable prognosis despite risk of destabilization; overall success depends on correct timing of the surgical procedure (Huber, 2011; Hirsbrunner et al., 1995; Kofler et al., 2016b).

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