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CASE REPORT
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Septic Nonunion in Radius and Ulna in a Dog: Treatment with Orthogonal Plating Associated with Corticospongious Bone Autograft

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ABSTRACT

***Background*:** A fracture stabilization strategy must be able to withstand the loads to which the bone will be subjected and be appropriate for the individual patient. Fractures of the radius and ulna are common in dogs; however, the incidence of complications is relatively high. Inadequate repair can result in complications. The treatment of long bone diaphyseal fracture-nonunion is challenging. While considering biological needs, a stable mechanical environment is pertinent for fracture healing. The aim of this study was to describe the treatment of a septic nonunion in the radius and ulna in a large breed dog which had suffered amputation of the contralateral forelimb through stabilization with orthogonal plating and the use of corticospongious bone autograft.

***Case*:** A 5-year-old male mixed breed dog, weighing 47 kg, with amputation of the right forelimb had been previously treated for fracture of the left radius and ulna with external immobilization for several weeks. The patient was admitted to our veterinary service 120 days after the initial trauma without effective bone consolidation and refracture after minimal load. The septic nonunion in the left radius and ulna was successfully treated with a custom locked plate 4.5 mm thick on the cranial surface of the left radius, a 3.5 mm thick locked plate on the lateral surface of the left ulna and application of a corticospongious bone autograft from the left iliac crest. Satisfactory return to function and clinical union were achieved at 20 and 75 days postoperatively, respectively. After consolidation, dynamization was performed in 3 stages until complete removal of the implants. The treatment provided an early return of limb function, complete bone consolidation and a good prognosis for the dog.

***Discussion*:** The healing of fractures of the radius and ulna can be problematic, and a poor choice of stabilization method can lead to complications such as delayed union, non-union, malunion and angular limb deformities. External immobilization proved to be the least effective technique in the treatment of diaphyseal fractures of the radius and ulna in dogs, even in larger breeds, when compared with the use of external skeletal fixators or plates and screws. The choice of external immobilization may explain the failure of the primary repair in this case. The patient only had this thoracic limb for support, which, in addition to a nonunion, also had osteomyelitis. Thus, rigid stabilization was necessary and, given the biological conditions presented, the use of autograft and antimicrobial treatment against bone infection were favorable for bone repair. Bone grafts have many functions, including improving the biological repair of skeletal defects and reducing time to healing in delayed unions and non-unions, as they stimulate early bridging callus formation. It is already known that to maximize the treatment against infection, bone vascularization in the focus must be present, in such a way, the use of autograft was again justified. Constructions with dual bone fixation (radial and ulnar) allow a significant increase in resistance to axial compression and caudocranial flexion when compared to the use of a radial plate alone and perform better under load-to-failure cycles than other constructions. The use of 2 plates in the present case was considered essential, due to the characteristics of the fracture and the patient. In this way, it was possible to achieve successful treatment by restoring limb functions, such as support and ambulation in a short period of time.

Keywords: bone plates, complications, dynamization, fracture healing, osteomyelitis.

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INTRODUCTION

Fractures of the radius and ulna are common in dogs and the incidence of complications is relatively high. Inadequate repair can result in nonunion, delayed union or malunion [4]. Stabilization of both the radius and ulna is usually required in complex fractures, in large or giant breed dogs, and in cats [11,14]. For this, the plates are applied to both the radius and the ulna, providing extremely rigid fixation with significantly increased resistance to axial compression and caudocranial flexion when compared to stabilization of the radius alone [4,11].

The bone repair processes benefit from consideration of biological and mechanical factors and the treatment of nonunions requires the utilization of numerous resources, especially when infection is present. Preservation or stimulation of the periosteal blood supply in conjunction with rigid fixation are thought to increase union rates and minimize complications. In nonunions, biological factors are almost always severely impaired, and bone grafts further aid repair [10].

Following forelimb amputation in a dog the biomechanics of gait undergo major changes. Stance time and vertical impulses are increased in all other limbs, and the remaining forelimb and the ipsilateral pelvic limb to the amputation compensate for the loss of braking and propulsion [7]. Thus, weight distribution increases by at least 7% in the contralateral forelimb and by 17% in both pelvic limbs [2,3,7].

This report described the treatment of a septic nonunion of the radius and ulna in a large breed dog with an amputation of the contralateral thoracic limb through stabilization with an orthogonal plate and the use of corticocancellous bone autograft.

CASE

A 5-year-old male mixed breed dog, weighing 47 kg, was treated at the Veterinary Hospital of UNESP - Campus of Jaboticabal. The dog had previously had an amputation of the right forelimb. Following a road traffic accident the dog had been treated, at another center, for fracture of the left radius and ulna with external immobilization for several weeks. The patient was admitted to our veterinary service 120 days after the initial trauma at which time there was no effective bone consolidation and refracture occurred after minimal load.

No significant abnormalities were detected on clinical examination. The orthopedic examination revealed atrophy of the muscles of the left thoracic limb, instability in the middle 3rd of the left radius and ulna and reduction in range of motion of the left elbow. There was a large, firm, soft tissue swelling adjacent to the fracture and a fistula on the craniomedial surface of the fracture focus. Mediolateral and craniocaudal radiographic projections revealed a septic nonunion in the middle 3rd of the left radius and ulna, with the presence of osteophytes, marked periosteal reaction, areas of cortical resorption and increased bone marrow density (Figure 1A & A').

The limb was immobilized with a modified Robert Jones bandage until the day of the surgical procedure and preoperative treatment was instituted with pantoprazole[1] [Pantoprazole® - 1 mg/kg BID, orally, 10 days], cephalexin[2] [Rilexine® - 25 mg/kg BID, orally, 10 days], metronidazole[3] [Metronidazole - 20 mg/kg BID, orally, 7 days], meloxicam[4] [Maxicam® - 0.1 mg/kg SID, orally, 4 days] and dipyrone sodium monohydrate[5] [Dipirona monohidratada - 25 mg/kg TID, orally, 7 days]. Osteosynthesis delayed until 15 days after presentation due to the time required to manufacture the customized plate for the radius.

Morphine sulfate[6] [Dimorf® - 0.3 mg/kg IM] was given as a pre-anesthetic medication and, after 15 min, anesthesia was induced with propofol[7] [Provive® - 5 mg/kg IV] and maintained with isoflurane[8] [Isoflurano] diluted in 100% oxygen. After induction, prophylactic antimicrobial therapy with cefazolin[9] [Cefazolina - 30 mg/kg IV] was given.

The dog was positioned in right lateral recumbency and the affected limb and the ipsilateral lumbosacral region were aseptically prepared. Access to the radius was obtained through a craniomedial incision. There was exuberant fibrosis which was removed, together with the devitalized bone tissue, with a gouge and a pneumatic bone saw under irrigation with sterile saline solution. Material was collected for bacterial and fungal culture and antibiogram. After exposing the bone fragments, the fibrosis between bone fragments was removed and anatomical reduction of the fragments was performed. A custom locked plate 4.5 mm thick and 15.6 cm long was implanted on the cranial surface of the radius. The plate had 6 holes, 3 proximal and 3 distal to the fracture line, in which bicortical screws were placed. Two of 4.5mm locked screws were placed at the proximal and distal ends of the plate and 3.5 mm srews in the other holes.

A corticospongy bone fragment was collected, via a dorsal approach, from the left iliac crest and the homogeneously fragmented graft was immediately embedded in bone marrow from the iliac crest and implanted at the radial fracture site. Access sites were closed using a synthetic non-absorbable suture.

Lateral, proximal and distal accesses were made for a minimally invasive left ulnar approach. A 3.5 mm thick locked plate with 12 holes was used and 3 bicortical locked screws were implanted in the proximal fragment and three bicortical locked screws in the distal fragment, all 3.5 mm in diameter. The incised tissues were routinely sutured with synthetic non-absorbable thread.

A modified Robert Jones bandage was placed for 21 days after surgery. The bandage was changed regulalry and intense passive physiotherapy was performed during these changes. Postoperatively, pantoprazole[1] [Pantoprazole® - 1 mg/kg SID, orally, 10 days], cephalexin[2] [Rilexine® - 25 mg/kg BID, orally, 10 days], meloxicam4 [Maxicam® - 0.1 mg/kg SID, orally, 3 days], tramadol hydrochloride[9] [Cloridrato de Tramadol - 4 mg/kg TID, orally, 7 days] and dipyrone sodium monohydrate[5] [Dipirona monohidratada - 25 mg/kg TID, orally, 7 days], until the results of microbiological tests were available.

In the 1st 10 days postoperative, the bandage was changed daily due to accommodate drainage of from the surgical wound in the proximal ulna. At 20 days postoperatively, the patient was able to use the operated limb for support and the soft tissue swelling had reduced significantly. Based on the results of microbiological tests, treatment with cephalexin[2] [Rilexine® - 25 mg/kg BID, orally, 30 days]. There were no other postoperative complications.

Mediolateral and craniocaudal radiographs of the left radius and ulna were taken immediately after the surgical procedure, as well as at 30 and 75 days after surgery (Figure 1B-D & B'-D'). The immediate postoperative radiographic examination revealed good axial alignment of the limb, adequate bone reduction and satisfactory positioning of the orthopedic implants. Subsequent radiographs showed progressive bone consolidation, with unstructured and uneven mineralization of the bridging callus and the fracture line still visible (Figure 1D and D').

Although further visits to the Veterinary Hospital were scheduled for radiographic follow-up the owner only presented the dog again 20 months after the surgical procedure at which time radiographic examination confirmed complete bone consolidation (Figure 1E & E'), in line with the findings of the orthopedic examination. At this time there was mild lameness in the affected limb and a cutaneous fistula was present in the distal region of the radius. The process of removal of the orthopedic implants for dynamization was initiated, and drug treatment was instituted with cephalexin[2] [Rilexine® - 25 mg/kg BID, orally] and pantoprazole[1] [Pantoprazole® - 1 mg/kg SID, orally] for 15 days at first.

In the 1st stage of dynamization (20 months postoperatively - 600 days), the most distal screws in each fragment secured by the radial plate (screws 3 and 6) were removed. This left a 4.5 mm screw and a 3.5 mm diameter screw in the proximal fragment and 2 others 3.5 mm screws in the distal fragment in the radial plate. In the ulna plate, the most distal screw of the proximal fragment and the most proximal and most distal screw of the distal fragment were removed. All implants removed were sent for bacterial and fungal culture and antibiogram. The current systemic treatments were continued until the results were obtained.

Bacterial culture identified *Escherichia coli*, resistant to the commonly used veterinary antibiotics including cephalexin. Therefore, treatment with ceftriaxone[11] [Ceftriaxona - 30 mg/kg BID, SC] was instituted for 30 days.

The 2nd stage of the dynamization process took place 80 days after the 1st dynamization (680 days after surgery). At this time the dog was able to use the limb and there was complete healing of the skin wound and incisions from the previous dynamization procedure. No other clinical or orthopedic problems were reported. Radiographic examination of the left radius and ulna revealed progressive bone consolidation at the sites of removal of the 1st implants and discrete bone callus (Figure 1F & F'). The radial plate was completely removed, leaving only the ulna plate *in situ*.

The 3rd and last stage of dynamization took place 50 days after the 2nd dynamization (730 days postoperatively). All remaining implants were removed from the left ulna. The previous radiographic evaluation had revealed the presence of dense bone callus in the radius, with virtually complete corticomedullary remodeling, and the patient was doing well clinically (Figure 1G-H & G'-H').

The last radiographic examination was performed 60 days after the 3rd dynamization (790 days postoperatively) and showed remodeling of the bone callus in the radius associated with progressive bone consolidation at the sites of removal of the ulnar implants. The fracture lines were no longer visible and bone density of both bones was increased (Figure 1I & I'). The animal was discharged at this time.

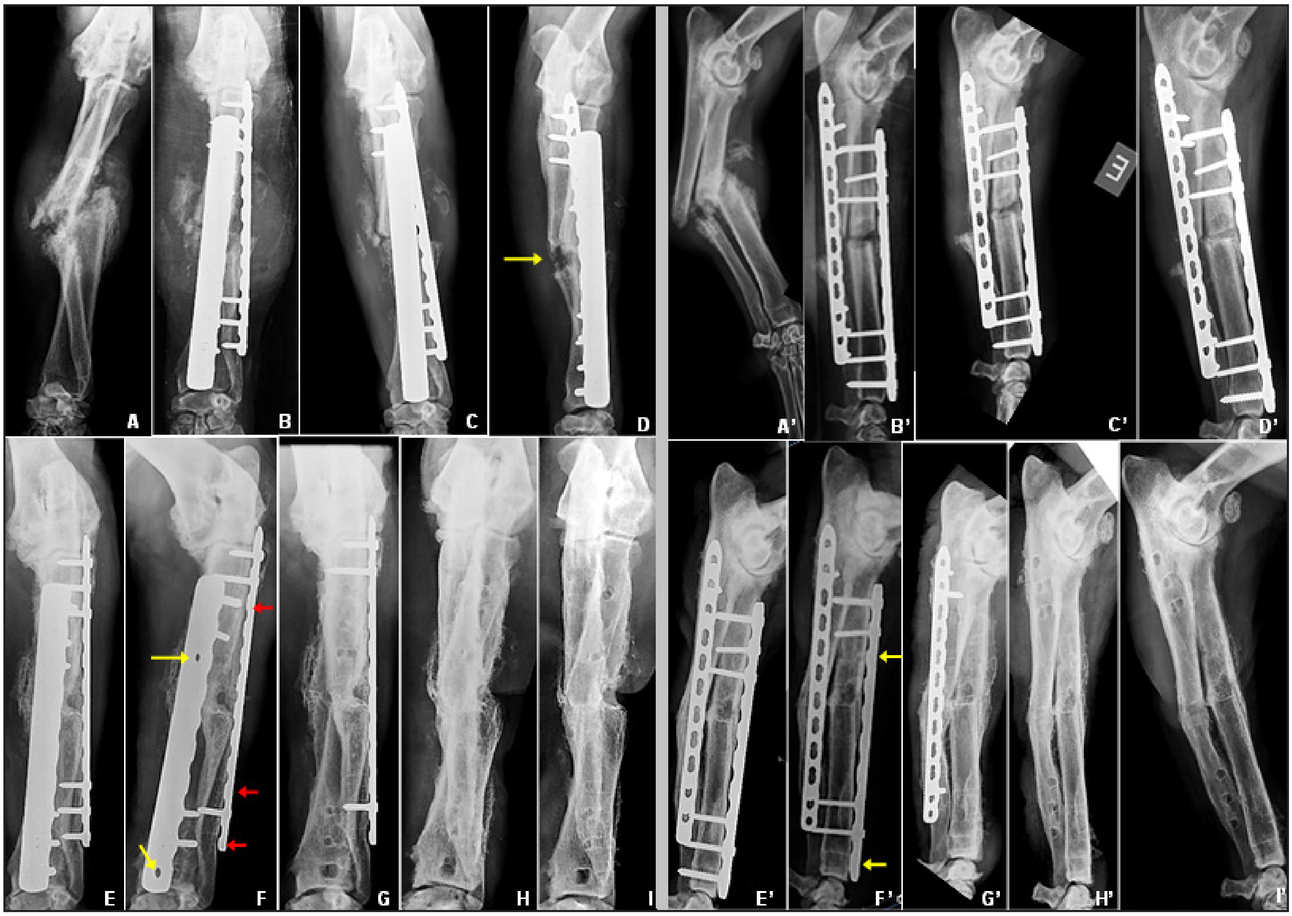

Figure 1. Radiographic images (craniocaudal projection in A - I and mediolateral projection in A' - I') of a 5-year-old male mixed breed dog showing septic nonunion of the left radius and ulna. A & A'- Preoperative image showing intense periosteal reaction (nonunion). B & B'- Immediate postoperative image (osteosynthesis using orthogonal plating). Note the plate locked on the lateral surface of the ulna with 3 screws in each bone fragment. C & C'- Image 30 days after surgery. There is a decrease in the periosteal reaction and fibrous callus. D & D'- Image at 75 days postoperatively. Note the beginning of bone union formation between the left radial and ulnar fragments. E & E'- Image at 20 months postoperatively. All implants were stable and showed no signs of migration. Bone union of both bones is noted. On this day, the patient underwent the 1st dynamization: in the radial plate, 2 screws were removed, the most distal of each bone fragment, and in the ulnar plate, the most distal screw of the proximal fragment and the most proximal and distal of the distal ulnar fragment bone fragment were removed. F & F'- Image at 22 months and 20 days (680 days) postoperatively, 80 days after the 1st dynamization. Note the absence of 2 screws on the radial plate (yellow arrows) and 3 on the ulna plate (red arrows). On this day, the patient underwent the 2nd dynamization, with removal of all radius implants. G & G'- Image at 50 days after the 2nd dynamization (730 days after surgery). Bone remodeling is noted in both bones. On this day, the 3rd and final dynamization was performed with the removal of all the implants from the ulna. H & H'- Image of the same day as the previous image, after removal of the ulnar implants. I & I'- Image 60 days after the last dynamization (790 days after surgery).

DISCUSSION

This case describes the stabilization of a septic bone non-union in the radius and ulna in a large dog that underwent amputation of the contralateral forelimb, through stabilization with an orthogonal plate and use of a corticospongy bone autograft. Rigid stabilization was necessary given the patient's conditions, which, in addition to the autograft and antimicrobial treatment against osteomyelitis, were favorable for this bone repair. In this way, it was possible to avoid euthanasia of the patient and return partial functions of the limb, such as support and short ambulation.

The healing of fractures of the radius and ulna can be problematic and a poor choice of stabilization method can lead to complications such as delayed union, non-union, malunion and angular limb deformities [6,8]. The antebrachium has several properties such as poor muscle coverage, narrow medullary canal and poor vascularization, that may explain the high incidence of these complications [1]. External immobilization proved to be the least effective technique in the treatment of diaphyseal fractures of the radius and ulna in dogs, even in larger breeds, when compared with the use of external skeletal fixators or plates and screws [4,12]. The choice of external immobilization may explain the failure of the primary repair in this case.

It is important to take into account the characteristics of the fracture and consider patient factors when selecting appropriate implants to achieve the necessary stability in the appropriate time. In this case the rigid fixation achieved with orthogonal plating was chosen to deal with 3 main factors: the presence of septic nonunion, the patient being an adult large breed dog and the previous contralateral forelimb amputation.

In the context of mechanobiology, the biological components of fracture repair were compromised and therefore, corticospongious bone autograft was also performed in this patient. Bone grafts have many functions including: improving the biological repair of skeletal defects and reducing time to healing in delayed unions and non-unions, as they stimulate early bridging callus formation [10]. The cancellous graft is typically used to provide live cells and growth factors that will stimulate the formation of new bone [10]. It is particularly useful in a biologically disadvantaged environments such as chronic nonunion.

A study analyzed the weight distribution on a force plate from dogs with amputated limbs and concluded that animals without the right forelimb support 39.26% of their weight on the left forelimb [3]. According to another study, dogs with 4 intact limbs support 31.77% of their weight on the left forelimb [2]. Therefore, based on these results, animals with amputation of the right forelimb transfer about 7.49% more weight through the contralateral forelimb. In turn, other study compared the biomechanical difference between dogs with and without amputation of the forelimb [7]. Ambulatory measurements were made across a force plate and spatial kinematic and kinetic data was recorded for each limb during the stance phase and concluded that the weight distribution increases by 14% in the remaining forelimb in amputees [7]. Therefore, in this context, when weight bearing is excessive, additional radial stabilization can be achieved with the application of an intramedullary pin or plate on the ulna [11].

Constructions with dual bone fixation (radial and ulnar) allow a significant increase in resistance to axial compression and caudocranial flexion when compared to the use of a radial plate alone [11]. In addition, that study reported that orthogonal plating on the radius and ulna perform better under load-to-failure cycles than other constructions. The use of 2 plates in the present case was considered essential, due to the characteristics of the fracture and the patient.

Most fractures heal without complications and plate removal is a controversial issue. However, in cases of previous osteomyelitis, such as this patient, it is important to remove all implants as soon as bone repair is achieved [9]. The owner in this case failed to present the patient for re-examination until 20 months after surgery, at which time the dog showed mild lameness on the affected limb and there was a cutaneous fistula in the distal region of the radius. These findings suggest that plate removal should have been carried out earlier.

Despite the radiographic findings of adequate bone consolidation, due to the history of complications and bone quality of the patient, dynamization was chosen in order to avoid refractures. Stabilization with locked plates can be done with minimal disturbance of the fracture region. This allows for biological healing of the fracture, whilst the locking mechanism assumes the mechanical load and thus minimizes micro-motion at the fracture site [13]. Dynamization can improve healing strength by altering the mechanical environment created by locked plates and dynamically stimulating natural bone healing through callus formation [5]. In the present case, it was decided to initially reduce the rigidity of the radial apparatus, removing the larger diameter screw (4.5 mm) from the distal end of the plate and increasing the length of the bridge crossing the fracture line when removing the distal screw of the proximal fragment. This new configuration provided greater micro-motion, allowing the formation of a discreet callus in the fracture zone, which increased the consolidation force. In addition, the holes left by the removal of the screws were able to heal, reducing bone fragility. Therefore, in the 2nd stage of dynamization, the radial plate could be completely removed and subsequent radiographic follow-up showed no signs of refracture and improving bone quality. Remaining implants were removed in the 3rd phase.

Therefore, stabilization with orthogonal plating of the radius and ulna associated with corticospongious bone autograft was effective in the treatment of septic nonunion in the radial and ulnar diaphyses of a large breed dog with a previously amputated contralateral forelimb. The unfavorable biological conditions at the fracture site and the patient characteristics necessitated the choice of a sufficiently rigid stabilization method. In addition, the use of corticospongious bone autograft and the concomitant systemic treatment of osteomyelitis were fundamental for successful bone repair. Finally, dynamization was used effectively to ensure that the implants were removed without complication.

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