Case report

A plate-rod construct for repair of a humeral diaphyseal fracture in a black howler monkey infant

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Abstract: An infant black howler monkey (*Alouatta caraya*), aged approximately three months, presented with a transverse fracture of the distal third of the right humeral shaft underwent surgical treatment using a plate-rod construct. A 1.00-mm diameter intramedullary pin was used in a retrograde fashion to reduce both the fracture and plate stress. The plate-rod construct was a seven-hole 1.5-mm veterinary cuttable plate, which was installed following the principles of biological osteosynthesis. The animal presented no pain in the postoperative exams and used the limb normally. Bone consolidation was observed for eighth weeks after surgery, showing that the treatment was effective.
Keywords: primate, surgery, bridge plate, biological osteosynthesis.

Introduction

Humeral fractures are common in dogs, cats, and humans. In most cases, surgical treatment is indicated since conservative treatments, such as bandages and plaster, are not very efficient at neutralizing the forces (torsion, compression, tension, shear, and bending) affecting the humerus and stabilizing bone fragments, thereby decreasing fracture healing (HARARI, 2002; SIMPSON, 2004). Surgically, these fractures can be treated with intramedullary pins, interlocking nails, plates and screws, and external fixators (HARARI, 2002; DUHAUTOIS, 2003; SIMPSON, 2004; KIRKBY et

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al., 2008). The reports of fracture treatment in wild primates are rare, and little is known about the techniques used in these species and the time required for bone healing and remodeling (TONG and GUIOT, 2013).

Currently, there is a need for an orthopedic surgical procedure that avoids additional damage to the blood supply to bone — especially at the fracture foci —, consequently improving bone healing and favoring an early return of function to the affected limb (PERREN, 2002). This procedure is an important element in the philosophy of biological internal fixation (PERREN, 2002). The use of bone plates as bridges may improve this method of osteosynthesis, depending on the surgical approach (PERREM, 2002; HUDSON, POZZI and LEWIS, 2009).

Considering the benefits of biological osteosynthesis and the scarcity of reports on fracture treatment in wild primates, this study evaluated a plate-rod construct for the repair of a humeral diaphyseal fracture in an infant black howler monkey (Alouatta caraya).

Case Report

A free-living primate of the black howler monkey species *Alouatta caraya*, belonging to the *Atelidae* family, aged approximately three months and weighing 350 g, with a history of physical trauma, could not move or place his limb on the ground. On clinical examination, swelling and crackling were observed in the distal region of the right humerus, and no neurological injury was observed. The radiographic examination showed a transverse fracture on the distal third of the right humeral shaft (Figure 1).

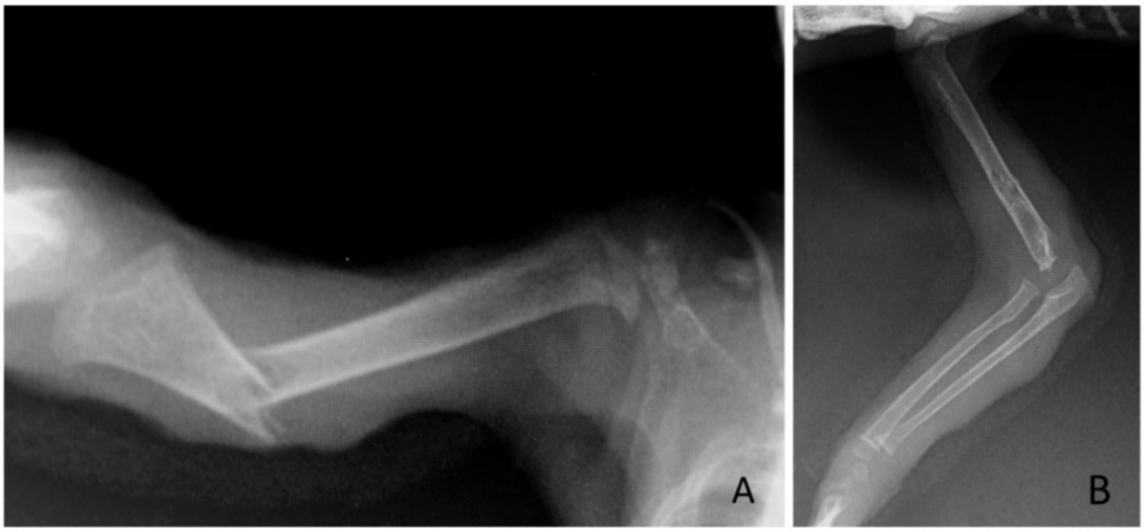

Figure 1: Preoperative craniocaudal (A) and mediolateral (B) projections of an infant black howler monkey's right humerus, showing a transverse fracture in the distal third of the bone diaphysis.

The animal underwent biological osteosynthesis to reduce the fracture, following sedation with 10 mg/kg of intramuscular (IM) ketamine, 0.2 mg/kg of IM midazolam, and pre-anesthesia of 0.2 mg/kg of intravenous (IV) tramadol. The animal was anesthetized and maintained with isoflurane inhalation using a universal steam vaporizer and a semi-open circuit. This procedure was performed two days after the trauma.

For the surgical procedure, the animal was placed in the left lateral decubitus position for a lateral approach to the right humerus. Two skin incisions were made: one on the proximal region (near the shoulder joint) and the other on the distal region (near the elbow joint) of the arm. After the greater tubercle of humerus and the deltoid tuberosity were identified by palpation, a 1.5-cm incision was made over the greater tubercle. Then, following the retraction of the skin and the subcutaneous tissue, an incision was made through the deep fascia along the lateral border of the brachiocephalic muscle. After the retraction of the brachiocephalic muscle and the fascia, a Metzenbaum scissor was inserted to create an extraperiosteal tunnel. The distal window was obtained by making a limited approach to the distal humeral metaphysis and the lateral epicondyle. The lateral epicondyle was palpated to determine the distal extent of the incision. A 1.0-cm long incision was made, extending proximally from the lateral epicondyle. After identifying the lateral head of the triceps muscle, and the retraction of the skin and the subcutaneous tissue, an incision was made through the deep fascia along the cranial border of the triceps. The retraction of the fascia and the triceps muscle exposes the supracondylar region of the humerus. An extraperiosteal tunnel was created by passing a Metzenbaum scissor to the brachialis muscle from the distal to the proximal incision. A 1.0-mm diameter Kirschner wire was inserted through the distal incision in the medullary canal of the proximal fragment toward the greater tubercle of the humerus, with minimal exposure and manipulation of the bone fragments and without damaging the clot formed. After having its end exteriorized, the wire was redirected into the medullary canal of the distal fragment. After placing a retrograde intramedullary pin, a 1.5-mm veterinary cuttable plate was prepared with seven holes to correctly conform to the size and shape of the bone, and was placed on the lateral face of the humerus, after insertion through the distal skin incision and passing by the extraperiosteal tunnel toward the proximal skin incision. When the plate was in the correct position, three 1.5-mm diameter bicortical screws were placed in the proximal fragment, and two 1.5-mm diameter bicortical screws were placed in the distal fragment (Figure 2).

Figure 2: Intraoperative image showing the surgical procedures to the humerus in an infant black howler monkey: visualization of the final positioning of the plate and the intramedullary pin.

Immediately after surgery, the animal underwent cryotherapy with an ice pack for 15 minutes and administration of 2 mg/kg of IV ketoprofen and 40 mg/kg of IV ceftriaxone.

Postoperative care consisted of activity restriction through confinement in isolated housing for two weeks. The animal received oral azithromycin (50 mg/kg once a day for four days), tramadol (2 mg/kg every 12 hours for two days), and ketoprofen (2 mg/kg every 12 hours for four days). The wound dressing was changed using chlorhexidine solution (twice daily for eight days).

Results

Immediately after surgery, complete radiographic examinations in the craniocaudal and mediolateral projections were taken. The examinations showed that the bone fragments and joints were aligned, the bone length was restored, and the implants were well-positioned without damaging the proximal and distal joints to the fracture (Figure 3).

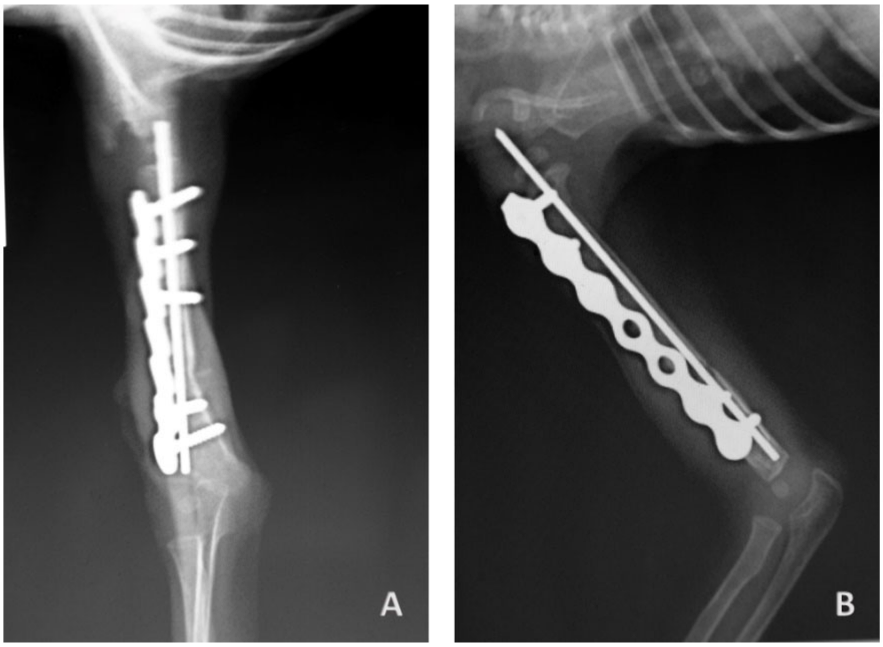

Figure 3: Immediate postoperative craniocaudal (A) and mediolateral (B) radiographic view of the right humerus in an infant black howler monkey showing correct bone alignment and implant position.

The animal could move the limb 24 hours after surgery and showed no signs of pain on the seventh day after surgery while using and moving the operated limb normally.

The patient underwent new clinical and radiographic exams eight weeks after surgery, which showed a normal function of the operated limb. The radiographic assessment found signs of moderate callus formation and showed that the implants were well positioned. No evidence of complications such as implant failure was noted. Clinically, the patient did not present muscle hypotrophy or angular limb deviations.

Clinical and radiographic exams were repeated at the 6th, 13th, and 18th month after surgery. These examinations showed that the animal was clinically normal, without muscle hypotrophy or limb deviations. The implants were well-positioned, no evidence of complications, such as implant failure, was noted, and the bone was completely remodeled (Figure 4).

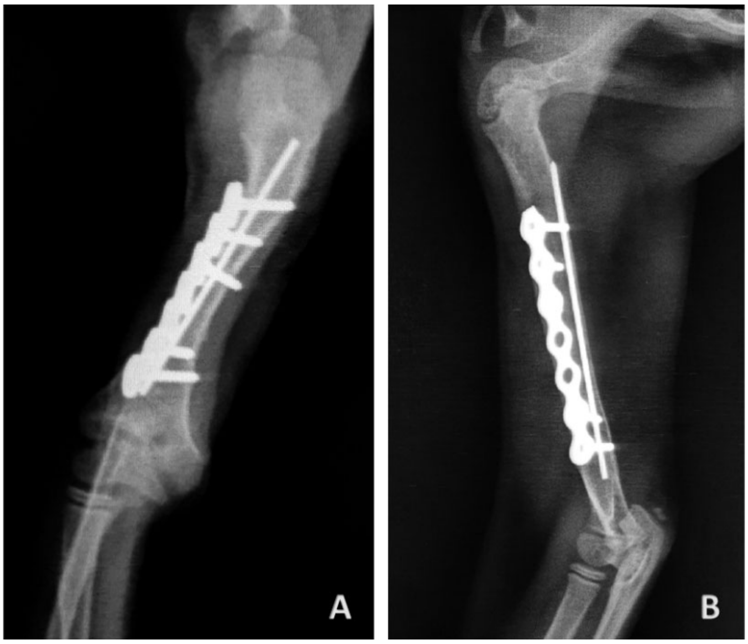

Figure 4: Follow-up craniocaudal (A) and mediolateral (B) radiographic views of the right humerus in an infant black howler monkey 18 months after operation showing bone consolidation, correct bone alignment, and correct implant position. No evidence of complications, such as implant failure or absence of radiolucency in bone tissue, is noted.

Discussion

The humeral shaft fractures in dogs and cats are usually surgically treated using plates and screws, interlocking nails, external fixators (linear or hybrid), or intramedullary pins (HARARI, 2002; DUHAUTOIS, 2003; KIRKBY, 2008). In children, these fractures are treated conservatively with bandages (KANCHERLA et al., 2012) or surgically using single or multiple intramedullary pins (TOMORI et al., 2017).

In the monkey, conservative treatments with cast were not performed because the animal would use their fractured limb during the early postsurgical period for locomotion and feeding, consequently needing a long-term immobilization in a cast. For humeral fractures, the external immobilization is not efficient to neutralize the forces that affect this bone (torsion, compression, tension, shear, and bending), which can impair bone healing (SIMPSON, 2004). The humerus is difficult to bandage appropriately because it is virtually impossible to immobilize the shoulder joint (SIMPSON, 2004). The selected surgical treatment involved the use of a bridge plate and an intramedullary pin. This pin, besides helping align the bone fragments and preserve the original bone length during surgery, reduces plate stress, which increases the lifespan of the implant (HULSE, 1997; REEMS, BEALE, and HULSE, 2003). Also, an intramedullary pin reduces the plate strain and increases the rigidity of the surgical apparatus (HULSE, 1997), which is suitable for a high strain fracture, such as this case. A compression plate was not used because conventional stable fixation with precise reduction usually requires a fairly extensive surgical approach to the bone, thus increasing the risk of delayed healing.

Intramedullary pins can be retrogradely or normogradely placed in the humerus in the proximal-to-distal (HULSE, 1997; SIMPSON, 2004) and distal-to-proximal directions (MILGRAN, 2012). In this surgical procedure, intramedullary pinning was done retrogradely because the distal skin incision exposed the fracture foci that was present in the distal third of the humeral shaft.

Although the plates can be fixed to the medial or lateral side of the humerus, in this case they were fixed to the lateral side of the bone. This approach was selected to decrease the risk of iatrogenic lesions to the vascular and nerve structures of the affected limb (SIMPSON, 2004; POZZI and LEWIS, 2009).

Current recommendations involve the preservation of as much bone vascularization as possible during orthopedic surgical procedures, even if the reconstruction of bone fragments is not perfect. This is the basis for biological osteosynthesis (PERREN, 2002; POZZI and LEWIS, 2009). Even though the minimally invasive plate osteosynthesis (MIPO), a classic procedure, was not used in this case, an attempt was made to gently manipulate the tissues, expose the bone fragments as little as possible, reduce the fracture using intramedullary pinning, and place the plate using a tunnel under the skin and muscles to preserve bone vascularization and facilitate fracture healing. The technique used to apply the plate to the humerus was described by Pozzi and Lewis (2009) and Schmierer and Pozzi (2017). According to the dimensions of the treated bone, the cuttable plate was used because it was the smallest available and it allowed the use of 1.5-mm screws.

The reports of fracture treatment in wild primates are rare, and little is known about the techniques used in these species and the time required for bone healing and remodeling. Tong and Guiot (2013) described the surgical technique and the postoperative outcome of antebrachial fractures in a mandrill monkey treated with MIPO. These authors did not use conservative treatments. Fracture healing was documented at four weeks, clinical union at 14 weeks, and callus remodeling at 24 weeks postoperatively. This report demonstrates the feasibility of MIPO in a primate and shows the adaptability of this technique across mammalian species.

The surgical technique used in this case was effective. While the expected fracture healing times were not available for black howler monkeys, the healing rate observed in this case seemed adequate. If the radiographic exams had been repeated before eight weeks after surgery, they would likely have shown a shorter healing time. The fact that the treated animal is an infant favored rapid bone healing.

The animal in this case report was followed for 18 months after the surgical procedure. During this period, it showed no signs of pain in the treated limb and used the limb normally for locomotion and feeding. The implants were not removed, as they were used in a way that presented no harm to bone growth, as demonstrated by the radiographic follow-up views. The radiographic exams also showed no bone structure damaged by the implant, proven by the absence of radiolucency in the bone tissue.

Conclusion

A plate-rod construct was feasible and effective in treating a transverse fracture of the distal third of the humeral shaft in an infant black howler monkey (*Alouatta caraya*).

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Osteossintese de úmero com a utilização de placa e pino intramedular para estabilização de fratura em um filhote de bugio preto

Resumo: Um filhote de bugio preto (*Alouatta caraya*), com aproximadamente três meses de idade, apresentando uma fratura transversa do terço distal da diáfise umeral, foi submetido a tratamento cirúrgico através da utilização de uma placa de reconstrução com função ponte associada a um pino intramedular. Um pino intramedular de 1,00mm de diâmetro foi utilizado de maneira retrógrada para auxiliar na redução da fratura e para diminuir o estresse sobre a placa. A placa utilizada foi uma de reconstrução de 1,5mm e, para sua colocação, seguiu-se os princípios da osteossíntese biológica. Em todas as avaliações pós-operatórias, o animal não demonstrava dor e utilizava o membro normalmente. Observou-se consolidação óssea na oitava semana após a cirurgia, mostrando que o tratamento utilizado foi eficaz.
Palavras-chave: primata, cirurgia, placa ponte, osteossíntese biológica.

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