Repair of a Radial Fracture with Radial Head Luxation in a Bugio Monkey (*Alouatta caraya*)

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Abstract

Bugio monkeys (*Alouatta caraya*) need their arms for locomotion, hygiene, and defence, and possess well-developed dexterity of their hands, depending on them for proper feeding. For this reason, appropriate treatment of thoracic limb fractures is not only essential but also challenging in this species. This report describes the successful treatment of a radial fracture associated with luxation of the radial head in a female, adult *Alouatta caraya*. The patient was admitted after a suspected traumatic event with a complete transverse fracture of the right radial diaphysis and subluxation of the ipsilateral radius head. Using a craniomedial approach to the radius, surgical stabilization was performed using a 1.7 mm micro series Fixin locking plate after open reduction in bone fragments. The patient had early use of the limb (24 hours postoperatively) and progressive improvement in its usual activities over the following weeks. Radiographic monitoring was performed at 30, 60, and 360 days postoperatively, and bone healing occurred with no complications. The treatment of fractures in primates is potentially challenging, requiring adaptation to primate anatomy and the specific living conditions of the species. Open reduction and stabilization of the radial fracture with a plate and manually reducing the luxated radial head effectively lead to long-term restoration of full function and of normal activities.

Keywords

► osteosynthesis
► radius fracture
► howler monkey
► primate

Introduction

Most primates have arms that are longer and more mobile than their limbs and some species also have a prehensile tail. Limbs are important, not only for locomotion but also for obtaining food.[1] The howler monkey (*Alouatta spp.*) is considered to be a predominantly leaf-eating species but can also be frugivorous. Its feeding habits make it to spend a high proportion of time in the treetops.[2] Any clinical and therapeutic approach to this species is challenging, as their anatomical, physiological, and behavioural characteristics are not fully known.[2] However, since there is substantial anatomical similarity of the locomotor system between monkeys and human beings, many techniques used in human orthopaedics can be applied to these monkeys in analogy.[3]

In general, radial fractures should be treated early because they severely impair limb function.[4] In wild animals, it is essential that surgical treatment yields stable anatomical reconstruction with rapid return of limb function.[5] Thoracic

limbs of primates fulfil functions which differ from quadrupeds, allowing for refined arm and hand movements. This dexterity is needed to handle small food items, such as fruits and nuts, and is essential for locomotion along thin tree branches.[2] The howler monkey, like a human, has opposable thumbs which are more mobile than the other fingers.[6] Unimpaired hand rotation, pronation, and supination are extremely important for survival, and its restoration can be a surgical challenge.[7]

Plates and screws are considered superior to other implants in the treatment of most radial fractures in a human[7] and in small animals.[8] The successful use of locking plates in several primate species has been described, but little is known on such injuries in howler monkeys.[3] We hereby report a radial osteosynthesis in a howler monkey (Alouatta caraya) using a precast locking plate.

Case Report

An adult, female howler monkey (Alouatta caraya), weighing 3.5 kgs, presented with lethargy, approximately 7% dehydration, and lameness without function of the right thoracic limb after a traumatic event. There was deviation of the axis of the right upper limb and soft tissue swelling around the right mid-antebrachium. The monkey was sedated with a combination of ketamine (6 mg/kg, Syntec, Santana de Parnaíba, SP, Brazil) and midazolam (0.2 mg/kg, Hipolabor, Sabará, MG, Brazil) intramuscularly (IM) to complete physical examination, initial emergency treatment, and laboratory and radiographic examinations. Lactated Ringer solution (150 mL) was administered subcutaneously, with tramadol hydrochloride (3 mg/kg IM, Teuto, Cravinhos, SP, Brazil, IM) enrofloxacin (7.5mg / kg, Bayer, São Paulo, SP, Brazil) and meloxicam (0.2mg/kg IM, Ouro Fino, Cravinhos, SP, Brazil). Thoracic, skull, and limb radiographs were taken with a digital radiography device (digital radiography

equipment; Siemens RG150/100 gl, Munich, Germany), revealing a complete transverse fracture in the mid-diaphysis of the right radius and a radial head luxation (►Fig. 1A). Surgical treatment was performed a day after the initial care.

Pre-anaesthetic medication consisted of ketamine (6 mg/kg IM, Syntec, Santana de Parnaíba, SP, Brazil) and midazolam (0.2 mg/kg IM, Hipolabor, Sabará, MG, Brazil). A left cephalic vein approach was created and the surgical field routinely prepared. The patient was pre-oxygenated by mask for 5 minutes and anaesthesia was induced with propofol (5mg/mL). The patient was intubated with an orotracheal probe and maintained in open Baraka circuit at a flow rate of 1 L/minute and 100% oxygen, using isoflurane (Cristália, Itapira, SP, Brazil) as a minimum alveolar concentration of 0.8%.

Additionally, a local anaesthetic block of the brachial plexus was performed with bupivacaine hydrochloride (0.2 mg/kg, Hypofarma, Ribeirão das Neves, MG, Brazil) guided by a neurostimulator. Monitoring (DL 1000 multiparametric monitor, Delta life) of electrocardiogram, pulse oximetry, non-invasive blood pressure, and rectal temperature was performed throughout the anaesthesia.

The animal was placed in a supine position, with the limb extended. A craniomedial approach to the radius was performed. In short, the radial extensor carpi muscles were identified and reflected cranially, and the round pronator and radial carpal flexor muscles were displaced caudally to expose the fracture site; cephalic vein, brachial vessels, and median nerve were minimally manipulated.

The luxation of the radial head was manually reduced during reduction in bone fragments and remained stable after fixation of the fracture. After reducing the bone fragments, a pre-contoured 1.7 mm micro series locking plate with six holes (Fixin, Rivoli, TO, Italy), five 1.7 mm screws, two proximal screws, and three distal screws were placed in

Fig. 1 Mediolateral and anteroposterior radiographic views showing a short complete oblique fracture in the middle diaphysis of the right radius and dislocation of the right radial head (A), postoperative (B), after 60 days (C), and 360 days (D).

Fig. 2 Photographic images of the clinical evaluation of the right thoracic limb 1 year after osteosynthesis. Adequate extension of the limb without signs of muscular atrophy (**A**) and (**B**), symmetry of the limbs without angular deviations (**C**), and complete movement of the metacarpophalangeal unit, grasping and opposition of the thumb (**D**).

the craniomedial direction on the radial diaphysis, manually assuring interfragmentary compression. The previously retracted muscles were repositioned and were covering the implant. Closure was effectuated routinely with polyglecaprone 25 (Caprofyl 2.0, Ethicon, São Paulo, SP, Brazil) in a simple continuous pattern. The skin was sutured with nylon (Mononylon 2.0, Ethicon, São Paulo, SP, Brazil) in a separate simple pattern. Postoperative radiographs were taken (►**Fig. 1B**), and meloxicam (Ouro Fino, Cravinho, SP, Brazil) 0.1 mg/kg, once daily, IM for 5 days, and enrofloxacin (Bayer, São Paulo, SP, Brazil) 5 mg/kg, once daily, IM for 5 days, were prescribed.

The animal recovered uneventfully and was kept in a restricted space in the wildlife enclosure at the hospital for 60 days; it fed twice a day with a variety of fruits and vegetables. Functional recovery of the limb started a day after the surgical procedure, with progressive use of the limb to aid locomotion. By 7 days postoperatively, the patient exhibited unimpaired movement of the arm, hand, and digits and was handling small objects and food. Radiographic follow-up was performed at 30, 60, and 360 days after surgery (►**Fig. 1C** and **1D**), under sedation as previously described, revealed satisfactory fracture union.

After 90 days, the animal was sent to a rehabilitation programme at the local zoo. Radiographic examination was performed 360 days after the operation, at which time the animal had no noticeable impairment, full articular movements without restrictions, and no changes were identified clinically (►**Fig. 2**).

Discussion

Osteosynthesis of appendicular fractures of primates in the wild should aim at rapid functional recovery of the limbs and at early return of the animal to its natural habitat. To this end, a fracture must be stabilized such as to reduce the likelihood of complications and the need for after care, and to enable survival in the wild.[5] We demonstrated, although only in one single case, that an upper limb fracture can be successfully treated in a bugio monkey through thorough surgical planning and by respecting species-specific anatomy and behaviour.

In our case, the patient was able to use the thoracic limb already in the immediate postoperative period for weight bearing and for feeding without apparent difficulties.

Since this primate species has very refined movements of hand and digits, including apposition of thumbs, the primary goal of fracture repair was full recovery of these complex movements which are important for feeding and locomotion on tree branches.[9,10] The long digits of bugio monkeys effectively increase their range of grip, which is important for handling food and for clinbing.[11,12] This great mobility and dexterity of the hands were clearly observable in the monkey reported here.

Because this wild living monkey had to be returned to its natural habitat as soon as possible, the most rigid and secure internal osteosynthesis was chosen. It had to be taken into consideration that this young female was likely to be exposed to substantial dangers when released to the wild and when disputing food resources and habitat with older and stronger competitors.[9]

Fractures of the forearm can have different shapes and may be associated with joint dislocations.[4] In this case, the patient presented with a dislocation of the radial head, which was returned to its anatomical position during the reduction in fragments of the radius fracture. The head of the radius in its anatomical position facilitated the fixation of the plate and the limb alignment. Open reduction and placement of an internal implant provided anatomical reconstruction and stability so that there was primary bone consolidation. To minimize the biological disadvantage of an open reduction,[13] the adjacent soft tissues were handled with great care, prioritizing the preservation of all muscle and vascular structures, which provided an excellent result in the execution of all movements postoperatively.

The locking plate was the implant of choice, as it offers limited contact between the implant and the bone, minimizing vascular injury and offering great angular stability.[14] Such characteristics allow a shorter time for bone healing compared with other methods of internal fixation, which is an important aspect for the treatment of wild animals.[3] Tong and Guiot[8] reported radial osteosynthesis using a locking

plate in a female old-world mandrill *(Mandrillus sphinx)*, obtaining excellent postoperative results, as did Pizzi and colleagues[15] on a femoral fracture of a chimpanzee (*Pan troglodytes verus*) using double plating. The use of locking plates in human radial fracture repair has been reported with 95 to 98% success rates.[16,17] All locking screws, *except the second distal screw*, were placed bicortically, as it is recommended in all wild animals due to the potentially high load factors acting immediately postoperatively.[8,18]

Surgical access to the radial diaphysis was obtained using a craniomedial approach, requiring no muscle incisions, which enabled rapid functional recovery of the limb. The critical structures on the medial region of the radius were carefully manipulated, especially the accessory cephalic vein in the distal portion of the diaphysis.

There are few studies referring to bone healing in monkeys[8–10,15]; in our report, complete union was observed 90 days after surgery, and no clinical, anatomical, or functional impairment was seen at the long-term postoperative evaluation at 1 year, with complete preservation of all refined movements of the hand and digits.

This case report details successful treatment of a radial fracture with radial head luxation in a bugio monkey *(Alouatta caraya)* using a locking plate.

Conclusion

The radial fracture with radial head luxation in a bugio monkey (*Alouatta caraya*) was successfully repaired, with immediate return to limb function and preservation of all complex arm and hand movements, which is indicative of the success of the treatment.

Conflict of Interest
There is no conflict of interest.

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