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Treatment of a malunion of the tibia and fibula in a giant anteater (*Myrmecophaga tridactyla*)

*[Tratamento de má união de tíbia e fíbula em tamanduá-bandeira (*Myrmecophaga tridactyla*)]*

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ABSTRACT

Vehicle collisions involving giant anteaters contribute significantly to the decline of this population. Although mortality rates at the time of trauma are high, many animals survive despite severe trauma and limb fractures. Treating these individuals is extremely challenging. This report describes the use of a corrective osteotomy to treat an angular deformity caused by inadequate healing of a tibial and fibular fracture in a young giant anteater. The animal was rescued on a highway by the Brazilian Institute for the Environment and Renewable Natural Resources (Ibama). He was presented at the University Veterinary Hospital with lameness of the left pelvic limb and edema in the middle region of the tibial shaft. The radiographic examination showed an exuberant callus and significant bone deviation in the middle third of the left tibia and fibula. Corrective wedge osteotomy and fixation with a 3.5mm locking plate and 2.5mm intramedullary pin were performed. In the immediate postoperative period, there was functional recovery of the limb and complete consolidation of the osteotomy was identified 60 days after the operation. The corrective wedge osteotomy technique was effective for the treatment of inadequate tibial consolidation in a young giant anteater, providing complete recovery of all limb functions.

Keywords: corrective osteotomy, fracture, wild, tamanduá-bandeira

RESUMO

As colisões de veículos envolvendo tamanduás-bandeira contribuem significativamente para o declínio dessa população. Embora as taxas de mortalidade no momento do trauma sejam altas, muitos animais sobrevivem apesar de traumas graves e fraturas de membros. O tratamento desses indivíduos é extremamente desafiador. Este relato descreve o uso de osteotomia corretiva para tratamento de uma deformidade angular causada por consolidação inadequada de fratura da tíbia e da fíbula em um tamanduá-bandeira jovem. O animal foi resgatado em uma rodovia pelo Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Ibama). Foi apresentado no Hospital Veterinário Universitário com claudicação do membro pélvico esquerdo e edema na região média da diáfise da tíbia. O exame radiográfico mostrou calo exuberante e importante desvio ósseo em terço médio da tíbia e da fíbula esquerdas. Foi realizada osteotomia corretiva em cunha e fixação com placa bloqueada de 3,5mm e pino intramedular de 2,5mm. No pós-operatório imediato, houve recuperação funcional do membro, e a consolidação total da osteotomia foi identificada aos 60 dias de pós-operatório. A técnica de osteotomia em cunha corretiva foi eficaz para o tratamento de consolidação inadequada de tíbia em um tamanduá-bandeira jovem, proporcionando a recuperação completa de todas as funções do membro.

Palavras-chave: osteotomia corretiva, fratura, selvagem, tamanduá-bandeira

INTRODUCTION

The *Myrmecophaga tridactyla*, commonly known as the giant anteater, is the largest of the three Brazilian species of anteaters, and it is under threat of extinction (Sesoko, 2012). The main threats to the species are the encroachment of agriculture into its natural habitat, forest fires and hunting. Consequently, anteaters have been obliged to migrate to urban areas and an

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increasing number of vehicle accidents have been recorded (Miranda, 2012), resulting in more animals presented for fracture repairs (Minto *et al*., 2021).

There is a lack of data on fracture stabilization in anteaters, and the poor understanding of bone healing in this species hampers the surgeon's ability to plan treatment effectively (Alves *et al*., 2020). Accurate fracture fixation is essential in anteaters as their locomotion is totally dependent on pelvic limb function, with hind feet adapted to run and achieve a bipedal stance in territorial struggles (Bonnon *et al*., 2015).

Orthopedic techniques described for dogs and cats have been used in anteaters. However, these techniques may not be effective due to the differences in anatomy between anteaters and other smaller species. The highly developed muscle mass, free-ranging lifestyle and relatively unknown anatomy of anteaters increases the risk of failure of these techniques (Zimmerman *et al*., 2010). Fracture repair in any wild animal necessitates use of a robust technique that, in addition to promoting rapid functional recovery of the limb, has a low rate of postoperative complications. This is important to minimize hospitalization and allow the patient a rapid return to natural behaviors (Johnson and Hulse, 2005). Poor fracture healing can result in limb dysfunction, thus increasing the risk of compromising survival in the wild (Ortunho *et al*., 2014). The present study reports, for the first time, the successful use of a corrective osteotomy comprising a plate and rod for the treatment of malunion of the tibia and fibula in a juvenile giant anteater (*Myrmecophaga tridactyla*).

CASE REPORT

A male juvenile giant anteater (*Myrmecophaga tridactyla*), weighing 4.2kg, was rescued by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) from a highway near Cáceres-MT/Brazil. It was presented with mild dehydration and left pelvic limb lameness with deviation of the bone axis and a painless, firm swelling in the tibial mid-shaft (Fig. 1). No wounds or abrasions were observed. After full physical examination, radiographic examination revealed a complete transverse fracture in the middle third of the left tibia and fibula, with evidence of advanced bone consolidation.

Figure 1. Photographic images of the left pelvic limb of the giant anteater (Myrmecophaga tridactyla), showing the bone deviation in the preoperative middle third (A); and after surgical correction in the immediate postoperative period (B).

An exuberant callus, discrete fracture line and misalignment of bone fragments were present (Fig. 2). The center of rotation of the deformity angle was defined as the intersection of the anatomical axis of the affected proximal and distal tibial shaft and the line representing the "normal" anatomical axis of the distal shaft based on the normal contralateral tibia. Assessed using the CORA method (Paley, 2003), the tibia had 70 degrees of caudal deviation and 27.5 degrees of lateral deviation.

The animal was moderately lame on the left pelvic limb and had mildly restricted movement. There was normal range of motion in the stifle, hip and tarsus when compared to the contralateral limb. Realignment of the tibia and fibula was considered necessary to improve ambulation. The method of choice for correcting the deviation was uniplanar osteotomy.

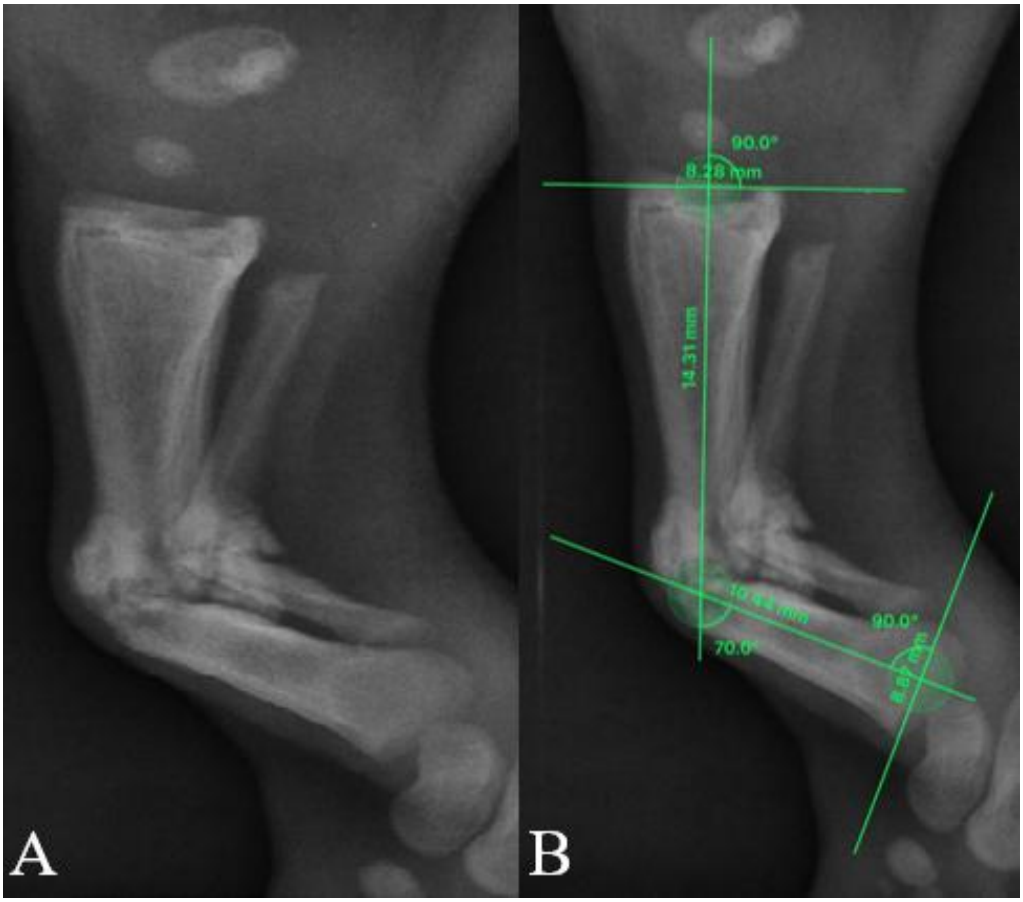

Figure 2. Craniocaudal radiographic images of the tibia and left fibula of the giant anteater (Myrmecophaga tridactyla), showing a complete transverse fracture in the middle third of the tibia and left fibula with advanced bone consolidation and formation of an exuberant callus (A); preoperative planning and measurement of angular deviations (B).

Surgery was performed the day after presentation. The patient was sedated with tiletamine and zolazepam (Zoletil 50®, Virbac, São Paulo, SP, Brazil) 2.5mg/kg, IM. After ten minutes, a cannula was placed in the cephalic vein and the affected limb was clipped. Anesthesia was induced with propofol (Propovan®, Cristália, Itapira, SP, Brazil) 6mg/kg, IV, and maintained with isoflurane (Isoforine®, Cristália, Itapira, SP, Brazil) 1L/min to effect using a Baraka circuit, providing 100% oxygen. Monitoring was performed using a DL 1000 multiparametric monitor (Delta life), with electrocardiogram, pulse oximetry, non-invasive blood pressure and temperature monitoring, throughout anesthesia. The patient was placed in

a supine position and the surgical field was prepared aseptically, with 2% chlorhexidine (Riohex 2%, Rioquímica, São José do Rio Preto, SP, Brazil) and alcohol 0.5% (Riohex 0.5 %, Rioquímica, São José do Rio Preto, SP, Brazil).

A craniomedial approach to the tibia was performed, with an excision bounded by the medial malleolus of the tibia distally. The subcutaneous tissue was dissected, and the leg fascia was incised, taking care to avoid the saphenous vessels.

The bone callus at the fracture site was exposed and the pre-created template was positioned on the cranial aspect of the tibia and the location of the 30º wedge opening was marked. Osteotomies were performed with an oscillatory saw and the bone wedge was removed, creating a bone defect. With the aid of bone reduction forceps, the distal and proximal segments were reduced and temporarily kept in the correct position by means of a 1.0mm Kirschner wire inserted in the medio-lateral direction. After reduction and alignment, a 2.5mm intramedullary pin was introduced in a normograde manner and a 6-hole, 3.5mm locking plate was placed.

Muscular fascia and subcutaneous tissue were closed with 2-0 nylon thread (Mononylon, Ethicon, São Paulo, SP, Brazil) in a simple continuous pattern, and the skin with 3-0 nylon thread (Mononylon, Ethicon, São Paulo, SP, Brazil) in a simple interrupted pattern. A modified Robert Jones bandage was placed for five days, and the animal was prescribed ketoprofen (Ketofen 10% ®, Merial, Campinas, SP, Brazil) 1mg/kg, SC for 3 days and cephalothin (Keflin 1g®, ABL, Cosmópolis, SP, Brazil) 30mg/kg, IV for 10 days. On the immediate post-surgical radiographic evaluation there was good apposition of the bone fragments, with a residual caudal deviation of 6 degrees and a lateral deviation of 15 degrees (Fig 3).

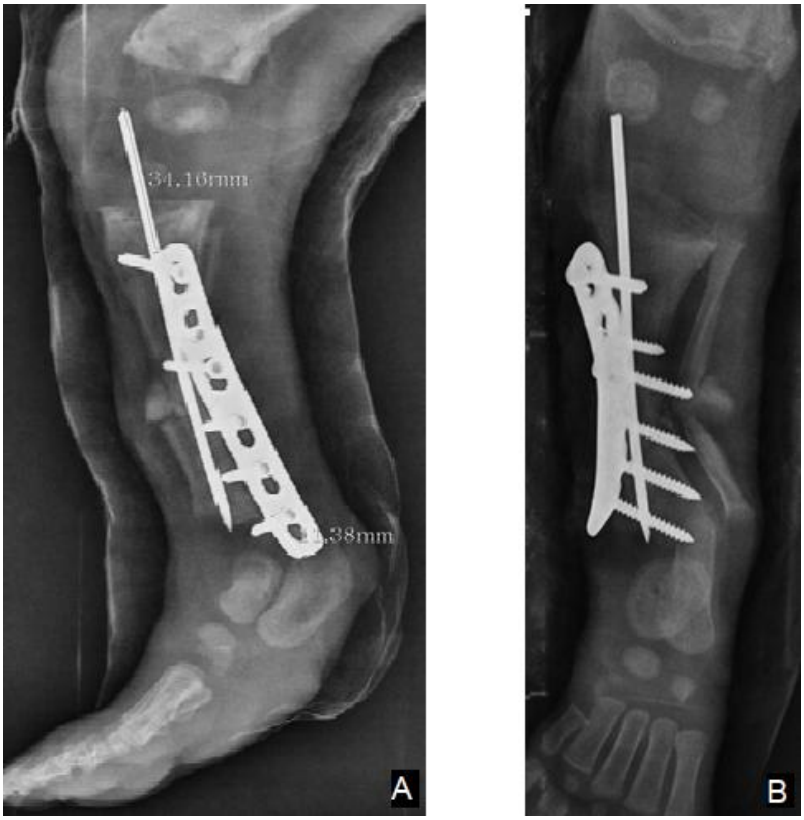

Figure 3. Radiographic images immediately postoperatively showing wedge ostectomy and osteosynthesis of the tibia and left fibula in a Giant Anteater (Myrmecophaga tridactyla) in (A) mediolateral and (B) craniocaudal projections. Note fixation with a 3.5mm locking plate and 2.5mm intramedullary pin with good approximation of the bone fragments and acceptable alignment.

The animal was kept confined in its own enclosure in the wild animal section of the Veterinary Teaching Hospital to restrict movement of the limb. It was fed a liquid to pasty diet initially made up of eggs, lactose-free bovine milk, and calcium-enriched cream. Subsequently, minced cooked meat, soy extract, honey, dog food, carrots and beets were added to the diet. One week later the animal was stable and had started to move its legs. Skin sutures were removed after 15 days and radiographs were taken at 15, 60, 90 and 180 days postoperatively.

At 15 days, there was a new organized bone callus and a visible fracture line; bone alignment was maintained. At 60 days, no fracture line was identified. Bone callus remodeling was noted at 90 days and a synostosis of the tibia and fibula was present at 180 days (Fig. 4). After 180 days, the patient was not lame and there were no locomotor changes, and it was moved to a rehabilitation program with other anteaters at the Zoo.

Figure 4. Radiographic images 180 days postoperatively following wedge osteotomy and osteosynthesis of the tibia and left fibula in Giant Anteater (Myrmecophaga tridactyla) in mediolateral and (B) craniocaudal projections. Note complete bone remodeling, absence of bone resorption around the implants and presence of synostosis of the tibia and fibula.

DISCUSSION

Orthopedic treatments in wild animals need to provide a rapid and consistent return to limb function, minimal risk of postoperative complications and guarantee full functional recovery, especially in young patients with reduced survival skills (Lin *et al*., 2005; Zimmerman *et al*., 2010). We demonstrated that a tibial malunion in a juvenile giant anteater could be successfully managed using techniques borrowed from small animals. Provided there was meticulous preparation for the procedure. It is important to take into account the anatomy of the tibia and fibula, using a well-known orthopedic technique and adequate fracture fixation to ensure rapid return to function and bone consolidation.

The giant anteater has some important musculoskeletal particularities, such as large and robust thoracic limbs, for the purpose of feeding and self-defense (Dahroug *et al*., 2009; Bonnon *et al*., 2015), and pelvic limbs, adapted for running and to support a bipedal position, important for territorial fights or attacks to termite nests. Thus, in this species pelvic limb dysfunction can potentially compromise the ability to survive in the wild. In this case, the animal required correction of a tibial angular deviation to restore the function of the pelvic limb. This procedure is routinely performed in a small animal practice (Malta *et al*., 2020) and human medicine (Liu *et al*., 2019), but it is potentially more challenging in anteaters due to their specific anatomy and limited data about orthopedic procedures in this species (Minto *et al*., 2021).

The procedure required meticulous planning based on knowledge of corrective osteotomies in dogs and cats. The CORA method was used to characterize the sagittal plane deformity and to plan corrective osteotomy on the lateral radiograph, a method used in other reports of corrective osteotomy (Kim and Lewis, 2014; Liu *et al*., 2019). The angle of deformity was defined as the intersection of the anatomical axis of the affected proximal and distal tibial shaft and the line representing the "normal" anatomical axis of the distal shaft based on the normal contralateral tibia. Even with osteotomy, there was residual caudal and lateral deviation in the fractured bone, due to the chronicity of the malunion, contracture of the associated musculature and only uniplanar correction. However, by 15 days postoperatively there was alignment of the bone in relation to the proximal and distal joint and formation of bone callus, making the residual deviation insignificant.

In this case, it was not only important to produce rapid healing, but also to correct the angular deviation to prevent development of joint disease due to the deviation of the bone axis. Young animals have rapid bone metabolism, and fracture consolidation can occur irregularly and result in misalignment despite clinical-surgical treatment. Furthermore, although there are no studies reporting the healing process in anteaters, it is likely that the bone healing of adult anteaters is not as effective as that of young animal (Ferrigno *et al*., 2003; Alves *et al*., 2020). In the case of this patient with a potential long life ahead, the correction of bone deviation, was necessary to align the limb and restore its length to ensure return of full function.

Bone fixation methods must be selected with care in anteaters to provide sufficient rigidity for healing to occur in the face of robust muscular activity and the absence of postoperative rest. A wedge osteotomy associated with osteosynthesis with an intramedullary plate and pin is a very effective technique, as it allows realignment of the bone axis, early limb support and a shorter recovery time (Latorre, 2012). The locked plate used in this case promoted stability and interfragmentary compression, providing a favorable mechanical environment for bone consolidation (Matres-Lourenzo *et al*., 2016). We opted for a very rigid construction for this animal and treatment was successful, despite the rapid functional recovery of the limb. The craniomedial approach to the tibia was used as this provides good access in dogs and cats (Latorre, 2012), and was very effective in the anteater, allowing exposure of the entire diaphysis for implant placement.

By 60 days post-operatively there was formation of bone callus and the absence of a fracture line. No complications were reported, and the functional results were excellent. This report shows that the correction of bone deviation in a young giant anteater using a wedge osteotomy with a locking plate and intramedullary pin, can successfully treat malunion.

CONCLUSION

We conclude that malunion in a young giant anteater was successfully treated using the wedge osteotomy technique and fixation with implants intended for small animals. However, an adequate construction that supports the animal's weight is necessary, allowing the immediate recovery of the limb's function.

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