

Plate rod in humerus fracture in *Caracara plancus*: Challenges and outcomes of a case

Page 1 a 7

*[Placa e pino em fratura de úmero em *Caracara plancus*: Desafios e estudo de caso]*J.R. Leitão , I.R. Rosado , T.T.P. Menezes , M.G. Lopes , E.G.L. Alves* 

Universidade de Uberaba, Uberaba, MG, Brasil

ABSTRACT

The aim of this case study was to apply a robust fixation method using the plate rod technique, which combines intramedullary pins with bone plates to provide rigid stabilization. Although commonly used in mammals, this technique has not yet been documented in avian medicine. The surgery involved detailed pre-operative evaluations and meticulous surgical planning, reflecting standards used in small animal orthopedics, to ensure that the implants were well-suited to the unique anatomical needs of the bird. In the post-operative phase, the bird was closely monitored, with follow-up radiographs showing successful implant alignment and advanced bone healing without any signs of infection. The outcome was positive, with the bird regaining full wing functionality and being released back into the wild after recovery at a wildlife rehabilitation center. This case highlights the effectiveness of the plate rod technique in managing complex fractures in avian patients, emphasizing its potential as a valuable option for similar cases, particularly in large and wild birds. The successful application and outcome of this approach provide a significant contribution to veterinary orthopedics, expanding potential methodologies for fracture treatment in avian species.

Keywords: orthopedics, birds, surgical, bone fixation, flight

RESUMO

O objetivo deste estudo de caso foi aplicar um método de fixação robusto usando a técnica de placa e pino, que combina pinos intramedulares com placas ósseas para proporcionar estabilização rígida. Essa técnica, embora comumente usada em mamíferos, ainda não foi documentada na medicina aviária. A cirurgia envolveu avaliações pré-operatórias detalhadas e planejamento cirúrgico meticuloso, refletindo padrões utilizados em ortopedia de pequenos animais, para garantir que os implantes fossem bem adaptados às necessidades anatômicas únicas do pássaro. No pós-operatório, o pássaro foi monitorado de perto, com radiografias de acompanhamento que mostravam o sucesso do alinhamento dos implantes e a cura avançada dos ossos sem sinais de infecção. O resultado foi positivo, com o pássaro recuperando a funcionalidade completa da asa e sendo liberado de volta à natureza após a recuperação em um centro de reabilitação de vida selvagem. Este caso destaca a eficácia da técnica de placa e pino no manejo de fraturas complexas em pacientes aviários, enfatizando seu potencial como uma opção valiosa para casos semelhantes, particularmente em aves grandes e selvagens. A aplicação bem-sucedida e o resultado desta abordagem fornecem uma contribuição significativa para a ortopedia veterinária, expandindo as metodologias potenciais para o tratamento de fraturas em espécies aviárias.

Palavras-chave: ortopedia, aves, cirúrgica, fixação óssea, voo

INTRODUCTION

The *Caracara plancus*, commonly known as the Southern Caracara, is a bird of prey found across a wide range of habitats in South America, from open areas to urban regions. The adaptability of

this species to urban environments increases its exposure to various risks, including trauma from vehicle collisions. Bone fractures, especially in the wings, are common injuries in wild birds and pose a significant challenge for veterinary medicine (Bennert *et al.*, 2016; Carrasco *et al.*, 2017; Katogiritis *et al.*, 2019).

*Corresponding author: endrigoalves@gmail.com
Submitted: May 1, 2024. Accepted: July 17, 2024.

The management of fractures in birds requires an approach that considers the unique anatomical and biomechanical characteristics of the avian skeleton, such as pneumatic bones with thin cortices and large medullary cavities (Ozsemir and Altunatmaz, 2021). Most osteosynthesis techniques used in birds involve intramedullary pins (Gayathri and Sinil, 2018) and external fixators due to their simplicity and reduced cost (Torres *et al.*, 2007). However, these techniques may not provide the necessary stabilization for complex fractures or in larger birds (Carrasco, 2019).

Recently, the plate rod technique, which combines the use of intramedullary pins with bone plates, has gained attention in veterinary orthopedics for providing more rigid stabilization of diaphyseal fractures of long bones (Vedrine and Gérard, 2018). Although this technique has been extensively studied and applied in mammals (Hulse *et al.*, 2000; Pearson *et al.*, 2015; Field *et al.*, 2016), its use in birds of prey has not yet been studied and reported in the literature.

Therefore, the objective of this study is to describe the application of the "plate rod" technique in the treatment of an old humeral fracture in a *Caracara plancus*, discussing the challenges faced and the outcomes achieved. The choice of this technique was motivated by the need for an approach that would provide adequate stabilization of the fracture, considering the chronicity of the injury and the biomechanical peculiarities of the caracara's skeleton.

CASUISTRY

A Southern Caracara (*Caracara plancus*), an adult male with a body mass of 833 grams, presented with a fracture in the left wing. Physical examination revealed poor nutritional status, mild dehydration, a heart rate of 213 beats per minute (bpm), respiratory rate of 65 movements per minute (mpm), rectal temperature of 40°C, and intense pain upon manipulation of the left wing.

During the orthopedic assessment, mobility and an increase in volume were observed on the medial side of the proximal part of the left humerus. Radiographic examination revealed a

multiple fracture in the proximal third of the left humeral diaphysis and intense proliferative bone reaction at the fracture site with the presence of a sequestrum, characterizing an old fracture with hypertrophic nonunion (Fig. 1).

The animal was anesthetized with dexmedetomidine (Dexdomitor®, Zoetis, Campinas, SP, Brazil) 15mg/kg, ketamine (Cetamin®, Syntec, Santana de Parnaíba, SP, Brazil) 3mg/kg, midazolam (Midazolam Hydrochloride, Hipolabor, Sabará, MG, Brazil) 0.5mg/kg, and morphine sulfate (Dimorf®, Cristália, Itapira, SP, Brazil) 0.5 mg/kg, all administered in the same intramuscular syringe. Fifteen minutes later, the animal allowed intubation with a No. 3.0 endotracheal tube connected to an open Baraká circuit delivering 100% oxygen at 1 L/min and isoflurane (Isoforine®, Cristália, Itapira, SP, Brazil) at a concentration of 0.5%.

Surgical planning considered the standards established for fracture fixation in dogs and cats, obtaining measurements of bone length (95.00 mm), bone diameter (6.10 mm), and medullary canal (5.00 mm) at the humerus isthmus. The largest possible plate that the bone could accommodate was used, employing a system that would be between 20% and 40% of the bone diameter with an intramedullary pin occupying at least 20% of the medullary canal.

With the bird positioned in dorsal recumbency and wings spread, the surgical field was prepared aseptically. The surgical approach began with a skin incision on the ventral surface of the humerus extending from the proximal to distal portion, followed by dissection of the subcutaneous tissue and identification of the brachial biceps and triceps muscles. The fracture focus was exposed by retracting the biceps cranially and the triceps caudally. Fibrosis areas and new bone formation were cleared from the fracture site, revealing the medullary canal closed in both fractured fragments (Fig. 2). The canal was opened with multiple perforations made with a 1mm Kirschner wire. A 1.5mm Kirschner wire was then introduced into the medullary canal (diameter = 4.2mm at the isthmus) entering through the fracture focus of the distal humeral fragment towards the ventral humeral condyle. The fracture was reduced, and the pin was directed towards the proximal

fragment up to the cortex adjacent to the scapulo-coracoid-humeral joint, reestablishing the alignment of the bone's longitudinal axis. A 1.5mm reconstruction plate with 16 holes was then placed in a bridge function. The plate was fixed to the ventral surface of the humerus with three screws at the proximal end and three at the distal end, each screw measuring 14 mm in length (Fig. 2). The approximation of the muscle fasciae was done in a sultan pattern, the subcutaneous layer in zing-zag, and the dermorraphy in wolff; all layers used poliglecaprone 25 3-0 (Carprofil®, Ethicon, São Paulo, SP, Brazil).

In the post-operative period, the patient was administered enrofloxacin (Kinetomax®, Bayer, São Paulo, SP, Brazil) 10 mg/kg, twice daily (BID), intramuscularly (IM) for seven days, and

meloxicam (Maxicam 0.2%, Ouro Fino, Cravinhos, SP, Brazil) 1 mg/kg, BID, IM for two days, after which the dose was reduced to 0.5 mg/kg BID, IM, for three more days. Tramadol hydrochloride (Teuto, Cravinhos, SP, Brazil) was also administered at 3 mg/kg, BID, IM, for seven days.

In the immediate post-operative radiological examination, the correct positioning of the implants and the proper alignment of the longitudinal axis of the bone were verified. At 65 days post-operatively, a follow-up radiograph was taken, showing a less apparent fracture line, and bone callus in an advanced stage of remodeling, maintaining the alignment and position of the implants (Figure 3).

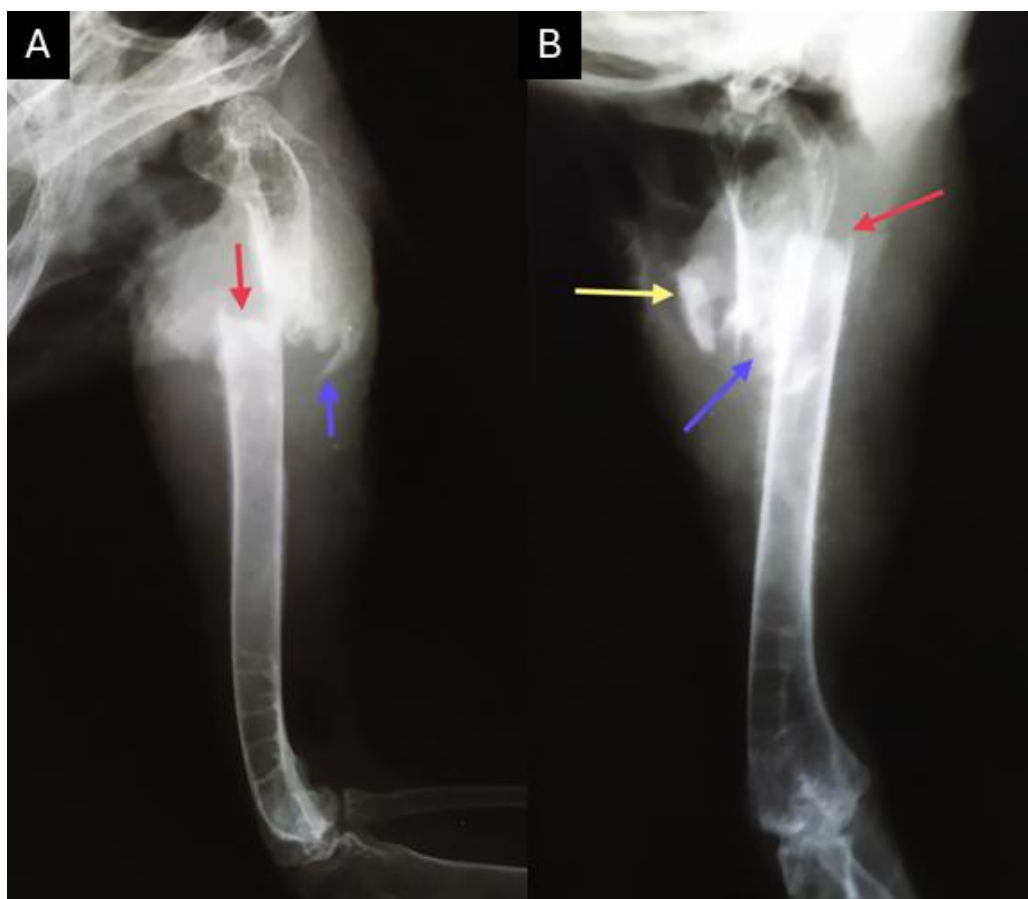


Figure 1. Pre-operative radiographic image of the humerus of a Southern Caracara (*Caracara plancus*) in medio-lateral (A) and cranio-caudal (B) projections, showing a multiple fracture in the proximal third of the left humeral diaphysis and intense proliferative bone reaction at the fracture site, involving a sequestrum (yellow arrow). The blue arrow indicates the proximal fragment and the red arrow the distal fragment.

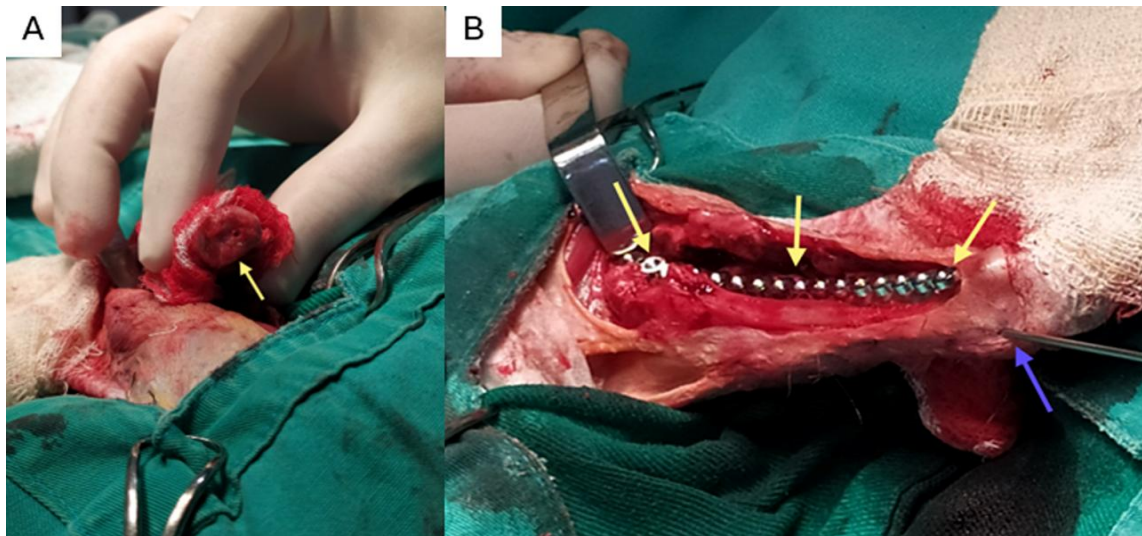


Figure 2. Intraoperative image of osteosynthesis in a Southern Caracara (*Caracara plancus*) with a left humerus fracture. Image "A" shows the bone fragment with the medullary canal closed and the first hole made to open the canal (yellow arrow). Image "B" shows the fracture stabilized with a 1.5 mm Kirschner wire positioned in the medullary canal and exiting through the ventral humeral condyle (blue arrow) and a 1.5 mm reconstruction plate with 16 holes applied in a bridge function on the ventral surface of the humerus (yellow arrows).

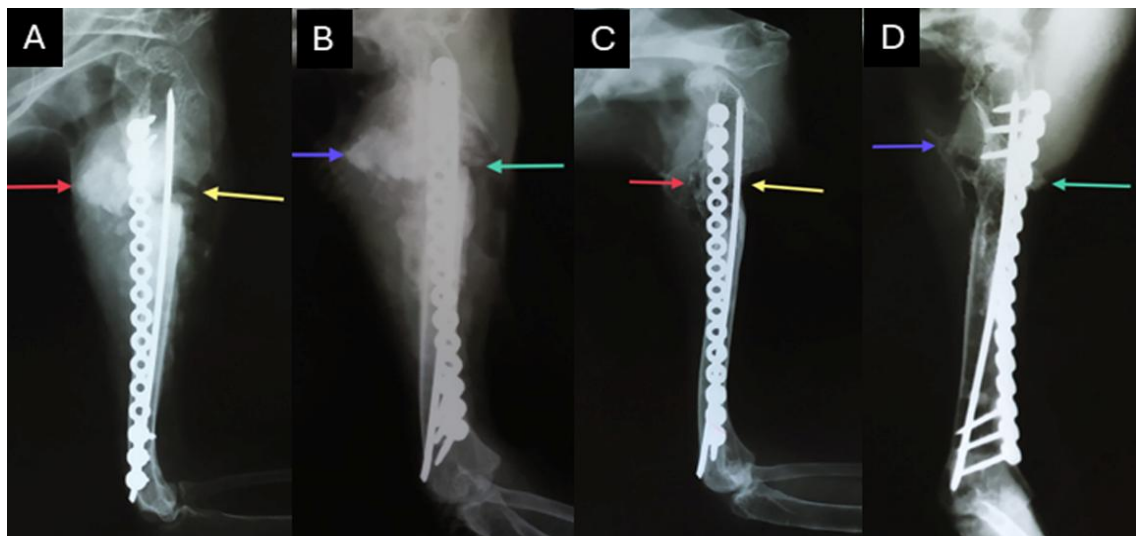


Figure 3. Radiographs taken immediately post-operatively (A and B) and at 65 days post-operatively (C and D) of an osteosynthesis in a Southern Caracara (*Caracara plancus*) with a left humerus fracture. Note the position of the implants and the bone alignment in the medio-lateral (A and C) and cranio-caudal (B and D) projections. The yellow arrow indicates the cranial face of the fracture focus, the red arrow the caudal face, the green arrow the lateral face, and the blue arrow the medial face.

To ensure the animal's health before its release, a meticulous evaluation was carried out to rule out the possibility of osteomyelitis due to the exuberant bone reaction observed at the fracture focus. On the 95th day after surgery, a sample of

material from the fracture focus was obtained by aspirative puncture for bacterial and fungal culture analysis. The results showed no microbial growth, dismissing the suspicion of bone infection. The patient remained clinically stable

and regained wing mobility during the recovery period. It was then transferred to a Wildlife Screening and Rehabilitation Center in Minas Gerais (CETAS MG), where it regained its flying capability ninety days post-operatively and was released into the rural area of Patos de Minas, MG.

DISCUSSION

Fixing fractures in birds can be challenging due to their unique anatomy and the need to preserve flight function. Various techniques using intramedullary pins (Gayathri and Sinil, 2018; Carrasco, 2019), external skeletal fixators (Torres *et al.*, 2007; Ozsemir and Altunatmaz, 2021), and plates (Gouvêa *et al.*, 2011; Bennert *et al.*, 2016) have been described and successfully employed for stabilizing these fractures in birds, each with its advantages and limitations.

The use of intramedullary pins for bird fracture fixation is widely spread and adopted due to its ease of application, the possibility of minimally invasive application, and its ability to offer internal stabilization while maintaining comfort and preserving the function of flight (Gayathri and Sinil, 2018). Additionally, this implant has the advantage of being combinable with various other fixation techniques, making it an economical choice particularly suitable for stabilizing smaller bones (Carrasco *et al.*, 2017). However, this technique has significant limitations, such as the reduced capacity to neutralize axial and rotational forces and the risk of pin migration (Carrasco, 2019). These limitations make the sole use of this technique inappropriate for the patient described in this report, necessitating the consideration of alternative or complementary fixation methods to ensure effective stabilization of the fracture.

External skeletal fixators represent a widely used technique in the treatment of fractures in birds, notable for their versatility and high capacity to neutralize forces acting on the fracture (Torres *et al.*, 2007). They are particularly useful in cases of complex fractures, as they can be applied in a minimally invasive manner and facilitate the treatment of wounds associated with bone injury (Katogiritis *et al.*, 2019). Additionally, external fixators allow for simple surgical revisions and are easily removable after bone regeneration (Carrasco *et al.*, 2017). However, the infection of

percutaneous pins can cause post-surgical discomfort, which in some cases, may lead to self-mutilation behaviors and even removal of the implants by the animal itself (Ozsemir and Altunatmaz, 2021). Considering that the patient was a wild bird exhibiting high levels of stress, techniques requiring frequent care such as external fixators were avoided. Such approaches could increase the animal's stress and compromise the recovery process, given the need for regular handling for adjustments and maintenance of the fixator.

The use of plates for fracture fixation in birds is not very popular due to some inherent disadvantages of this technique, which include the more invasive surgical approach, potential interference with adjacent soft tissues, possible restriction to flight function due to the additional weight and volume of the plates, and the difficulty in adjusting the plates to the variability of shapes and sizes of avian bones (Carrasco *et al.*, 2017). However, plates also offer significant advantages, such as the ability to provide rigid stabilization of the fracture, neutralizing all forces involved, and allowing precise alignment of the bone fragments (Gouvêa *et al.*, 2011; Bennert *et al.*, 2016). These features are particularly beneficial in complex fractures, aiding in the rehabilitation and early recovery of the bird. Therefore, they can be a valuable option in some specific cases like that of the bird described in this report.

The selection of the plate-rod fixation technique for stabilizing the fracture in the hawk described in this report was based on several factors. The fracture was old with signs of non-union, which typically implies a greater challenge for bone consolidation, requiring an approach that provided adequate stabilization for an extended period. Moreover, the patient was a large, wild bird with aggressive behavior, complicating post-surgical management. Given these circumstances, it was imperative that the fixation method be internal and offer sufficient rigidity to support early use of the affected limb. This was essential to expedite the recovery process and allow for the re-introduction of the patient to its natural habitat as quickly as possible.

The incorporation of an intramedullary pin into the plate stabilization, forming the plate-rod system, provides significant reinforcement to the

fixation mechanism, especially in terms of resistance to bending or flexing forces, which are the main causes of failure in plate fixation of fractures in pigeons (Gouvêa *et al.*, 2011). Additionally, the insertion of the intramedullary pin ensures proper bone alignment, facilitating the placement of the plate and speeding up the surgical procedure.

Biomechanical studies conducted with models and canine bones corroborate the efficacy of this approach, demonstrating that the combination of a plate and intramedullary pin provides more robust fracture stabilization. This configuration allows for better neutralization of bending, shearing, compression, and torsional forces acting on the fracture (Field *et al.*, 2016). Thus, the plate-rod system presents itself as a viable and efficient alternative for treating fractures, especially in cases where there is a need for more resistant and durable fixation, such as the case reported here involving an old fracture in a relatively large and wild bird.

Hulse *et al.* (2000) suggest that the plate rod technique is particularly advantageous in complex or comminuted fractures, where an isolated plate may not provide sufficient support to ensure proper consolidation. They highlight that combining the plate with an intramedullary pin can lead to faster recovery, allowing an earlier return to normal function of the affected limb. This is especially relevant in patients who require mobility for their quality of life or survival, such as in many bird species. Finally, Vedrine and Gérard (2018) emphasize that the plate rod technique is versatile and can be adapted to different types of fractures and bone anatomies, offering a customized solution for each case. This flexibility is crucial for effective fracture treatment in a wide range of patients, from small animals to birds and large mammals.

A fundamental aspect for the success of plate rod constructions is the appropriate planning of the apparatus, considering the specific characteristics of the fracture. It is essential to correctly choose the fixation system, the length of the plate, and the size of the intramedullary pin. However, there are no specific standards for birds, which led us to use the parameters applied in dogs and cats for planning the fixation in the patient of this study, and fortunately, we were successful. Considering the diameter of the humerus at its

isthmus, the 1.5mm plate system corresponds to 24.56% of this measurement, which is within the range considered acceptable for dogs and cats (20 to 40%). Nevertheless, the 2.0 mm system, which corresponds to 32.79% of the bone diameter, could also have been used according to the guidelines for dogs and cats. The choice of the smaller system was made with the intention of reducing the weight of the implants, which could facilitate flight, and because of the confidence that the plate rod construction supports a much higher load than a construction with only a plate.

The size of the plate, which occupied 75.79% of the bone's length, likely contributed to the stability of the construction. In dogs, one of the fundamental guidelines for using plates in a bridging function is to maximize the extension of the plate along the bone (Pearson *et al.*, 2015). This ensures better load distribution and optimizes the working area of the plate, thus minimizing the risk of implant failure due to fatigue.

Finally, another significant factor in plate-rod constructions is the diameter of the intramedullary pin, which in the reported case exactly corresponded to 30% of the diameter of the medullary canal's isthmus. This ratio is crucial to ensure the strength and proper stability of the fixation, allowing for effective and safe recovery of the patient. The study conducted by Hulse *et al.* (2000) investigated the effect of the intramedullary pin size on reducing bone plate stress and determined the lifespan and stiffness of the plate-rod construction. Constructions were tested with intramedullary pins occupying 30%, 40%, and 50% of the diameter of the medullary cavity, in addition to a construction with only a plate. The results showed that as the diameter of the intramedullary pin increased, the stress on the plate decreased. For each 10% increase in the pin's diameter, the stress on the plate was reduced by approximately 20%. Moreover, the stiffness of the construction increased as the size of the pin increased. The authors recommend the use of a pin that occupies between 35% and 40% of the diameter of the medullary cavity, as this reduces the stress on the plate, increases the lifespan of the construction, and allows for microdeformation of the fracture plane, necessary to stimulate bone healing.

It is important to highlight that, although the complete recovery of wing functionality was slow, it was effectively achieved, this being a fundamental criterion for evaluating the success of the treatment, especially in wild patients destined for reintroduction into nature, as was the case with the bird in this report. The plate-rod fixation technique demonstrated significant advantages in terms of fracture stabilization, prevention of complications, and functional recovery, proving to be a valuable option in the treatment of bone fractures.

Despite the success achieved with the plate-rod technique in this case, it is essential to recognize its limitations and challenges. The technical complexity of the approach and the associated risks of complications, such as infection and implant rejection, require advanced surgical skills and a lack of specific parameters for choosing implants. Additionally, the high cost of orthopedic implants can be a limiting factor for their application in wildlife rehabilitation centers, necessitating careful evaluation of viability in each case.

CONCLUSIONS

In conclusion, the plate rod technique is a viable option for treating complex fractures in birds of prey, but it is essential to carefully evaluate each case to determine the most appropriate approach.

ACKNOWLEDGEMENTS

The authors express their sincere gratitude to CAPES for the scholarship provided through the CAPES/PROSUP program, and to the University of Uberaba for supplying the necessary infrastructure for the care and maintenance of wild animals. Special thanks are also extended to Dr. Carlos Alberto Valera, Prosecutor of the Public Ministry of the State of Minas Gerais, who has dedicated efforts towards the care and maintenance of wild animals.

REFERENCES

BENNERT, B.M.; KIRCHER, P.R.; GUTBROD, A. *et al.* Evaluation of two miniplate systems and figure-of-eight bandages for stabilization of experimentally induced ulnar and radial fractures in pigeons (*Columba livia*). *J. Avian Med. Surg.*, v.30, p.111-121, 2016.

CARRASCO, D.C. Avian orthopaedic surgery. *Vet. Clin. North Am. Exot. Anim. Pract.*, v.22, p.104-108, 2019.

CARRASCO, D.C.; SHIMIZU, N.S.; FORBES, N.A. Review and advances in avian orthopaedic surgery: part 1 — introduction. *Comp. Anim.*, v.22, p.104-108, 2017.

FIELD, E.J.; PARSONS, K.; ETCHES, J.A. *et al.* Effect of monocortical and bicortical screw numbers on the properties of a locking plate-intramedullary rod configuration. An in vitro study on a canine femoral fracture gap model. *Vet. Comp. Orthop. Traumatol.*, v.29, p.459-465, 2016.

GAYATHRI, S.L.; SINIL, K.S. Surgical correction of diaphysary humeral fracture in a pariah kite (*Milvus migrans*). *Indian J. Sci. Res.*, v.19, p.21-24, 2018.

GOUVÊA, A.S.; ALIEVI, M.M.; NORIEGA, V. *et al.* Microplacas de titânio em fraturas de tibiotarso em pombos domésticos. *Cienc. Rural*, v.41, p.476-482, 2011.

HULSE, D.; FERRY, K.; FAWCETT, A. *et al.* Effect of intramedullary pin size on reducing bone plate strain. *Vet. Comp. Orthop. Traumatol.*, v.13, p.185-190, 2000.

KATOGIRITIS, A.; BARRY, S.L.; FINCH, N. Key ring fixator: a novel external fixation technique for avian long bone stabilization. *J. Avian Med. Surg.*, v.33, p.161-170, 2019.

OZSEMIR, K.G.; ALTUNATMAZ, K. Treatment of extremity fractures in 20 wild birds with a modified Meynard external fixator and clinical assessment of the results. *Vet. Med. Czech*, v.66, p.257-265, 2021.

PEARSON, T.; GLYDE, M.; HOSGOOD, G.; DAY, R. The effect of intramedullary pin size and monocortical screw configuration on locking compression plate-rod constructs in an in vitro fracture gap model. *Vet. Comp. Orthop. Traumatol.*, v.28, p.95-103, 2015.

TORRES, B.B.J.; MUZZI, L.A.L.; ALVES, E.G.L. *et al.* Fixação esquelética externa em fratura tarsometatarsica de seriema (*Cariama cristata*): relato de caso. *Arq. Bras. Med. Vet. Zootec.*, v.59, p.155-159, 2007.

VEDRINE, B.; GÉRARD, F. Veterinary Cutdown Plate in a Plate-Rod Construct for Repair of Diaphyseal Femoral Fractures in the Cat. *Vet. Comp. Orthop. Traumatol.*, v. 31, p.479-487, 2018.