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Stabilization and Long-Term Outcome of a Tibiotarsal Fracture in a Turkey Vulture (*Cathartes aura*) Using a Supracutaneous Plating Technique

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Abstract

The aim of this study was to report the successful outcome of a tibiotarsal fracture in a turkey vulture managed with a supracutaneous plating technique. This is a case report study design. A juvenile male turkey vulture (*Cathartes aura*) was presented unable to walk. Physical exam revealed instability in the left tibiotarsus. Radiographs confirmed a comminuted mid-diaphyseal fracture of the left tibiotarsus. The turkey vulture underwent fracture stabilization using fluoroscopic guidance with a 12-hole 2.4-mm locking compression plate (LCP) placed in a supracutaneous fashion with locking screws proximally and distally. The turkey vulture was ambulatory immediately following surgery, and lameness had resolved by day three. Four weeks postoperatively, radiographs demonstrated loss of cortical bone density, and the construct was dynamized. At 6 weeks postoperatively, radiographs revealed a bridging callus, and all implants were removed. Following an additional 2 weeks of cage rest, recheck radiographs confirmed continued fracture healing and increased cortical density. At week nine, the turkey vulture was transitioned to a pre-release flight cage where the vulture was noted to set flight, land, grasp, walk, and perch normally. The turkey vulture was released 12 weeks postoperatively. This case report documents the successful functional outcome of a closed, comminuted mid-diaphyseal fracture of the tibiotarsus in a minimally invasive manner utilizing a supracutaneous plating technique. Based on a literature search, this is the first report utilizing supracutaneous plating for a tibiotarsal fracture in a turkey vulture.

Keywords
- tibiotarsus
- Turkey vulture
- supracutaneous plating
- fracture

Introduction

Long-bone fractures occur in avian wildlife as a result of trauma.[1] While the true incidence is unknown, one retrospective study documented a 6.6% incidence of tibiotarsal fractures in a population of raptors presenting for long-bone fractures to a referral institution.[1]

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Described stabilization methods for tibiotarsal fractures in avian wildlife include intramedullary (IM) pinning, external skeletal fixation (ESF), ESF with IM pin tie-in, plate osteosynthesis, interlocking nail, cerclage wire fixation, external coaptation, and various combinations of these methods.[2,3] Despite successful outcomes, each repair method has advantages and disadvantages due to the unique challenges when applied to avian wildlife such as raptors, vultures, or large waterfowl.

Unique aspects of fracture repair in raptors include thin and brittle bone cortices, bipedal locomotion necessitating a rapid return to function, minimal soft tissue coverage, scant cancellous bone availability for autogenous grafting, and associated trauma damage to vascular and nervous structures.[4] An ideal fixation method would preserve fracture biology, be inexpensive, be removed prior to releasing wildlife, provide rigid fixation, and allow early return to function.[4] Unfortunately, a one-fix-all methodology for fracture stabilization in avian wildlife is not realistic given the variety of fracture configurations that occur.[1] The most common fixation method used in raptors includes the tie-in ESF[4] but other fixation methods including IM fixation alone[5] or IM with internal plate fixation have been described.[4] Additionally, the natural destructive behaviour of raptors toward orthopaedic implants, bandages, and splints increases the level of postoperative challenge to manage while promoting stabilization and early return to function. The following case report may provide a feasible and repeatable approach for stabilizing long bone fractures in avian wildlife.

We searched Medline through PubMed with the following string "(supracutaneous OR external) AND (plate OR plating) AND fracture AND (avian OR bird OR wildlife)" on January 9, 2022. Only one article describing supracutaneous plating in a bird was retrieved.[6]

Case Presentation

A juvenile (less than 1 year), suspected male, turkey vulture (*Cathartes aura*) was presented to the Oklahoma State University Veterinary Teaching Hospital by a good Samaritan for being found down and non-ambulatory. The vulture was in good body condition and weighed 1.52 kg. Physical examination identified instability in the mid-diaphysis of the left tibiotarsus with moderate crepitation and no visible wounds. The turkey vulture was unable to rise or ambulate. A closed, highly comminuted fracture of the mid-diaphysis of the tibiotarsal bone was confirmed on radiographs (►**Fig. 1**). Callus formation was evident despite persistent instability on palpation. The turkey vulture was started on meloxicam (Meloxidyl, Aspen Veterinary Resources, LTD, Liberty, Missouri, United States; 1 mg/kg PO every 24 hours) and a constant rate infusion of fentanyl (Fentanyl, AmerisourceBergen, Conshohocken, Pennsylvania, United States; 3 µg/kg/h IV), lidocaine (Lidocaine HCl injectable solution 2%, Aspen Veterinary Resources, LTD, Liberty, Missouri, United States; 6 mg/kg/h IV), and colloid (Hetastarch, Hospira, Inc., Lake Forest, Illinois, United States; 15 mL/kg/d IV) and crystalloid fluids (Plasma-Lyte-A, Baxter Healthcare Corporation,

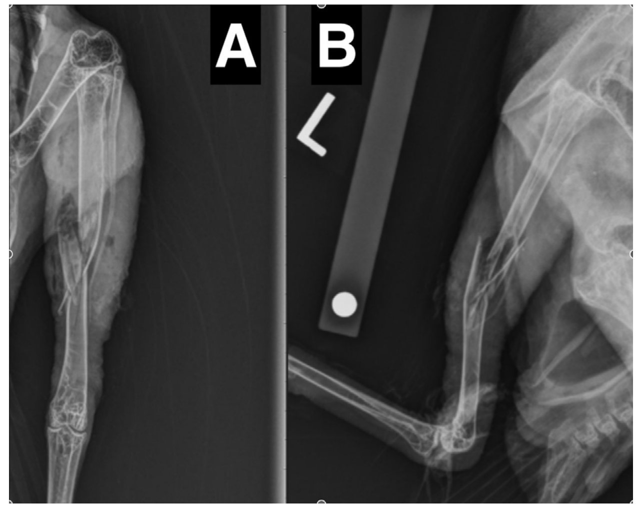

Fig. 1 Ventrodorsal (**A**) and medio-lateral (**B**) radiographic projections taken at presentation revealing a closed, highly comminuted mid-diaphyseal fracture of the left tibiotarsus in a wild turkey vulture (*Cathartes aura*).

Deerfield, IL; 150 mL/kg/d IV). The catheter lost its patency therefore, analgesia was provided using hydromorphone (Hydromorphone HCl injection 2 mg/mL, West-Ward, Eatontown, New Jersey, United States; 0.3 mg/kg IM every 12 hours).

Procedure

The turkey vulture was premedicated with hydromorphone (0.3 mg/kg IM) and anesthetized with 5% isoflurane (Isoflurane, USP, Aspen Veterinary Resources, LTD, Liberty, Missouri, United States) in 100% oxygen via a facemask. Intubation with a 4.5-mm uncuffed endotracheal tube secured the airway. A new IV catheter was placed in the right ulnar vein, and a lidocaine and Plasma-Lyte-A infusion were administered as previously described. The isoflurane was maintained at 2 to 3% and the oxygen was maintained a 2 L/min throughout the procedure.

The turkey vulture was placed in dorsal recumbency with the left limb suspended. The limb was plucked free of feathers, starting from the mid-femur and extending distally and surgically prepared using a standard aseptic technique. The tibiotarsus-metatarsus and femoro-tibiotarsus joints were identified using a 25-gauge hypodermic needle and their alignment was confirmed under fluoroscopy (OEC One, GE, Boston, Massachusetts, United States) guidance (►**Fig. 2**). The anatomical axis was restored with digital manipulation to replicate preoperative imaging of the contralateral limb. A 2-cm incision was made laterally over the proximal and distal metaphysis of the left tibiotarsus. The fit of a 12-hole plate was confirmed using fluoroscopic guidance. A 2.4-mm locking compression plate (LCP) (DePuy Synthes, West Chester, Pennsylvania, United States) was placed exterior to the skin and maintained in position using one diverging 1.1-mm Kirshner wires (IMEX Veterinary Inc., Longview Texas, United States) on either side of the fracture gap. Placement of the diverging Kirshner wires was made with

Fig. 2 Image illustrates joint femoro-tibiotarsal joint identification with a 25-gauge needle and placement of an LCP and temporary stabilization with diverging Kirshner wires. LCP, locking compression plate.

fluoroscopic guidance by selecting the screw holes over the intact bones that were closest to the fracture gap proximally and distally (►**Fig. 3**). The plate was positioned 1 to 3 mm away from the skin and maintained manually by the surgical assistant (M.L.). A 2.4-mm locking guide (DePuy Synthes, West Chester, Pennsylvania, United States) was applied to the selected plate holes and each hole drilled with a 1.8-mm drill bit (DePuy Synthes, West Chester, Pennsylvania, United States). A metric depth gauge (DePuy Synthes, West Chester, Pennsylvania, United States) was used to measure the length of the pilot holes. Three 2.4-mm locking screws (DePuy Synthes, West Chester, Pennsylvania, United States) proximally and distally were inserted manually at the level of the initial incisions. Screws number 1 to 3 measured 20 mm, screws 10 and 11 measured 18 mm, and screw 12 measured 16 mm in length, respectively. Incisions were apposed using 3–0 nylon in a simple interrupted pattern between screws (►**Fig. 4A, B**).

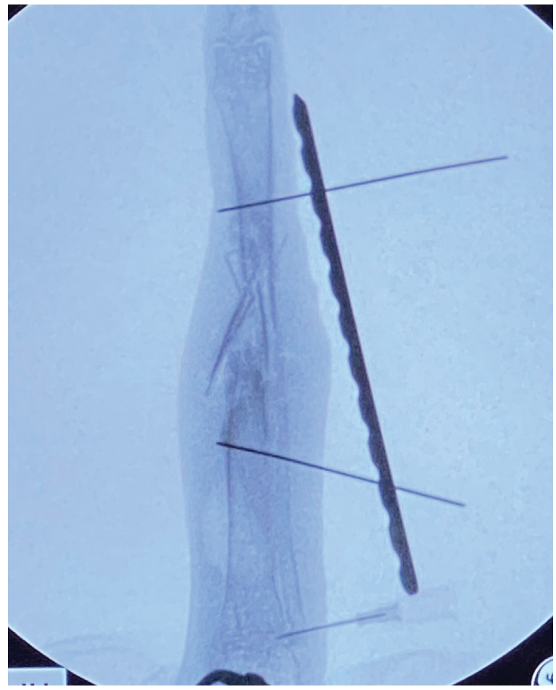

Fig. 3 A fluoroscopic image of the LCP with temporary fixation using diverging Kirschner wires. LCP, locking compression plate.

The turkey vulture was maintained in rehabilitative indoor confinement postoperatively for a total of 9 weeks. The bird was housed in a $73 \times 84 \times 87$ cm metal wall cage with the bottom covered in a paper sheet and a towel for the initial 4 weeks. No perch was offered in this cage. The vulture was then transitioned to a run measuring $160 \times 82 \times 220$ cm with a perch for the remaining 5 weeks. A light protective bandage was placed over the implant. A non-adhesive Telfa pad (Covidien, Dublin, Ireland) was placed over the implant, followed by 2-inch cast padding (Covidien, Dublin, Ireland) in two layers, then 2-inch stretch bandage (Covidien, Dublin, Ireland), and finally Vet Wrap (3M, St. Paul, Minnesota, United States) was used to cover. All these layers extended approximately 0.5 inches proximally and distally of the implant. The turkey vulture was allowed full usage of the operated limb without additional internal or external coaptation. Postoperatively, the bird was maintained on the lidocaine constant rate infusion for 24 hours before it was discontinued. Hydromorphone was continued as previously described until 5 days after the procedure. Trimethoprim/sulfamethoxazole (Sulfatrim, pai Pharmaceutical Associates, Inc., Greenville, SC; 30 mg/kg PO every 12 hours) was given for 14 days and meloxicam was continued for 10 days. Bandage changes and cleaning of the implant with diluted betadine (Betadine10%, Avrio Health LP, Stamford, Connecticut, United States) were performed under manual restraint every 24 hours for 7 days, every 48 hours for 7 days, then every 72 hours until plate removal. At approximately 3 weeks postoperatively, the patient began to damage the proximal and distal edges of the bandage. To prevent this, 2-in Elastikon (Johnson-Johnson, New Brunswick, New Jersey, United States) was added to the proximal and distal aspects of the bandage. The turkey vulture then started to damage

Fig. 4 Radiographs of the left tibiotarsus of a wild turkey vulture (*Cathartes aura*) immediately postoperative (**A, B**), at 4 weeks postoperative (**C, D**), at 6 weeks postoperative (**E, F**), and at 8 weeks postoperative (**G, H**).

the adhesive bandage, so the entire bandage was covered with the adhesive material which alleviated the issue. From that point until plate removal at 6 weeks, it was added as a part of its bandage changes.

Outcome

Return to ambulation with a mild lameness was noted immediately postoperatively (day 0) and while in strict confinement, the turkey vulture was ambulating without any overt lameness by day 3 postoperatively. Normal avian behaviours (e.g., eating, vocalizing, and defensive postures) were restored at the end of the first week after surgical intervention.

At 4 weeks postoperatively, the turkey vulture was placed under general anaesthesia for radiographs. This set of radiographs confirmed evidence of hard callus formation expanding the fracture gap. In addition, loss of bone density was noted within the diaphysis proximal and distal to the fracture line (►**Fig. 4C, D**). While under general anaesthesia,

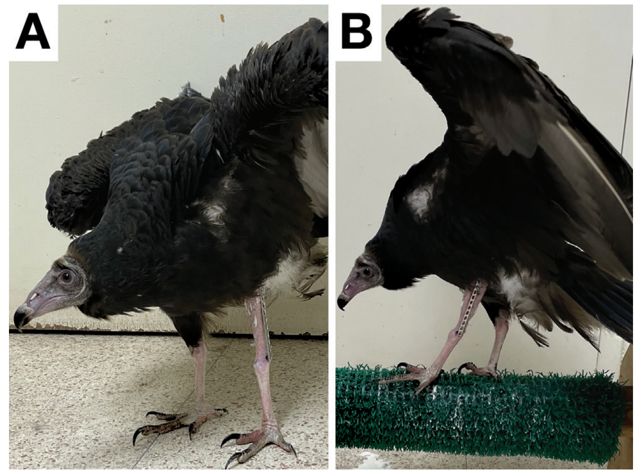

Fig. 5 (**A, B**) A wild turkey vulture (*Cathartes aura*) with a supracutaneous LCP at 6 weeks postoperative and immediately prior to plate removal. LCP, locking compression plate.

partial destabilization, described as dynamization of the construct by removing the screws immediately adjacent to the fracture was performed, and the turkey vulture was transitioned to a larger enclosure with the goal being to decrease stiffness in the construct and induce micromotion and strain within the fracture gap.[7,8] At 6 weeks postoperatively, the turkey vulture was again placed under general anaesthesia for repeat radiographs. These radiographs confirmed improved callus formation that bridged the fracture (►**Fig. 4E, F**). As a result, the implant was removed while under anaesthesia, and the bird remained in confinement for observation.

At 8 weeks postoperatively, a third set of radiographs under general anaesthesia confirmed continued fracture healing and increased cortical density (►**Fig. 4G, H**). At week nine, the turkey vulture was transitioned to an outdoor pre-release flight cage. This flight cage measured $30 \times 10 \times 15$ ft and has two tall posts with heights of 7 ft and perches of varying sizes that ascend its height. The vulture was monitored once daily and was observed to fly between the two high perches, land, grasp, walk, and perch normally. It was also noted that the turkey vulture could descend to the ground to feed, land normally, and return to the high perches afterward (►**Fig. 5**). The turkey vulture was released back into the wild 12 weeks postoperatively.

Discussion

This case report describes the successful treatment of a tibiotarsal fracture in a juvenile male turkey vulture using a supracutaneous plating technique. A single case report has previously described a successful outcome using the same surgical technique for a tarsometatarsal stabilization in a bald eagle.[6] In that report, the eagle was successfully released after complete recovery, like the outcome reported here.

Supracutaneous plating has previously been described and established for fracture fixation in human primates, dogs, and cats.[9–12] Reported benefits include minimal soft tissue envelope disruption, the ability to easily retrieve implants from a patient, and an option to manage any concurrent soft tissue injuries while maintaining the mechanical properties of the locking plate fixation. The authors also believe that full biologic osteosynthesis is achieved with this technique due to zero disruption of the fracture hematoma. Additionally, supracutaneous plating subjectively decreases life-threatening excessive bleeding which is a particular surgical concern in avian spcies.[13]

Similar to an ESF, the construct is external to the skin. Biomechanical studies have compared the circumference of the ESF connecting bar or free-form organic material against a plate constructs elsewhere.[14] Likewise, biomechanical studies comparing a simple linear ESF and an externally placed LCP reported stiffness was superior in the LCP construct.[15] An additional benefit of an LCP supracutaneous construct, compared with ESF is that the LCP lies within 1 to 3 mm away from the bone, and the profile of the construct equals the thickness of the plate plus the distance between the plate and the bone. This results in an LCP supracutaneous construct with a much lower profile and improved ergonomics. This is particularly important for birds where a bulky ESF may impair normal functions such as perching. This technique also prevented impingement of other cavities such as the coelom, pectoral muscles, wings, or proximal crus. Considering these challenges, we elected to place the plate on the lateral aspect of the crus contrary to the traditional medial placement in other species.[9–12]

Anatomical reconstruction and internal fixation or using an ESF construct with an IM tie-in fixation system, may result in a permanent implant. To successfully re-release wildlife, metallic implants that could pose a hazard to its predators should be avoided. Therefore, successful and complete removal of a supracutaneous construct is always performed.

In this case, the tibiotarsal fracture was successfully managed using supracutaneous plating. Further studies that include additional subjects for evaluation of long-term outcome, perioperative complications, benefits, and pitfalls in comparison to other fixation methods are welcomed.

Conflict of Interest
None declared.

Acknowledgments
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References

1 Bueno I, Redig PT, Rendahl AK. External skeletal fixator intramedullary pin tie-in for the repair of tibiotarsal fractures in raptors: 37 cases (1995-2011). J Am Vet Med Assoc 2015;247 (10):1154–1160
2 Guzman DS, Bubenik LJ, Lauer SK, Vasanjee S, Mitchell MA. Repair of a coracoid luxation and a tibiotarsal fracture in a bald eagle (Haliaeetus leucocephalus). J Avian Med Surg 2007;21(03): 188–195
3 Redig PT, Cruz L. Fractures. In: Samour J, ed. Avian medicine. 2nd ed. London: Mosby Elsevier; 2008:215–226
4 Helmer P, Redig PT. Surgical resolution of orthopedic disorders. In: Harrison G, Lightfoot T, eds. Clinical Avian Medicine. 2nd ed. Palm Beach: SPIX Publishing; 2006:761–774
5 Yoon HY, Fox DB, Jeong SW. Long bone fractures in raptors: 28 cases (2004–2007). J Vet Clin 2008;25(03):215–217
6 Montgomery RD, Crandall E, Bellah JR. Use of a locking compression plate as an external fixator for repair of a tarsometatarsal fracture in a bald eagle (Haliaeetus leucocephalus). J Avian Med Surg 2011;25(02):119–125
7 Goodship AE, Kenwright J. The influence of induced micromovement upon the healing of experimental tibial fractures. J Bone Joint Surg Br 1985;67(04):650–655
8 Henschel J, Tsai S, Fitzpatrick DC, Marsh JL, Madey SM, Bottlang M. Comparison of four methods for dynamization of locking plates: differences in the amount and type of fracture motion. J Orthop Trauma 2017;31(10):531–537
9 Bansal A, Alawa S, Sonkar D, et al. Supracutaneous locking compression plate as an external fixator in compound metaphyseal and diaphyseal fractures of tibia. Int J Orthop Sci 2020;6(03): 633–636
10 Thein WM, Mohamad Y, Lwin T, Htun AT. Supracutaneous plate: a comparable alternative to external fixator in the treatment of open fracture. Int J Orthop Sci 2018;4(02):959–962
11 Nicetto T, Longo F. Supercutaneous plating for the treatment of traumatic injuries of the appendicular skeleton in dogs. Vet Comp Orthop Traumatol 2019;32(02):149–157
12 Nicetto T, Longo F. Supracutaneous plating using a locking plate for the treatment of a tibial fracture in a cat. Can Vet J 2017;58 (06):585–590
13 Bennett RA. Surgical considerations. In. Ritchie BW, Harrison GJ, Harrison LR, eds. Avian Medicine. 1st ed. Lake Worth: Wingers Inc.; 1994:1081–1095
14 Amsellem PM, Egger EL, Wilson DL. Bending characteristics of polymethylmethacrylate columns, connecting bars of carbon fiber, titanium, and stainless steel used in external skeletal fixation and an acrylic interface. Vet Surg 2010;39(05): 631–637
15 Ang BFH, Chen JY, Yew AKS, et al. Externalised locking compression plate as an alternative to the unilateral external fixator: a biomechanical comparative study of axial and torsional stiffness. Bone Joint Res 2017;6(04):216–223

