ELBOW ARTHRODESIS FOR SALVAGE OF A DISTAL HUMERAL FRACTURE IN A TAKAHE (*Porphyrio hochstetteri*)

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INTRODUCTION

Arthrodesis of avian joints, especially in wild birds, is uncommon, due to the absolute requirement of near perfect wing and leg function for release of flighted birds. In the takahe (*Porphyrio hochstetteri*), an endangered ground-dwelling bird native to New Zealand and perhaps also pet and captive birds that do not need complete function of the wing for flight, elbow arthrodesis may be considered as an alternative to amputation for salvage procedures of the thoracic limb.

The takahe, the world's largest flightless rail, is an iconic species endemic to New Zealand. The species was believed extinct until 1948, when rediscovered in the rugged alpine landscape of the Murchison Mountains, Fiordland, South Island. Since the 1980's takahe have been intensively managed, both in their native range in Fiordland, as well as on several predator-free offshore islands and a mainland sanctuary. Despite such protracted efforts, the total population remains at approximately 227 adult birds (Wickes et al., 2009).

CASE REPORT

An 11 year old female takahe from Maud Island, was presented to the referring veterinarian following Department of Conservation (DoC) rangers noting a dropped left wing on routine distance examination. A physical examination and plain radiographs revealed a displaced left humeral fracture and the bird was referred to the New Zealand Wildlife Health Centre (NZWHC) for treatment.

On arrival at the NZWHC, the bird was bright and alert, weighing 2.1kg. The left wing was placed in a wing to body bandage, and butorphanol was given 4mg/kg IM in addition to supplemental feeding by crop tube for stabilisation prior to initial diagnostics.

For all procedures requiring general anaesthesia, the takahe was induced by mask, then intubated with a size 35 Cole tube and maintained with isoflurane in oxygen. Pain relief was provided with 2 mg/kg butorphanol IM given 15 minutes pre-operatively and also at the end of the procedure. Thermal and fluid support were provided, as well as bolus doses of crystalloids and colloids when required during surgery. Blood pressure, heart rate, respiratory rate, end-tidal CO_2 and electrocardiogram were monitored throughout.

After 24 hours, general anaesthesia was used for blood collection and radiography. Haematology was normal, a biochemical profile revealed a moderate elevation in CK and AST, and blood lead was low (0.015umol/L). Left lateral and ventrodorsal radiographs (Figure 1a and 1b) confirmed a

displaced, distal left humeral fracture in the supracondylar region. The fracture ends were rounded, consistent with a chronic non-union. There was also a second, chronic healing fracture of the right radial diaphysis which was bridged by smoothly marginated new bone.

Figure 1a. Ventrodorsal radiograph on admission showing distal left humeral fracture and healed right radial fracture

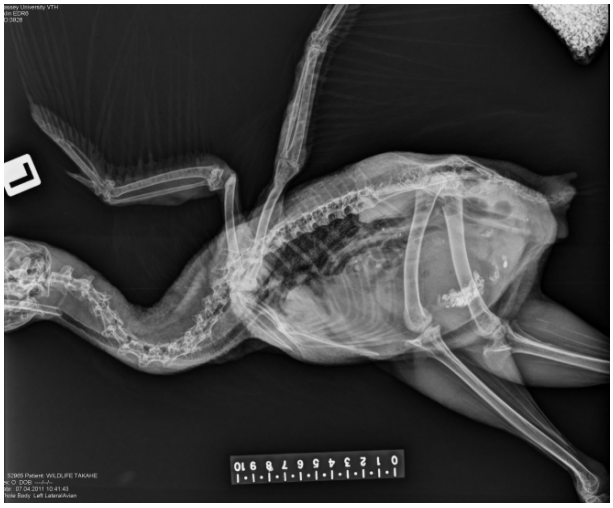

Figure 1b. Left lateral radiograph on admission showing distal left humeral fracture and healed right radial fracture

The initial surgical plan was to cross-pin the distal humerus, but this was modified intra-operatively due to the fragility of the distal fragment. Normograde intramedullary pinning through the distal fragment into the proximal humerus was performed after debriding the fracture ends using rongeurs. Post-operatively, the wing was stabilised in a wing to body bandage and the bird given amoxicillin clavulanate 125mg/kg PO bid. Unfortunately, post-operative radiographs the following day showed that the pin had pulled out through the distal fragment and was no longer engaging the medulla. A more extensive surgery, involving an open dorsal approach to the elbow and extensive debridement of fibrous callus to better visualise the bone fragment was performed two days later. The fracture was realigned, re-stabilised with an intramedullary pin, and bandaged. Repeat radiographs 24 hours post-operatively showed satisfactory placement of the pin in proximal humerus and distal fragment lateral condyle, however the medial condyle appeared to have fragmented (Figure 2a and 2b).

Figure 2a. Postoperative ventrodorsal radiograph showing IM pin placement and fragmentation of condyles

Figure 2b. Postoperative anterioposterior radiograph showing IM pin placement and fragmentation of condyles

Following this surgery, the bird improved in demeanour and began to gain weight. Butorphanol was discontinued and the bird treated with meloxicam 0.2mg/kg PO sid. The amoxicillin clavulanate was discontinued ten days post-operatively and bandage changes were undertaken every three days. The left wing showed outward signs of healing and radiographs were scheduled for four weeks after surgery. During this time, the bird was housed in a large (3 x 5m) hospital room with turf substrate. Three weeks post-operatively swelling was noted around the elbow and an area of necrotic debris became apparent at the wound site. On exploration, this debris sloughed to expose underlying bone, deep tissues and the intramedullary pin. The pin was removed and a swab was taken for aerobic and anaerobic culture and sensitivity. Radiographs showed extensive lysis of the humeral condyles, extending up into the medulla of the humerus, as well as the proximal radius and ulna (Figure 3). The wound was debrided and irrigated with high pressure sterile saline, and then rebandaged. The bird was started on amoxicillin clavulanate 125 mg/kg PO bid and enrofloxacin 15 mg/kg PO bid. Culture results showed a mixed moderate growth of *Clostridium perfringens*, *E.coli*, *Enterococcus* spp. and *Enterobacter cloacae* that were sensitive to the antibiotics already being used.

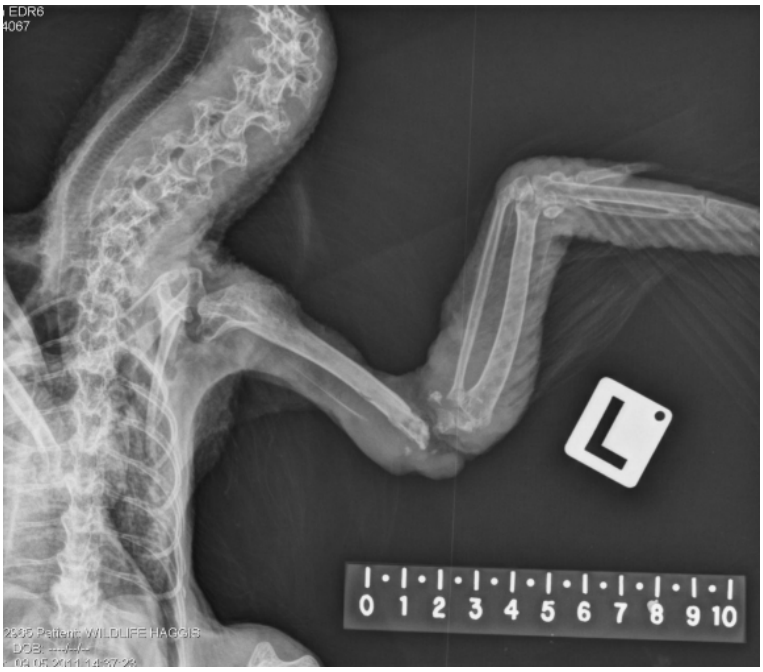

Figure 3. Ventrodorsal radiograph showing osteomyelitis of left elbow

At this point, the preferred option of amputating the wing was presented to the Department of Conservation Takahe Team. The DoC team would not agree to an amputation, as they felt that both full wings were required in free-ranging birds for signaling purposes as well as waterproofing. If this outcome could not be achieved, they would opt for euthanasia. Given their decision, an elbow arthrodesis was planned.

The joint was exposed by an incision over the dorsal aspect of the elbow. The skin in the area was undermined, and the joint capsule and associated fibrosis were incised to expose the necrotic joint. The articular cartilage of the proximal radius and ulna was removed and the distal humerus was debrided with rongeurs to expose visually healthy bone. The entire area was then flushed with sterile saline. A K wire was bent and inserted into the medulla of both bones to help hold the wing in the desired angle of flexion. A Type One trans-articular external skeletal fixator was constructed by inserting three threaded interface pins into the dorsal surface of the ulna and three into the humerus. A stabilising wire was wound around the threaded pins and fastened with acrylic to hold the joint in a flexed position of around 45°. Once the joint was stabilised in a flexed position, a wedge resection of the pre-patagial membrane was undertaken, with apposition of the subcutaneous tissues of the humerus and antebrachium, in order to minimise excess soft tissue between them. The wing was bandaged with Melolin, Soffban and Vetrap in a wing to body bandage. Post operative radiographs showed satisfactory positioning of the limb but there was a larger gap between the radius, ulna and humerus than would be preferred (Figure 4). The middle fixator pin in the ulna was judged to be just adjacent to the bone. Despite these shortcomings in the repair, the decision was made not to repeat surgery.

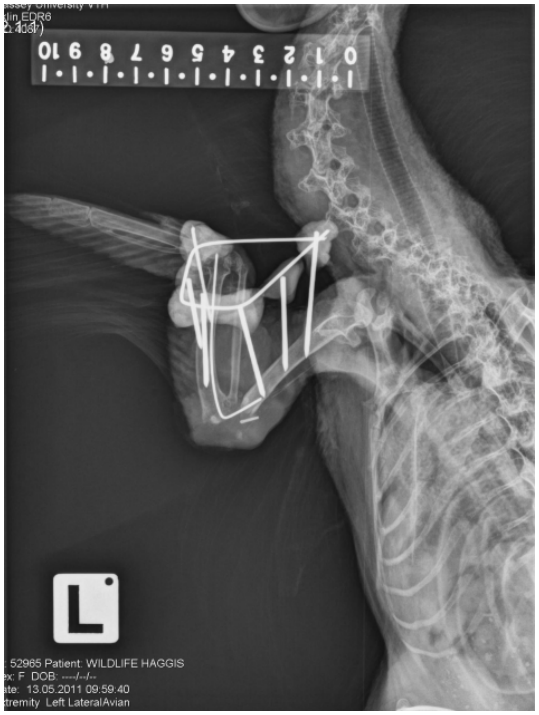

Figure 4. Dorsoventral radiograph showing transarticular fixator in place on left wing

The bird continued to improve following surgery. Further post-operative radiographs showed good alignment of bone ends, despite some movement of the K wire distally out of the medulla of the humerus. The wing was stable in flexion with a good vascular supply distal to the arthrodesis. The bandage was removed completely after two weeks.

Further post-operative radiographs taken six weeks post-operatively showed the elbow retained in a similar position to the previous study, with some bony bridging of the humerus to the radius and ulna. However, there were also signs of implant loosening, evidenced by decreased radio-opacity around the ulnar and distal humeral pin tracts. Eight weeks post operatively, the ulnar pins were noticeably loose and there was a stable callus formed at the elbow. The external fixator was removed in entirety under general anaesthetic and the wing was clinically stable, although slightly dropped. Following monitoring for two days, the takahe was returned to Maud Island for a hard release, which was reported by DoC rangers to go smoothly.

DISCUSSION

In free-ranging flighted birds, it is essential that there is near perfect wing function in order to survive in the wild. Any rotation or reduction in range of motion of the wing can affect flight. Fractures near a joint, even if repaired, are associated with a poor prognosis as ankylosis, periarticular fibrosis and patagial contracture are common complications, preventing normal limb function and failure to qualify for release. Arthrodesis should be considered as an option in addition to amputation, for salvage procedures, for fractures close to the joint and articular pathology, when a wing with less than perfect function is acceptable (Van Wettere and Redig, 2004).

As an alternative to amputation, arthrodesis has the advantage that although the range of motion in the elbow is severely restricted, the wing can still be used for balance. In this case, it was also

critical to salvage the wing for cosmetic and waterproofing purposes. The transarticular fixation method as undertaken with this bird is a similar technique to that used for surgical treatment of elbow luxation (Ackermann and Redig, 1997). When used to treat elbow luxation however, the device was only used to stabilise the joint for 5-7 days. For fusion of the elbow in this case, the apparatus was in place for over nine weeks.

The rate of fracture repair and bone healing is thought to be dependent on several factors including displacement of bone fragments, the amount of damage to the blood supply, whether an infectious agent is present and the amount of motion at the fracture site (Martin and Ritchie, 1994). In addition to these, elbow arthrodesis may have prolonged healing due to the different mechanisms of healing in medullary bones (radius and ulna) compared to pneumatic bone (humerus). Pneumatised bones are theorised to have a slower rate of healing than medullary bones due to their relative avascularity and greater reliance on periosteal blood supply to form a callus (James et al., 1978). As seen with 'Haggis, the clinical stability of a fracture may precede radiographic evidence of bone healing by at least three weeks (Martin and Ritchie, 1994).

When there is poor anatomic fracture alignment and in cases where there is a bony deficit as was present with this case, secondary bone healing occurs. This involves the stages of induction, inflammation, soft callus formation, hard callus formation and remodelling (Bennett and Kuzma, 1992). In a joint arthrodesis, fusion could be improved and accelerated by use of a bone graft. This could have increased the speed of healing in this bird but would have been contra-indicated at the time of arthrodesis due to widespread infection and necrosis in the elbow joint. Cortical bone grafts can provide structural support and have been shown to be beneficial in avian fracture repair but there are no readily available sources of autogenous cortical bone in birds unless collected from comminuted fractures. Cortico-cancellous and cancellous bone may be preferred due to increased surface area and a larger number of viable cells for stimulating new bone production (Martin and Ritchie, 1994). Harvest sites for grafting are more accessible and include the sternum, the most caudal ribs or the proximal tibiotarsus.

In ground-dwelling birds such as the endangered takahe, where precise use of the wings for flight is not required, arthrodesis is an option for salvage procedures of the thoracic limb.

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