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OPEN-COMMINUTED MID HUMERAL FRACTURE IN A LONG-TAILED MACAQUE (*Macaca fascicularis*) – CASE REPORT

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ABSTRACT

A 2-year-old long-tailed macaque (*Macaca fascicularis*) was presented to the University Veterinary Hospital, Universiti Putra Malaysia for a traumatic injury to the left arm. Physical examination findings revealed a lacerated wound of 2 cm x 1 cm with distal humeral bone segment was protruding out from the muscles and skin. There were delayed pain sensation and withdrawal reflex of the left upper arm. Radiographic findings revealed discontinuity of the left humerus at the mid-shaft with a single fragment from the distal segment at the fracture site. The fracture was repaired with an open reduction and fixation technique with a combination of intramedullary pinning and cerclage wire. The patient regained motor function of the arm after six weeks of intramedullary pin implantation. Here we describe the severity of each grading system and the principles of open fracture management in macaques.

Keywords: Primate, open-comminuted fracture, internal fixation, fracture management

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INTRODUCTION

The long-tailed macaque (*Macaca fascicularis*) is from the Family of Cercopithecidae. These macaques can be found widespread throughout the mainland and islands of Southeast Asia but are rapidly declining due to rapid urbanisation and deforestation (Eudey, 2008). Anthropogenic land-use change has forced these animals to coexist in human-dominated landscapes and incorporated into the urban settings and some are kept as pets (Malaivijitnond & Hamada, 2008). Consequently, such coexistence leads to trauma and self-injuries especially fractures in the macaques.

Fracture is the break in the continuity of a bone which further is classified on the direction and location, the number of fracture lines and the presence or absence of an external wound (Newton & Nunamaker, 1985). An open fracture is an osseous disruption whereby the fracture and its haematoma communicate directly with the break of the skin and underlying soft tissues, while a closed fracture refers to fracture without an open wound (Buteera & Byimana, 2009). Classification of fracture based on direction and number of fracture lines include the transverse, oblique, spiral and comminuted fractures. Comminuted fractures are fractures with multiple fracture lines and range from three-piece fracture fragments to a highly comminuted fracture of five or more bone fragments (Johnson, 2013).

CASE DETAILS

History

A 2-year-old male long-tailed macaque, weighing 0.74 kg and kept in an indoor cage was attacked by a cat while the macaque was in the cage. The owner found the macaque with a fractured and protruding bone from the left arm. The macaque was presented to the University's Veterinary Hospital, Universiti Putra Malaysia on the same day for treatment.

Clinical Findings

Physical examination revealed that the macaque was in tachycardia and tachypnea with a 5% dehydration status. A 2 cm x 1 cm laceration was observed at the mid-section of the left upper forelimb with the distal humeral bone was protruding out of the skin and muscles. Neurological examination

for pain sensation and withdrawal reflexes of the affected arm indicated delayed responses. The macaque was restrainted physically using doubled layered leather gloves without any sedation or anaesthesia during the physical examination.

Treatments and Diagnostic Workups

Cranio-caudal and latero-medial radiographs revealed discontinuity of the left humerus at the mid-shaft with a single fragment from the distal segment protruding out at the fracture site (Figure 1). Evidence of soft tissue swelling surrounding the fracture site was noticed. Initial care and treatment were provided on the day of the presentation. The open wound at the left mid-upper forelimb was cleaned using diluted chlorhexidine (1:20). Wound irrigation was done with 0.9% sodium chloride (0.9% NaCl, B. Braun Medical Industries, Malaysia) and diluted povidone-iodine (1:20) was placed topically around the fracture site. A Modified Robert Jones (MRJ) bandage was applied for temporary immobilisation and wound protection. The macaque was hospitalised and treated with subcutaneous isotonic crystalloid fluid therapy: Lactated Ringer [20 mL/kg/day SC, per bolus (Compound Sodium Lactate, B. Braun Medical Industries, Malaysia)]; antimicrobial, enrofloxacin [5 mg/kg SC, once; Baytril 5%, (Bayer, OLIC Thailand Limited, Thailand)]; non-steroidal anti-inflammatory, meloxicam [0.1 mg/kg SC, once; (Melosafe, Safecon Lifesciences, India)], and nerve supplement, vitamin B 12 [(1 tab, p.o., s.i.d for 10 days (Methylcobal, Eisai Co., Ltd., Tokyo, Japan)]. The corrective surgery was scheduled on the next day of hospitalisation and the plan was to perform an open reduction followed by fixation with a combination of intramedullary (IM) pin and cerclage wires.

Surgical Procedure

The macaque was fasted approximately 12 hours prior to the surgical procedure to avoid regurgitation during the procedure. It was premedicated with midazolam, 0.5 mg/kg, i.m. (Domi Inj, 5 mg/ml, CCM Duopharma Bio Tech, Malaysia). Following sedation, the animal was induced with isoflurane 5% (Isoflurane USP 100%, Piramal Healthcare Limited, India) and intubated with an endotracheal tube size 2.0 mm. General anaesthesia was maintained with 2.5% isoflurane vaporised in 100% oxygen using a rebreathing system. The animal was then placed in a right lateral recumbency before routine surgical skin preparation was carried out at the affected limb. The wound was classified as grade II open fracture with a minimal degree of contamination. Wound

irrigation was carried out using 0.9% sodium chloride and antibiotic solution of metronidazole (Metrogyl® injection 5 mg/ml, Unique Pharmaceutical Laboratories, India) to reduce the bacterial loads at the fracture site. A cranio-lateral approach was adopted to expose the fracture site of the humeral mid-shaft. The skin was incised from the proximal to the distal end of humerus cranio-laterally exposing subcutaneous fat and brachial fascia. Both of these tissues were incised along the same line to visualise the brachiocephalicus muscle and brachialis muscle. The brachiocephalicus muscle was then retracted cranially and brachialis muscle caudally using muscle retractors to expose the fracture segments. Bone holding forceps were used to distract the proximal and distal bone fragment in an open reduction technique. The bone fragments were then levered along the fracture line for anatomical reduction. A 1.6 mm three-faced trocar Steinmann pin was inserted to stabilise the fracture using the standard retrograde technique. In retrograde IM pin placement, the pin was inserted into the medullary canal of the proximal bone segment and driven to exit at the intertubercular groove of the humerus. The fracture was reduced and the pin was then driven in a normograde manner into the distal bone segment. The extra length of the pin was removed, leaving an approximately of 12 mm in length exiting from the proximal humerus which was then bent and curved before burying under the soft tissue (Figure 2). Size 2-0 cerclage wires were placed circumferentially around the proximal and distal bone fragment to provide a rigid stabilisation at the fracture site. The brachiocephalicus muscle and skin were closed routinely with cross-mattress and horizontal mattress suture pattern respectively using Vicryl® 4-0 absorbable sutures (Polyglactin 910, Ethicon®, Belgium). A post-operative radiograph was taken to confirm the IM pin was placed in the bone marrow cavity without interfering the elbow joint. In addition, light bandaging was applied to avoid the animal from licking or biting the surgical site.

Post-operative Care

Reassessment of the suture site on the following day showed intact sutures, dry and clean soft tissue with minimal swelling. Post-operative medications include antimicrobial treatment, amoxicillin trihydrate (11 mg/kg, p.o., b.i.d, for 7 days; Dyna Amoxycillin 125 mg/5ml, DynaPharma, Malaysia); analgesic medication, tramadol hydrochloride (3 mg/kg SC, t.i.d for the first 24 hours post-operative, Analab injection, Biolab Co. Ltd, Thailand); and non-steroidal

anti-inflammatory treatment, meloxicam (0.1 mg/kg SC, for 5 days). Prior to discharge, the client was advised to strictly cage rest the macaque and removing all hanging structures in the cage that could possibly induce injury until recovery. IM pin removal was only able to be performed at week-16, due to the client's unavailability to follow-up at week-10 which initially scheduled. The macaque was anaesthetised with the similar anaesthetic protocol that was used during the fracture repair and prepped in a routine manner. The skin was incised approximately 10mm at the curved tip of IM pin prominence that was embedded in the tissue. A smaller incision was advance straight on the deltoideus muscle at the pin prominence to expose the pin. Once the pin was located, a pin puller was used to gently retract the pin out of the medullary cavity. The muscle and skin were then closed with a simple interrupted suture pattern using Vicryl® 4-0. Post-operative radiograph follow up at day-120 indicate extensive callus formation with bone remodelling at the fracture site (Figure 3). Nonetheless, healing was satisfactory where the macaque was able to use and move the affected arm in a normal manner.

Figure 1 Radiographic views of the left humerus indicate discontinuity at mid-shaft of humerus with bone fragment between the fracture site. (1A: cranio-caudal view and 1B: lateral view)

Figure 2 Post-operative radiograph shows IM pin placement is in the bone marrow cavity without interfering the elbow joint and the four cerclage wires are intact at the bone circumference. (A: cranio-caudal view & B: lateral view)

Figure 3 Post IM pin removal radiographs shows bone remodelling with extensive callus formation at distal humerus, good axial alignment and complete healing. (A: cranio-caudal view & B: lateral view)

DISCUSSION

In the current case report, midazolam was used as a sole premedication agent without any other combination of neuroleptic drugs in the macaque to achieve an adequate sedation (Shilo *et al*., 2010; Bertrand *et al*., 2017). The premedication agent was successfully delivered through intramuscular injection and produces a smooth degree of unconsciousness. In most wild animals and macaques, ketamine and xylazine combinations are widely used due to the aggression and unpredictability of behaviour (Majie *et al*., 2014). However, respiratory depression and muscle rigidity are common complications induced by xylazine and ketamine respectively (Shilo *et al*., 2010). Combination of both midazolam and isoflurane inhalant had acted as a safe and effective anaesthetic agent. Furthermore, the main aim was to provide muscle relaxation, and also for smooth, non-ataxic and no excitement recovery.

Grading of open fractures is important in the decision for the optimum management and treatment. The grading system of an open fracture is based on the description by Gustilo *et al*. (1984) (Table 1), thus, in this case, the fracture was classified as grade II pertaining to the size of the laceration was 2cm x 1cm with minimal contamination, and moderate soft tissue damages.

The principles of open fracture management consist of antibiotic prophylaxis, debridement and irrigation, fracture management and wound closure (Cross III & Swiontkowski, 2008; Buteera & Byimana, 2009). Antibiotic prophylaxis significantly reduces the rate of infection in open fracture (Cross III & Swiontkowski, 2008). Antibiotics that are commonly recommended for open fractures including cephalosporin, aminoglycoside, and penicillin. Antibiotic prophylaxis was administered to the patient immediately on the day of presentation and post-operatively for 7 days which was critical in reducing the possibility of infection. Debridement and irrigation are crucial in removing all debris, non-viable tissue and lose cortical bone fragments. Wound irrigation can be carried out using normal saline and antibiotic solution to reduce the bacterial loads (Buteera & Byimana, 2009). In this case, wound cleaning was done to remove the contamination from the open wound, and metronidazole antibiotic solution was used for wound flushing prior to the wound closure.

A fracture can be managed via external or internal fixation such as plate and screw or IM pinning. The choice of fixation methods depends on the type and severity of the fracture. External fixation remains the mainstay of severe open fractures such as grade IIIA or IIIB (Roberts *et al*., 2005). On the other hand,

Table 1 Classification of open fractures according to Gustilo *et al*. (1984)

Grade	Features
I	• Wound <1 cm • Wound comes from the "inside-out" (sharp bone lacerates skin) • Minimal contamination and soft tissue damage
II	• Laceration >1 cm • Moderate soft tissue damage • Minimal contamination
IIIA	• Extensive soft tissue damage • Massive contamination • Severely comminuted/ segmental fracture • Adequate soft tissue coverage
IIIB	• Extensive soft tissue damage • Massive contamination & comminution • Periosteal stripping and bone exposure • Inadequate soft tissue for closure-reconstructive procedures needed
IIIC	• Arterial injury requiring vascular repair

IM pinning was used due to the small bone circumference in which the suitable plate size was not available and the nature of the animal makes external fixation method not feasible. In this case, internal fixation using IM pinning was a more appropriate and practical choice due to reasons stated above. Furthermore, the end of the tip was bent and buried within the soft tissue to prevent the animal from pulling out the IM pin and to avoid pin related injuries to the animal.

Early wound closure should be achieved to reduce the risk of infection and the timing of closure depends on the adequacy of initial debridement and degree of wound contamination (Buteera & Byimana, 2009). A primary wound closure was adopted during the surgical repair in this case because it was graded as grade II open fracture with minimal contamination. Post-operative care and management are crucial to ensure a successful healing outcome. Post-operative medications such as antibiotics, analgesics, and anti-inflammatory were prescribed as prophylaxis and treatment against bacterial infection, pain relief and to reduce inflammation (Roberts *et al*., 2005). Possibilities of post-operative healing complications include osteomyelitis, delayed union, non-union, and malunion. Osteomyelitis is of particular concern in this case as the nature of the wound was an open fracture. Therefore, prophylactic antibiotic and aseptic surgical technique are required to reduce the risk of infection. Light coaptation or protective bandage was applied in this case to prevent the macaque from accessing and licking the

suture site which may lead to infection, suture breakdowns, and self-inflicted injuries.

Post-operative care is often problematic in primates due to their aggression (Majie *et al*., 2014), but the present animal was docile as it had been kept and raised by a pet owner. The animal was placed in a smaller cage to restrict its movement. Strict cage rest with minimal arm usage was initiated for at least six to eight weeks. Physiotherapy is required in helping the animal to regain its normal limb function and passive range of motion.

CONCLUSION

Assessment and grading of an open fracture are important for the decision making of the fracture management. The principles of open fracture management should be adhered to ensure an optimal healing outcome. In managing a fracture case in a non-human primate, the considerations that should be taken into account include an internal fixation method using IM pinning with the end of the tip, is bent to ensure it is buried within the soft tissue and a protective bandage is important post-operatively to limit the animal access to the suture site.

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