Surgical Repair of a Rostral Maxillary Beak Fracture Using an Improvised Metal Implant Scaffolding and Dental Acrylic Prosthesis in a Pet Double Yellow-Headed Amazon Parrot (*Amazona ochrocephala oratrix*)

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ABSTRACT

A 23-year-old male double yellow-headed Amazon parrot *(Amazona ochrocephala oratrix)* presented for a traumatic maxillary beak fracture. On initial examination, the parrot had an open complete fracture of the rostral third of the maxillary beak that exposed the underlying pre-maxillary bone and blood supply. A supporting apparatus was created using five 23-gauge hypodermic needles, placed at varying angles through the rostral edges of the exposed bone, forming a pyramidal scaffolding for the prosthesis. One layer of dental acrylic was applied over the apparatus. Two 28-gauge wire loops were placed laterally through the rostral rhinotheca followed by a second layer of acrylic. The inside-out approach for securing the scaffolding apparatus provided enhanced stability against the strong kinetic forces of the parrot's beak. This allowed the parrot to return to normal diet and activity very rapidly after the procedure. Six months after placement, the prosthesis came off revealing a partially regenerated rhinotheca. The open rostral maxillary fracture in this Amazon parrot was managed by means of a scaffolding framework and dental acrylic prosthesis that resulted in an immediate return to beak function and normal regrowth of the rhinotheca.

Keywords: *Amazona ochrocephala oratrix;* Double Yellow-Headed Amazon Parrot; Avian; Prosthesis; Fracture Repair; Scaffolding Apparatus.

INTRODUCTION

Beak fractures are a common and at times challenging presentation for avian veterinarians. A good understanding of the associated anatomy and repair options is essential for a successful outcome. The beak consists of an upper or maxillary beak and lower or mandibular beak. These structures are covered by a hard keratin sheath called the rhinotheca for the maxillary beak and gnathotheca for mandibular beak (1). Fractures that occur in the rostral third of the beak are able to regenerate and a full return to beak function is possible. Fractures that occur caudal to this point often result in irreversible damage (2, 3). Prostheses have been used in many different species as a means of fracture repair. They can be used as a temporary replacement to allow the patient to return to normal function (self-feeding) while the rhinotheca regenerates. Prostheses are commonly constructed

Figure 1: Open complete fracture to the rostrum maxillaris in a 23 year-old intact male double-yellow headed Amazon parrot. The fracture was caused by a fall from five feet in height at home. This resulted in exposure of the underlying bone and vascular supply.

using an epoxy or acrylic material and are then secured to the remaining beak through the use of intramedullary pins, Kirschner wires, or cerclage wires (4, 5, 6, 7). However, the forces applied to the prosthesis often cause displacement and failure before proper healing can be achieved (1, 8). In previous reports, significant wear, displacement, and premature loosening commonly occurred with protheses used for beak fracture repairs (2, 4). In the reported successful cases, many interventions and adjustments were needed in order to keep the prosthesis in place and properly secured (9, 10, 11). An improper occlusion of the beak can result in a lack of function, leading to anorexia and impairment of the healing process (5, 12). These challenges can result in added cost and stress to the patients, veterinary staff and owners.

In the parrot of the present report, a unique scaffolding apparatus was created to account for and properly distribute the strong forces associated with psittacine beaks. This allowed for increased longevity of the prosthesis compared to other reports. In addition, proper anchoring of the prosthesis to the remaining trabecular bone prevented premature loosening due to keratin turnover.

The technique in the present report required little intervention and resulted in a rapid return to function for the patient. This simple technique involved inexpensive materials that are readily available to clinicians. This report aims to describe an efficient method of beak prosthesis that can aid clinicians managing similar fractures in psittacines.

CASE REPORT

A 23-year-old 470-g (1.036-lb) intact male pet double yellow-headed Amazon parrot (*Amazona ochrocephala oratrix*) was evaluated due to a fractured maxillary beak acquired from a fall from a height of five feet. On physical examination, the bird was quiet, alert, and responsive with normal respiratory effort. Closer beak examination revealed an open complete fracture to the rostrum maxillaris with irregular edges, exposing the underlying bone and blood supply (Figure 1). The rostral third of the maxilla was absent and the fracture site was bleeding slightly due to the initial injury. The rest of the physical examination was unremarkable.

The parrot was sedated with midazolam (0.5 mg/kg IM once; Midazolam Hydrochloride, Hospira, Lake Forest, IL, USA) to allow wound cleaning and placement of tissue adhesive (VetBond Surgical Glue 3M, St. Paul, MN, USA) at the fracture site to achieve hemostasis. A blood sample was obtained from the right jugular vein for a complete blood cell count (CBC) and plasma biochemistry analysis, and the results revealed a moderate anemia with a packed cell volume (PCV) of 31% (reference 49-55%) (13). The anemia was attributed to blood loss from the recent trauma. Dental radiographs (Schick 33, Sirona Dental Inc, Long Island City, NY, USA) of the fractured maxilla were obtained and the results revealed no evidence of additional injury or abnormalities. Supportive treatment was initiated on the

Figure 2: Prosthetic created for the bird from Figure 1 to repair the fracture. Five 23-gauge, 1.5in hypodermic needles were placed in the cortex and the cancellous bone of the maxilla. Four needles were placed bilaterally, with two on each side, and one dorsally to create a supportive framework.

day of presentation with meloxicam (1.0 mg/kg PO q 24h; Metacam oral suspension, Boehringer Ingelheim Animal Health USA Inc, Duluth, GA, USA) for analgesia and enrofloxacin (30 mg/kg PO q 24h; Baytril, 22.7mg/mL, Bayer HealthCare LCC, Shawnee Mission, KS, USA) to prevent secondary bacterial infection. Fifteen milliliters of Lactated Ringer's solution (32ml/kg SC once; Lactated Ringers Solution, 10 mL/kg, Vetivex Veterinary Lactated Ringers Inj. USP, Dechra Veterinary Products, Overland Park, KS, USA) were given to replace fluid losses. Flumazenil (0.1 mg/kg IM once; Flumazenil, Hikma Farmaceutica, Terrugem, Portugal) was given to reverse sedation. Once recovered, the patient was gavage fed with 6 mls of critical care formula (20 mL/kg PO once; Avian Critical Care Diet, EmerAid Intensive Care Omnivore, Emeraid LLC, Cornell, IL, USA).

Two days after initial presentation, anesthesia was induced with 5% isoflurane (Isoflurane, Akron, Lake Forest, IL, USA) in 5 L/min of 100% oxygen via facemask and the bird was intubated with a non-cuffed size 3.0 mm endotracheal tube. Anesthesia was maintained with 1-2% isoflurane in 1 L/min of 100% oxygen on a non-rebreathing circuit. A 24-gauge IV catheter was placed in the right jugular vein, and Lactated Ringer's solution was administered at a rate of 5 ml/kg/hr. Enrofloxacin (30 mg/kg IV) was diluted in 0.9% NaCl at a ratio of 1:4 and administered IV over ten minutes. Meloxicam (1 mg/kg IM once; Metacam injectable, Boehringer Ingelheim Animal Health USA Inc, Duluth, GA, USA) was administered into the pectoral muscle. During the procedure, ketamine (4 mg/kg IV once; Ketastet, Zoetis, Parsippany, NJ, USA) was administered to provide analgesia and help maintain a stable plane of surgical anesthesia without increasing isoflurane concentration. A heating pad was used to help maintain normothermia, and the pulse was monitored with an ultrasonic Doppler flow detector (Model 811-B Doppler Flow Detector, Parks Medical Electronics, Las Vegas, NV, USA) over the left brachial vasculature.

The patient was placed in sternal recumbency, and the fracture site was aseptically prepared with a chlorhexidine (2%) solution. Five 23-gauge, 1.5 inch hypodermic needles (23-guage, 1-1.5 inch hypodermic needle Exelint International Co., Redondo Beach, CA, USA) were inserted between the cortex and the cancellous bone of the maxilla. Two needles were placed along the lateral margin, with the distal ends angled towards one another, on each side. One needle was placed dorsally. This created a pyramidal scaffolding to provide prosthesis stability (Figure 2). The free ends of each needle protruded approximately 3 cm from the rostral tip of the exposed bone and were secured together using a single 28-gauge wire loop (28-gauge stainless steel wire, Integra Miltex, York, PA, USA). A layer of dental acrylic (Protemp Plus, 3M ESPE Dental Products, Saint Paul, MN, USA) was placed over the scaffolding to provide additional stability. Once the first layer hardened, a pilot hole was created through the rostral lateral aspects of the rhinotheca using a 23-gauge needle. A 28-gauge wire was passed through the hole and secured as a free loop, providing bilateral anchoring and stabilization for a second layer of the dental acrylic that was placed around the entire rostral aspect of the maxilla, creating a prosthesis. Dental radiography was performed to confirm correct implant placement (Figure

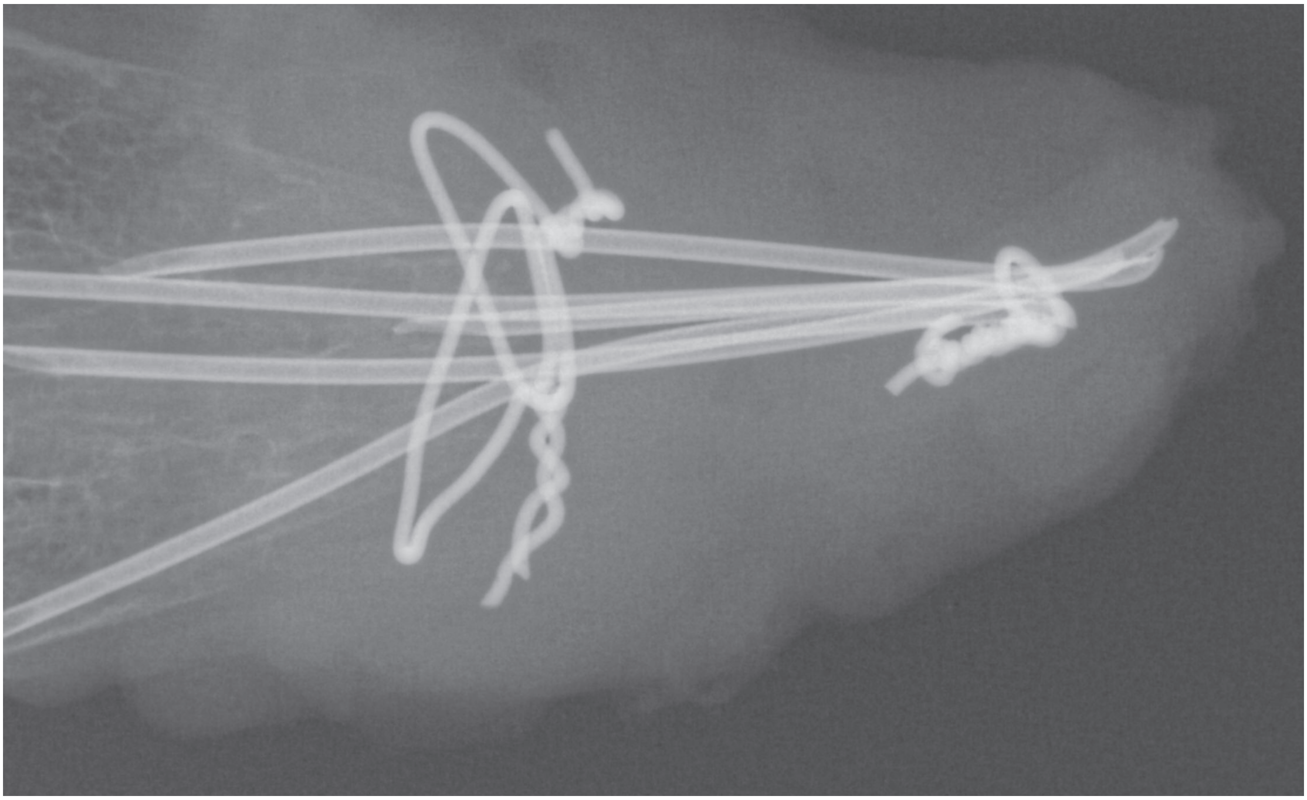

Figure 3: Post-operative dental radiographs were taken of the bird from Figure 1 to confirm proper placement of the prosthetic. It was further stabilized using 28-gauge cerclage wireo around the free ends of the protruding hypodermic needles. A layer of dental acrylic was placed over the scaffolding to provide additional stability. Once this hardened, a pilot hole was drilled bilaterally through the rostral lateral aspect of the rhinotheca using a 23-gauge needle. Another 28-gauge wire was passed through the hole and tied as a free loop to provide bilateral anchoring and stabilization for a second layer of the dental acrylic.

3). Once the acrylic was completely cured, it was shaped into a robust rhinotheca prosthesis form using a rotary tool (Dremel Tool, Emerson Electric Co., St. Louis, MO, USA) (Figure 4). The patient recovered from anesthesia without complication. Following recovery, the bird was gavage fed 6 mls of a commercial avian critical care diet (20 mL/kg PO Q4 hours; Avian Critical Care Diet, EmerAid Intensive Care Omnivore, Emeraid LLC, Cornell, IL, USA) every four hours. Within twelve hours of recovery from surgery, the patient began to show interest in eating and drinking independently. Meloxicam (1 mg/kg, PO, 24hr) and enrofloxacin (30 mg/kg, PO, q24hr) were administered. Given the rapid recovery, the parrot was discharged one day post-operatively. The fracture site showed no signs of bleeding or loosening of the implant at the time of discharge, and the owner was instructed to continue meloxicam (1mg/kg PO q24hr) for three more days and enrofloxacin (30mg/kg PO q24hr) for ten days.

The day following discharge, the parrot began eating soft foods (apples, bananas) and some pelleted diet as normal at home. Two days after the prosthesis placement, the parrot returned for a follow up examination where it was assessed to have normal eating and ambulatory activity.

Two weeks after initial presentation, the parrot presented for reexamination and its body weight was 487g (1.07 lb). A small separation of the most caudal layer of the acrylic along the right dorsal rhinotheca was discovered. This was determined to not affect the overall stability of the prosthesis. On reexamination six weeks after initial presentation, his body weight was 490g (1.08 lb), the prosthesis was stable, and the parrot was doing well at home. A minor discoloration on the medial aspect of the prosthesis was observed, likely due to food pigmentation and determined to not affect the stability of the prosthesis. Ten weeks after initial presentation, the parrot presented for reexamination with a body weight of 510g (1.12 lb) and the prosthesis was noted to be stable.

Figure 4: After placement of the prosthesis on the bird from Figure 1, the acrylic resin was shaped using a rotary tool to provide proper occlusion of the beak and aid in return to normal function. The patient was able to eat and drink independently within twelve hours post-operatively.

Figure 5: The bird from Figure 1 was examined six months after the initial injury and three days after the prosthesis fell off naturally at home. Slight thickening of the rhinotheca and mild discoloration where the prosthesis was previously attached was observed, but otherwise there were signs of normal regrowth, shape, and strength of the rhinotheca. The patient had returned to full function of the beak and was doing well.

Fourteen weeks after initial presentation the parrot was reexamined and tattered tail feathers were noted on physical examination, suggestive of improper preening possibly due to the prosthesis. Five months after initial presentation, evaluation of the prosthesis revealed lifting edges of the prosthesis from the underlying beak at the caudal margins and slight side-to-side movement was evident. A Dremel tool was used to shorten and shape the rostral end of the prosthesis to account for regrowth via lengthening of the rhinotheca in order to maintain a normal occlusion. Due to the concerns of loosening of the prosthesis, recheck dental radiographs and prosthesis removal were recommended but declined by the owners. Six months after the initial presentation, the prosthesis came off at home (Figure 5). As reported by the owner, the parrot was eating and drinking normally. The parrot was examined three days after loss of the prosthesis, which revealed slight thickening of the rhinotheca and mild discoloration where the prosthesis had been attached, but otherwise normal regrowth, shape, and strength of the rhinotheca. There was no evidence of trauma from the loss of the prosthesis and all pieces of the implant were accounted for. His body weight had remained stable at 510 g (1.12 lb) for every recheck appointment. According to the last update from the owner, approximately three years after the initial injury, the parrot had regained full function and shape of the beak and continued to eat and ambulate normally.

DISCUSSION

The use of prostheses as a means of beak fracture repair in psittacines comes with a unique set of challenges. One of the most notable difficulties is high kinetic forces imposed upon the prosthesis (1, 8). For example, a maxillary fracture has been repaired in a blue-and-yellow macaw (*Ara ararauna*) using wire and an acrylic resin cap that resulted in initial stabilization, but was followed by loosening over time, with subsequent wire and resin adjustments due to the extent of force, placed on the acrylic (4).

The prosthesis utilized for the parrot of the present report was able to overcome this challenge through its unique scaffolding framework. The framework consisted of hypodermic needles placed in a pyramidal shape and multiple layers of dental acrylic. This might have distributed the forces evenly throughout the prosthesis and increased its stability, thus allowing it to sustain stronger compression forces at the fracture site compared to an acrylic cap alone (4). The strength of this design prolonged the use of the prosthesis and decreased the need for repeated repairs or adjustments.

Significant wear, irritation, and potential infection of surrounding tissues is a common concern associated with the use of k-wires, hypodermic needles, or similar materials as a matrix for an acrylic prosthesis (2). Securing the scaffolding framework with rostral and bilateral wire loops along with layers of dental acrylic provided multiple levels of stability which resulted in minimal movement of the pins and minimized rotational forces on the prosthesis. Thus, there was very little wear and irritation to the surrounding tissues in this case, protecting the integrity of the prosthesis and surrounding tissues.

The internal placement of the scaffolding framework was integral to the security and long-term success of the prosthesis of the present report. Many prostheses lose stability over time due to normal keratin turnover which causes premature loosening. Previous reports have found success using materials such as intramuscular (IM) pins and inter-fragmentary wire (4, 5, 6). However, these methods may not be suitable for psittacines or fractures such as the one addressed in the case of the current report. For example, in one case, threaded IM pins were used to anchor an acrylic prosthesis for an avulsed beak in an ibis (*Threskiornithinae),* which resulted in successful stabilization for two years (6). However, in the Amazon parrot of the present report there was a complete fracture resulting in complete separation of the rostral half of the maxillary beak. Subsequently, most of the dermis was left intact and able to regenerate (2, 3). Over time, keratin turnover would likely result in premature loosening of the prosthesis from the beak if it were secured with IM pins alone. In addition, the small size of the remaining maxillary beak did not allow for the insertion of larger threaded pins for prosthesis anchoring. If placed without any anchor method, an acrylic prosthesis would slough off prematurely due to normal keratin turnover (5). In the Amazon parrot of the present report, this challenge was addressed by securing the prosthesis internally to the bone of the maxilla rather than the keratin tissue. This inside-out approach allowed for improved stability and longevity of the prosthesis. It should be noted that the prosthesis of the present report did begin to detach from the beak on either side due to normal keratin growth, but this was not observed until about five months after placement. The prosthesis fell off naturally at home six months after initial presentation, which is consistent with the amount of time it takes for complete regrowth of the rhinotheca in psittacines (2, 14). Both the continuous keratin growth and small size of the remaining beak were overcome with the method employed in securing a functional prosthesis in this case.

Another case report described complete mid-maxillary beak fractures of the underlying bones in a white-naped crane (*Grus vipio)* and sandhill crane *(Grus Canadensis)* (5). The fractures in these two cases were successfully stabilized using orthopedic wire, proximal and rostral to the fracture line, to hold the fracture fragment flush with the remaining beak. An acrylic splint overlaid the fracture (5). Although the stabilization was successful in these two cases, there are several limitations with this approach when considering psittacines. In small psittacines, there may not be enough tissue for this type of stabilization, which may result in *in-situ* surgical failure or early post-surgical failure (5). This technique also requires that the fracture fragments are not completely separated in order to achieve anatomical alignment during repair. In this case, the rostral fragment was completely separated from the beak and would not have been suitable for fixation to the remaining beak tissue.

Dental acrylic resin has been utilized in many different beak surgeries due to its ability to harden by cold curing, thus preventing iatrogenic damage via intense heat as seen with other types of acrylic molding (7). It has been used to stabilize incomplete fractures in a variety of ways. These include the creation of a protective cap, as an additional layer of stabilization to wire fixation methods, and as a full prosthesis as mentioned previously (1, 4, 5, 15, 16). Dental acrylic has been used to prevent injury by placing it over protruding orthopedic wire ends, as well as to correct beak deviations and prognathism (5, 7, 15). In the prosthesis created in this case, the specific acrylic layering technique coupled with the scaffolding apparatus allowed for superior stabilization of the prosthesis. Acrylic resin was first placed onto the scaffolding after it was secured to the maxillary bone. 28-gauage wire was then passed through a pilot hole and tied as a free loop at each lateral margin to complete the inside-out anchoring technique. This provided the foundation for a second layer of acrylic around the entire rostral aspect of the beak, thus completing the prosthesis.

The use of acrylic resin in this manner has not been reported previously in the repair of a maxillary fracture in a psittacine. It appears that this anchoring method added significant stability compared to the use of single layer acrylic prostheses.

Additional advantages to using dental acrylic resin and hypodermic needles for repair for beak fractures are that these materials are familiar and readily available to practitioners, fairly inexpensive, and easy to place. In contrast, several other methods of fracture stabilization including additive manufacturing, bone plates, and alloplastic/heteroplastic beaks are often more expensive, less available in general veterinary practice, and require advanced training for appropriate placement (9, 10, 17, 18, 19). Despite eventual success, previous cases using these methods have reported challenges such as initial failure and injury to the patient, frequent adjustments to the fixators, and long term changes to the bird's diet and lifestyle (9, 10, 11). These challenges may not be as easily overcome in a clinical setting as they would require more frequent intervention, subsequent stress to the patient, and cost to the owner.

Daily management of fracture repairs can be a source of stress and pain, and potentially delay the healing process. The method of the present report resulted in a rapid return to function of the beak and subsequently decreased the amount of daily care required. In general, fractures located in the rostral one third of psittacine beaks will result in regeneration, while fractures more caudal to this will most likely result in irreversible damage to the dermis and an inability to regenerate (3). In the latter's case, return to full beak function was unachievable (8, 20). Previous reports often recommend a lifelong change in diet and husbandry such as soaking pellets, feeding unshelled seeds and nuts, separating cage-mates as well as removing perches from the enclosure to avoid further beak damage (5). While most psittacines are able to adapt to a partial or full loss of their beak, the daily management of these cases can become difficult for both the bird and the owner (1, 8, 20). The treatment of the beak fracture in the present report resulted in near proper occlusion of the beak via acrylic prosthesis while allowing for normal healing and regrowth of the rhinotheca. This is a significant advantage as malocclusion of the beak can lead to anorexia and dehydration and thus impede the healing process (5, 12). The prosthesis in this case allowed for rapid return to function with normal diet and husbandry post-surgery (as evident by its increased weight gain post-operatively), which did not alter the integrity of the prosthesis due to its achieved stability (1).

Tattered tail feathers were noted during reexamination fourteen weeks post initial presentation for the parrot of the present report. This indicated that preening was impaired, likely from the prosthesis. However, this was of minor consequence to the patient's quality of life post-operatively and no other impairments to beak function were reported for the entire time the prosthesis was in place.

In this case, a pet double yellow-headed Amazon parrot was successfully treated for an open complete rostral maxillary fracture by means of an improvised hypodermic needle scaffolding, dental acrylic prosthesis that was anchored to the beak from an inside-out approach. This technique provided stability against the strong kinetic forces associated with psittacine beaks, thus allowing for increased longevity of the prosthesis and rapid return to function for the bird. Complete healing of the rhinotheca was evident within six months after the initial injury. This fracture stabilization technique allowed for rapid treatment response, was simple to perform, and the materials utilized were both inexpensive and readily available for most clinicians. Dental radiographs were utilized due to their superior level of detail to assess the fracture both before and after the prosthesis was placed.

This clinical report may aid clinicians managing similar beak fractures in psittacine species.

CONFLICTS OF INTEREST STATEMENT

The authors report no actual or potential conflicts of interest relative to this paper.

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