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Clinical Report

Diagnostic Approach Using Computerized Tomography and Successful Surgical Resolution of a Palatine Luxation and Entrapment in a Blue and Yellow Macaw (*Ara ararauna*)

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Abstract: A seven-month-old male blue and yellow macaw (*Ara ararauna*) was presented with an inability to move the maxillary beak after flying into a clothesline. Unsuccessful attempts to reduce the beak were performed, first by the owner at home and later within the same day by the referring veterinarian under general anesthesia. The patient was referred for assessment and treatment 5 days later. A palatine luxation and entrapment with a possible fissure of palatine bone was suspected based on history, a physical examination, and radiographic imaging. Another unsuccessful attempt to manually reduce the beak was performed under general anesthesia. A computed tomography (CT) scan was scheduled to evaluate the skull further. Rostrodorsal displacement and entrapment of the palatine bone on the rostral edge of the interorbital septum in the mesethmoid region were identified. In addition, the CT images provided useful information for the veterinary team to rule out other skeletal abnormalities, rendering a significantly more detailed evaluation of the skull bones before surgical intervention. Surgery was performed after the previously published pin insertion method over the dorsal aspect of the palatine bone. Pressure in the ventral direction was then applied on the pin while simultaneously further hyperextending the maxillary beak to unhook the palatine bone from the interorbital septum. The present case report describes an in vivo diagnosis of palatine luxation and entrapment in a blue and yellow macaw by means of a CT scan and successful surgical resolution.

Key words: Ara ararauna, avian, computed tomography, surgery, palatine luxation and entrapment, rostroparasphenopalatal luxation, blue and yellow macaw

CLINICAL REPORT

A seven-month-old male blue and yellow macaw (*Ara ararauna*) weighing 970 grams was referred because of an inability to move his beak after flying into a clothesline. The patient experienced 2 episodes of the upper beak locking in hyperextension. The owner stated that he was able to manually reduce the beak to its normal position after the beak became hyperextended the first time. After the second incident, manual resolution was not possible, and the owner sought veterinary care on the same day.

At the referring veterinary practice, a full physical examination, radiographic imaging, and an unsuccessful attempt to manipulate the beak into its normal position were performed under general anesthesia. Radiographic imaging showed no clear signs of injury. The patient was discharged and prescribed a nonsteroidal anti-inflammatory medication (meloxicam 1 mg/kg PO q12h × 5 days; Metacam, Boehringer Ingelheim Vetmedica GmbH, Ingelheim/Rhein, Germany) and hand-fed soft food (Harrison's Recovery Formula, Brentwood, TN, USA). After 5 days of treatment, the animal was referred to the authors' veterinary hospital. Upon arrival, the patient was in good body condition, alert, and vocalizing in a normal manner. The upper beak remained immobile and was still in the same position previously described by the referring veterinarian (Fig 1). The patient was sedated with midazolam (1 mg/kg intranasally; Laboratorios Normon SA, Madrid, Spain). General anesthesia was induced with 5% isoflurane (Isoflurin, Vetpharma Animal Health, Barcelona, Spain) in a 2 L/min oxygen flow via face mask. After induction, the macaw was maintained on 2.5% isoflurane in 2 L/min

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Figure 1. Image of a 7-month-old male blue and yellow macaw (*Ara ararauna*) at presentation with the upper beak locked in a hyperextended position due to a palatine luxation and entrapment. Note the physiologic position of the mandible, which maintained normal mobility.

oxygen flow via facemask to allow for further clinical evaluation. The physical examination revealed that the beak was locked in hyperextension, causing pain upon palpation at the palatal region under a light plane of anesthesia. The jugal arches were symmetrical and apparently well-articulated. The craniofacial hinge was locked in a hyperextended position with no apparent pain. The mandible had normal mobility. No other abnormalities were identified during the examination. The authors were unsuccessful in manually manipulating the upper beak during this anesthetic event. While anesthetized, radiographic images in the right and left lateral, oblique, dorsoventral, and ventrodorsal projections were collected and revealed hyperextension of the upper beak. After the anesthetic procedure, the bird recovered uneventfully from anesthesia. The radiographic images revealed slight asymmetry of the palatine bone compatible with a fissure in the right middle region, and cranial rotation of the quadrate bones with rostral displacement of the jugal, palatine, and pterygoid bones (Fig 2A through D). No abnormalities involving the craniofacial hinge were observed.

Rostroparasphenopalatal luxation with a possible fissure of palatine bone was diagnosed based on clinical and radiographic findings. To further evaluate the skull, a contrast computed tomography (CT) scan of the head was performed the following day under general anesthesia as previously described. A 26-gauge IV catheter was inserted in the medial metatarsal vein of the right

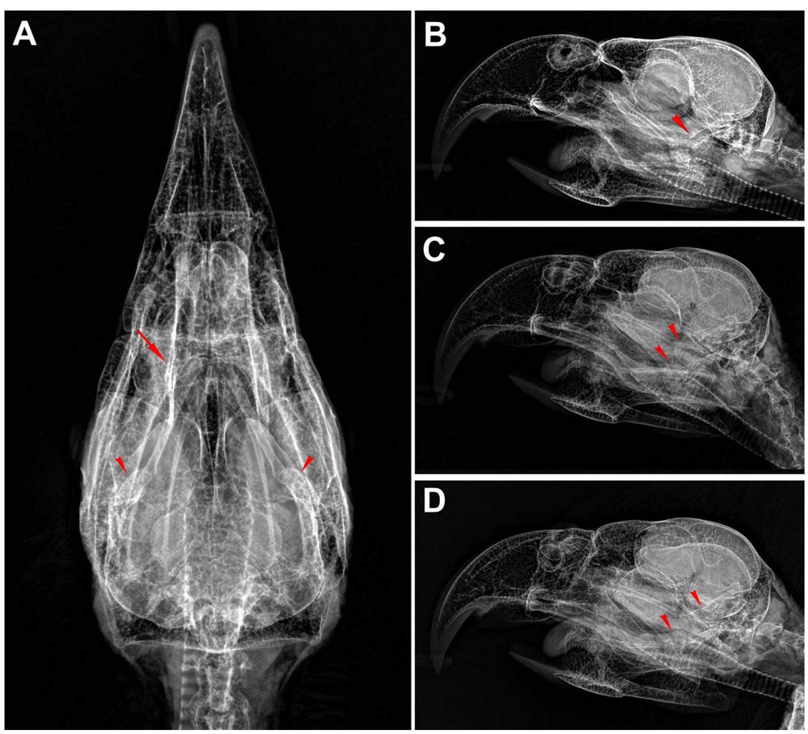

Figure 2. Radiographic images of the skull of a 7-month-old male blue and yellow macaw (*Ara ararauna*) with the upper beak locked in a hyperextended position due to a palatine luxation and entrapment in (A) ventrodorsal, (B) lateral, (C) right oblique, and (D) left oblique planes. Note (A) the slight asymmetry of the palatine bone in the ventrodorsal view (red arrow) and (B through D) the cranial rotation of the quadrate bones (red arrowheads) resulting in excessive rostral displacement of the maxillary beak, pterygoids, palatine, and jugal bones.

hindlimb, flushed with 2% heparin solution (Laboratorios Farmacéuticos Rovi, SA, Madrid, Spain), and a 3-way infusion extension line purged with 0.9% saline solution (B. Braun VetCare SA, Rubí, Barcelona, Spain) was attached. The acquisition was performed with the patient in sternal recumbency, with the head and neck extended cranially in a horizontal position using a Toshiba Aquilion 64 Multislice CT Scanner (200mA 120kV; 512 × 512 matrix and 9-cm field of view diameter; Toshiba Imaging Systems Division, Irvine, CA, USA). High-resolution bone and soft tissue reconstruction algorithms were used with the following parameters: WL 550 WW 2550, slice thickness 0.5 mm, and reconstruction interval of 0.4mm (bone); and WL 50 WW 500, slice thickness 1 mm, and reconstruction interval of 0.8 mm (soft tissue). Acquisition with the soft tissue algorithm was repeated 13 and 52 seconds after the IV nonionized iodine contrast injection (600 mg I/kg IV; Optiray 300, Guerbet Ireland ULC, Mulhuddart, Dublin, Ireland), followed by a bolus of 1 mL of 0.9% saline solution.

The CT images confirmed the rostrodorsal displacement of the palatine bones (rostroparasphenopalatal luxation) with entrapment on the rostral edge of the interorbital septum in the mesethmoid region. The entrapment involved the palatine bone at the site of the syndesmosis and the rostral tips of both pterygoids, which are articulated to the palatines at this region (Figs 3A through D and 4A through F) (Supplemental Videos S1 and S2). The presumed fissure of the right palatine bone was not identified and, therefore, not considered a contributing problem. Asymmetry in the attenuation of the palatine bones was noted, with the left side presenting higher attenuation (mean 167 HU; maximum 745 HU) in the rostral area close to the entrapment site, compared with the right side (mean −98 HU; maximum 560 HU). Both the cortical bone and the pneumatized cavity were hyperattenuated (Fig 3A). The rostral and ventral aspects of the internal cavity of the interorbital septum had a loss of aerial structure with increased positive attenuation in the CT images (up to 93 HU) (Fig 3C and 4A) (Supplemental Videos S1 and S2). No post-contrast enhancement was observed. Our top differential diagnoses for the beak abnormality after the CT image evaluation were inflammation, edema, or hematoma related to trauma. Other differential diagnoses considered were incidental anatomic variation or inflammatory changes due to an etiology other than trauma.

The CT images also showed the integrity of the nasal and frontal bones (including nasofrontal joint), jugal, quadrate, and the pterygoid bones. The position of the jugal bones was slightly asymmetric with the left side slightly elevated (up to 2.3 mm) compared with the right (Fig 3C). Because the articulations of the jugal bones with the nasal and quadrate bones were in a symmetric position, subtle differences in the shape of the jugal bones (incidental anatomic variation) were considered the most probable cause.

Nasofrontal, palato-pterygoid, pterygoid-quadrate, maxilla-jugal, jugal-quadrate, and quadrate-squamosal joints were normal in appearance; however, rostral rotation of both quadrate bones and rostral displacement of both jugal bones was evident (Fig 4E).

Surgery was scheduled for the day after the CT imaging. The patient was fasted for 8 hours before the procedure. The bird was premedicated with butorphanol (2 mg/kg IM; Butomidor, AG, Wels, Austria) and midazolam (2 mg/kg IM). The patient was anesthetized as previously described and intubated with a non-cuffed silicone 3 mm endotracheal tube. A 26-gauge IV catheter was placed in the medial digital vein of digit III of the left foot, and fluid support (NaCl 0.9%,10 mL/kg/hr IV) was provided during the procedure. To maintain normothermia, the patient was placed over an electrical heating blanket (MaxKare Heating pad XKHT-102; Shenzhen XuMaoBo Trade Development Co, Shenzhen, Guangdong, China) and covered with a disposable tissue-based absorbent pad (Pivellon Medical Empapador de adulto; Pivellon SL, Toledo, Spain). A LifeWindow Lite Monitor (Digicare Animal Health, Boynton Beach, FL, USA) was used to measure an electrocardiogram, blood pressure, pulse oximetry, perfusion and plethysmographic variability index, capnography, and esophageal temperature. Meloxicam (1 mg/kg IV) and marbofloxacin (5 mg/kg IM; Vetoquinol Especialidades Veterinarias, SA, Madrid, Spain) were administered after the patient was intubated. The surgical site was prepared by removing the scarce feathers from the infraorbital fossa and applying topical 0.05% chlorhexidine and 70% ethanol solutions. The patient was positioned in dorsal recumbency.

The surgery consisted of placing a 2-mm intramedullary pin using a manual pin chuck. The pin, as previously described by Foerster et al,[1] was introduced transversely over the jugal bone and through the infraorbital sinus, dorsal to the palatine bone, and across the skull from one side to the other, taking care to avoid damaging the ethmomandibularis muscles, which traverse this area dorsoventrally (Fig 5) (Supplemental Video S3).[2] The procedure requires the following 2 synchronized actions: additional pressure is applied to force the maxilla into further hyperextension while simultaneously exerting pressure on the palatine bone using the pin, displacing the palatine bone rostrally,

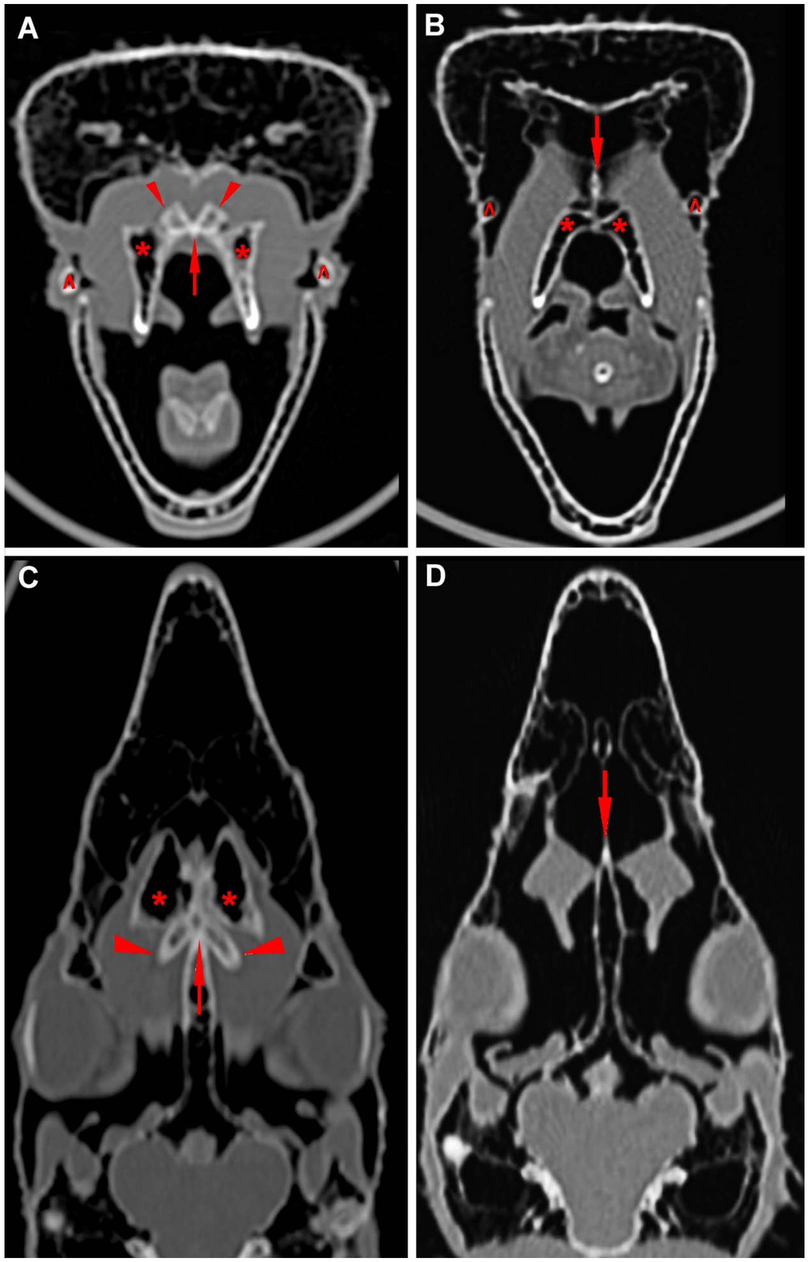

Figure 3. Computed tomography images of the 7-month-old male blue and yellow macaw (*Ara ararauna*) with the upper beak locked in a hyperextended position due to a palatine luxation and entrapment in transverse (A) and coronal (C) planes. Note the site of entrapment of the palatine (*) and the pterygoid bones (red arrowheads) on the rostral edge of the interorbital septum (red arrow). Note the increased attenuation of the rostral and ventral aspects of the interorbital septum and the differences in attenuation of the palatine bones (with the left one showing higher attenuation) and the slightly asymmetric position of the jugal bones (^) with the left one slightly elevated over the right. Computed tomographic images from a healthy macaw in transverse (B) and coronal (D) planes are provided for comparison. Note that, in the healthy bird, the position of the palatine bones (*) is ventral to the tip of the interorbital septum (red arrow).

and unlocking it from the interorbital septum and allowing it slide into its normal anatomical position (Supplemental Video S4).

Midazolam was reversed with flumazenil (0.1 mg/kg IV; Fresenius Kabi España SAU, Barcelona, Spain). Anesthetic recovery was uneventful, with complete recovery of voluntary upper beak mobility observed immediately after the patient regained consciousness (Fig 6). One hour after recovery, the patient was able to eat. A pelleted diet (Harrison's High Potency Coarse) soaked in water and finely chopped fruit were provided to minimize efforts with the beak. Postoperative treatment

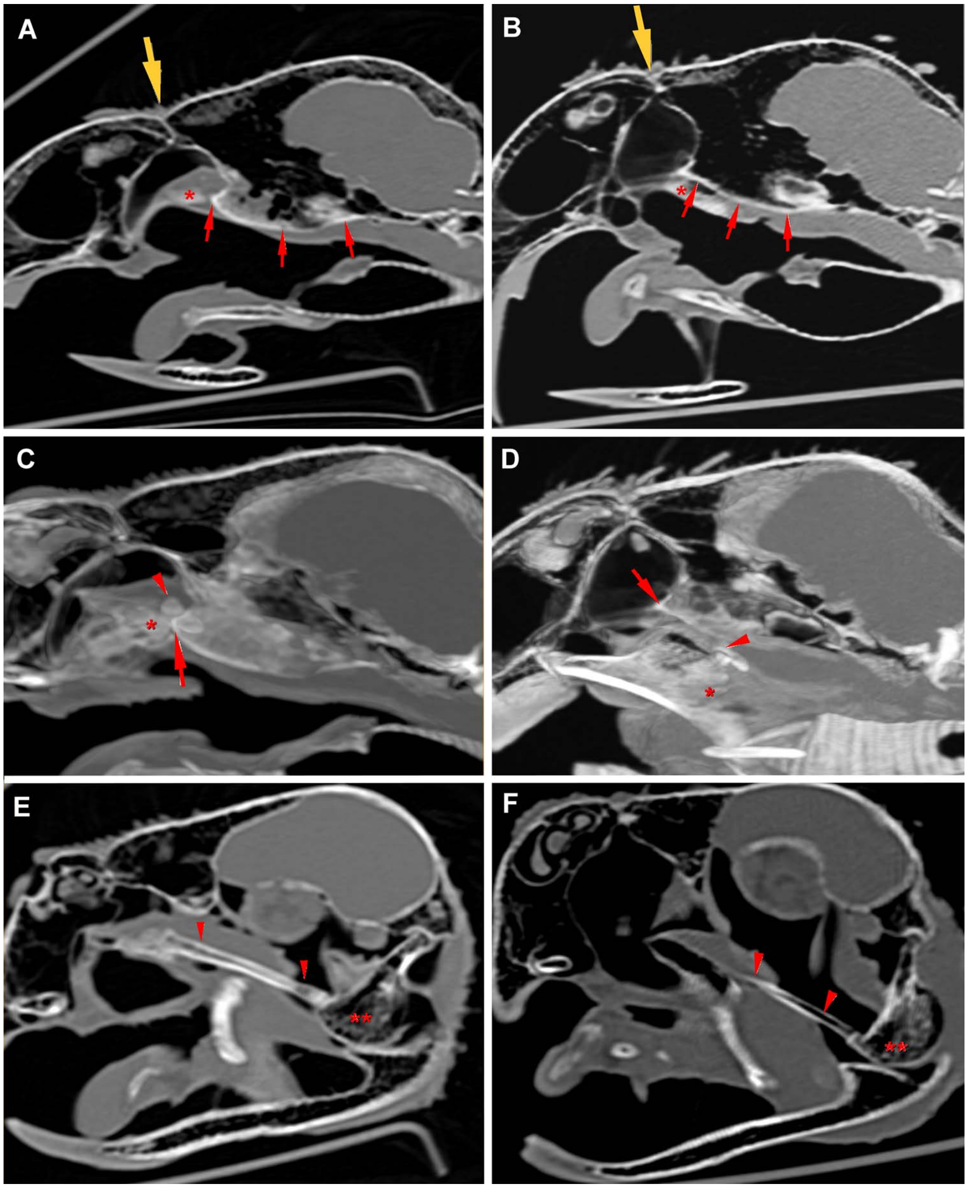

Figure 4. Computed tomography images of a 7-month-old male blue and yellow macaw (*Ara ararauna*) with the upper beak locked in a hyperextended position due to a palatine luxation and entrapment in sagittal (A, C) and oblique (E) planes. Note the rostrodorsal displacement and entrapment of the palatine (*) and pterygoid (red arrowheads) bones on the hook-shaped interorbital septum (red arrow), the intact nasofrontal joint (yellow arrow), and the rostral rotation of the quadrate bones (**). Computed tomography images from a healthy macaw in sagittal (B, D) and oblique (F) planes are provided for comparison. Note the increased attenuation of the rostral and ventral aspects of the interorbital septum and that, in the healthy bird, the position of the palatine bones (*) is more caudal and ventral to the tip of the interorbital septum (red arrow).

included meloxicam (1 mg/kg PO q12h × 10 days) to manage the pain and marbofloxacin (5 mg/kg PO q24h × 10 days) to prevent infection of the infraorbital sinus after pin placement.

The patient was discharged 3 days after surgery and was eating on its own. One year after the surgery, follow-up telephone conversations with the owner confirmed that the beak still maintained normal function.

DISCUSSION

Palatine luxation and entrapment are uncommon conditions that have only been described in *Psittaciformes*. Historically, the understanding of this condition was based on anatomical studies performed on cadavers.[1,3–5] In the patient presented in this article, a CT scan allowed for an in vivo visualization of the mechanism of the entrapment. As it was previously thought, palatine

Figure 5. Intraoperative image of a 7-month-old male blue and yellow macaw (*Ara ararauna*) in dorsal recumbency during a surgical procedure to correct a palatine bone luxation and entrapment. The procedure involves 2 synchronized actions after placing a pin through the infraorbital sinus. First, additional pressure (red arrow) is applied to extend the maxillary beak into a further protracted position. Simultaneously, ventrally directed pressure is applied to the palatine bone using the pin (blue arrow). This action frees and displaces the palatine bone ventrally from its entrapment, allowing it to slide back into its normal anatomical position.

Figure 6. Image of a 7-month-old male blue and yellow macaw (*Ara ararauna*) with the upper beak in physiologic position after surgical intervention to correct a palatine luxation and entrapment. Note the small wound rostral to the eye where the surgical pin was placed through the infraorbital sinus.

luxation and entrapment occur when the pterygoid and palatine bones suffer excessive rostral displacement, and they catch the rostral edge of the interorbital septum on the ventral aspect of the skull (Supplemental Video S5). This results in hyperextension of the upper bill and consequently leads to an inability to close the beak.[1,3,4,6,7] The present report describes an in vivo diagnosis of palatine luxation and entrapment in a blue and yellow macaw by means of CT imaging and its successful surgical correction. The terms "rostroparasphenopalatal luxation," "palatine bone luxation," "luxation of the upper beak," and "luxation of the pterygoid-parasphenoid-palatine complex" were previously used; however, in our opinion, the term "palatine luxation and entrapment" appears to be more appropriate.[1–5,8]

This condition has only been described in some species of psittacine birds, likely because of their unique evolutionary characteristics, which have resulted in a prokinetic skull with greater versatility and range of motion.[1,4,7,9,10] The pterygo-palatine complex arises from the union between the palatine and the pterygoid bones through a syndesmosis, where both structures are joined by fibrous connective tissue that gives it a range of movement.[1,4–7] The palatine bones articulate rostrally with the maxillary bone in a synovial joint and dorsally with the rostroparasphenoid bone in a diarthrosis that also allows some displacement.[1,4–7] The pterygoid bones articulate with the palatine bone rostrally and with the quadrate bone caudally in synovial joints.[1,4–7] It has been reported that the pterygoid bones also articulate with the parasphenoid bone in some species.[11–13] The quadrate bone is considered the key bone in the initiation of prokinetic movements of the skull because it articulates with the lower jaw, the jugal, and the pterygoid bones.[1,4,6,7] The nasofrontal hinge, the synovial joint formed by the union between the nasal bone and the frontal bone of the skull, allows for greater mobility in psittacine species, which is not as developed in other taxonomic orders of birds.[4,14] The rotation of the quadrate bone is the starting point in a chain of movements that results in the opening or closing of the upper beak, depending on whether their rotation is rostral or caudal.[1,4,7,9] The main protractor of the maxillary beak is *M. protractor pterygoidei et quadrati*. When this muscle contracts, the quadrate bones rotate rostrally, pushing the pterygoids, palatine, maxillary beak, and jugal bones rostrally.[1,4,7,10,15]

In the case described in the present report, the entrapment occurred after a traumatic episode, as has been hypothesized in previously published cases.[1,3,7] In 2 blue and yellow macaws described in previous reports, 1 suffered from a luxation by hitting the ground after being shaken by its owner, and the other was attempting to bite a large wooden dowel.[1,2] In 2 other cases reported in smaller psittacines, the cause was not clear. In a lovebird (*Agapornis roseicollis*), the palatine luxation and entrapment were identified while the bird was inside its cage, and in a red-crowned parakeet (*Cyanoramphus novaezelandiae*), trauma was suspected but not confirmed.[3,5] Manual reduction of the condition was unsuccessful in all of the cases.[1–4]

A presumptive diagnosis can be based on a history of trauma, a physical examination with a characteristic hyperextension of the maxillary beak, and radiographic images.[1–3,5,7] However, radiographic imaging alone may not provide sufficient evidence to diagnose the luxation and entrapment or effectively rule out other bony lesions that may be involved.[1,3,9,16–18] The relatively small size of the patients, the superimposition of structures, and anatomical variability among psittacine birds in this area of the skull, can make it difficult to confirm the site of entrapment, the integrity of the skull bones, and to rule out other bony or soft tissue abnormalities.[1,3] In this case, several radiographic projections were used that revealed hyperextension of the maxillary beak, rostral rotation of the quadrate bones, rostral displacement of the pterygoid and jugal bones from their normal position, and a slight asymmetry of the palatine bones that was deemed compatible with a fissure. A presumptive diagnosis of rostroparasphenopalatal luxation was determined using skull radiographic images of other macaws as references. Luxation of the nasofrontal hinge was ruled out. The CT imaging was recommended to confirm the diagnosis and thoroughly evaluate skull bone integrity before surgery. A CT scan has significant advantages over radiographic images when evaluating the skull because it eliminates the superimposition and provides high-definition images of bony structures.[3,17,19] In this case, the CT study allowed for confirmation of the luxation of the rostroparasphenopalatine articulation with rostrodorsal displacement and entrapment of the palatine and pterygoid bones on the rostral edge of the interorbital septum (mesethmoidal ridge). In addition, it helped to rule out other skeletal lesions, rendering a significantly more detailed evaluation of the bones of the skull before surgical intervention.[19,20]

When comparing skulls of macaws with other psittacines or domestic fowl, both in cadavers and in CT images, the key anatomical difference is in the region of the interorbital septum, just rostral to the end of the parasphenoid bone, where the mesethmoidal region begins. In this area, *Ara* genus macaws possess a broader and more prominent longer hook-shaped rim, which is not present in all psittacine species. The combination of the broader rim and greater development of the frontal hinge are offered as possible explanations of why macaws seem to be more predisposed to palatine luxation and entrapment.[1,3]

The main differential diagnosis that can cause transient hyperextension of the maxilla with recovery of the normal position of the maxillary bone is subluxation of the frontonasal hinge. This condition has been described in pediatric birds attempting to fly and catching their beaks on stationary objects.[1,3,16]

There are some anecdotal reports of spontaneous resolution or correction after manual manipulation. Recently, a noninvasive therapeutical approach was described by placing a rod-shaped tool horizontally at the angle between the upper and lower beak.[8] Surgical treatment, as previously described, is required if noninvasive methods are not successful.[1,7,21,22] Owing to the specific anatomy and size variation between the different psittacine species, modification of the surgical technique is required on a case-by-case basis.[1–3,5,7,21] In the technique previously described in a blue and yellow macaw, anchoring the jugal arch to the suborbital arch with sutures after resolving the luxation was described.[1–3,7] This step was not performed in the smaller parrot case reports, and their recoveries were satisfactory, which indicates that anchoring the jugal arch to the suborbital arch with sutures may not be mandatory, even in large parrots.[3–5] In the 2 studies previously reported in macaws, the recovery time and postsurgery beak function were not reported. One macaw died 15 minutes after surgery. In similar cases in smaller psittacine birds, the animals were able to eat within 2 hours of the surgical procedure.[1–3,5,10] In our case, the recovery time was similar, indicating a good prognosis once the risks associated with anesthesia and surgery are no longer present.

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