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Successful conservative management of multiple skull fracture and quadrate-mandibular medial luxation in a blue-and-yellow macaw (*Ara ararauna*)

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Abstract

Background We present a case of beak trauma not previously been reported in a blue-and-yellow macaw (*Ara ararauna)* and its successful conservative treatment. Several cases of fractures affecting the mandibular, maxillary and maxillofacial bones and pterygo-palatine dislocations, which have been studied using traditional radiology and CT; however, quadrato-mandibular luxation has never been described, individually or associated with other trauma.

Case presentation A 4-year-old blue-and-yellow macaw (*Ara ararauna*) was referred for a recent head trauma. The parrot exhibited right lower beak deviation, difficulty in grasping food and difficulty closing the beak. The parrot was referred for multiple traumatic fractures involving the pterygoid bone, jugal bone and right mandibular arch. The X-ray projections showed an incomplete fracture of the right pterygoid bone, two fracture sites on the right jugal arch, and slight mediorostral displacement of the right quadrate bones. Computed tomography (CT) confirmed the X-ray findings, and indicated additional trauma. The right quadrate bone luxation was manually reduced, and conservative treatment was elected. Analgesia and nonsteroidal anti-inflammatory drugs were provided. Moreover, a soft food-based diet was recommended for 3 weeks to facilitate recovery and reduce facial bone movements and tension. The parrot started eating dry food approximately 1 month after the trauma; full return of apparently normal beak function was achieved by 2 months.

Conclusions The CT examination allowed us to obtain a more detailed and complete view of the fractures and traumas and to evaluate the complex articular system of the Psittaciformes beak. For these reasons, CT is recommended for birds with a history of head trauma to select the best treatment for the specific case.

Keywords Ara ararauna, Fracture, Luxation, Avian medicine, Beak, Skull

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Background

We present a case of beak trauma not previously been reported in a blue-and-yellow macaw (*Ara ararauna)* and its successful conservative treatment.

Case presentation

A 4-year-old blue-and-yellow macaw (*Ara ararauna*) was referred to the exotic department (AvianDoc) of the Centro Veterinario Gregorio VII of Rome, for additional imaging examination after being bitten by a German shepherd dog. The referring clinician reported radiologically suspected multiple fractures involving the pterygoid bone, jugal bone, and right mandibular arch. On physical examination, the parrot appeared calm and slightly depressed, with its eyes remaining partially closed; however, the parrot was alert and responsive while interacting with the owner and during manipulations. Multiple skin wounds on the head and a right lower beak (gnathotheca if referring to keratin sheath layer) deviation associated with difficulties in closing the beak and grasping food were observed (Fig. 1). Rostral maxillary prokinesis seemed to be intact. The physical examination did not reveal additional abnormalities. The body condition of the parrot was considered good, and the recorded weight was 1050 g.

With the owner's consent, the parrot was premedicated with butorphanol tartrate[1] (1 mg/kg) and midazolam[2] (2 mg/kg) injected intramuscularly; 25 ml of warmed lactated Ringer's solution was administered subcutaneously. After 15 min, general anaesthesia was induced using a face mask delivering 3% isoflurane[3] in 2 L/min oxygen and 3 radiographic projections were obtained.

Right latero-lateral (LL), ventro-dorsal (VD) and left dorsal/right ventral lateral oblique (LO) projections were obtained. On all the projections, an incomplete fracture of the rostral third of the right pterygoid bone and fractures of the rostral and caudal third of the right jugal arch were identified (Fig. 2). The exact delimitation of the quadrate bones and the quadrato-mandibular joints were difficult to determine in the LL and LO projections due to the overlap of the surrounding structures. Conversely, the VD projection allowed clear identification of the quadrate bones; the left bone was normal in shape and positioning compared to the right bone, which was slightly rostrally displaced but remained intact (Fig. 2c). These radiographic findings confirmed the suspicion of the referring clinician regarding the presence of multiple fractures and dislocation of the quadrate bone.

However, to fully characterize all the fractures and investigate the joints involved in the trauma, a computed

Fig. 1 (**a**) Clinical presentation photograph of the blue-and-yellow Macaw (*Ara ararauna*), showing a slight deviation of the rhinotheca (upper beak) to the left. (**b**) Photo of the same subject on the day of discharge (post-repositioning procedure), showing proper alignment of the rhinotheca and gnathotheca (upper and lower beak)

[1] Dolorex® 10 mg/ml, Intervet Srl, Milano, Italy.

[2] Midazolam 5 mg/ml, Accord Healthcare Srl, Milano, Italy.

[3] Isoflo Zoetis Srl, Rome, Italy.

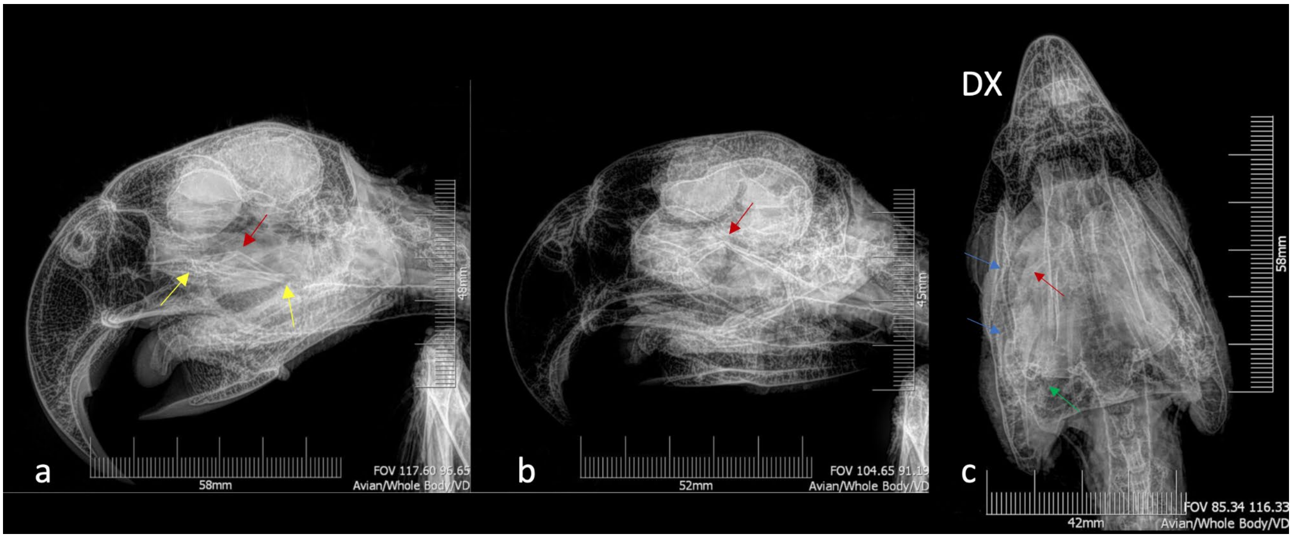

Fig. 2 Radiographic right latero-lateral view of (**a**) the pterygoid bone fracture (red arrow) and jugal arch fractures (yellow arrows). Left dorsal/right ventral lateral oblique view of (**b**) the fracture of the right pterygoid bone (red arrow). Ventro-dorsal view of (**c**) the fractures of the pterygoid bone (red arrow) and the right jugal arch (blue arrows) and medial luxation of the right quadrate bone (green arrow)

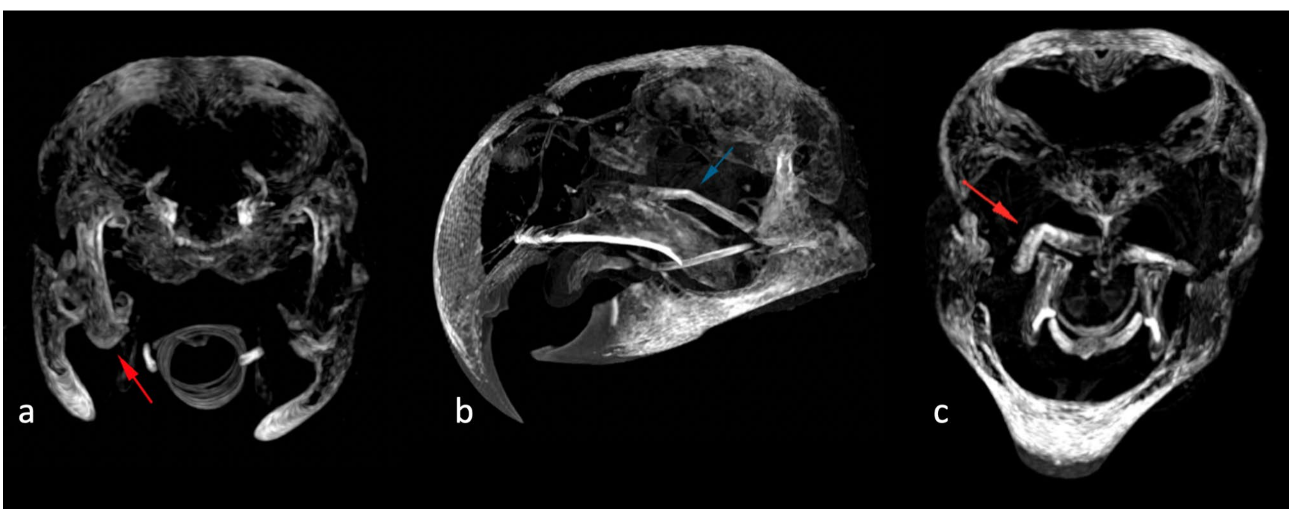

Fig. 3 (**a**) Transverse CT section in maximal intensity projection (MIP). Right quadrato-mandibular rostroventral luxation (red arrow). (**b**) Parasagittal CT section in MIP. Incomplete fracture of the right pterygoid bone (blue arrow). (**c**) Transverse CT section in MIP. Incomplete fracture of the right pterygoid bone (red arrow)

tomographic (CT) examination was performed with a 16-slice multidetector CT scanner[4] with the patient in dorsal recumbency. Acquisition in helical mode was performed in the cranio-caudal direction with beam collimation of 0.7 mm, voltage peak of 130 kV, tube current of 150 mAs with SAFIRE 1 and pitch of 0.6 mm. Standard CT images were reconstructed with soft tissue (Kernell: Br-40) and hard tissue (Kernell: Br-60) filters with 0.6 mm thickness and 0.3 mm reconstruction interval. Images were reviewed using a medical images analysis software (Osirix MD v.13.0.2 Bernex Switzerland).

[4] SOMATOM® go.Top, Siemens Healthcare s.r.l., Milano, Italy.

The cross-section images revealed ventral and rostral luxation of the right quadrate bone associated with a complete fracture of the apex of the ipsilateral mandibular medial process, which was medially displaced. The bone fragment measured approximately $2.5 \times 2.7 \times 2.5$ mm (Fig. 3a). Quadrate and mandibular bones showed an ill-defined area of hyperattenuation resulting in a partial loss of bone pneumatization, which was attributed to intraosseous haemorrhage. The quadrato-jugal, quadrato-pterygoid and quadrato-squamous joints remained congruent. In addition, an incomplete fracture of the rostral third of the right pterygoid bone was assessed with a deformity of approximately 125° of

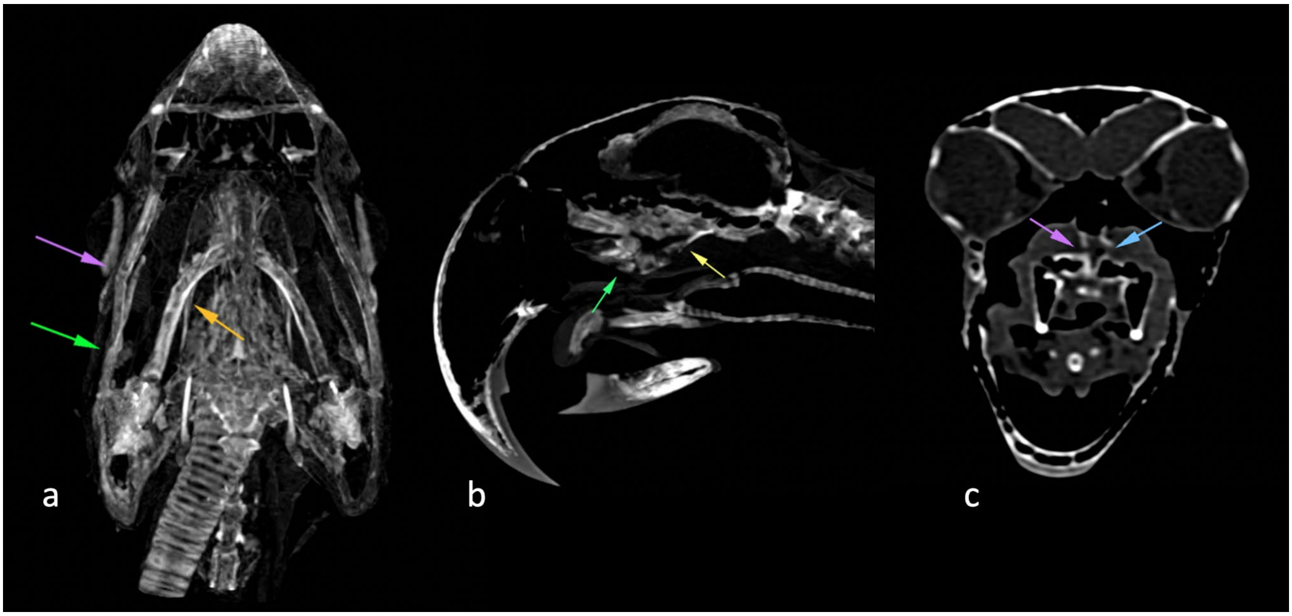

Fig. 4 Dorsal CT section in MIP. (**a**) Incomplete fractures of the right pterygoid bone (orange arrow) and of the jugal arch (pink and green arrows). Sagittal CT section in MIP. (**b**) Fragmentation of the parasphenoid bone (yellow and green arrows). Transverse CT image. (**c**) Bilateral pterygo-palatine subluxation (pink and blue arrows)

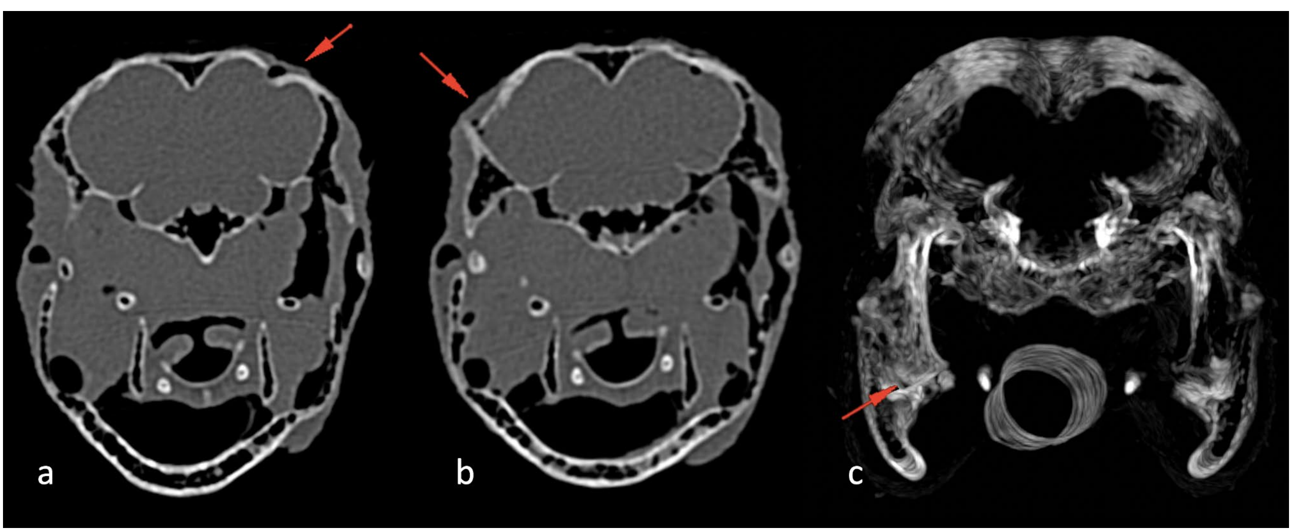

Fig. 5 Transverse CT sections showing the left parietal (**a**) and right temporo-occipital (**b**) calvaria fractures (red arrows). Transverse CT section in MIP obtained after manual reduction of the quadrate luxation, showing normal repositioning of the quadrate bone in the quadratic fossa (**c**)

the longitudinal axe of the bone (Figs. 3b and c and 4a). The right jugal arch had multiple fracture sites (3 incomplete fractures without displacement of the bone fragments), namely, the rostral, middle and caudal thirds. The ventral portions of the parasphenoid lamina and parasphenoid rostrum had comminuted fractures (Fig. 4b); the pterygo-parasphenoid and left palatine-parasphenoid joint relationships were compromised, with consequent left pterygo-palatine subluxation (Fig. 4c). Finally, CT images showed 2 mildly depressed fractures of the calvarium involving the right temporo-occipital bone and left parietal bone with minimal bone fragment displacement. Very small intracranial air bulla was associated with the left parietal bone fracture, however, the brain appeared to have normal attenuation, with the limitation of the absence of intravenous contrast media injection (Fig. 5a and b).

After imaging acquisition, a manual reduction of the quadrato-mandibular luxation was elected and successfully performed under the same anaesthesia. Tension was applied to the upper beak (rhinotheca if referring to keratin sheath layer) to protract it rostrally, while pressure was applied to the left quadrato-mandibular (opposite side of the dislocated one) in a ventromedial direction, while the right mandibular joint was pushed rostrolateral. This movement allowed the reduction of the dislocated right quadrato-mandibular joint. The opening and prokinetic movements were tested to evaluate the correct joint repositioning and its stability. All skin wounds were examined, cleaned, and disinfected. None of them required specific surgical debridement.

A postreduction CT scan was performed. Correct repositioning of the quadrate bone in the quadratic fossa (Fig. 5c) and the realignment of the lower beak were observed. Upon awakening, the parrot showed stable realignment and evident improvement in natural movements of the beak. Finally, as all the fractures were closed, the mandibular and parasphenoid fractures were complex, and the fractured bone fragments (pterygoid bone and jugal arch) had a partially preserved alignment, a conservative approach was elected. The parrot was discharged with analgesic and anti-inflammatory therapy, consisting of tramadol[5] (15 mg/kg PO, q 8 h) and meloxicam[6] (1 mg/kg PO q 12 h for 10 days), respectively. For the skin wounds, daily local disinfection and Iruxol[7] (antimicrobial ointment) application were prescribed. In addition, a soft food-based diet consisting of homogenized fresh fruit and boiled legumes was recommended to facilitate food intake in the first weeks after dislocation reduction. Tramadol was administered only once by the owner due to important sedative side effects; furthermore, the parrot did not show any major discomfort. After 48 h, the owner reported the restored ability to eat independently, although only soft food and in modest quantities. Subsequent clinical checks showed a progressive functional recovery of the normal prokinetic movements of the beak and reacquisition of the prehensile ability to handle and grasp food, including seeds and pellets. Three months later, the parrot was able to feed on its own and perform normal beak movements. At present, no reoccurrence has been reported.

Discussion and conclusion

To the authors' knowledge, the beak trauma described in this report has not previously been reported. Conservative treatment after manual luxation reduction of the quadrato-mandibular joint was successful. In the literature, there are several cases of fractures affecting the mandibular, maxillary and maxillofacial bones and pterygo-palatine dislocations, which have been studied using traditional radiology and CT; however, quadrato-mandibular luxation has never been described, individually or associated with other trauma [1–4].

In Psittaciformes, the movement of the beak occurs through a process known as prokinesis or cranial kinesis, that is, the ability to move the upper beak dorsally and rostrally, independently of the lower beak. The upper jaw functions as a rigid triangular block that rotates on the craniofacial hinge (in this order, it constitutes a true synovial joint), which is a flexible zone at the border between the neurocranium and the facial skeleton, allowing movement of the psittacine upper beak [5, 6]. This movement involves the complex interaction of numerous bones: the maxillary bone, mandibular bone, jugal arch, pterygoid bone, palatine bone and quadrate bone [7]. The maxillary bones (premaxillary and maxillary bones) form the bony base of the maxillary rostrum (upper beak) and articulate caudally with the neurocranium (frontal bones), forming the craniofacial junction, and laterally with the jugal arches [7–10]. The mandibular bones form the bony base of the mandibular rostrum (lower beak). These articulate rostromedially with the contralateral mandibular bone (mandibular symphysis) and caudally with the quadrate bones through their joint portion, which consists of a concave quadratic fossa and two bony processes: the lateral process and medial process [7]. The lateral process represents the site of insertion of the adductor muscles of the mandible (elevator of the lower beak), and the medial process is the site of insertion of the medial pterygoid muscle (depressors of the superior beak) and the depressor of the mandible muscle [7–11]. Each jugal arch has a bar shape and consists of 3 fused bones: the maxillary jugal process (rostral portion), jugal bone (middle portion) and quadrato-jugal bone (caudal portion). This articulates rostrally with the maxillary bone and caudally with the quadrate bone [7]. Pterygoid bones are rod-shaped. Their rostral ends articulate with the parasphenoid bone and the palatine bones and medially with the contralateral pterygoid bone (pterygo-pterygoid joint). The caudal extremities of the pterygoid bones articulate with the quadrate bones. Together, the pterygoid, palatine and quadrate bones form the quadrato-palatine bridges [7–10]. Palatine bones are flat bones oriented in a rostrocaudal direction and articulate dorsally with the rostrum of the parasphenoid and with the pterygoid bones and medially with the contralateral palatine bone [7–10]. The parasphenoid bone is an unpaired skull bone composed of a caudal portion (parasphenoid lamina), which constitutes the ventrorostral portion of the base of the skull, and a rostral portion (rostrum of the parasphenoid), which articulates ventrally with the palatine bones [7]. Quadrate bones play a central role in the complex beak kinesis of psittacine birds; they constitute a link between the neurocranium, mandible and maxilla. Each quadrate bone has 3 processes. Caudo-dorsally,

[5] Tramadol, Altadol 50 mg/ml, Formevet S.r.l., Milano, Italy.

[6] Metacam® 5 mg/ml, Boehringer Ingelheim, Noventana, Italy S.p.A.

[7] Iruxol®, Smith & Nephew S.r.l, Agrate Brianza, Italy.

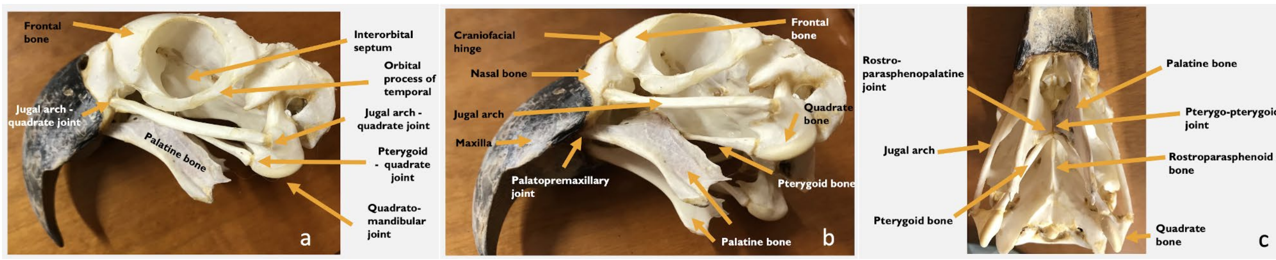

Fig. 6 Normal anatomy of the skull bones of a blue-and-yellow Macaw (*Ara ararauna*). The lower beak (mandibula) has been removed for a better visualization of the upper beak bones

the otic process articulates with the squamosal and otic bones. Rostro-dorsally, the orbital process represents the origin of the deep pseudotemporal muscle. Ventrally, the mandibular process articulates with the mandible; it also forms movable joints with the quadrato-jugal bone (laterally) and the pterygoid bone (medially) [5–7]. Rostral rotation of the quadrate bone pushes the pterygoid-palatine complex and the jugal arches, causing elevation of the upper jaw; in contrast, caudal rotation moves the upper jaw downwards [5–7]. The normal anatomy of the skull of a blue-and-yellow macaw (*Ara ararauna*) is illustrated in Fig. 6, with the nomenclature of bones and joints.

Imaging plays a fundamental role in avian medicine, and radiographic evaluation is often the first step in investigating skeletal diseases in birds [12, 13]. It is used to identify most bone pathologies of the skull (fractures, hyper- or hypocalcaemia, neoplasia) [14]. However, due to the overlapping structures of the head, radiographs provide limited interpretations of the complex anatomy of the avian skull, such as the bones involved in beak movement, especially in their articular relationships [12, 13]. In addition, birds have a large number of cranial bones, which are small in size and have a thin bone cortex and a high degree of bone pneumatization [15–17].

In this case, the radiological examination yielded a strong diagnostic suspicion of quadrato-mandibular joint luxation. The LL and LO projections did not allow us to completely investigate such complex trauma. However, the identification of the quadrate bones was achieved with the VD projection.

Computed tomography allows us to carry out a more in-depth anatomical study of these structures, as it provides the highest spatial resolution and allows us to produce multiplanar images and three-dimensional reconstructions, assuming a decisive role in the study of bones and joint structures [12, 13, 16, 17]. In this case, CT examination confirmed radiographic suspicions (pterygoid, jugal, and mandibular fractures as well as quadrato-mandibular luxation) and provided further pathological findings, such as a comminuted fracture of the parasphenoid bone, pterygo-palatine subluxation and 2 depressed calvaria fractures. Therefore, CT is advised for birds with severe head trauma to obtain a comprehensive view of the lesions and to choose the best treatment.

Another possible advantage of CT examinations is optional injection of intravenous iodinated contrast media, which is helpful for investigating soft tissue trauma. In this case, we did not perform postcontrast CT because our patient did not show any neurological signs.

In conclusion, closed reduction of the luxation was chosen in this case; this choice was made considering the location and complexity of the mandibular and parasphenoid fractures and the partially preserved alignment of the bone fragments (pterygoid bone and jugal arch). Long-term follow-up CT imaging was not performed due to financial and geographical distance constraints. However, 2.5 years after the trauma, the owner reported a complete resumption of food prehension and normal use of the beak.

This case report suggests that not all complex beak fractures in psittacine birds require surgical treatment and that conservative therapy in specific cases can provide positive results.

Abbreviations

CT	Computed tomography
LL	Latero-lateral
LO	Lateral-oblique
VD	Ventro-dorsal

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Not applicable.

Author contributions
CC was a major contributor in analyzing and interpreting the patient data regarding the case management and manuscript writing. LG was a major contributor in manuscript writing and literature review. VDP, AV, FDI, analyzed and interpreted the patient data. All authors read and approved the final manuscript.

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Data availability
All data used in the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The present case report has received ethical approval by the ethics committee of the University of Parma "Comitato Etico per la Sperimentazione Animale dell'Università di Parma".

Competing interests

The authors declare no competing interests.

Informed consent for publication

Owners gave written consent for their pet's personal or clinical details along with any identifying images to be published in this study.

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