Surgical Procedures of the Psittacine Head and Skull

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The anatomic form and function of the psittacine skull is complex. The biomechanics of cranial kinesis and lower mandibular function are related to an intricate combination of 13 synovial joints, numerous linkage ligaments and eight major pairs of muscles. Chronic forms of sinusitis, boney deformities of the skull and injuries all may necessitate surgical intervention in parrots. Luxation of the palatine bone can be corrected by ventrally directed force applied to the palatine bone with an intramedullary pin while the upper mandible is forcefully overextended. Surgical approaches to the infraorbital sinus can be performed comparatively easily, enabling access to many aspects of this sinus, the pterygoid and jugal bones. Surgical placement of pins transversely through the frontal bones can be used to provide a fulcrum with which force can be delivered for the surgical address of some selected beak deformities. Trephination can be used to enable access to sinus spaces within the maxilla and frontal bones.

Anatomy of the beak and skull

The avian skull remains remarkably uniform throughout all bird groups. There are several reptilian features of the skull, including a single occipital condyle, movable quadrate and pterygoid bones, the quadrate bone articulating with an articular bone which is part of the lower jaw, and a lower jaw consisting usually of six fused small bones instead of one large one as would be seen in mammals. Most of the unique skull morphology of parrots seems to be a product of the increased kinesis of their skulls.

The beak is composed of the rostrum maxillare (upper mandible or bill) and the rostrum mandibulare (lower mandible or bill). These terms refer to the entire structures, which are each composed of keratin, soft tissues, (dermis) and bone. The term used to describe the upper beak keratin layer is the rhinotheca, and the keratin covering of the lower beak is termed the gnathotheca. Keratin is essentially a hard skin surface and is produced by the dermis of the beak with varying contributions from the cere. Both keratin surfaces are made up of a covering type (very thin) and a pressure bearing type (very thick) of keratin. Covering type keratin is located on the outer and lateral surfaces of the upper and lower beak. Pressure bearing type keratin is located on the undersurface of the upper mandible, the piercing/shearing point of the upper mandible and at the shearing edges of the lower mandible (tomia). Keratin normally migrates rostrally along the surface of the beak and laterally from the vascular bed. The bony segment of the upper mandible contains extensions of the infraorbital sinus and the rostral diverticulum of the infraorbital sinus. The maxillary rhampotheca adjoins the frontal bone via a kinetic joint (the craniofacial hinge joint), which varies in its degree of flexibility amongst avian taxa but appears to be a highly mobile and synovial joint in psittacine species.

Upper mandible

The upper mandible is formed by paired and fused premaxillary and nasal bones. In most birds the upper jaw functions as a rigid triangular block which may be elevated or depressed, and that hinges at the flexible junction of the upper jaw with the brain case.[1] This type of cranial kinesis is known as prokinesis, where the movement of the jaw occurs at the junction of the jaw and the braincase. In the rhynchokinetic upper jaw, the bony movement of the upper jaw occurs rostral to the junction of the jaw and the braincase. Movement of the upper beak requires the movement of four pairs of bones: the jugal arch, the pterygoid, palatine and quadrate bones. Movement of the upper jaw is also made possible by the presence of flexible elastic zones in the facial bones. In prokinetic birds, a short elastic zone called the craniofacial elastic zone occurs at the junction between the braincase and the nasal and premaxillary bones. In large parrots, this zone is converted into a synovial articulation called the craniofacial hinge.

Lower mandible

The two rami of the avian mandible are fused in the rostral midline at the symphysis. The quadrate bone forms the primary link between the lower jaw and the cranium. Articular and linkage ligaments unify function of the lower mandible with the braincase, the palate and the upper mandible. These linkage ligaments join the upper and lower mandibles together mechanically, resulting in coupled kinesis, in which the movements of the upper and lower jaws are somewhat dependent on one another.

Palate

The palate is formed by a combination of the palatal processes of the premaxillae and maxillae, the palatine bones, the vomers, the jugal arches, and the pterygoid and quadrate bones. Unlike the palate of mammals, the avian palate does not form a complete shelf between the nasal and oral cavities. The internal nares lie between the vomers and the palatine bones, rostrally. The pterygoid articulates rostrally with the rostral portion of the palatine bone and caudally with the quadrate bone in a synovial hinge joint. The jugal arch consists of three bones fused together (quadratojugal and jugal bones and the jugal process of the maxillary bone). The jugal arch articulates rostrally with the maxilla and caudally, it forms a ball and socket joint with the quadrate bone. The quadrate bones are immensely mobile and function as the key elements in most of the movement of the upper and lower mandibles: articulating with the lower jaw (mandible), the braincase, the jugal arch and the pterygoid bone. The joint formed between the quadrate and the braincase is a double articulation. Rotation of the quadrate bones rostrally pushes on the pterygoid and jugal arches rostrally, resulting in an upward push being applied to the palatine bone, causing it to slide rostrally on the central boney ridge of the ventral brain case (os mesethmoidale) and forcing the upper jaw swings upward at the craniofacial hinge (protraction). Rotation of the quadrate bones caudally causes the upper jaw to swing downwards.

The muscles of the jaws

In most birds, 7 pairs of muscles act on the upper and lower jaws. Parrots have 2 unique pairs of muscles and lack 1 of this original 7 pair. Parrots do not have pseudotemporalis profundus, which is common in other bird species groups. Two muscles open the jaws, the protractor pterygoidei et quadrati by raising the upper jaw, and the depressor mandibulae by lowering the lower jaw. Two muscles simultaneously close both the upper and lower jaws, the pterygoideus and pseudotemporalis profundus The Pterygoideus in parrots also functions in the movement of the lower mandible forward (protraction) and in lowering the upper jaw during chewing. Three muscles raise the mandible: Adductor mandibulae externus, Pseudotemporalis superficialis, and Adductor mandibulae caudalis. The 2 unique pairs of muscles that are present in parrots are Ethmomandibularis and Pseudomasseter. The Ethmomandibularis closes and protracts the lower jaw, and the Pseudomasseter raises the lower mandible. Rostral rotation of the quadrate bone at its articulation functions to open the upper mandible, and this action is accomplished by the contraction of the protractor quadrati, pseudotemporalis superficialis, adductor mandibulae caudalis, and adductor mandibulae externus. Extension of the quadrate-mandibular joint (opening the lower jaw) is accomplished by contraction of the depressor mandibulae. Flexion of the quadrate-mandibular joint (closing the lower jaw) is accomplished by contraction of the psueudotermporalis profundus, the psuedomasseter, the ethmomandibularis, and the pterygoideus. The mandibular nerve provides the primary motor innervations for the muscles of mastication, with the exception of the depressor mandibulae, which is supplied by the facial nerve.

Surgical procedures

Palatine bone luxation repair

The clinical appearance of luxation of the palatine bone is hyperextension of the upper mandible. Diagnosis is confirmed on a basis of history, physical examination, and radiographic findings. Functional luxation occurs when the palatine bone is moved rostrally and then slips dorsally beyond its normal end-point on the mesethmoidal bony ridge at the ventral base of the braincase.

Surgical procedure

To reduce the luxation, an intramedullary pin is introduced transversely across the infraorbital sinus dorsal to the palatine bones. The upper mandible is hyperextended while the luxated palatine bones are concurrently reduced by applying ventrally directed pressure towards their normal anatomic position. This then enables the palatine bone to slide back over the mesthmoidal ridge, allowing the upper mandible to return to normal position. Additional stabilization can be provided by passing absorbable suture around the suborbital arch and jugal bones bilaterally, or around a trans-maxillary pin placed in the proximal central maxilla.

Trans-sinus pinning

Scissors beak deformities are characterized by a bending of the upper beak rhinothecal keratin and/or bone to one side to varying degrees, with the resultant overgrowth of the opposing lower gnathotheca. As force vectors are applied during the bird's regular use of its beak, this deformity usually will become progressive, ultimately generating a "scissors" effect. Secondary deformities of the occlusal ledge of the rhinothecal keratin, or the maxillary or lower mandibular bone may develop. Trans-sinus pinning is used in birds with near-normal skull ossification in order to apply tension bands and correct these deformities.

Surgical procedure

A threaded intramedullary pin is placed transversely into the frontal bone from the opposite of the direction of deviation, just caudal to the naso-frontal hinge and caudal-ventral to the nares. The pin is placed with careful attention to the angle of entry. An incorrect angle of entry can result in inadvertent penetration of the naso-frontal kinetic joint or the eye. Pass the pin evenly through the frontal sinus, and seat it in the opposite side of the skull at an identical exit site as the entrance location. On the opposite side, bend the pin to a 90-degree angle, parallel with the longitudinal axis of the upper mandible. At approximately the same length as the upper mandible, cut the pin off with wire cutters. This produces an "L" shaped pin, with the short portion placed through the frontal sinuses, and the longer portion angling down the lateral length of the upper mandible. Curl the end of this pin in a tight 360 degree manner. Variably sized rubber bands can be used to apply tension from the K wire to the tip of the beak, keeping in mind that gentle tension is usually all that is needed with young birds. In some birds, a second small wire may need to be placed through the distal aspect of the upper mandible, with which to attach your tension bands.

Upper mandibular extension prosthesis

Mandibular prognathism in younger birds may be addressed comparatively easily and effectively by applying an upper mandibular prosthesis. This process functionally extends the upper mandible, preventing placement of the upper mandible into the lower, enabling normal occlusion and a normalization of the range of motion of the hyperflexed and hyperextended prokinetic joints.

Surgical procedure

A variety of acrylic products can be used for this procedure. A functional cap, extending from the cere distally, and encompassing the pressure bearing keratin at the occlusal ledge of the upper mandible is progressively structured. The prosthesis is structured to duplicate and exaggerate the relative dimensions of a normal upper mandible, so that the bird can function normally when it is applied. The lower mandible must not be able to extend out and beyond this prosthesis, and the tomium of the gnathotheca should be capable of applying normal force at the area of the occlusal ledge of the rhinotheca.

Ramp prosthesis

A ramp prosthesis is used for the surgical correction of scissors beak deformities in some large parrots. The principle on which this method rests is by forming a mechanism that opposing force can be applied against the scissors deformity, from an apparatus affixed to the lower mandible. This procedure is typically used in young birds, as opposed to adults.

Surgical procedure

The first component of this procedure is one of corrective grinding of the pressure bearing keratin of the upper and lower mandibles. The gnathothecal tomium is ground and trimmed in an angle that is opposite the direction of overgrowth seen in a scissors deformity, leaving the highest point on the same side of the scissors deformity. Concurrently, any overgrowth of the occlusal ledge of rhinothecal keratin is ground, in order to enable a more normal force vector delivery.

A wire mesh foundation is then cut and shaped, specifically designed to fit over the entire outer aspect of the lower mandible, and extending upward in a ramp on the same side that the upper mandible is deviated. This wire base is attached to the lower mandible using fine cerclage wires, which are applied by lacing through 22 guage needles that are inserted through the wire and entire lower mandible and into the oral cavity, and then back out a second hole. These wires re lightly twisted tight, enough to hold the wire mesh in place. Layers of acrylics are then placed and hardened in order to produce a functional cap that encompasses the entire outer aspect of the lower mandible, extends up the dental ramp, and wraps along the inside of the lower mandible beneath the tongue. The height of the ramp is designed to be great enough to prevent the upper mandible from extending up and over it. The angle of the ramp is carefully set, to correctively apply enough force to the upper so that the two mandibles are showing normal occlusion when the mandibles are opened and closed. Potential complications from the use of a ramp prosthesis include the development of abnormal lower mandibular alignment at the quadrates, fractures of the delicate mandibular wall in young birds, or mechanical damage to the prosthesis caused by the bird's own behaviors.

Surgical approach to the infraorbital sinus, jugal arch and pterygoid

The body of the infraorbital sinus is a large and spacious triangular cavity under the skin in the lateral region of the upper mandible, and rostroventral to the eye. The inner walls of this sinus cavity consist entirely of soft tissues, primarily the muscles of mandibular kinesis. The lumen of the sinus has two exits, both of which are situated in the dorsal walls of the sinus. Infectious or neoplastic disorders may necessitate surgical access to this area, in order to identify the agent(s) or processes involved, and surgically address them. In addition, surgical access to the infraorbital sinus can offer a window to the jugal arch and the pterygoid bones for the purpose of fracture repair.

Surgical procedure (Anodorhynchus and Ara species)

The skin ventral to the jugal arch is incised, exposing the lateral wall of the sinus. Retract the upper mandible (closing), while extending the lower mandible (opening). This functionally enlarges the sinus space, and enables greater access within. Incise into the infraorbital sinus space ventral to the jugal arch. The infraorbital sinus space can be visually inspected, and magnification loupes with a focal light source, operating microscopy or endoscopy can be used in selected cases for deeper visualization if indicated. Identify and caudoventrally retract the pseudomasseter, pseudotemporalis superficialis and adductor mandibulae, and rostrally retract the ethmomandibularis. The midshaft of the pterygoid will be visualized deep and caudally. Both the jugal arch and the pterygoids are pneumotized and hollow, enabling the potential for fracture repair methods using hexalite shuttle pins and bone cement. Closure of the surgical site is accomplished in two layers: the lateral wall of the infraorbital sinus and the skin.

Sinus trephination

Indications for sinus trephination may include the known or suspected presence of neoplasms or specific infections localized in the sinus cavities beneath cancellous bone of the skull. The more common areas where trephination may be performed include the dorsal aspect of the frontal bone, caudal to the nasal-frontal hinge, and the maxillary bone of the upper mandible. Maxillary trephination allows surgical access to the nasal diverticulum of the frontal sinus. When trephining into the frontal bone, care needs to be taken in order to avoid injury to the eyes or the orbits.

Surgical procedure

After making a skin incision, holes are drilled into the frontal bone about ½ to 2/5 the distance from the rostral most plane of the eye to the naris. Cortical bone is removed until the cancellous bone above the supraorbital sinus is visualized. Drilling continues into the sinus, widening the hole to an appropriate diameter. Following the collection of appropriate samples for diagnostic investigation and the remainder of the surgical procedure, the sinus is irrigated. Flush should enter the oral cavity following sinus flushing to confirm proper hole placement.

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