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## **Do the upper lateral nasal cartilages exist? The concept of septolateral cartilages**

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## Abstract

**Background:** In the cartilaginous nose, classical surgical anatomy describes 2 triangular upper lateral cartilages (ULCs) framing the lateral sides of the mid-third of the nasal pyramid, which articulate with the superior edge of the quadrangular cartilage (QC) of the nasal septum. This anatomic arrangement in 3 distinct cartilage parts is, however, controversial.

**Objective:** The present study aimed to describe the articulation between the ULCs and the QC, avoiding dissection artefacts.

**Materials and methods:** Six nasal pyramids were taken in monobloc from fresh cadavers and imaged on micro-MRI with 0.4 mm slice thickness. Images were interpreted jointly by 2 head and neck surgeons and a radiologist.

**Results:** The cartilage skeleton supporting the mid-third of the nasal dorsum in all specimens presented as 2 septal plates backing onto the midline and curving on either side to form a continuous dome under the inferior aspect of the piriform aperture.

**Conclusion:** Like the alar cartilages framing the tip of the nose, there are two continuous septolateral cartilages (SLCs) framing the mid-third of the nasal pyramid, likewise showing 2 cruras, medial and lateral, joined in a dome. The SLCs (also known as triangular cartilages) thus cannot be separated as 2 individual anatomic structures. These findings are in line with the shared embryological origin of all the elements composing the fibrocartilaginous nose in evo-devo theory.

## Key-words

Rhinoplasty, septoplasty, nasal cartilage, internal nasal valve

## **Introduction**

Surgical anatomy of the cartilaginous nose classically describes 2 alar or lower lateral cartilages (LLCs) more or less completely encircling the nostrils, and 2 triangular upper lateral cartilages (ULCs) framing the lateral sides of the mid-third of the nasal pyramid at the superior edge of the quadrangular cartilage (QC) of the septum [1-4].

The embryological development of these cartilage parts is not known [5], and their inter-articulations are unclear [3, 6]. Current anatomy textbooks and surgical technique descriptions, including recent publications, roughly reproduce centuries-old anatomic drawings (Figure 1).

Surgical correction of nasal dorsum kyphosis by resecting its osteocartilaginous convexity and thereby detaching the ULCs from the superior edge of the QC is at risk of an esthetic blemish in the form of an inverted “V”-shaped deformity of the nasal pyramid and, functionally, of iatrogenic nasal obstruction [7, 8].

Understanding nasal pyramid anatomy and in particular the articulation between the bony and the cartilaginous pyramid is fundamental for developing surgical techniques to correct deformities, whether developmental or traumatic.

The aim of the present study was to provide an update on knowledge on the articulation between the ULCs and the QC, using 3D micro-MRI images.

In 1951, Straatsma & Straatsma [6] challenged the classical concept of articulation between 3 parts (superior edge of the QC flanked by 2 triangular cartilages) in supporting the dorsum mid-third. They argued that the ULCs may be continuous with the septal cartilage in the cranial part and separated from it by a conjunctive interface in the caudal part. This anatomic study was never replicated, but attracted our attention as it is in line with evo-devo theory of nasal development.

## **Material and Method**

### *Specimens*

Nasal pyramids were removed in monobloc in the anatomy laboratory from frozen fresh cadavers after 48 hours' thawing before sampling). After circumferential incision of soft tissue with a scalpel, the bony pyramid was released from the face ~~by osteotome~~ by means of two basal lateral osteotomies freeing the frontal maxillary apophyses, then two transverse osteotomies separating them from the frontal bone at the root of the nose. The QC was carefully sectioned by scissors along the vomer rail, and the section was prolonged so as to include the adjacent perpendicular ethmoidal plate up to the root of the nose (Figure 2).

Specimens were positioned in a conservation medium of physiological saline solidified by agarose, supplemented with amphotericin B, penicillin and streptomycin to limit the development of microorganisms liable to cause tissue damage. Specimens, included in the medium in liquid phase, solidified after 24h in a cold room.

One nasal pyramid was dissected in the anatomy laboratory on a complete head to allow radio-anatomic comparison at the end of the micro-MRI study.

Studies on anonymous donated specimens do not require review board approval in our institution.

#### *Imaging technique*

Images were acquired on a 3T MR scanner (Magnetom Prisma; Siemens Healthcare GmbH, Germany) with an 8-channel array coil originally developed for small animals (8 Channel Array Rat, Rapibiomed GmbH). A 3D turbo-flash sequence with water excitation was used for all acquisitions, with the following parameters: repetition time: 30 ms; echo time: 11.6 ms; 8 excitations; GRAPPA acceleration factor: 2; matrix: 512 x 512; field of view: 54 x 54 mm<sup>2</sup>; 6/8 partial Fourier acquisition factor in phase; slice thickness: 0.4 mm; tilt angle: 30°. These settings gave resolution of 0.1 x 0.1 x 0.4mm<sup>3</sup>.

#### *Data collection*

Images were jointly interpreted by 2 head and neck surgeons and 1 radiologist, using Object Research System (ORS) Visual software version 1.5.1.1915 (Montreal, Canada). Slices were perpendicular to the dorsum, and systematically read from the tip to the root of the nose.

### **Results**

Six nasal pyramids were harvested and underwent micro-MRI. In all cases, the UCLs and nasal bones could be identified (Figures 3-5).

All 6 specimens showed a cartilaginous nose comprising: 1) a caudal part of a few mm with discontinuity between the superior edge of the septal cartilage and the lateral cartilages, the 3 parts articulating like the ridge of a 2-sided roof (Figure 3); 2) a cranial part of a few cm where the superior edge of the septal cartilage formed an “M”, with the lateral branches in continuity with the quadrangular septal plate at the 2 continuous cartilage domes separated by a furrow of variable depth, but always clearly visible; the septal cartilage showed 2 quadrangular plates joined together in 3 specimens (Figure 4) and a single part in the other 3: the cranial “M” extended to a greater or lesser degree under the nasal bones in the 6 specimens (Figure 5).

A 7<sup>th</sup> nasal pyramid was dissected in the anatomy lab after the micro-MRI study, for radiologic-anatomic comparison (Figure 6). Decorticating the nasal dorsum revealed a septolateral cartilaginous dorsum, centered on a medial furrow, perpendicular to the QC and separating 2 septolateral domes opening out from a caudal ridge, giving an overall “Y” shape. The caudal septolateral ridge was prolonged for several mm by the free superior QC edge. The “M”-shaped cephalic cartilage dorsum extended for several mm under the bony roof of the piriform orifice, from which it could easily be dissected free.

## **Discussion**

The present micro-MRI study of the cartilaginous nasal dorsum confirmed the anatomic findings of Straatsma & Straatsma [6]. The ULCs are not individualized anatomic structures and the cartilaginous dorsum is not formed by articulation between two ULCs and the superior edge of the QC. The study suggests that the cartilaginous dorsum is formed by the junction of two septal cartilage plates, the superior edges of which curve into domes with lateral insertion on the ogival roof of the piriform orifice. Just as the tip of the nose is formed by the junction of two alar cartilages, the dorsum seems to be formed by two continuous septolateral cartilages, arched at their upper edges. Like the alar cartilages, each presents a lateral crura, a dome and a medial crura; whereas the medial crura of the alar cartilages touch while remaining separate, those of the septolateral cartilages are joined or even fused, forming an apparently single cartilage plate: the quadrangular or septal cartilage.

This anatomic concept of the cartilaginous dorsum follows from the embryological development of the cartilaginous nasal pyramid (Figure 7), the classical interpretation of which needs resituating in its evolutionary context.

The first embryological precursors of the nose are the paired symmetrical olfactory placodes that form on the unpaired frontal and medial bud raised by the cephalic end of the neural tube. The olfactory placodes invaginate toward the tube, becoming two olfactory wells the raised edges of which are each bordered at their hemi-circumferences by a medial and a lateral olfactory process (Figure 7a). The two medial processes fuse to form the intermaxillary process (Figure 7b). Subsequent embryological development is poorly known, and variably interpreted. Classically, the intermaxillary process is said to give rise to the entire cartilaginous nasal dorsum and upper lip philtrum while the lateral olfactory processes form the lateral sides of the nasal pyramid (Figure 7c) [9, 10]. The problem with the classical interpretation is that composite structures as complex as the alar and septolateral cartilages would have multiple embryological origins while the overlapping of the cephalic edges of the septolateral cartilages and the caudal edge of the nasal bones would have a single origin.

A different concept, based on parallelism between embryological development and the evolution of species, provides what should be a more rational account of nasal pyramid anatomy [11, 12]. According to this theory, the intermaxillary process resulting from the junction of the medial olfactory processes penetrates the midface following the invagination of the bottom of the olfactory wells until it meets and joins with the perpendicular plate of the anterior skull-base ethmoid bone. During invagination, each process keeps its primary attachment to the maxillary bud, detaching the apophysis which articulates under the frontal bone. At the same time, invagination continues, bringing the lateral olfactory processes up against the midline, forward of the fused medial olfactory processes, forming the alar cartilages (Figure 7d).

Thus, each olfactory well is framed by an alar and a septolateral cartilage and is held open by their elasticity. Only the septolateral cartilages can fuse at their medial junction so as to form a single septal QC, the dual origin of which, however, can be seen at the superior edge, which is divided and curves on either side toward the original attachment on the internal side of the frontal maxillary apophysis. The nasal bones are bones of the calvaria membrane, filling the upper diastasis between the left and right frontal maxillary apophyses.

A common embryological origin for all elements of the fibrocartilaginous nose is also confirmed by the concept of olfactory fascia [13]. The walls of each olfactory pit differentiate upward as olfactory mucosa lining the ethmoid bone and then in two successive cartilages, one septolateral beginning from the invagination of the medial olfactory process, and the

other alar beginning from the lateral olfactory processes brought into contact with the midline anterior to the septolateral cartilage by the invagination of the blind end of the olfactory pits driven by the olfactory neurons as they establish their cerebral connections. Anatomic dissection shows that the olfactory mucosa remains attached to the cranial end of the septolateral cartilage by fibro-aponeurotic tissue lining the internal side of the piriform orifice and forming an integral part of the olfactory fascia [14]. However, new dissections and micro-MRI studies are needed to determine the anatomy of the junction between the lateral edges of the septolateral and alar cartilages, which may contain sesamoid cartilages and are known as “scroll ligament”.

The anatomic concept of the olfactory nose has practical implications for nasal pyramid surgery. Ablating an osteocartilaginous convexity of the dorsum, as in Joseph’s technique, interrupts the physiological continuity of the septolateral cartilages by resecting their domes. Keeping the olfactory conduits, and notably the internal nasal valve, open is probably directly due to elastic folding of the superior end of the septolateral cartilages. Complete sectioning of the domes thus inevitably results in the lateral sides of the nasal pyramid collapsing like a hammock between the lateral edges of the piriform orifice, which rise up under the skin in an inverted “V”, and the lateral ridges of the alar cartilages, which tilt backward, altering the aspect of the tip of the nose. The sunken lateral sides rest against the nasal septum and can close the internal valve, inducing respiratory discomfort. Ablating an osteocartilaginous convexity of the dorsum, as in Joseph’s technique, thus always necessitates repair, most often by spreader grafting. Collapse of the septolateral dorsum, on the other hand, is prevented by techniques that spare the dorsum, such as those of Cottle [15] and Gola-Saban [16, 17] or disarticulation septorhinoplasty [14].

## **Conclusion**

The present study clarified fibro-cartilaginous nasal pyramid anatomy. The concept of triangular and quadrangular cartilages can be replaced by a concept of septolateral cartilages meeting at the midline, with the superior edges curved under the piriform orifice ogive to maintain internal nasal valve opening. Septolateral, like alar, cartilage anatomy thus presents lateral and medial cruras joined in a dome.



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### **Figure 1: Variant schematizations of septolateral cartilage in textbooks**

a: Gray's drawing [4] presupposes two LNCs (lateral nasal cartilages) articulated at the superior edge of the septum (NB=nasal bones; GAC=grand alar cartilage)

b: Morris's drawing [3] presupposes continuity between two LNCs bridging over the septal cartilage

c: The drawing by Legent et al. [2] presupposes two triangular cartilages articulated basally on the superior edge of the septal cartilage except at the caudal end, where a notch remains

### **Figure 2: Anatomic specimens for micro-MRI study**

#### **Figure 3: Transverse micro-MRI slice of caudal part of cartilaginous dorsum**

The lateral cartilages (LC) articulate with the superior edge of the quadrilateral cartilage (QC), from which they are separated by a thin dark band (arrows) (\* fragment of right alar cartilage)

#### **Figure 4: Transverse micro-MRI slice of cranial part of cartilaginous dorsum**

The septal cartilage comprises two conjoined quadrilateral lateral plates. The two quadrilateral cartilages (QCs) are separated by a dark medial band (black arrow); the superior end forms a plicature in continuity with the lateral cartilage (LC); the two plicated domes are separated by a medial furrow (white arrow)

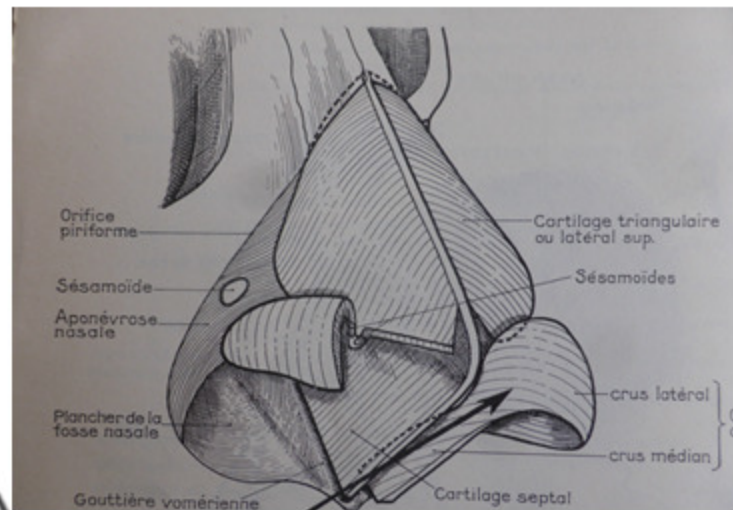
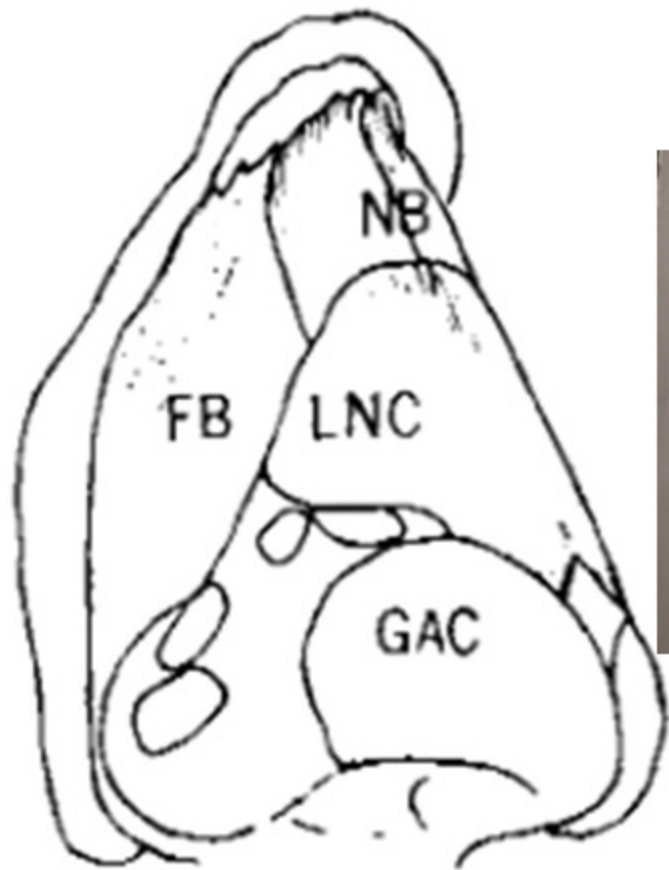
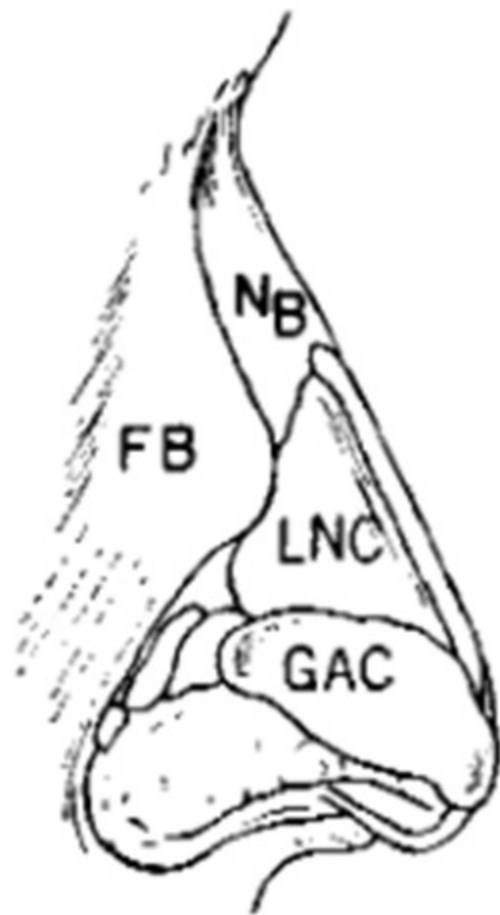
#### **Figure 5: Transverse micro-MRI slice of cartilaginous dorsum through the end of the piriform orifice**

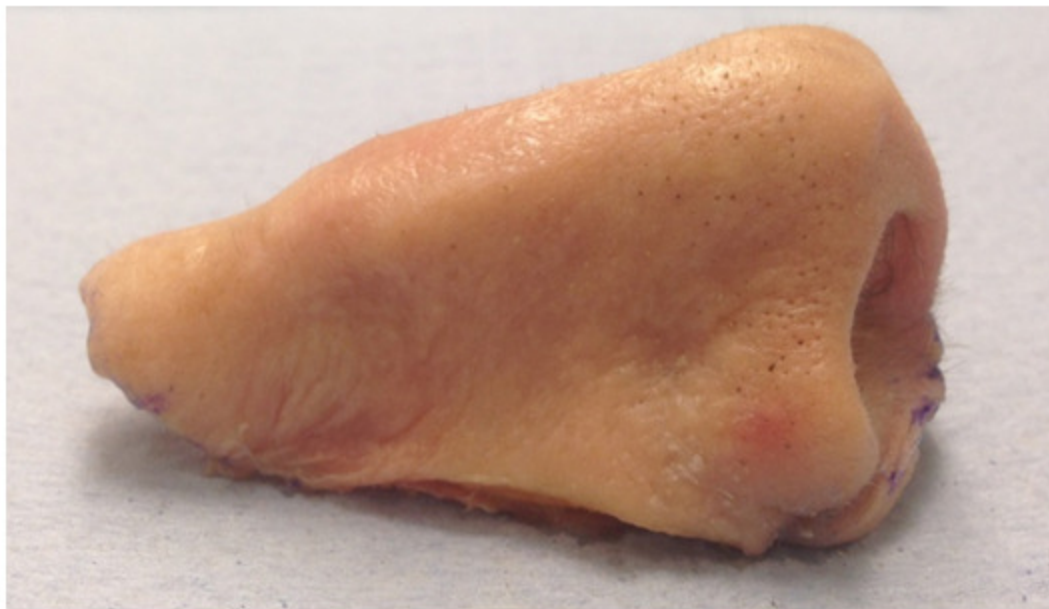
The "M"-shaped cranial part of the cartilaginous dorsum extends under the bony roof of the piriform orifice (NB = nasal bones; QC =quadrilateral cartilage; LC = lateral cartilage; \*=frontal maxillary apophysis)

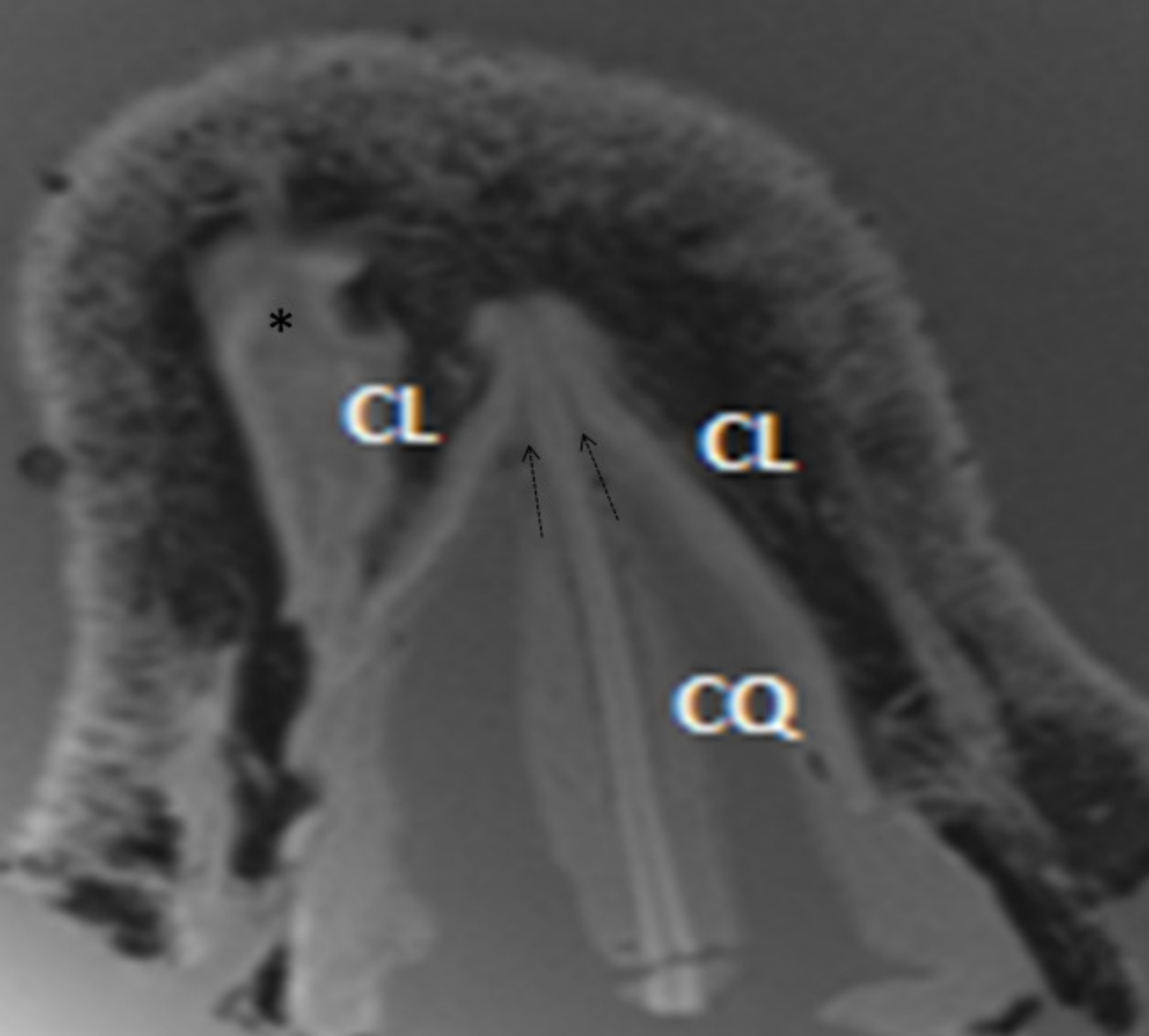
**Figure 6: Decortication of cartilaginous nasal dorsum**

Alar cartilages (\*) separated from septolateral cartilages. Piriform orifice edge cut by bone nibbler (white arrows)

**Figure 7: Embryological development of cartilaginous nasal pyramid according to classical theory and evo-devo theory**





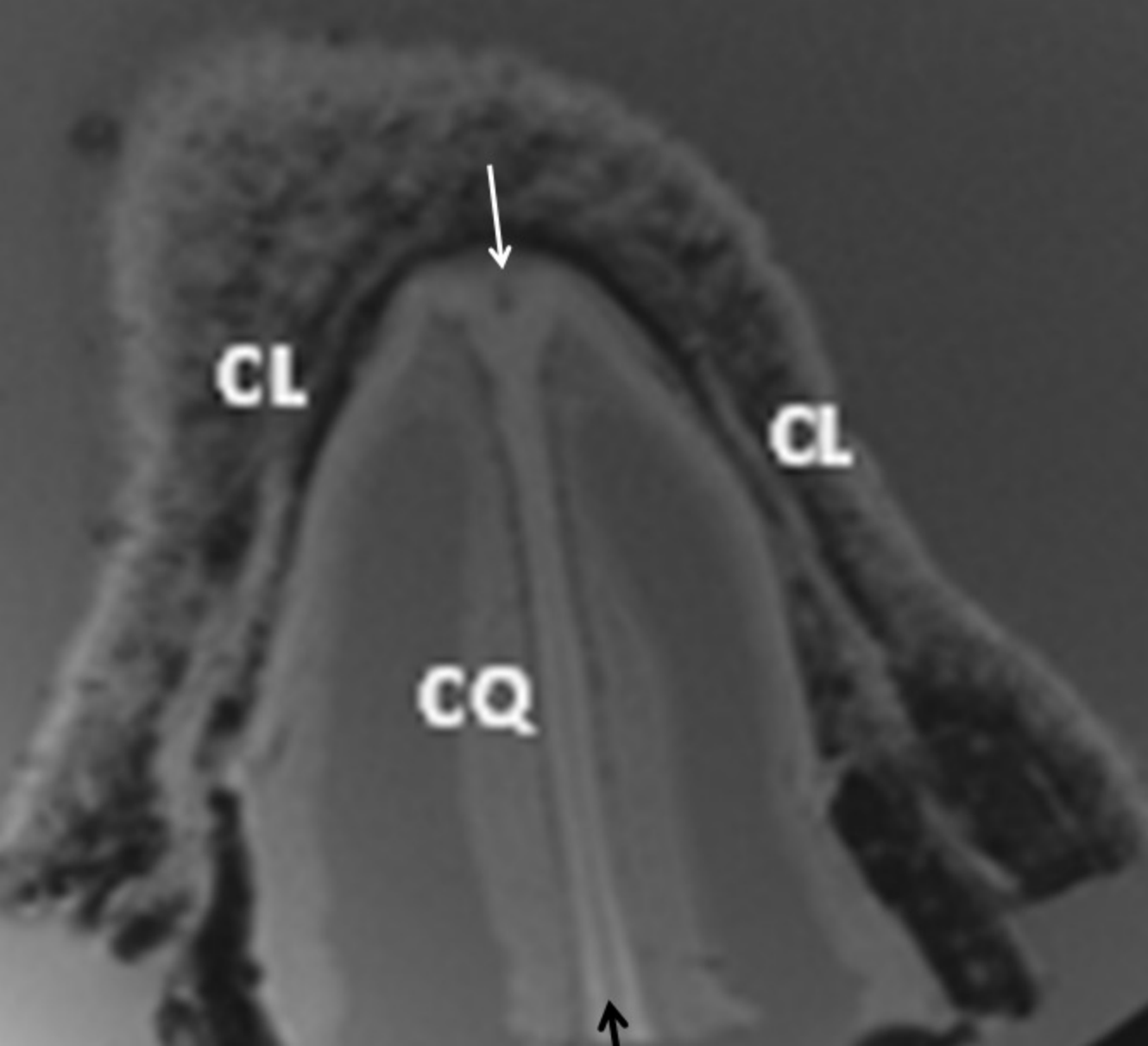


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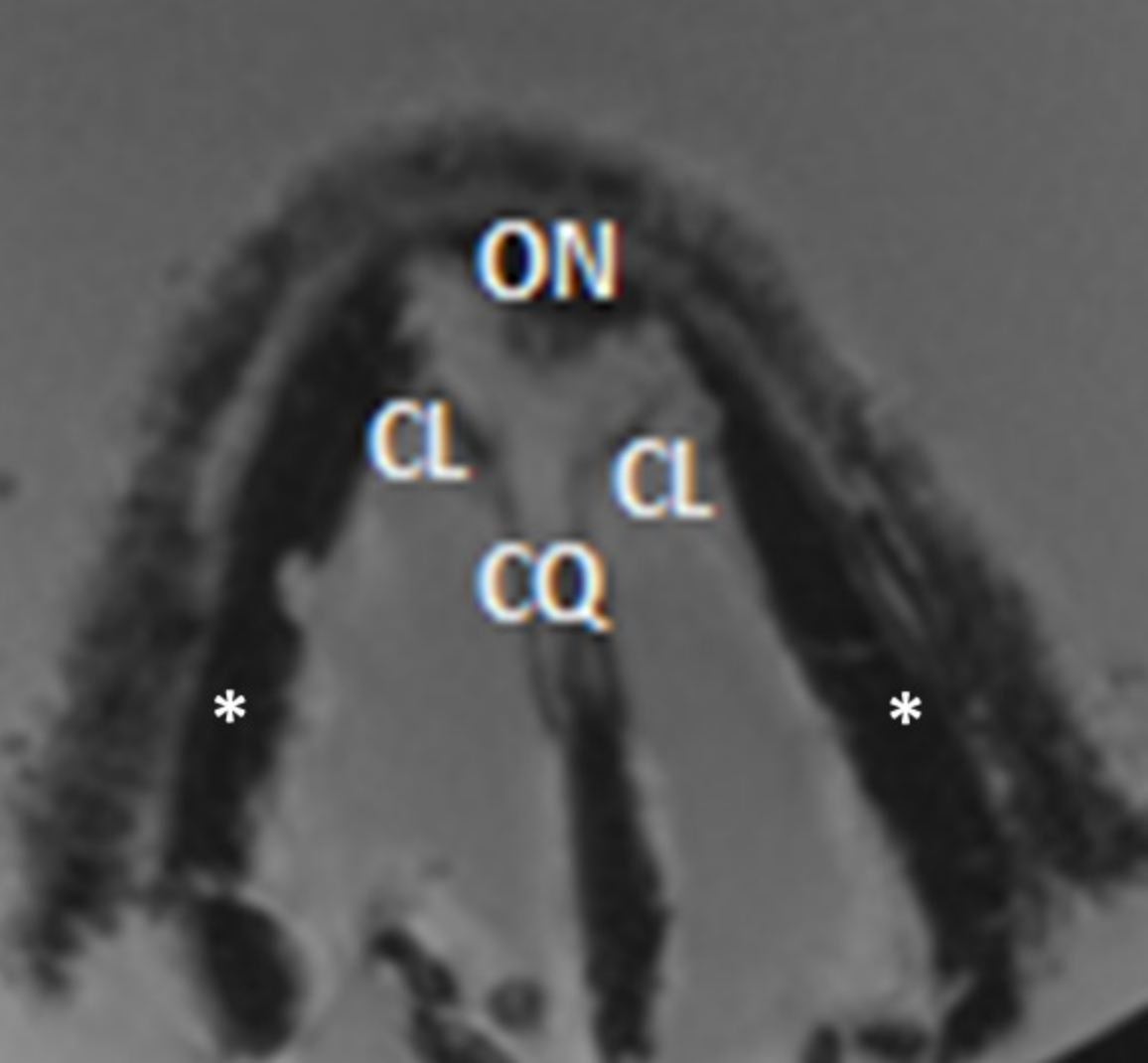
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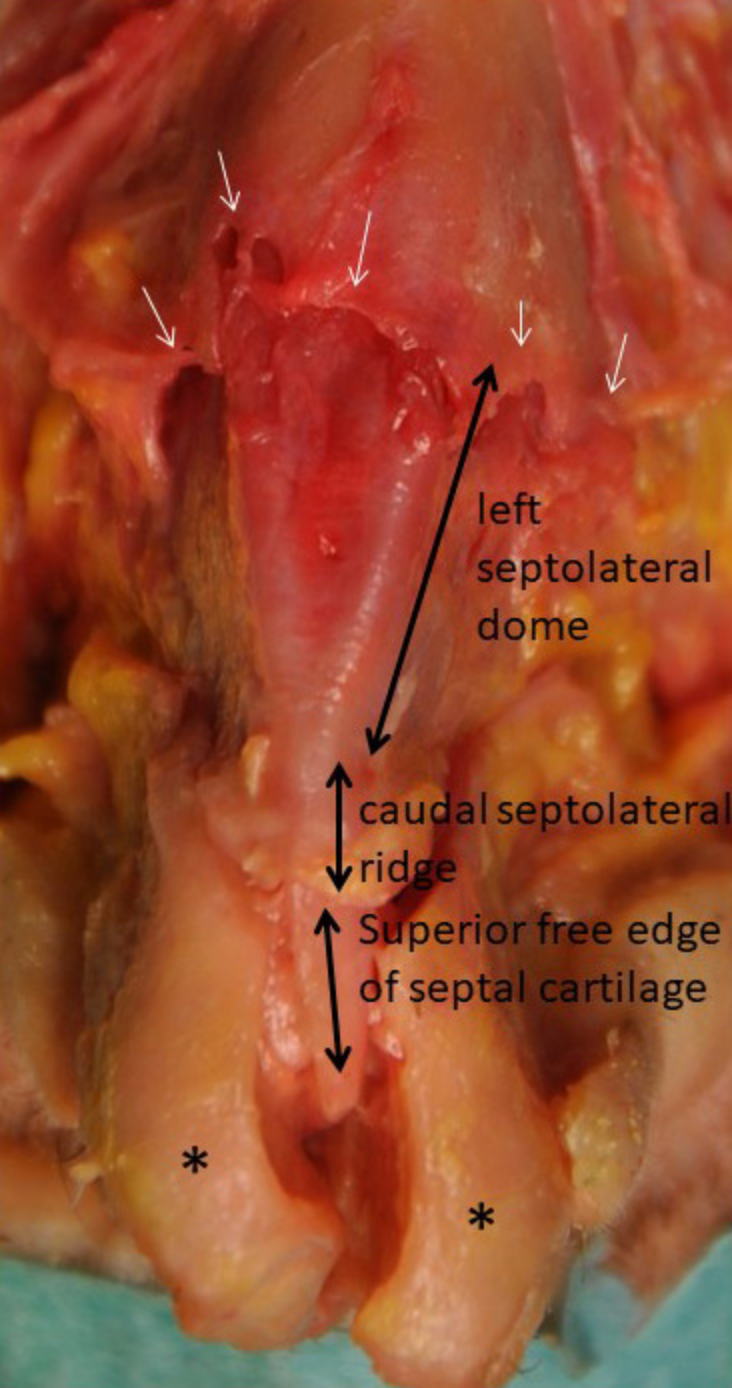
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left  
septolateral  
dome

caudal septolateral  
ridge

Superior free edge  
of septal cartilage

\*

\*

