The Premaxillary-Vomerine Junction: An Anatomic Viewpoint

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In clinical cases of bilateral cleft lip and palate, surgical repositioning of the protruding premaxillary segment has been accomplished through a procedure of resecting the vomer and nasal septum straight up to the roof of the nasal cavity. (*9, 10, 11*) The crux of this procedure is that the resection be made well behind a premaxillary-vomerine epiphyseal line. The existence of such an epiphyseal growth line between the premaxilla and vomer prompts a brief comment from an anatomic or developmental viewpoint.

The present paper is concerned with (1) the anatomic nature of this growth line and, if present, (2) tracing its development. The presence of such a strategically located epiphyseal line would add a new dimension to other reports that the cartilaginous nasal capsule and septum play an important role in pre- and perinatal human facial growth.

Procedures

Forty-two human embryos and fetuses, free from macroscopic facial defects, were studied. The sample had an age distribution from approximately seven (18 mm crown-rump length) through sixteen weeks (135 mm C-R length). This distribution was chosen to represent the embryonic period in which the premaxillary-vomerine junction progressively develops from a preskeletal (mesenchyme) to a skeletal (cartilage, bone) unit. Moreover, comments bearing on the association between development of the facial skeleton and either normal or abnormal palatal development might logically be made since the sample also represented palatal development prior to, during and immediately following closure of the palatal shelves.

Specimens were fixed in neutral buffered formalin (10%), paraffin-embedded, sectioned serially, and stained alternately with a trichrome connective tissue (Masson, Mallory) and routine hematoxylin and eosin stains. Embryos were sectioned either in the frontal, transverse or sagittal planes through the face so that the best three-dimensional view of the

This research was supported, in part, by General Research Support Grant 5S01-RR 0538-10, National Institutes of Health.

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premaxillary-vomerine junction could be attained. In every case, the complete set of serial sections for each embryo was read with routine light microscopy.

Results

Specific comment on the premaxillary-vomerine junction might more effectively be made within the framework of the developing skeletal tissues around the junction. The following observations can logically be broken down into prechondral and chondral stages of nasal capsular (including septum) development. As might be expected, skeletal formation conformed to no clear-cut age limits but, instead, to a gradation in development fitting the observed age groupings. Superimposed upon the development of the cartilaginous facial skeleton was a progressive onset and enlargement of ossification centers for the membranous facial bones.

Embryos of the estimated 6.5–7.5 week (fertilization age) group (18–24 mm C-R length) showed progressively darker-staining condensations of mesenchyme which clearly marked the locations of the future nasal capsule, including its roof, lateral wings, septum and related minor cartilages. Skeletal development of the lower jaw, by comparison, was relatively more advanced at this stage, as evidenced by the appearance of distinct chondrocytes of Meckel's cartilage. Progressing toward the 24 mm embryos of this group, a definite temporal synchrony in development was observed between the chondrification of the nasal septum and two paraseptal cartilages flanking its inferior edge.

In older embryos (24 mm C-R length and longer) chondrification of the septal cartilage followed anteroposterior and superoinferior gradients. Inferior to the most anterior position of the septum, centers for the two paraseptal cartilages appeared, in frontal sections, as elongate cartilaginous masses extending from the premaxilla (primary palate) diagonally upward and posteriorly on each side of the lower edge of the cartilaginous septum. It is important to note that, when in the premaxillary field, both the right and left paraseptal cartilages, or their dense-staining mesenchymal anlage, interlocked with the upper limits of the mesenchymal masses which subsequently formed the nasal surface of the premaxillary bone. In other words, the paraseptal cartilages were situated chiefly above the plane of the palate. As the paraseptal cartilages "moved" diagonally upward and posteriorly toward Jacobson's vomeronasal organ, their superior poles were medially-inclined and each of the cartilages was in a septal field. This septal field, along the inferior edge of the cartilaginous nasal septum, was defined by an extension of septal perichondrium which flowed downward from both sides of the septum to wrap over the lateral faces of each paraseptal cartilage. The septal-paraseptal perichondrium of one side was continuous with that of the other side in an inferiorly convex line. This arrangement of septal perichondrium significantly increased the height of the septal cartilage field by adding approximately ten percent of septal height as condensed connective tissue cells. In three-dimensional reconstructions, this sleeve-like extension of the perichondrium also appeared to form a diagonal tract or trough housing the two paraseptal cartilages in a direct line from the anterior nasal spine upward to the right and left vomeronasal organs. Each organ typically was situated along a line perpendicular to the palate through crista galli. In older embryos and fetuses, with progressive ossification of the facial skeleton, the vomerine centers appeared immediately posterior to the junction between the primary and secondary palates, i.e., incisive canal. The primary and secondary segments of the hard palate were joined by a relatively vertical zone having all five fibrous layers of a typical suture. No cartilage was observed in the suture.

The vomerine bone at 27 mm C-R length appeared as a single ossification center within the septal field inferior to the cartilaginous nasal septum between the posterior tips of paraseptal cartilages on either side of midline. The two ossification centers progressively united (at approximately 40 mm C-R length), in part, to form an elongate, U-shaped trough when seen in a frontal section. At approximately 65 mm C-R length the anterior end of the vomer overlapped the posterior ends of the paraseptal cartilages in the region immediately below the vomeronasal organs. The vomer continued to increase in length and to change shape so that by 100 mm C-R length a frontal section through the bone assumed a Y-shape. With coalescence of both halves of the vomerine ossification centers, the beginnings of a fibrous type articulation between the vomer and hard palate was easily detected. Again, no evidence of a cartilaginous joint, e.g., epiphysis, synchondrosis, was observed at the premaxillary-vomerine junction in the entire series.

Throughout the entire group of embryos observed, from seven through sixteen weeks, and especially with increasing embryo size, cartilage observed adjacent to the premaxillary-vomerine area was clearly derived from the nasal capsule. In a true sagittal section, the cartilaginous nasal septum extended down from the anterior cranial base to end in the mesenchyme and connective tissue immediately above the nasal surface of the palate. Reading each serial section lateral to the midline nasal septum, a small, elongate bar of cartilage did appear above the primary palate near the anterior nasal spine and extended to the area of the vomeronasal organ (Figures 1a, 1b). These bars, on the right and left sides, were interpreted as the paraseptal cartilages. And, depending on the orientation of the serial section being observed, the cartilage could have been easily identified in a position between the vomer and primary palate (Figure 1c). The same developmental history of the paraseptal cartilages and premaxillary-vomerine junction was observed in embryos sectioned frontally and transversely.

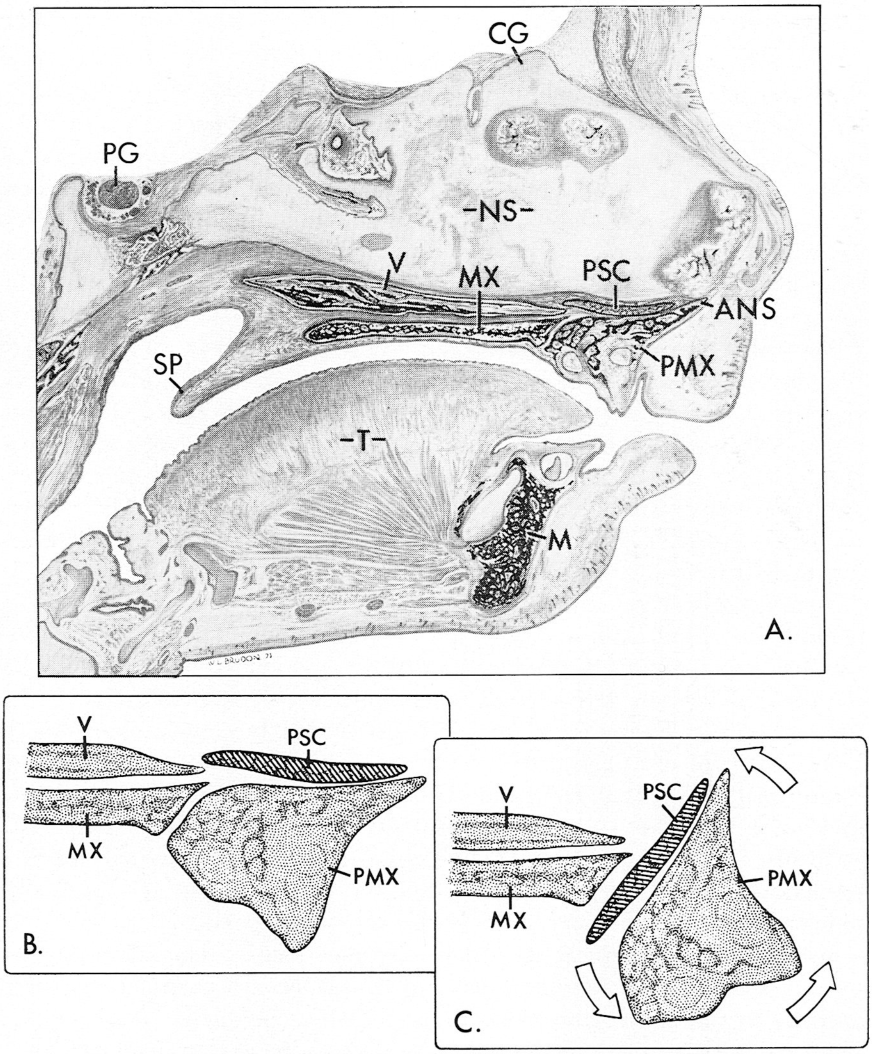

FIGURE 1a. The pertinent anatomy of the premaxillary-vomerine junction is shown in this drawing from a sagittally-sectioned 135 mm C-R length (est. 17.5 wks.) human fetus showing no facial clefts.

FIGURE 1b. An enlarged schematic representation of the skeletal components and their geographic relations based on the normal anatomy of *Figure* 1a.

FIGURE 1c. Schematically shows how the geographic relations of the structures seen in *Figure* 1b might be changed with the abnormal rotation of the premaxilla (counter-clockwise) in individuals with complete clefts of the lip and palate. Note in *Figure* 1c the repositioning of the paraseptal cartilage mass into the premaxillary-vomerine junction.

ANATOMICAL KEY: Pituitary gland (PG), crista galli (CG), nasal septum (NS), soft palate (SP), vomerine bone (V), paraseptal cartilage (PSC), premaxilla or primary palate (PMX), palatal processes of maxilla or secondary palate (MX), tongue (T), anterior nasal spine (ANS), mandible (M).

Discussion

The role of the embryonic nasal capsule in the normal and abnormal development of the face has been a subject of considerable attention. (*2, 12, 13, 14, 15*) In almost every case, emphasis has been placed on the role of the growing nasal septum in providing the almost mechanical thrust carrying the face downward and forward from the cranial floor. Recently, and in the context of a surgical procedure recessing the anteriorly-displaced premaxilla in cleft palates, still another growth site has been identified as the cartilaginous joint, or epiphyseal line, between the premaxilla and vomer. (*9, 10, 11*)

Several observations made in the present study appear relevant in explaining the existence and developmental nature of the reported epiphyseal line between the premaxilla (primary palate) and vomer. First, systematic examination of serially-sectioned human fetuses (section by section) clearly showed progressive stages in the development of a fibrous suture at the overlapping premaxillary-vomerine junction. Throughout the entire study, there was no evidence of a cartilaginous epiphysis linking these two bones. The obvious discrepancy concerning the existence or nonexistence of a premaxillary-vomerine epiphysis is not without some explanation. First, Monroe (*9*) appears to have based the existence of a cartilaginous epiphyseal line primarily on its appearance in a single parasagittal section derived from a newborn with complete clefts of the lip and palate. Examination of his figure 2 clearly shows a diagonally placed strip of cartilage between the premaxilla and vomer. This same figure also shows that the premaxilla was abnormally rotated upward and out (clockwise) so that the nasal surface of the premaxilla and the strip of cartilage, referred to above, appear situated in the overlapping premaxillary-vomerine junction. Location of this cartilage normally along the nasal surface may well be the key observation.

In this study of fetuses with normally positioned premaxillae, appropriate parasagittal histological sections also showed a cartilaginous strip parallel to the nasal surface of the premaxillary segment of the palate. However, serial tracing of this cartilage, section by section, from the midline laterally, revealed that the cartilage arose from the superior (nasal) border of the premaxillary field immediately off the midline, and extended upward toward the vomeronasal organ following a path which clearly bypassed the limited, but overlapping, zone between the premaxilla and vomer. Additionally, reading of sections through the entire head demonstrated that these cartilages were paired. These observations fit well with the classical descriptions of the developing human skull including the paraseptal cartilages. (*3, 4, 5, 6, 7, 8*) Phylogenetically, the paraseptal cartilages are prominent parts of the chondrocranium and are relatively long lasting skeletal elements in animals with functional vomeronasal sensory organs. However, after having a prominent period in human prenatal development, these same cartilages progressively assume a vestigial character and disappear in the first years of life. These observations suggested that the premaxillary-vomerine epiphyseal line reported by Monroe may be in reality a section through a paraseptal cartilage and that the position shown for the cartilage may be atypical due to the abnormal rotation of the premaxilla in cases of cleft lip and palate.

Whether these paraseptal cartilages have an epiphyseal function in facial growth, as suggested by Monroe, is without supportive data. On the other hand, that anatomical abnormalities of these cartilages are associated, but probably not causally, with early stages of human palatal clefting and defective development of the nasal capsule, including the septum and paraseptal cartilages, has been shown in studies of early skeletal development in normal and cleft lip/palate human embryos. (*1*) The observations of Avery and co-workers coincide well with the atypical arrangement of the small cartilage islands shown in Monroe's coronal sections through a clefted newborn jaw, with the provision that the small islands of the cartilage observed by Monroe between the premaxilla, septum and vomer are considered paraseptal cartilages.

Summary

Based on a systematic study of forty-two serially sectioned human fetuses, it appears that the premaxillary-vomerine junction is that of a typical fibrous joint rather than a cartilaginous epiphyseal line. The basis for the reported premaxillary-vomerine epiphysis seems to have arisen from observing, in a single parasagittal section, a cartilaginous island which had been rotated into that bony junction with the abnormal rotation of the premaxilla upward and out in a case of complete clefts of the lip and palate. A similar cartilage was identified in the present study as a paraseptal cartilage whose normal orientation is upward from the premaxilla toward the nasal septum rather than abnormally downward and posteriorly toward the premaxillary-vomerine junction. Although the existence of a premaxillary-vomerine epiphysis could not be confirmed as a typical structure of the developing human craniofacial skeleton, this observation, in itself, obviously does not preclude the possibility of cartilage developing in the area as either primary or secondary responses to a cleft in the area.

References

1. Avery, J. K., Happle, J. D., and French, W. C., Development of the nasal capsule in normal and cleft formation. *Cleft Palate Bull.*, *7:* 8, 1957.
2. Babula, W. J., Jr., Smiley, G. R., and Dixon, A. D., The role of the cartilaginous nasal septum in midfacial growth. *Amer. J. Orthodont.*, *58:* 250–263, 1970.
3. Bardeen, C. R., The development of the skeleton and of the connective tissues. In: Manual of Human Embryology, Edited by F. Keibel and F. P. Mall, J. B. Lippincott Co., Philadelphia, 292–453, 1910.
4. DeBeer, G. R., The Development of the Vertebrate Skull. Oxford University Press, Oxford. 552 pp, 1937.
5. Keith, A., Human Embryology and Morphology, 5th Edition. William Wood and Co., Baltimore, 182–206, 1933.

6. Kernan, J. D., Jr., The chondrocranium of a 20 mm human embryo. *J. Morphol., 27:* 605–645, 1916.
7. Lewis, W. H., The cartilaginous skull of a human embryo twenty-one millimeters in length. Contrib. Embryol. (Carnegie Instit., Washington), *9:* 299–324, 1920.
8. Macklin, C. C., The skull of a human fetus of 40 mm. *Amer. J. Anat., 16:* 317–426, 1914.
9. Monroe, C. W., The surgical factors influencing bone growth, in the middle third of the upper jaw in cleft palate. *Plast. Reconstr. Surg., 24:* 481–497, 1959.
10. Monroe, C. W., Recession of the premaxilla in bilateral cleft lip and palate, a follow-up study. *Plast. Reconstr. Surg., 35:* 512–530, 1965.
11. Monroe, C. W., Griffith, B. H., McKinney, P., Rosenstein, S. W., and Jacobson, B. N., Surgical recession of the premaxilla and its effect on maxillary growth in patients with bilateral clefts. *Cleft Palate J., 7:* 784–793, 1970.
12. Moss, M. L. and Bromberg, B., The passive role of nasal septal cartilage in mid-facial growth. *Plast. Reconstr. Surg., 41:* 536–542, 1968.
13. Salinger, S., The nasal septum: Some observations on its relationship to palatal deformities. *Brit. J. Plast. Surg., 5:* 129–137, 1952.
14. Sarnat, B. G. and Wexler, M. R., Growth of the face and jaws after resection of the septal cartilage in the rabbit. *Amer. J. Anat., 18:* 755–768, 1966.
15. Scott, J. H., The cartilage of the nasal septum. *Brit. Dent. J., 95:* 37–44, 1953.