SOME RELATIONSHIPS BETWEEN EMBRYOLOGY AND SURGERY OF THE NOSE

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Every animal starts life as a tiny bit of plasma weighing about 5/1000 of a milligram. This little piece of living tissue multiplies over a million times during the first several weeks of life under the direction of the deoxyribonucleic acid or DNA. It is well known that animal and human sperms can be preserved for future use, and it is now possible to use the deep freeze technique to preserve the unfertilized human ovum outside the mother for later fertilization.

After the ova is fertilized the cells divide and redivide to form the morula stage which consists of a solid group of cells which looks like a mulberry. The cells continue to multiply to form the blastula stage which is a hollow ball of growing cells. The ball then invaginates to form the gastula stage giving the ectoderm and entoderm layers, and soon the mesoderm begins to form between the two layers. The embryo begins to lengthen or have axial growth, and down the center of the back of the developing embryo there is an invagination of tissue which later becomes the central nervous system. The frontonasal eminence of the embryo has areas of specialized epithelialization in the ectoderm and the first of these to appear is the primary ectodermal tissue which will become the nose. The olfactory placode develops on the nasofrontal process just above the stomodeal region during the third embryonal week. This is almost the same time as the placode for the eye and the placode for the ear appear. The tissue around the olfactory placode enlarges to form a horseshoe shaped elevation, open orally, and due to localized proliferation of the mesenchymal tissues deep within the placodes, where is a rapid increase in the size of the medial and lateral elevations which now become known as the medial and lateral nasal processes. About the sixth week the maxillary process begins to migrate forward from posteriorally and laterally. It meets and fuses with the lateral nasal process, also called the glabellar process, then it progresses a little further to join and fuse with the medial nasal process, and finally it grows completely to the midline to fuse with the equivalent from the other side, and, thereby, seal off the bottom of both the horseshoe openings. This makes two complete anterior nostrils with a primitive septum in between at about the sixth and one-half week of development. Very soon afterwards the nasal process posteriorly ruptures through forming the primitive posterior choana, which is the nose arrangement of the frog.

At about the seventh week the tecto-septal membrane, which is formed in maxillary mesoderm, grows mesially underneath the ectoderm of the stomo-

deum and the tecto-septal membrane meets its fellow of the opposite side and forms the rudiment of the septum in the midline of the roof of the mouth. Also in the seventh week the palatal processes develop from the maxilla. Early in their development they lie alonside the lateral margins of the tongue. Accelerated growth on the lateral margins causes the processes to grow toward the midline where they join and fuse with the lower border of the nasal septum. The incisive foramen marks the point where the maxillary elements of the hard palate join the premaxilla elements of the hard palate.
The cartilagenous nasal capsule is formed by condrification of paraxial and maxillary mesoderm. The cartilage forms in the midline septal area and also in the lateral nasal wall area. Condrification begins low and anteriorly, and progresses upward and backward. Early in embryonic development the mesial and lateral cartilage elements form a complete cartilage capsule around the nasal chambers. Keith (1948) calls this nasal cartilage capsule the "core of the face".

Growth of the head and face is generally a regular and continuous process with the greatest increase in size occurring in the first three years of life. Between the third and tenth years the increase is relatively less rapid and growth rate decreases markedly after that. There are several different kinds of bone in the face and skull, and these bones grow by several different methods. One method of growth is at the suture lines. At each suture line there are two growth centers, one for each bony unit. These are independent of each other in their growth, and one may grow faster than the other. Another method of bone growth is the appearance of an ossification center within the chondrocranial cartilage. Growth is by replacement of cartilage as occurs in a typical long bone with an epiphysial plate. Growth also occurs by surface deposition of bone independent of underlying structures. The deposition and resorption process is important in the later shaping of the face where functional factors play more of a role in contrast to early development where genetic factors guided the development. An example of functional factor effect is the increased density of the facial cancellous bone occurring in puberty at the time of increased development and functional activity of the muscles of mastication.
The external nose grows in a consistent downward and forward direction to age eighteen. The growth of soft tissues of the external nose is directly related to the growth of the nasal bones. Growth is accelerated up to age three and is slower but constant from that time forward for most girls. The majority of boys have a spurt of growth centering around the thirteenth or fourteen year age, and a few girls will have a spurt of growth about twelve years of age. During the time of accelerated growth the nasal bone tends to project or incline in a more forward direction creating an elevation of the profile or a hump.
The nasal bone begins to develop at the eighth week of embryonic life, and it continues to enlarge for years. The source of the ossification of this bone is just below the area which later will be the junction of the frontal bone with the nasal bone. The ossification center is in the pericondrium, and this is an example of ectochondral bone formation. The bone forms in the perichondrium and lies on top of the cartilage. The cartilage remains underneath the bone to some degree for your entire life. When you are born

you have the cartilagenous core of your face, and your nasal bones are on top of, or external to, the cartilage capsule. Absorption of cartilage from underneath the nasal bones begins after the first year of life. Absorption starts under the nasale and progresses distally. The nasal bones in the adult are well defined, and the cartilage has been absorbed almost completely from underneath the bones. The amount of cartilage remaining underneath the distal portion of the nasal bones is variable. In the adult there usually is about three millimeters of overlap, but it is not unusual for the cartilage to extend up to half the length of the nasal bones.
In children the amount of absorption of the underlying cartilage is quite variable, and when dealing with the nasal injury of a child the rhinologist should consider that he is dealing with, essentially, a cartilagenous structure. The small nasal bones can be repositioned over the partially resorbed cartilage vault.

There is a common finding in the X-ray views of relatively minor nasal injury. The distal portion of the nasal bone is broken off but remains in good position. The anatomy of the region implies that the bone fragment was pushed back into position by the spring of the underlying cartilage. Another point to remember in regard to nasal injury repair and rhinoplasty repair is that the attachment between the nasal bone and the underlying cartilage is not a strong attachment. Blood and secretions may relatively easily dissect between the bone and the cartilage to separate them. Postoperatively when the fluid has absorbed, the straight contour of the dorsum may be marred by a step-off at the end of the nasal bone. To guard against this occurrence the intra-nasal pack should be placed firmly underneath the cartilage vault to elevate it against the underside of the nasal bones.

A number of skulls in the anatomical laboratory were photographed and studied. The nasal bones showed great variation in length, width, thickness, and proportion of the external bony vault which they made up. Pictures in texts show other developmental anomalies. In one skull the nasal processes of the maxilla extended to the midline, with complete absence of the nasal bone. In another skull the nasal processes of the maxilla did not meet, but had the perpendicular plate of the ethmoid between them at the dorsum. In another skull there was unequal development of nasal bones with a tertiary nasal bone indicating a third ossification center. May I cite the case of one of my patients who had a large, long, humped nose, and the X-ray showed that he had no nasal bones at all!
The relationship of this bit of embryology to our surgery is that the surgeon should know what makes up the nose; he should know where it came from; and he should know possibilities of disturbed development and patterns of growth to give him a plan of surgical solution of the problem.
The vomer bone is an ectochondral bone and develops in the same way as the ectochondral nasal bones. There are ossification centers on both sides of the primitive cartilage septum in the pericondrium of the septum. The ossification begins very far posteriorly, about halfway up the posterior border of the septum, and continues forward and downward and at birth there are two plates of bone with a small plate of cartilage between them. The two plates of bone gradually thicken and the cartilage between them is

absorbed. This anatomical situation can continue up until the age of six years. However, on one occasion I operated on a nose and found this condition in an adult, indicating early arrested development which produced the situation in an adult which should have been present in a person under the age of six.
The ossification of the ethmoid bone occurs by the process of direct replacement of the cartilage by bone. The ethmoid complex begins to ossify laterally in the area of the sinuses and turbinates during the fifth fetal month. The ossification continues in the sinus area and progresses across the upper nasal vault into the cribriform plate area. The cribriform plate is fibrous at birth, and it is not ossified until well into the first year. The ossification of the perpendicular plate of the ethmoid occurs either from continuation of ossification of the cribriform plate, or from a separate center of ossification which is high and posterior in the prependicular plate area. This development continues, I think, for almost all of a persons life. It has been experienced by all of your septal surgeons that the older the patient you operate on, the smaller the quadrangular cartilage. The quadrangular cartilage gets smaller and smaller, in general, as the patient gets older and older, and this is due to the continuing ossification of the perpendicular plate at the sacrifice of size of the quadrangular cartilage. Mosier demonstrated that at birth the septum is completely made up of cartilage except for the small plates of vomer bone external to the cartilage low on the septum. The adult septum has a small quadrangular cartilage distal to the perpendicular plate of the ethmoid. Often in a teenager you will find cartilage continues back to the face of the sphenoid. The tongue of cartilage between the vomer and the perpendicular plate is of varying lengths and widths in different cadavers depending upon the age of the cadaver when he died. The clinical application of this information about the development of the perpendicular plate is that the rhinologist should avoid surgical trauma to the upper posterior portion of the septum in children in order not to effect the ossification center.

The premaxilla is a peculiarly shaped bone which contributes to the hard palate, anterior alvoelus, and the septum. The premaxilla is a small bone in the newborn and it remains small and contributes very little to the septum until the patient is about six years old. It contributes to the palate by forming the posterior portion of the sockets of the upper incisor teeth. When the permanent incisor teeth develop and erupt at six years of age there is an increase in the size of the body of the premaxilla and a tremendous increase in the size of the wing or the perpendicular portion of the premaxilla. The premaxilla contributes much more to the adult septum than the very small perpendicular portion of the premaxilla contributes to the infant septum. An injury to any part of the premaxilla may be reflected in maldevelopment or malpositioning of the incisor teeth, or in maldevelopment of the septal portion of the premaxilla, or both.
The area of the maxillary spine and pyriform aperature shows evidence of increasing maturation and differential development. This can be seen in a comparison of primates such as the macaque, the gorilla, the Australian aborigine and the white man. Ontological studies of developing humans from birth to adulthood indicate that there is a change comparable to the philogenetic change in the region of the spine and pyriform crest. The six month

old infant has an incompletely developed spine and no pyriform crest, whereas, the white adult normally has a large spine and a definite pyriform crest. It is common to find malformed maxillary spines and malformed or incompletely formed pyriform crests in persons whose noses were injured in childhood. Injury to the premaxilla area is often revealed later in life when development of the upper incisor teeth is defective or out of position. Injury to the body of the premaxilla, which adds mass to the anterior upper jaw and supports the four upper incisor teeth, may effect the development of the teeth, the maxilla, and also the septum. Injury to the perpendicular portion of the premaxilla, which contributes to the substance of the septum, may cause developmental deformities of the septum, the maxilla and the incisor teeth.

The paraseptal cartilage is a minor portion of the nasal cartilage capsule of the developing embryo. The paraseptal cartilage is found on both sides of the septum near the floor of the nose. Zuckerkandl studied this structure, and it was observed and written about as long ago as the early 1700's. The paraseptal cartilage develops from an anterior center and a posterior center and it reaches its greatest size in the four month human embryo after the anterior and posterior elements join. In lower animals the paraseptal cartilage supports Jacobson's organ which is an accessory organ of olfaction. The paraseptal cartilage is quite large in the cat, rabbit, and other animals. In man Jacobson's organ atrophies completely. I have been looking for a Jacobson's organ for years, but never have I seen one.

The eventual fate of the paraseptal cartilage is for the anterior portion of it to fuse to the septal cartilage and become part of the processus lateralis ventralis of the inferior border of the anterior septal cartilage. The posterior portion atrophies and disappears. Occasionally, the rhinologic surgeon will find remnants of paraseptal cartilage within the septal space alongside the lower portion of the septal cartilage or vomer bone.

One of our collegues has reported an infant's nose which had a tremendously thick septum and a very reduced airway. Surgical exploration revealed three distinct cartilages in the septal space. The cartilage on each side of the middle cartilage plate was removed. Apparently, these were overdeveloped anomolous paraseptal cartilages.

Deviations of the septum, in general, come from unequal growth or from trauma. The unequal growth perhaps is due to the stimulating presence of a paraseptal cartilage or an ossified paraseptal cartilage lying alongside the lower septum, especially in the vomer area.

In 1930 Chauncy Wen made a very thorough investigation of primate nasal development. Consider the nose as two simple parallel tubes joined together in the middle with common wall between the two tubes called the septum. The prosimians are the simplest forms of the primate family. They are little monkey-like creatures, and on the nasal cartilage of the prosimian you will find the beginnings of the supra-alar sulcus. This sulcus will divide off the lobular cartilage from the upper lateral cartilage or roof cartilage. The New World platyrrhines go through a similar but more advanced development in that the supra-alar sulcus extends across the tube and almost separates completely the lobular cartilage from the roof cartilage. The separation of the lobular cartilage from the roof cartilage is not complete in the platyrrhines.

In the Old World catarrhines the supra-alar sulcus does completely separate the lobular cartilage from the roof cartilage, but this separation does not occur until the animal reaches adulthood. In the ape family the separation is completed also.

In the developing human embryo we can follow the same stages of phylogeny. In the prosimian stage there is the beginning of the supra-alar sulcus. In the platyrrhine stage there is more extensive, but not complete separation of the lobular cartilage by the supra-alar sulcus. In the catarrhine stage the lobular cartilage is completely separated from the roof cartilage, and this occurs in the white embryo just about two weeks before it occurs in the colored embryo. Infrequently, children are born with evidence of arrested development of the basic nasal tube structures. There may be two parallel tubes or perhaps only one complete tube with the other tube malformed and malpositioned. Maturation of development may cease at any stage of the embryo's growth, and these deformities are present on living babies who deserve a surgeon who understands the origin of their problem.

The dental profession has been very active in working out the embryology and development of the face, especially the jaws and teeth. Dr. Sarnat has been experimenting for over fifteen years using rabbits and monkeys for animal research, and serial X-ray studies of children using the Broadbent cephalometer. One experiment to measure growth at the suture lines was to drill a little hole in the bone and pack it with dental amalgram. This was done on each side of the many suture lines of the facial bones, e.g., nasofrontal, nasomaxillary, zygomaticomaxillary. The metal amalgam was accurately placed and measured on the speciman. Standardized X-rays were made at regular time intervals as the animals grew. This was an interesting study, but, unfortunately, it did not prove very much except that there are areas of relative growth at various times between the different bones of the face.

Another of Dr. Sarnat's experiments was to remove the junction of the frontal bone with the nasal bone of a rabbit. This is the area which he had found was the area of greatest growth in the bones. Later he sacrificed the animal and found the removal of this area not only did not inhibit growth, but the extirpated area was increased in size. In other words, the factors of growth were such that growth continued in spite of the fact that the suture lines had been eliminated. Suture lines are considered to be the growth centers of the face bones. In another experiment Dr. Sarnat removed half of the hard palate, and the end result was that the development of the palate and upper teeth was practically uninfluenced. He then operated on the condyle or the jaw joint of the animals and found that this had a terrific effect on the development of other facial structures. The zygoma was not well developed. The maxilla was much less developed on the operated side than on the unoperated side and the occlusion of the teeth and many other things were effected. The symmetry of the pyriform aperture was disturbed.

Then with Dr. Manual Wexler he performed a most interesting experiment. They removed a portion of the nasal septum in the region of the premaxilla area or what we would think of in the adult as the Kiesselbach area. The operated animals were allowed to grow, and there were many effects of the septal surgery. The snout was shorter, and it had a much

greater angle, and the incisor teeth did not meet. When the incisors did not meet there was a disastrous effect upon the dentition, and all these secondary effects were from an injury in what Mosher (1909) called "the area of the septum mosaic". The next experiment which Drs. Wexler and Sarnat (1961) performed was simply to displace the cartilagenous septum out of the premaxilla vomer groove and see what effect that had on the development of the septum, the snout, and related structures. After growth had occurred the displaced septal cartilage had some lateral displacement, but this was the maximum deformity and there was no unusual development of the snout which actual removal of septum in this area had caused.
The point has been made several times that the growth and development of the nose can be inhibited or arrested. The point should also be made that growth and development can be stimulated or accelerated. The cause of inhibition or stimulation might be any one of a number of things depending on the size of the individual at the time. Direct trauma to the nose is almost impossible for the fetus, yet direct injury to the nose is a common and frequent occurrence when the fetus passes through the birth canal. Direct injury is a frequent event throughout life, especially early childhood and through the athletic teen years. Surgery of the nasal septum is to be included among the injuries to the nose. Therefore, let us conclude that injury to the face or nose, including surgery, can cause direct and indirect effects on the nose, and these effects may be stimulation and acceleration of growth and development, or inhibition and arrest of growth and maturation.

There are some lines present about the lobule which indicate or even delineate the lobular cartilage and some underlying structures. We have already gone through the work of Chauncy Wen on the ontogeny and phylogeny of the nose, and emphasis was put on the supra-alar sulcus which separates the lobular cartilage from the roof or upper lateral cartilage. The supra-alar sulcus is visible on the nose as the supra-alar line. The lateral alar line is visible marking the lateral extent of the lobular cartilage. It is often seen as a continuation of the alar facial line. There may be a dimple in the lateral wall of the external nose indicating the point where the latero-inferior portion of the lobular cartilage curls medially. Inside the nose it helps form the cul-de-sac of the vestibule which shapes and forms the air currents entering the internal os. On the inside of the nose the point opposite the external dimple is one of the baffles of the nose and should not be mistaken for a cartilage tumor if it is unusually prominent.
The inferior border of the lobular cartilage is visible as the infra-alar line. The skin of the alar rim stretches across the upper portion of the nostril inferior to this cartilage and creates the ventricle of the vestibule which is an expiratory baffle. There may be a flattening or even dimpling at the nostril tip due to the relation of the infra-alar line to the underlying ventricle. This dimple effect gives a narrowing or neatness and sensitivity to the tip of the nose which enhances the appearance of the nose. It is a line of beauty.
The lobular line is usually a continuation of the alar facial groove or line. The lobular line is created by the shape of the lateral crus of the lobular cartilage. Ordinarily, the lateral crus is slightly convex in shape and the

lateral nasal wall is a smooth curve. If the lateral crus is concave in shape the lobular line may result. This gives a thin appearance to the nose, and this effect can be created surgically to give the desired narrow appearance. Another line at the lobule is the linea nasalis. This line is a horizontal depression across the nose at the level of the cephalic margin of the lobular cartilages. This line is present as a result of injury. The injury may be the repeated tiny injuries of a child wiping and itching his nose in the allergic salute, or it may be due to one or more serious nasal injuries. The linea nasalis is very difficult to eliminate surgically because of the underlying fibrous tissue which makes it most difficult to manage. Almost any tissue implant placed under the linea will become absorbed.

There is another line about the lobule which is concerned with maturation and development. Throughout the body the overlying skin closely reveals the underlying hard tissue anatomy. The bony pyriform crest is reflected as the anterior narial line at the lower portion of the internal os. This line develops only if the underlying bone develops. The line is present in mature whites who have had normal maturation of the pyriform crest. The anterior narial line is absent in those persons who have the ethnic background which does not have a bony pyriform crest. The anterior narial line is absent in those persons who have the ethnic background which does not have a bony pyriform crest. The anterior narial line is absent in those persons who have had maturation inhibited before the age of six when the pyriform crest begins to develop. Trauma to the region of the anterior maxilla or premaxilla may cause an anatomical lack of development of the pyriform crest which simplifies the septum operation using the maxilla-premaxilla approach.

There is a method by which one can remember the lines about the lobule. The supra-alar line represents the line of embryology; the lateral alar line and dimple represent the line of function; the infra-alar line is the beauty line; the linea nasalis is the line of injury; the lack of the anterior narial line implies certain ethnic origin or early injury.

SUMMARY

The embryology, phylogeny, and ontogeny of the face and nose was reviewed. The origin of some surgically important structures and their anatomical relationships was emphasized. The application of this knowledge to clinical problems was discussed. Growth and development of the nose is fairly rapid up to age three years, and after that it is slower but regular and continuous in the growth pattern. Trauma can inhibit or accelerate growth and maturation. Lines and grooves of the lobule of the nose were described and their embryological and anatomical origin was explained.

SUMARIO

Se hace una revisión de la embriología, filogenia, y ontogenia de la cara y de la nariz. Se hace énfasis del origin de algunas importantes estructuras guirúgicas y sus relaciones anatómicas de ambos. Se explica someramente la aplicación de estos conocimientos hacia problemas clínicos. El crecimiento y desarrollo de la nariz es relativamente rápido hasta la edad de tres años.

Después sigue un desarrollo lento y regular y progresivo. Los traumatismos pueden inhibir o acelerar el crecimiento y maduración. Las líneas y configuración del lóbulo de la nariz son descritos, así como también se explican el origen anatómico y embriológico de las mismas.

REFERENCES

1. Arey, L. B., 1954: Developmental anatomy, Sixth Ed. W. B. Saunders Co.
2. Beck, F. W., 1963: Paraseptal cartilage in some animals including man. Laryngoscope, 73, 288-305.
3. Brash, 1956: Human embryology. Oxford Univ. Press London.
4. Brodie, A. G., 1941: On the growth pattern of the human head from the third month to the eighth year of life. Amer. J. Anat., 68, 209-262.
5. Cottle, M. H., 1953: The role of the rhinologist in rhinoplasty. Laryngoscope, 63, 608.
6. Cottle, M. H., 1954: Nasal roof repair and hump removal. Arch. Otolaryng., 60, 408.
7. Cottle, M. H., 1956: Early nasal injury, a factor in nasal, septal, dental, and facial deformities. Scientific exhibit. Amer. Med. Assoc. Meeting.
8. Cottle, M. H., 1951: Nasal surgery in children. Eye, ear, nose, and throat monthly, 30, 30.
9. Crow, M. B.,1924: The comparative anatomy of the nose as a guide to its surgical and medical treatment. The Practitioner 112, 174-185.
10. Derry, D. E., 1937: Two skulls with absence of pre-maxilla. J. Anat., 72, 295.
11. Frazer, J. E., 1940: A manual of embryology. Williams and Wilkins, Baltimore.
12. Hamilton, W. J., Boyd, J. D. and Mossman, H. W.: Human embryology, Williams and Wilkins, Baltimore.
13. Horowitz, M. S., 1958: Congenital anomaly of nasal structures. Arch. Otolaryng., 67, 364.
14. Johnson, E. H., 1936: The narial margins in man. J. Anat., 71, 356.
15. Klaff, D. D., 1956: Surgical anatomy of the antero-caudal portion of the nasal septum. Laryngoscope, 66, 995.
16. Keith, Sir Arthur, 1948: Human embryology and morphology. Sixth Ed. Williams and Wilkins, Baltimore.
17. Kirschner, J. A., 1955: Traumatic nasal deformity in the newborn. Arch. Otolaryng., 62, 139.
18. Manera, J. F., Subtelny, J. D.,: A cephalometric study of the growth of the nose. Amer. J. Orthod., 47, 203-205.
19. Mosher, H. B., 1909: The influence of the premaxilla upon the form of the hard palate and upon the septum. Items of Interest, 31, 481-515.
20. Negus, Sir Victor, 1958: The comparative anatomy and physiology of the nose and paranasal sinuses. E. & S. Livingston Ltd., Edinburgh and London.
21. Negus, Sir Victor, 1955: The comparative anatomy and physiology of the respiratory tract in relation to its clinical problems. Ann. roy. Coll. Surg. Engl., 16, 281.
22. Riggs, R., 1956: Case report. Amer. Rhinologic Soc., New Orleans Meeting.
23. Rosenberger, H. C., 1934: Growth and development of the naso-respiratory area in childhood. Ann. Otol. Rhinol. Laryng., 43, 494-512.
24. Sarnat, B. G., 1963: Postnatal growth of the upper face: Some experimental considerations. Angle Orthodont, 33, 139-161.
25. Schaeffer, Parsons, J., 1920: The nose and olfactory organ. Blakiston's Son & Co.
26. Scott, J. H., 1954: Heat regulating function of nasal mucous membrane. J. Laryng. and Otol. 68, 308.
27. Scott, J. H., 1962: The growth of the cranio-facial skeleton. Irish med. J., sixth series, 438, 276-286.
28. Schultz, A. H., 1918: Development of external nose in whites and negroes. Carnegie Institute Papers, 272, 173.
29. Schultz, A. H., 1918: Relation of the external nose to the bony nose and nasal cartilages in whites and negroes. Am. J. Physical Anthropology, 1, 329.
30. Steiner, A., 1959: Certain aspects of nasal trauma in the prenatal-natal period. Maryland State, Med. J., 8, 557-569.

31. Straatsma, B. R., Straatsma, C. R., 1951: The anatomical relationship of the lateral nasal cartilage to the nasal bone and the cartilage of the nasal septum. Plastic and Reconstr., Surg., 8, 443.
32. Straith, R. E., Teasley, J. L., Von Linde, M. G., Moore and Lawrence, T., 1955: The treatment of lateral deviations of the nose by pin fixation. Plastic and Reconstr. Surg., 15, 346.
33. Subtelny, J. D., 1959: A longitudinal study of soft tissue facial structures and their profile characteristics, defined in relation to underlying skeletal structures. Amer. J. Orthod., 45, 481-507.
34. Warbrick, J. G., 1960: The early development of the nasal cavity and upper lip in the human embryo. J. Anat., 94, 351-362.
35. Wen, C., 1930: Ontogeny and phylogeny of the nasal cartilages in primates. Carnegie Instit. Papers, 414, 111.
36. Wexler, M. R. Sarnat, B. G., 1961: Rabbit snout growth. Arch. Otolaryng., 74, 305-313.
37. Wexler, M. R., Sarnat, B. G., 1965: Rabbit snout growth after dislocation of nasal septum. Arch. Otolaryng., 81, 68-71.

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