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THE EVOLUTION OF THE NASAL SEPTUM AND THE FORMATION OF SEPTAL DEFORMITY

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Summary

Morphological abnormalities of the nasal cavity, particularly of the nasal septum, were interpreted from the viewpoint of evolution. Septal deformity was explained to be an inevitable condition resulting from the autonomic growth force of the septal cartilage, which exists from the earliest mammals; the relationship of the septal cartilage with the vomer supporting it from below; the regression of the maxillo-facial cranium and the enlargement of the neurocranium after the primate stage; and the changes in the cranial base. Therefore, the author proposed that septal deformity was a paradox which occurred as a result of evolution.

INTRODUCTION

Nasal septal deformity is a condition that is encountered daily by the clinical otorhinolaryngologist. For this reason, much research has been focused on the subject of its treatment. Fewer studies, however, have dealt with the etiology or the processes involved in the occurrence of septal deformity. In my view, it is important to consider etiology in investigating the treatment of septal deformity and to recognize the connection between the manner of evolution of the nasal septum and the formation of septal deformity. Therefore, I made a complete report of my findings in Japanese in Oto-rhino-laryngology Tokyo (Vol 29:2 Suppl., April 1986) and in English in Acta Otolaryngologica (Suppl. 443, January 1988).

The purpose of this paper is to present a summary of these earlier treatises.

PREVIOUS THEORIES ON THE STRUCTURE AND FORMATION OF THE HUMAN NASAL SEPTUM

In non-primate mammals, sub-human primates, and Man, the nasal septum is composed of the septal cartilage, the perpendicular plate (posterosuperior to the septal cartilage), and the vomer (inferior to the septal cartilage). It has been reported that sometimes in Man, the process that extends posteriorly from the septal cartilage may form a sphenoidal process (processus sphenoidalis) that lies between the perpendicular plate and vomer and reaches as far as the sphenoid bone. However, it has also long been known that during the development of the nasal septum, there is a vomerine cartilage (cartilago vomeris) that extends posteriorly from the septal cartilage within a deep sulcus (sulcus vomeris) at the superior edge of the vomer and that with further development this becomes the vomerine process (processus vomeris), which is embedded within the vomer itself. This vomerine process has been reported to be closely associated with the formation of abnormal projections of the nasal septum. Although patients with nasal septal deformity present clinically with an endless variety of morphological abnormalities, these can basically be classified as one of two types: curvature of the anterosuperior portion of the nasal septum or projection at the border between the septal cartilage or perpendicular plate and vomer. The cause of these morphological abnormalities has traditionally been attributed to an imbalance between the growth force of the nasal septum and that of the surrounding tissues. However, almost no attempts have been made to elucidate why such an imbalance should occur. Therefore, I decided to investigate this issue from an evolutionary viewpoint, focusing on the condition of the nasal septum within the cranium and its responses to various changes.

EVOLUTION OF THE NASAL SEPTUM

A. From the origins to the mammalian stage

According to the literature, the internal nares first appeared in the Crossopterygii (including the Coelancanthini, a type of Choanoichthyes), the advanced form of the Osteichthyes. The external and internal nares were connected by ducts, and there was no nasal cavity. In the Crossopterygii and amphibians, moreover, the vomer bones were small and aligned horizontally in the anterior part of the roof of the mouth. As evolution proceeded through reptiles to the mammal-like reptiles, the vomer bones widened along the horizontal plane. Then, at the most advanced stage of the mammal-like reptiles, immediately before the evolution into mammals, the primary palate began to form, and the horizontally-aligned vomer bones "stood up" vertically and fused along their internal surfaces. The superior portion of this fused vomer formed a sulcus. The cartilaginous nasal septum, which had developed from the laminar, cartilaginous nasal capsule, became embedded in the sulcus and began to grow in an anterior direction. At this stage, the secondary palate also formed posterior to the primary palate, thus completing the nasal cavity. At the same time, the primordium of the ethmoid bone developed bilaterally from the nasal capsule. The basic mammalian nasal cavity was thus completed at this stage.

B. From the mammalian stage to the human stage

Comparison of the nasal cavity in non-primate mammals, sub-human primates, and Man reveals several characteristic differences. The nasal cavity is long (along the anterior-posterior axis) and low in non-primate mammals, short and high in Man, and of an intermediate shape in sub-human primates (Figure 1). In non-primate mammals, the jaw is relatively large, and the brain

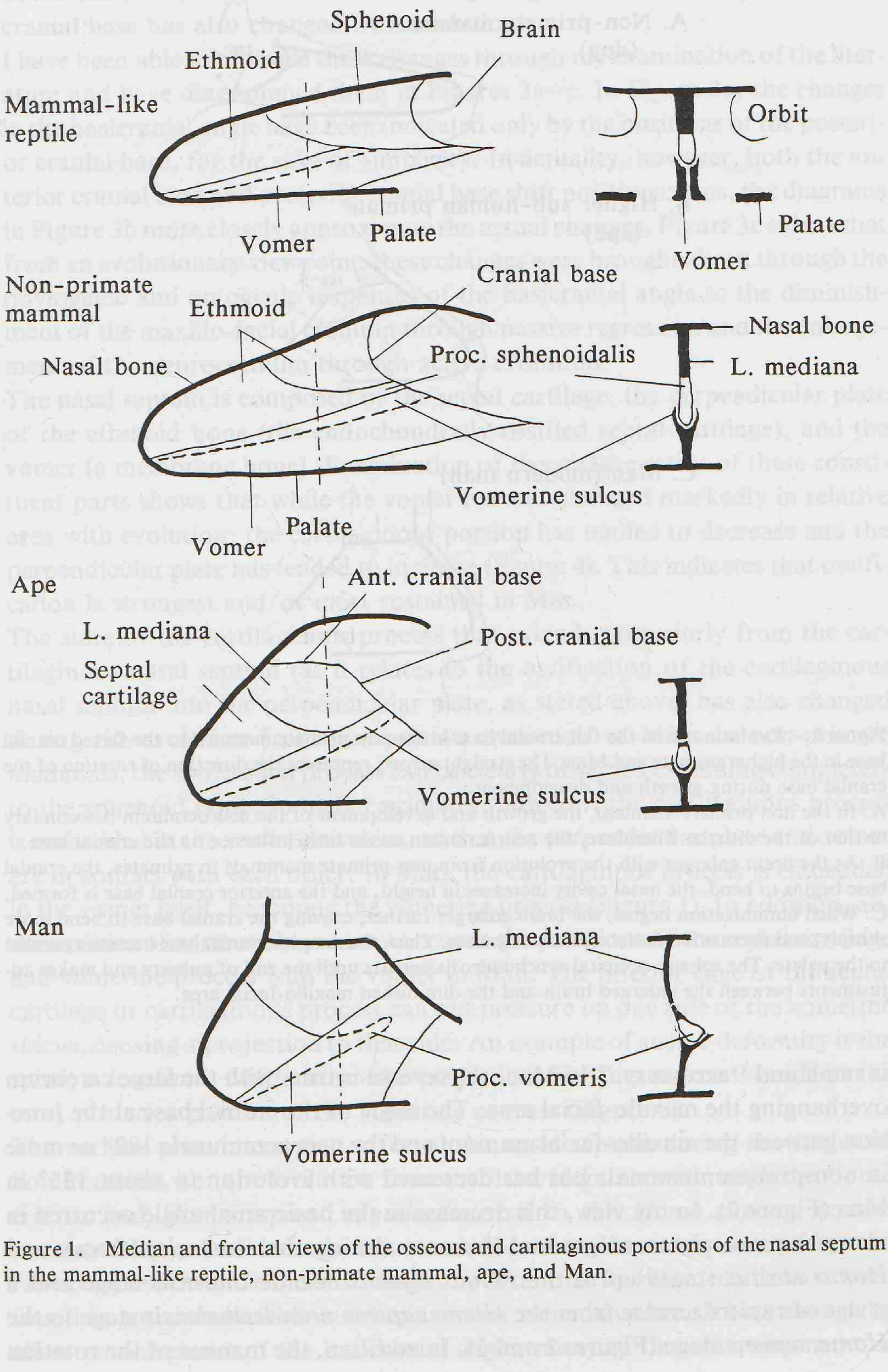

Figure 1. Median and frontal views of the osseous and cartilaginous portions of the nasal septum in the mammal-like reptile, non-primate mammal, ape, and Man.

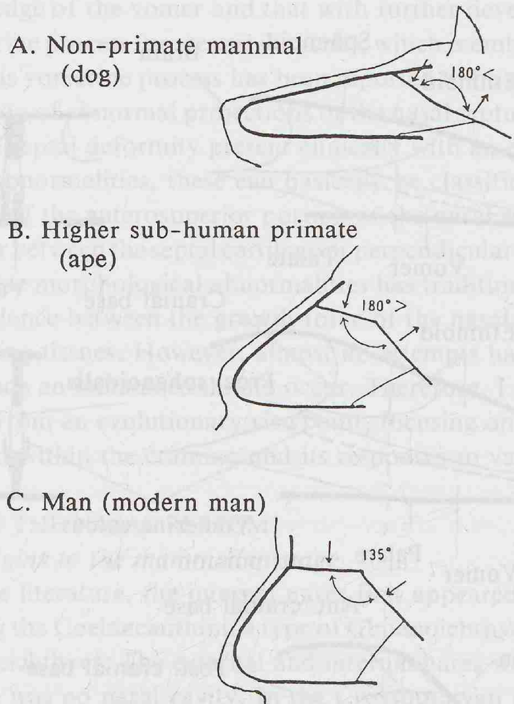

Figure 2. Evolution from the flat cranial base in the non-primate mammal to the flexed cranial base in the higher primate and Man. The straight arrows represent the direction of rotation of the cranial base during growth and development.
A. In the non-primate mammal, the growth and development of the neurocranium is secondary to that of the muzzle. Therefore, the neurocranium exerts little influence on the cranial base.
B. As the brain enlarges with the evolution from non-primate mammals to primates, the cranial base begins to bend, the nasal cavity increases in height, and the anterior cranial base is formed.
C. When hominization begins, the brain enlarges further, causing the cranial base to bend more sharply, and the maxillo-facial cranium regresses. Thus, the anterior cranial base becomes parallel to the palate. The spheno-occipital synchondrosis persists until the end of puberty and makes adjustments between the enlarged brain and the diminished maxillo-facial area.

is small and "accessory." In Man, the reverse is true, with the large cerebrum overhanging the maxillo-facial area. The angle of the cranial base at the junction between the maxillo-facial cranium and the neurocranium is 180° or more in non-primate mammals but has decreased with evolution to about 135° in Man (Figure 2). In my view, this decrease in the basicranial angle occurred in two phases: a phase of gradual decrease during the *Australopithecus* and *Homo erectus* stages up to the *Homo sapiens neanderthalensis* stage and a phase of rapid decrease from the *Homo sapiens neanderthalensis* stage to the *Homo sapiens* stage (Figures 2 and 5). In addition, the manner of the rotation of the basicranial angle that occurs during the growth and development of the cranial base has also changed with evolution.

I have been able to estimate these changes through my examination of the literature and have diagrammed them in Figures 3a–c. In Figure 3a, the changes in the basicranial angle have been indicated only by the positions of the posterior cranial base, for the sake of simplicity. In actuality, however, both the anterior cranial base and posterior cranial base shift positions: thus, the diagrams in Figure 3b more closely approximate the actual changes. Figure 3c shows that from an evolutionary viewpoint, these changes were brought about through the phylogenic and ontogenic responses of the basicranial angle to the diminishment of the maxillo-facial cranium through passive regression and the enlargement of the neurocranium through active evolution.

The nasal septum is composed of the septal cartilage, the perpendicular plate of the ethmoid bone (the endochondrally ossified septal cartilage), and the vomer (a membrane bone). Examination of the surface ratios of these constituent parts shows that while the vomer has not changed markedly in relative area with evolution, the cartilaginous portion has tended to decrease and the perpendicular plate has tended to increase (Figure 4). This indicates that ossification is strongest and/or most sustained in Man.

The state of the cartilaginous process that extends posteriorly from the cartilaginous nasal septum (as it relates to the ossification of the cartilaginous nasal septum into the perpendicular plate, as stated above) has also changed during the evolution from non-primate mammals to Man. In non-primate mammals, the sphenoidal process can be clearly observed extending completely to the sphenoid bone. In higher primates, however, the cartilaginous process is embedded in the vomerine sulcus, so that the perpendicular plate and vomer are in contact with each other. In Man, the cartilaginous process is embedded in the vomer itself, becoming the vomerine process (Figure 1). In addition, abnormalities of various shapes may occur at the junctions of the septal cartilage and vomerine process with the vomer in Man. The inferior edge of the septal cartilage or cartilaginous process can put pressure on one side of the vomerine sulcus, causing a projection to that side. An example of such a deformity is the spine, a localized, Matterhorn-like projection that juts out to the side at the most posterior portion of the vomerine process (Figure 8).

The various phenomena that affected the nasal septum during the stages of hominization, i.e., the evolution from the *Australopithecus* through the *Homo erectus* and *Homo sapiens neanderthalensis* to the *Homo sapiens sapiens* (modern Man), should also be examined. However, because it is only from the *Homo sapiens neanderthalensis* stage and after that fossilized skulls have been found in any considerable number and that some have been intact enough to allow measurement of the basicranial angle, many of the observations must

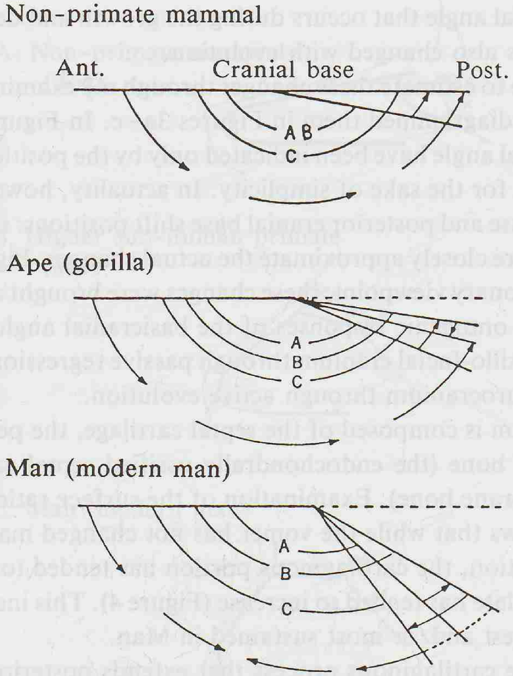

Figure 3a. Evolutionary changes in the basicranial angle and its manner of rotation. (Diagrams by author based on data from the literature).
The outermost arrows indicate the direction of rotation of the cranial base. A represents the basicranial angle during the early half of the fetal period; B, the angle during the latter half of the fetal period; and C, the angle in the adult. Left, anterior direction; right, posterior direction.
In the non-primate mammal, the cranial base is flexed to a certain degree during the fetal stage. As the animal matures, the maxillo-facial cranium grows and becomes prominent, so the basicranial angle widens to 180° or more.
When evolution proceeds to the stage of higher sub-human primates, the enlargement of the neurocranium causes the cranial base to become flexed more sharply than in the non-primate mammal in the early half of the fetal period. In the latter half of the fetal period, the basicranial angle widens similarly as in the non-primate mammal. By the time the animal reaches adulthood, the angle decreases slightly because the neurocranium enlarges more than in the non-primate mammal. In the non-primate mammal and the sub-human primate, the anterior cranial base and the posterior cranial base both rotate in a counter-clockwise direction. This is probably due to the direction of enlargement of the cerebrum during its growth and development.
After evolution proceeds to Man, the cranial base becomes flexed even more sharply than in the non-primate mammal or sub-human primate during the early half of the fetal period. During the latter fetal period, this angle widens somewhat. As the individual grows to maturity, the angle decreases sharply. In other words, the manner of increase and decrease of the basicranial angle is similar to that in sub-human primates, but the ultimate size of the angle after maturity is much smaller in Man. It should be noted that while the anterior cranial base rotates in a counter-clockwise direction similarly as in the non-primate mammal and sub-human primate, the posterior cranial base rotates in a clockwise direction. This manner of rotation is completely different from that which occurs in the non-primate mammal and sub-human primate.
These differences in the basicranial angle and its manner of rotation in the non-primate mammal, →

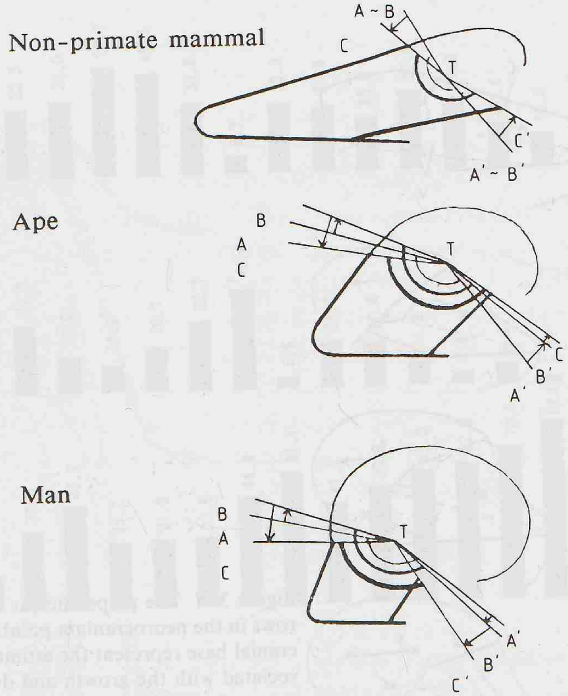

Figure 3b. ABC and A′B′C′ correspond respectively to ABC in Figure 3a. T is the intersection of the anterior cranial base and the posterior cranial base. The thick solid line represents the basicranial angle after adulthood.

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sub-human primate, and Man can be attributed to the regressive and progressive evolution of the maxillo-facial cranium and neurocranium, respectively, and to the responding changes in the cranial base at their junction. In the non-primate mammal, the growth and development of the maxillo-facial cranium is more prominent than that of the neurocranium. In the sub-human primate, the maxillo-facial cranium begins to regress, while the neurocranium begins to show marked growth and development. In Man, the evolution of the neurocranium proceeds further in extension of that which occurred in the higher sub-human primate. In particular, Man's upright posture and bipedal ambulation cause the posterior cranial cavity (occipital lobe, cerebellum) to enlarge markedly, resulting in the unique manner of rotation of the cranial base.

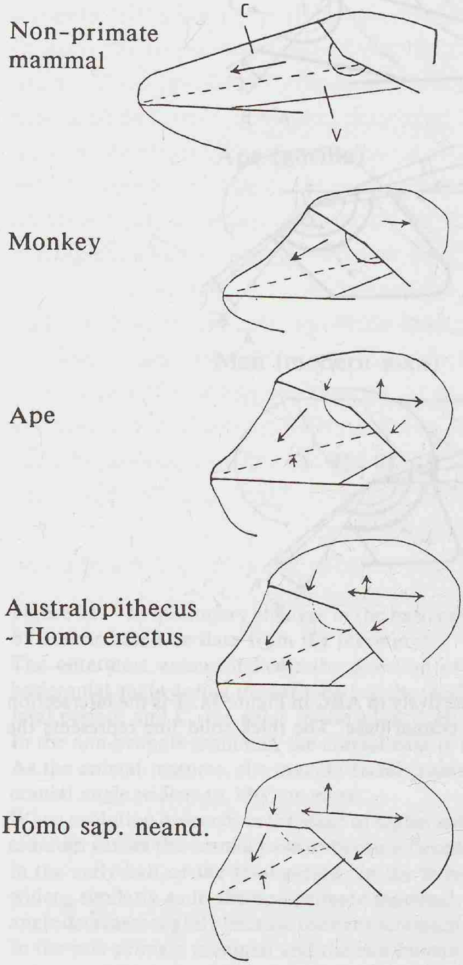

Figure 3c. The perpendicular arrows and arrows in the neurocranium pointing toward the cranial base represent the estimated vector associated with the growth and development of the cerebrum.
The length of the arcs indicate that the basicranial angle decreases with evolution.
The arrows within the nasal septum pointing anteroinferiorly represent the direction of growth and development of the septal cartilage; the direction of growth changes with evolution from a horizontally-oriented direction to a vertically-oriented direction. The upward-pointing arrows represent the resistance of the vomer to the inferiorly-directed growth of the septal cartilage. The anteriorly-pointing arrow in the *Homo sapiens sapiens* (modern Man) indicates that when the growth force of the septal cartilage is resisted by the vomer, the surplus force is directed anteriorly.
C, septal cartilage; V, vomer; dotted line, boundary between C and V.

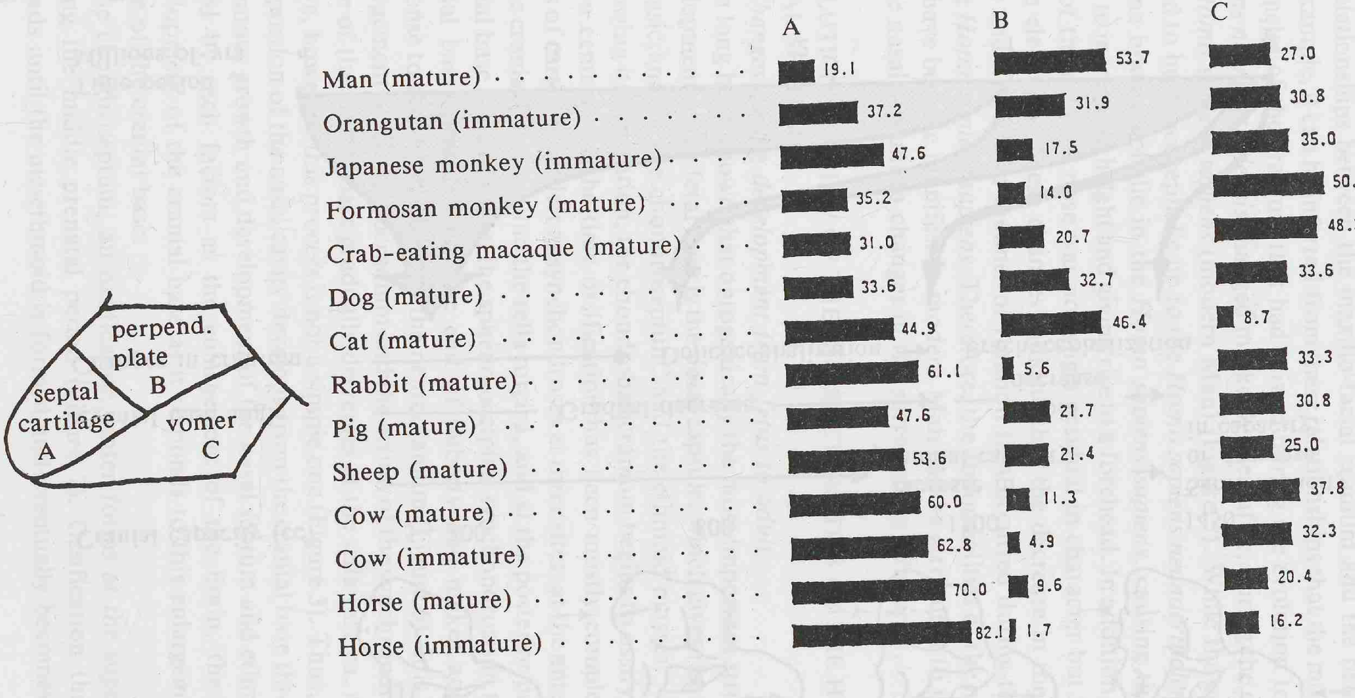

Figure 4. Relative surface areas (%) of the constituent parts of the nasal septum. The surface ratios of the septal cartilage and perpendicular plate are in almost inverse proportion, with the relative area of the perpendicular plate being largest in Man. The surface ratios of the vomer seem to show no relation to those of the septal cartilage or perpendicular plate.

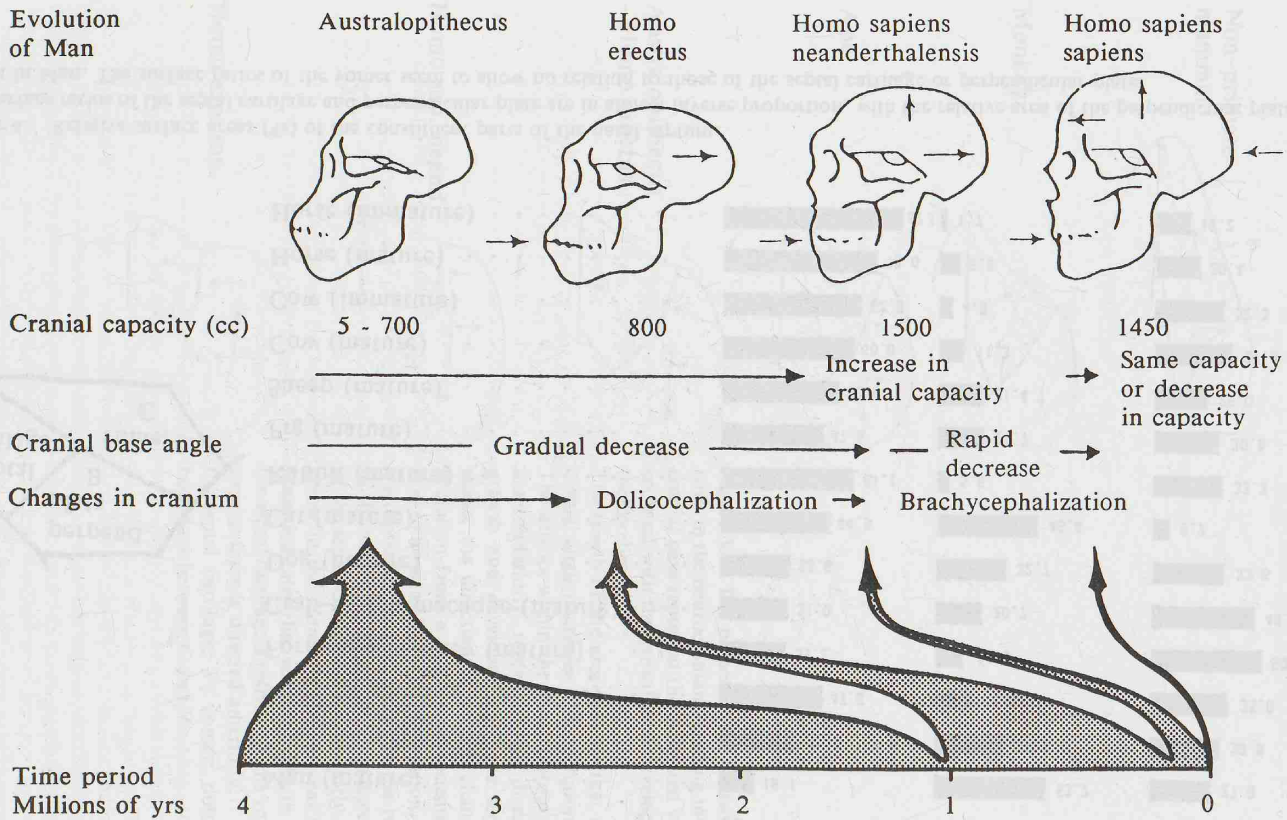

Figure 5. Changes in cranial capacity and shape during hominization.
In the lateral views of the cranium, the arrows pointing to the right indicate the regression of the maxillo-facial cranium, while the arrow pointing to the left indicates brachycephalization.

necessarily involve analogical inferences made from the temporary relationships between fossil Man's periods of existence and from the external and spatial relationships between the maxillo-facial cranium and the neurocranium. For example, it can be inferred from these relationships that the morphological tendencies of the cranium that had existed during the evolution to the *Homo sapiens neanderthalensis* changed markedly thereafter, during the evolution to the *Homo sapiens sapiens* (modern Man) (Figure 5). While the cranium had tended to be dolicocephalic up to the *Homo sapiens neanderthalensis* stage, it became brachycephalic in the *Homo sapiens sapiens*, causing the neurocranium to increase in height and giving rise to a forehead. In addition, the projection of the external nose was no longer residual in character but involved an active elevation. These changes indicate that the decrease in the basicranial angle and its peculiar manner of rotation first occurred during the evolution to the *Homo sapiens sapiens*. Therefore, the abnormalities of the nasal septum that have become manifest in modern Man can be attributed to the response of the nasal septum to changes in the surrounding structures.

EVOLUTIONARY VIEW OF THE CHARACTERISTICS OF THE HUMAN NASAL SEPTUM

A. Changes during development from fetus to adult

It has long been known that ontogenically the most important structure in the development of the fetal nose is the nasal capsule, which gives rise to the chondrobasicranium, the chondroseptum, and the ethmoid masses.

Following its generation, the chondrobasicranium begins to ossify at its ossification centers. By the time ossification has been mostly completed, insular areas of cartilage are left as synchondroses at three sites: at the anterior portion of the cranial base, around the sella turcica, and at the posterior portion of the cranial base. One of these, the spheno-occipital synchondrosis in the posterior cranial base, persists until the end of puberty and makes adjustments in response to the enlargement of the neurocranium (Figure 6). It is through this enlargement of the neurocranium and the action of the synchrondroses that the angle of the cranial base gradually decreases at the sella turcica. As explained above, however, this process is not a simple one (Figure 3). Thus, as the superior portion of the nasal cavity develops from the cranial base through the autonomous growth and development of the nasal septum and ethmoid, it is affected by such factors as the enlargement of the brain, the growth and development of the cranial base as it responds to this enlargement, and the angle of the cranial base.

In the chondroseptum, an ossification center forms at the superior portion during the middle prenatal period (Figure 7). Ossification then gradually spreads until the mesethmoid is formed and eventually becomes the perpen-

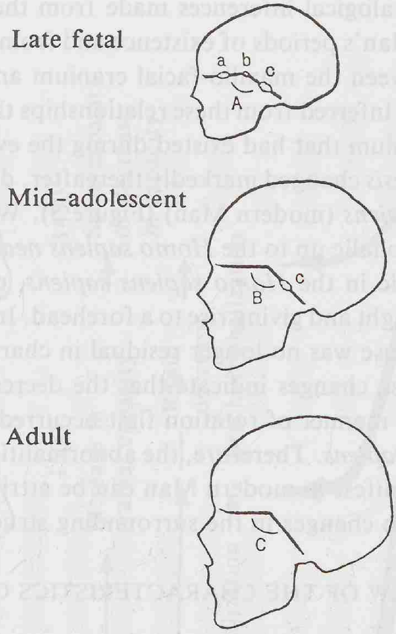

Figure 6. Synchondroses and the growth and development of the human cranial base. The synchrondroses make adjustments for the growth and development of the neurocranium. The width of the basicranial angle decreases in the order of A, B, C. The duration of persistence of the synchrondrosis (which is the residual cartilage of the nasal capsule) decreases in the order of c, a, b, with the synchondrosis in the posterior cranial base remaining until the end of puberty.

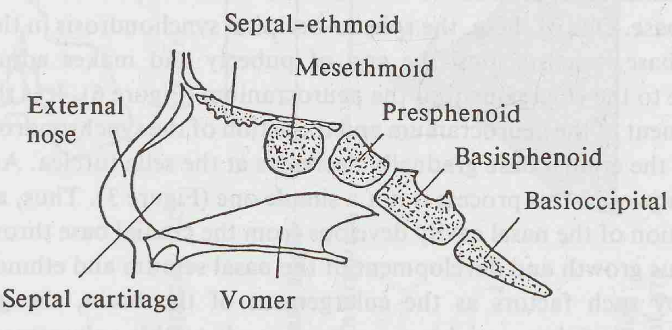

Figure 7. Median view of sites of ossification in the cranial base of a human fetus at 4-5 months. Growth and development occurs through the spread of ossification through osteogenesis at the synchondroses between the ossified areas. The first site of ossification in the septal cartilage is the mesethmoid.

dicular plate of the ethmoid in the adult. I reported in 1952 on the presence of a weak line of ossification along the anteroinferior and inferior edges of the perpendicular plate that persists into adulthood. Such an ossification line seems to exist in non-primate mammals and sub-human primates as well. The significance of this ossification line will be discussed in a later section.

A notable characteristic in Man is that morphological abnormalities of the nasal septum, although still of only slight degrees, are already found in high incidence (approximately 25%) during the fetal period and that they already show a tendency to be located to the left side. This is a unique characteristic that is based on the autonomic growth and development of the chondroseptum in the human fetus. The high incidence and ''left-sidedness'' persist until adulthood, at which time the incidences of left-sided and right-sided deformities become about equal. In a previous study, I found that this is due to the increase in complexity of the morphological abnormalities after adulthood.

B. Relationship between the ossification line and morphological abnormalities (curvature and projection)

As stated above, two types of cartilaginous processes, i.e., the sphenoidal process and the vomerine process, can be found extending posteriorly from the cartilaginous nasal septum in Man. In both cases, an ossification line exists at the superior edge in extension of the superior edge of the septal cartilage. Stronger ossification is marked by the presence of a vomerine process rather than a sphenoidal process. Therefore, as I have previously reported, the former type of process is found in higher incidence in Man, who has marked abnormalities of the nasal septum.

The nasal septum is shown in median view through various stages of human development in Figure 8. These diagrams are based on the results of my investigation of the relationship of the septal cartilage and its cartilaginous process to the vomer. Type A, as well as a slightly more advanced version, is also found in non-primate mammals; the cartilaginous process here corresponds to the sphenoidal process. Type B, on the other hand, is also found in higher primates; in this type, the inferior edge of the perpendicular plate and the posterior part of the superior edge of the vomer are in contact with each other, and the cartilaginous process is embedded within the vomerine sulcus. Types C, D, and E are unique to Man; the cartilaginous process is embedded within the vomer itself and the superior edges of the vomerine sulcus are fused together, so that the process can be referred to as the vomerine process. The process is long in Type D and short in Type E. There is a higher tendency for marked projections to occur when the process is short. A typical example of such a projection is the spine.

Projections are formed because chondrogenesis and ossification occur at the

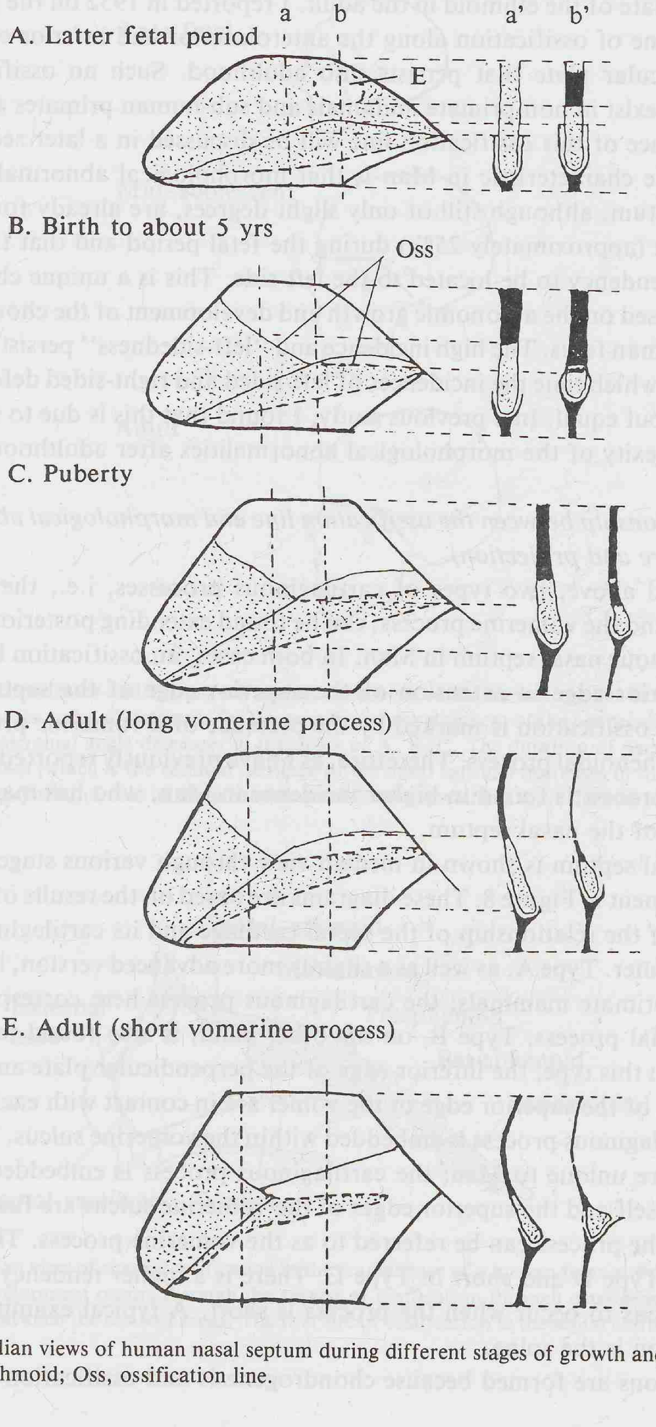

Figure 8. Median views of human nasal septum during different stages of growth and development. E, mesethmoid; Oss, ossification line.

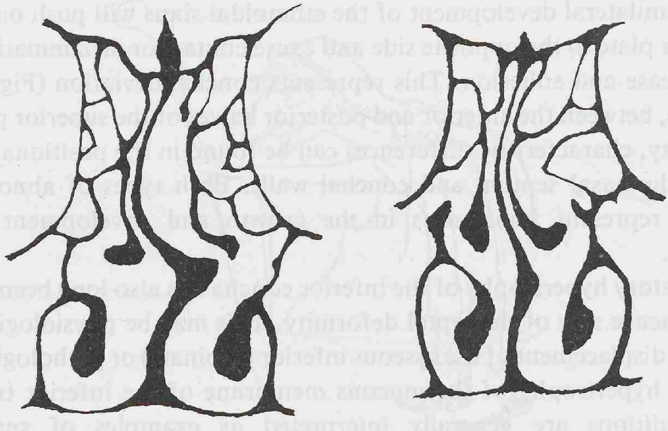

Figure 9. Septal deviation (A) and conchal deviation (B).

superior edge of the cartilaginous process in extension of the ossification line. This causes the inferior edge of the process to exert pressure on the vomerine sulcus. The vomer resists, but is eventually pushed out and forms a projection. The cartilaginous nasal septum, on the other hand, also enlarges through its autonomous growth force, so that curvature frequently occurs in the vicinity of the ossification line, particularly in the upper anterior portion. Thus, it can be seen that septal deformities are most likely to occur, as a rule, in the upper anterior portion of the septum (curvature), in the area of the vomerine sulcus (ridge), and along the inferior edge and at the tip of the cartilaginous process (ridge and spine).

C. The nasal septum and conchal walls (lateralization of the ethmoidal sinus)
There have been few reports on the relationship between the nasal septum and the conchal walls. Through my investigations, however, I have concluded that these structures show distinctive relationships that are almost totally unique to Man and that have much significance clinically, pathologically, and surgically. In the anterior half of the nasal septum, it is not rare for the upper part of the septum to curve and exert pressure on the conchal wall (middle and superior conchae) on the convex side, resulting in contact of the apposing conchal and septal walls or in infection and inflammation that may cause their adhesion. This represents displacement of the conchal wall due to septal curvature (Figure 9a). On the other hand, in the upper part of the posterior half of the nasal septum, the perpendicular plate is generally extremely thin. So, there is greater likelihood that pressure exerted medially by the conchal wall due to

vigorous unilateral development of the ethmoidal sinus will push out the perpendicular plate to the opposite side and cause contact or inflammation resulting in disease and adhesion. This represents conchal deviation (Figure 9b). Therefore, between the anterior and posterior halves of the superior part of the nasal cavity, characteristic differences can be found in the positional relationships of the nasal septum and conchal walls. Both types of abnormalities, however, represent imbalances in the growth and development of these structures.

Compensatory hypertrophy of the inferior concha has also long been observed on the concave side of the septal deformity. This may be physiological (compensatory displacement of the osseous inferior turbinate) or pathological (compensatory hypertrophy of the mucous membrane of the inferior turbinate). Both conditions are generally interpreted as examples of space-filling phenomena. However, there seems to be a strong tendency for the latter to occur in relation with inflammation.

D. The nasal septum and external nose

In my view, no other species has a structure that corresponds morphologically to Man's external nose: the external nasal pyramid is unique to Man. It was formed when the homologous structure in non-primate mammals and subhuman primates remained intact during the regression of the maxillo-facial cranium, became elevated after the beginning of hominization, and became further elevated after the evolution to the *Homo sapiens sapiens*. This elevation is believed to have corresponded chronologically with the above-mentioned reduction in the basicranial angle, the change in its manner of rotation, the change in the state of the cartilaginous process of the nasal septum, the intensification of septal deformities in general, and the increase in complexity of the external nasal cartilage. In other words, the external nose is thought to have become elevated because these phenomena caused the septal cartilage to exert stronger force on surrounding structures during its development and ossification and because this stress was directed toward the direction of least resistance, i.e., anteriorly toward the external nasal pyramid.

Because the ossification line of the nasal septum persists throughout life, the external nose does not contract like the osseous tissue surrounding it. Therefore, as an individual grows older, the external nose becomes more prominent, so that it sometimes even resembles the hawk-like nose attributed to witches (Figure 10).

Another factor involved in the elevation of the external nose is the formation of the anterior nasal spine. It is said that the anterior nasal spine did not exist in the *Homo sapiens neanderthalensis*. Even in the *Homo sapiens sapiens*, it varies in size according to the degree of development of the external nasal

Figure 10. Representation of the hawk-like nose attributed to witches or hags. The nose becomes more prominent in old age because it is the only structure in the face that does not regress with age. (Drawing by author)

pyramid. Therefore, it can be surmised that the anterior nasal spine developed to support the anteroinferior edge of the septal cartilage from below when the external nose became elevated in the *Homo sapiens sapiens*, particularly modern Man.

SEQUENCE OF CHANGES DURING GROWTH AND DEVELOPMENT OF HUMAN NASAL SEPTUM

This section will examine the sequence of changes that occur during the growth and development of the human nasal septum (Figure 11; numbers in brackets below refer to the corresponding numbers in the figure).

First, the nasal capsule [1], i.e., the laminar chondrobasicranium, appears during the first half of the fetal period. The nasal capsule then gives rise inferiorly to the sagittally-positioned cartilaginous septum [2] and to the cartilaginous ethmoid masses on both sides of the septum. The superior surface of the nasal capsule corresponds to the basilar plane of the neurocranium, so that it is forced to respond in various ways during the following growth and development of the cerebrum. In particular, ossification spreads in the chondrobasicranium from three ossification centers. Eventually, only insular sites of cartilage, i.e., the synchondroses, remain to play important roles in the flexion of the cranial base that will occur during its growth and development.

The cartilaginous septum begins to grow and develop during the first half of fetal period. By the time it starts to do so, however, it has already formed a junction [3] with the vomer, which supports it from below. Even during the fetal period, minute asymmetrical abnormalities caused by the development of

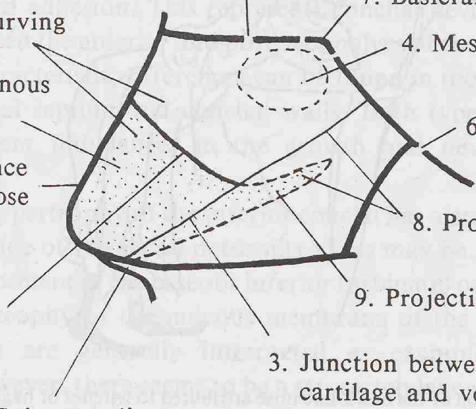

Figure 11. Changes in human nasal septum during growth and development.

the cartilaginous septum and the response of the vomer can be clearly observed histopathologically. The early occurrence of abnormality at this junction is believed to be due to an imbalance between the forces of growth and development of the nasal septum and vomer. Factors involved in this imbalance no doubt include the relationship between the autonomous, active growth of cartilaginous tissue and the passive response of osseous tissue, as well as the fact that this junction is the first site in the cranium where the cartilaginous septum, which is undergoing endochondral ossification, comes into contact with the vomer, which is undergoing intramembranous ossification.

Next, an ossification center appears in the posterosuperior portion of the chondroseptum immediately anterior to the basicranial angle. As ossification spreads, the mesethmoid [4] is formed and eventually becomes the perpendicular plate. Along the junction between the chondroseptum and the perpendicular plate, i.e., along the anteroinferior and inferior edges of the perpendicular plate, ossification of a weak degree persists throughout life. This ossification line [5] has a vital significance for the organism. The nasal septum is the only site in the body where ossification persists throughout life. In my view, this is because the nasal cavity performs a vital function for the organism, whether it is respiration in Man and sub-human primates or olfaction in non-primate mammals, and if such a vital space should contract and regress with age like other osseous tissue, the very survival of the organism would be endangered. Therefore, ossification persists at this site so that the nasal septum can continue to act as a supporting structure for the nasal cavity and prevent such a contraction from occurring.

Of the synchondroses in the cranial base, the spheno-occipital synchondrosis [6] persists the longest. Because this synchondrosis remains until the end of puberty, the cranial base can continue to develop, i.e., the posterior cranial base can shift in a clockwise direction toward the nose, until the individual reaches adulthood, thus continuing to exert biodynamic stress on the nasal septum. In this way, the basicranial angle [7] diminishes and, through the regression of the maxillo-facial cranium and the enlargement of the cerebrum (particularly the frontal lobe), rotates in a manner that is unique to Man.

The nasal septum generally develops and grows in an anterior-posterior direction along the long axis of the maxillo-facial cranium in non-primate mammals. However, this has changed to a diagonal anterior-posterior direction in sub-human primates and further to a diagonal vertical direction in modern Man. As mentioned above, this evolutionary shift in the direction of growth of the nasal septum is mainly attributable to the various effects of the enlargement of the cerebrum (via the cranial base) and the regression of the jaw (caused mainly by the diminishment of masticatory strength). Such influences naturally affect the septal cartilage, with its capacity for autonomic growth, and the vomer, which supports it from below. It can therefore be concluded that in this way, the sphenoidal process of the non-primate mammal became the vomerine process of the *Homo sapiens sapiens* [8] and that marked morphological abnormalities came to be manifested along the edge of this cartilage. In addition to the marked degree of septal abnormalities in the adult, it should also be noted that abnormalities (although only of slight degree) are found even in the fetus in Man.

The continuation into adulthood of the slight ossification along the border of the cartilaginous septum and the perpendicular plate results in bow-like curvature of the nasal septum at this junction [10], as well as in the elevation of the external nose [11]. The cartilage at the anteroinferior edge of the external nose is believed to provide stimulus for the formation of the supporting anterior nasal spine.

Thus, from an evolutionary, ontogenic, and developmental viewpoint, the relationship between modern Man's nasal septum and cranium and the interrelationships among the various components of the nasal septum can be explained in the following way: these organs and tissues are acting to preserve their respective spaces while being restricted by various constitutional, genetic factors. Moreover, during the course of their growth and development, they each show different systems of time and space. In other words, since each of these related structures or groups of structures change morphologically at different relative speeds and in different relative positions, there occur sites where structural balance is easy to maintain and others where it is not. As the process proceeds, completely different morphologies may result. Some struc-

tures may evolve progressively, others may regress and disappear, and still others may come to protrude out from among related structures.
Such phenomena are contradictory in an evolutionary sense. However, since evolution may be considered to intrinsically include the element of paradox (as represented by asymmetry) and to proceed while trying to eliminate this element, one may not even feel it necessary to refer to the term "evolutionary paradox" in discussing the evolution of the human nose. At the present time, however, there is still no consensus that will allow us to make such a judgment.

CONCLUSION

This treatise has outlined my view that the morphological abnormalities occurring in the human nasal cavity are due to a paradox that occurred inevitably as a result of the evolution of Man. It has also served to present a conclusion I have reached from my many years of clinical experience: that in order to make the correct diagnosis and carry out the appropriate (particularly surgical) treatment in common diseases of the naso-paranasal sinuses, it is necessary to understand this inevitable evolutionary paradox as completely as possible.
This treatise has outlined in simpler and more condensed form the ideas presented in "The formation of the nasal septum and the etiology of septal deformity: The concept of evolutionary paradox," originally published as a supplement to Acta Otolaryngologica (Suppl. 443, January 1988).

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