The Relationship Between the Cartilaginous Nasal Septum and Maxillary Growth During Human Fetal Life

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The role of the cartilaginous nasal septum has been discussed by many authors in the past. Scott (*8*) and Scott and Dixon (*10*) have emphasized its importance in the downward and forward growth of the maxilla, acting as a thrusting force.

Gregory (*4*), on the other hand, has suggested that since the nasal septum is firmly anchored to the midline region of the maxilla, as the maxilla moves downward and forward by sutural growth it carries with it the nasal septum. In this situation, the growth of the septum must be considered as merely a compensatory mechanism.

Material and Method

In the present study, fetuses belonging to the University of Bergen (Bergen material) and the Anatomy Department, Queen's University of Belfast, Northern Ireland (Belfast material) have been used. The terms Bergen or Belfast material do not primarily refer to nationality or ethnic groups, but to different techniques used in preparing the material for measurement.

The Bergen material consisted of 87 fetuses between the fetal ages of 10 and 33 weeks. The fetal heads were sectioned parasagittally immediately lateral to the nasal septum. All linear and angular measurements were made by placing transparent film on the sectioned surface of the sagittally cut head and tracing the points required for each linear measurement or angle onto the film under a stereo-microscope.

The Belfast material consisted of sagittally sectioned histological slides of 72 fetuses, 15 μ in thickness, between the ages of about 10 and 32 weeks.

From each series of fetal sections, the slide nearest the midline sagittal plane was selected, the criterion being that the whole of the nasal septum and cranial base should be clearly distinguishable. Under a stereo-micro-

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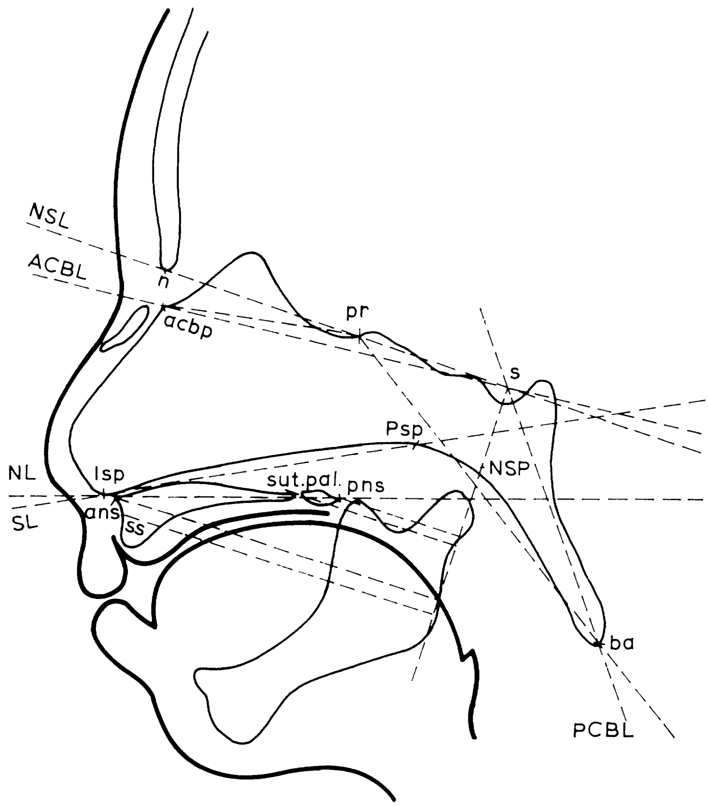

FIGURE 1. Reference points, reference lines, angles, and linear measurements. *acbp-anterior cranial base point:* the point of intersection between the most anterior part of the horizontal cribriform plate, the more vertical uppermost part of the nasal septum, and the M.S.P. *n-nasion:* point of intersection between the fronto-nasal suture and the M.S.P. In the fetal material the most caudad point on the frontal bone is used. *lsp-lower septal point:* point of intersection between the anterior vertical and lower horizontal margins of the nasal septum and the M.S.P. *psp-posterior septal point:* point in the M.S.P. on the deepest concavity of the curvature between the most posterior part of the horizontal lower margin of the nasal septum and the more vertical pharyngeal part of the cranial base. *ans-anterior nasal spine:* the tip of the anterior nasal spine in the M.S.P. *pns-posterior nasal spine:* the tip of the posterior nasal spine in the M.S.P. *sut.pal.-transverse maxillopalatine suture:* a point midway between the nasal and oral surfaces of the transverse maxillopalatine suture in the M.S.P. *ss-subspinale:* point in the M.S.P. where the anteroinferior contour of the anterior nasal spine merges with the maxillary alveolar process. *pr-prosphenion:* the intersection between M.S.P. and the junction between the ethmoid and sphenoid elements of the cranial surface of the anterior cranial fossa. *s-sella:* the center of the sella turcica in the M.S.P. *ba-basion:* point of intersection between the M.S.P. and the anterior border of the foramen magnum. *ACBL-anterior cranial base line:* a line through acbp and s. *PCBL-posterior cranial base line:* a line through s and ba. *NSL-nasion sella line:* a line through n and s. *SL-septal line:* a line through lsp and psp. *NL-nasal line:* a line through ans and pns. *NSP-nasion sella perpendicular:* a line through s perpendicular on NSL. *HL-occipitofrontal diameter:* the distance from glabella to the external occipital protuberance. In this study the HL has been used in assigning the developmental stage of the fetus. *ACBL-PCBL:* angle between the anterior and posterior cranial base lines. *NSL-PCBL:* angle between NSL and the posterior cranial base line. *pr-s-ba:* the angular relationship of the spheno-occipital

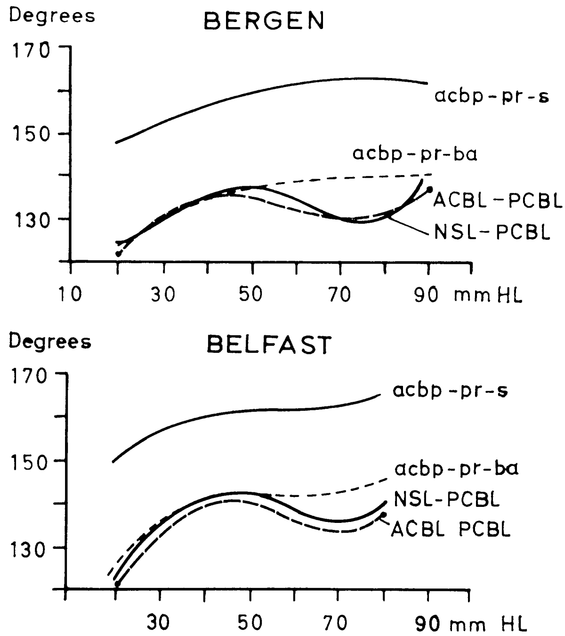

FIGURE 2. Curves showing the developmental angular changes found in the angles ACBL-PCBL, NSL-PCBL, acbp-pr-s and acbp-pr-ba.

scope the various reference points were defined and traced onto a transparent film.

The linear dimensions were measured to the nearest 0.5 mm and the angles to the nearest 0.5°. Reference points, reference lines, angles, and linear measurements are defined in Figure 1.

This study was performed in order to clarify certain quantitative and qualitative changes occurring in the craniofacial areas in the sagittal plane during fetal life. With this in mind, all the variables have been correlated to the occipitofrontal diameter (HL). A polynomic regression equation has been used varying from second to fourth degree, depending on which value of r (correlation coefficient) gave the best description of association between the variables where this is an improvement on a linear regression equation. Where the different variables have been correlated toward each other, a linear regression equation has been used.

Results

The cranial base angles, ACBL-PCBL, NSL-PCBL, acbp-pr-s, and acbp-pr-ba, all showed an actual increase in the fetal period under investigation in both the Bergen and Belfast materials (Figure 2, Table 1).

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part of the cranial base. *acbp-pr-s:* the angular relationship of the spheno-ethmoidal and the anterior cranial base. *SL-ACBL:* the angular relationship between the septal line and anterior cranial base. *SL-PCBL:* the angular relationship between the septal line and the posterior cranial base.

TABLE 1. Angles of the cranial base and upper face showing a significant change during fetal development.

	value at 20.0 mm HL	*value at 86.0 mm HL*
ACBL-PCBL		
Bergen	124.1°	138.2°
Belfast	121.0°	138.2°
NSL-PCBL		
Bergen	122.3°	136.7°
Belfast	122.7°	140.3°
acbp-pr-s		
Bergen	148.8°	163.2°
Belfast	149.5°	166.0°
acbp-pr-ba		
Bergen	123.8°	141.9°
Belfast	124.0°	145.6°
SL-PCBL		
Bergen	103.1°	117.3°
Belfast	102.7°	123.1°

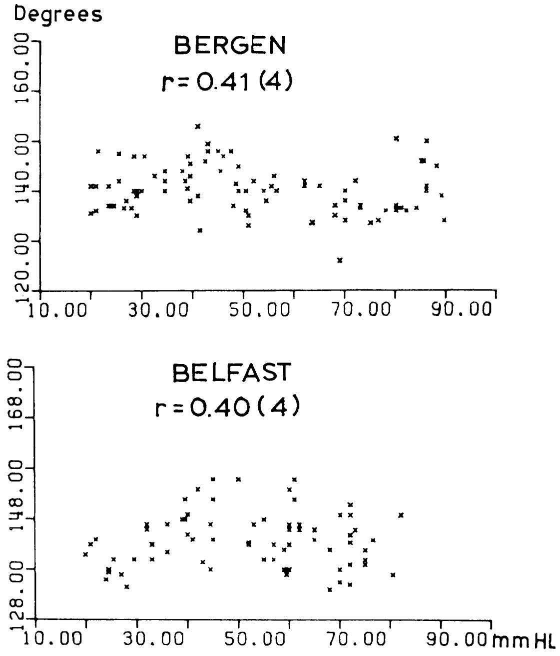

FIGURE 3. Scatter diagrams over the spheno-occipital angle pr-s-ba. No significant developmental changes were found in this angle.

The spheno-occipital angle, pr-s-ba, however, displayed no significant changes with the developmental stage of the fetuses (Figure 3).

The angular relationship between the septal line (SL) and the anterior cranial base line (ACBL) exhibited no significant developmental changes,

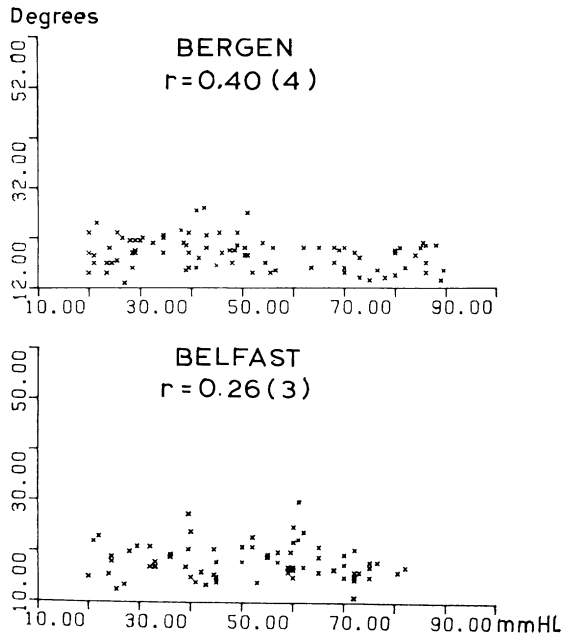

FIGURE 4. Scatter diagrams over the angle between the septal line and the anterior cranial base line (SL-ACBL). No significant developmental changes were found in this angle.

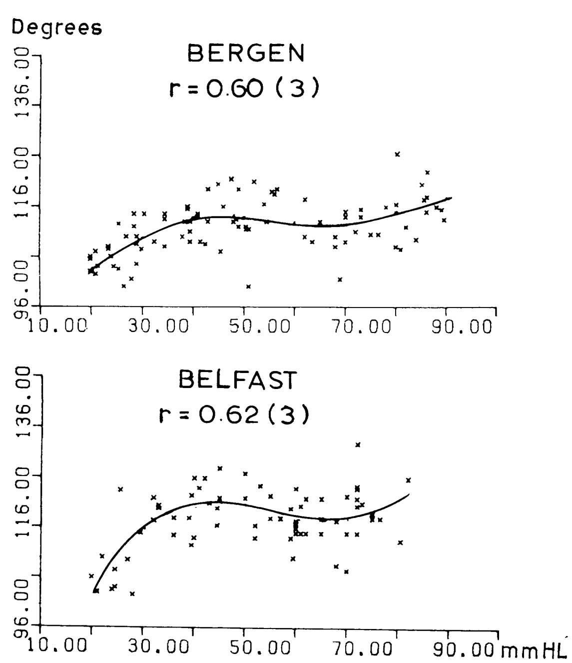

FIGURE 5. Curves showing the developmental changes in the angle between the septal line and the posterior cranial base line (SL-PCBL).

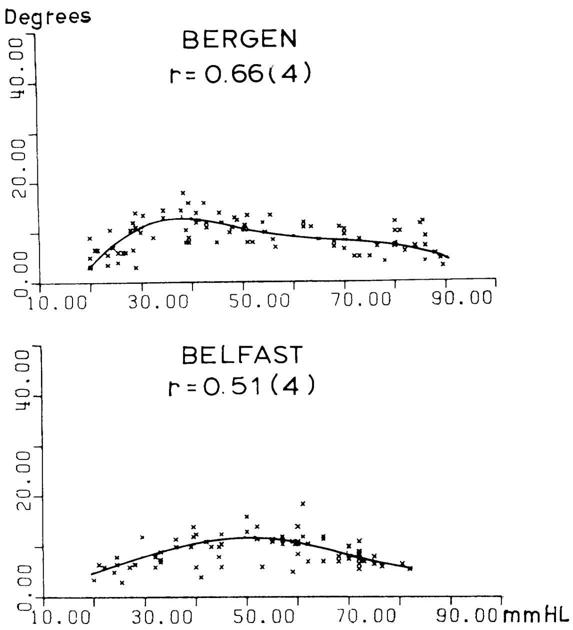

FIGURE 6. Curves showing the developmental changes occurring in the angle NL-NSL.

TABLE 2. Linear measurements of the cranial base and upper face showing a significant increase during fetal development.

	value at 20.0 mm HL	*value at 20.0 mm HL*
pns-NSP		
Bergen	2.5 mm	10.6 mm
Belfast	2.6 mm	10.3 mm
sut.pal.-NSP		
Bergen	3.4 mm	15.5 mm
Belfast	3.7 mm	17.7 mm
lsp-NSP		
Bergen	6.8 mm	33.0 mm
Belfast	7.1 mm	32.1 mm
ss-NSP		
Bergen	5.7 mm	30.2 mm
Belfast	6.6 mm	28.8 mm

whereas the angle between the septal line (SL) and the posterior cranial base line (PCBL) showed an increase rather similar to the angle ACBL-PCBL (Figures 4, 5, Table 1).

The angle between the nasal line and the nasion sella line (NL-NSL) showed an initial increase followed by a gradual decrease. The net increase in the whole period was 1.0° and 0.2° for the Bergen and Belfast materials respectively (Figure 6).

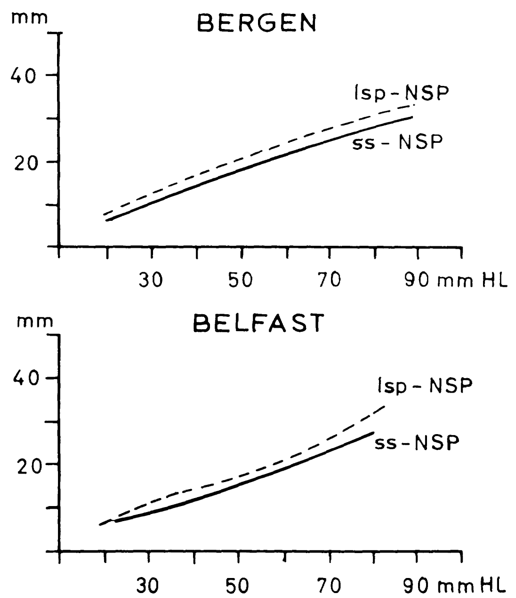

FIGURE 7. Curves showing the linear increase in the dimensions lsp-NSP and ss-NSP.

The following linear measurements were taken: PNS-NSP, sut. pal.-NSP, lsp-NSP, and ss-NSP. PNS-NSP showed an increase of 8.1 mm (Bergen material) and 7.7 mm (Belfast material), while sut.-pal.-NSP increased by 12.1 mm (Bergen material) and 10.0 mm (Belfast material) (Table 2).

The anterior point of the nasal septum, lsp, increased by 26.2 mm (Bergen material) and 25.0 mm (Belfast material) when measured from NSP, while subspinale (ss) increased by 24.5 mm (Bergen material) and 22.2 mm (Belfast material) measured from NSP (Figure 7, Table 2).

Positive correlation was found between SL-PCBL and ACBL-PCBL, between NL-NSL and SL-ACBL, and between ss-pns and lsp-NSP (Table 3).

Discussion

The cranial base from foramen magnum to the region of the foramen caecum is preformed in cartilage which is continuous with the cartilage of the nasal capsule, the latter including the cartilage of the nasal septum.

Ford (*3*), Levihn (*6*), and Kvinnsland (*5*) described an opening out (flattening) of the cranial base during human fetal life, in contrast to the gradual decrease in the cranial base angles found by various observers during postnatal life (*1, 2, 9*).

In the present investigation, the following angles all showed a significant increase during fetal development: ACBL-PCBL, NSL-PCBL,

TABLE 3. Correlation coefficients between the variables in the upper face and cranial base.

	n	*ACBL-PCBL*	*NL-NSL*	*ss-pns*	*ss-n-sm*
NSL-PCBL					
Bergen	87	0.97			
Belfast	72	0.99			
SL-PCBL					
Bergen	87	0.83			
Belfast	72	0.84			
SL-ACBL					
Bergen	87		0.50		
Belfast	72		0.65		
lsp-NSP					
Bergen	87			0.99	0.69
Belfast	72			0.99	0.50

acbp-pr-s, and acbp-pr-ba; while the angular relationship of the spheno-occipital element of the cranial base (pr-s-ba) exhibited no significant correlation to the developmental stage of the fetus. These findings would suggest that the spheno-occipital part of the cranial base is rather stable during fetal life and the angular changes that take place in the cranial base in all probability occur in or near the region of the spheno-ethmoidal junction (prosphenion).

The angle between the septal line (SL) and the anterior cranial base line (ACBL) displayed no significant developmental changes, whereas the angle between the septal line (SL) and the posterior cranial base line (PCBL) showed an increase rather similar to the cranial base angle ACBL-PCBL. This would suggest that the cartilaginous nasal septum is stable in its angular relationship with the anterior cranial base and changes its angular relationship with the posterior cranial base in conjunction with the anterior cranial segment; in other words, it behaves as part of the anterior cranial portion.

The angle between the nasal line (NL) and the nasion sella line (NSL); that is, the angle expressing the relationship between the anterior and posterior height of the upper face, showed an initial increase followed by a gradual decrease. This could indicate that the nasal line (NL) ultimately follows the same trend as the cranial base and nasal septum in their angular behavior to the posterior cranial base. The initial increase in the angle NL-NSL can possibly be explained by the restraining action of the circum-maxillary bony components, especially the zygomatic bone, which could account for the lagging behind of the palatine processes of the maxilla and palate bones in following suit with the cranial base and nasal septum in their angular relationship to the posterior cranial base.

The fact that there is positive correlation between SL-PCBL and

ACBL-PCBL, and between NL-NSL and SL-ACBL seems to substantiate these assumptions.

To measure the relative forward growth of the facial complex in relation to the sella (s), several of the facial points were measured from the nasion sella perpendicular (NSP). The anteroposterior relationship of the most posterior point of the bony palate (pns-NSP) showed an increase of 8.1 mm (Bergen material) and 7.7 mm (Belfast material), while the distance sut.pal.-NSP increased by 12.1 mm (Bergen material) and 10.0 (Belfast material).

From these findings it would seem that the transverse maxillopalatine suture is shifted forward during fetal life from a more posterior position in early embryonic life to a more anterior position in later embryonic life.

The anterior growth of the nasal septum was measured by the distance lsp-NSP and the corresponding anterior growth of the maxilla was measured by the distance ss-NSP. In all fetal stages the anterior growth of the septum (lsp-NSP) was slightly in excess of the anterior growth of the maxilla (ss-NSP). Furthermore, the lower septal point (lsp) was always found anterior to the anterior nasal spine (ans).

The present findings, therefore, regarding the angular changes of the cranial base, nasal septum and hard palate, the forward shift of the transverse maxillopalatine suture, and the fact that the anteroposterior growth of the septum (lsp-NSP) was in the whole growth process investigated in advance of the corresponding anteroposterior growth of the maxilla, seem to support Scott's (*8, 9*) and Schulz's (*7*) views, that the cartilaginous nasal septum is a primary growth effector of the upper face, at least in prenatal life.

Summary

The cranial base angle NSL-PCBL shows an increase during fetal life. The spheno-ethmoidal part of the cranial base becomes flatter while the spheno-occipital element shows stability. This indicates that the angular changes taking place in the cranial base in fetal life in all probability occur in the region of the spheno-ethmoidal junction (pr). The cartilaginous nasal septum is stable in relationship to the anterior cranial base, and the palatal plane seems to be under the influence of the nasal septum. The transverse maxillopalatine suture is shifted forward during fetal growth. In all fetal stages the anterior growth of the nasal septum was slightly in excess of the anterior growth of the maxilla.

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References

1. BJØRK, A., Cranial base development. *Amer. J. Orthod., 41,* 198–225, 1955.
2. DABLOW, A., Über Korrelationen in der phylogenetischen Entnicklung der schädelfum. *Morph. Tb., 67,* 84, 1931.
3. FORD, E. H. R., The growth of the fetal skull. M.D. thesis, University of Cambridge, 1955.
4. GREGORY, W. K., *Our Face from Fish to Man.* New York: G. P. Putnam's Sons, 1929.
5. KVINNSLAND, S., A preliminary report on the angular changes of the cranial base in human fetuses. Det kongelige norske videnskabers selskaps forhandlinger. *Bind, 40,* 11, 1967.
6. LEVIHN, W. C., A cephalometric roentgenographic cross-sectional study of the craniofacial complex in fetuses from 12 weeks to birth. *Amer. J. Orthod., 53,* 822–848, 1967.
7. SCHULTZ, A. H., Relation of the external nose to the bony nose and nasal cartilages in whites and Negroes. *Amer. J. phys. Anthro., 1,* 329–338, 1918.
8. SCOTT, J. H., The cartilage of the nasal septum. *Brit. dent. J., 95,* 37–43, 1953.
9. SCOTT, J. H., The growth of the nasal cavities. *Acta otolaryng. (Stockh.), 50,* 215–223, 1959.
10. SCOTT, J. H., and A. D. DIXON, *Anatomy for Students of Dentistry.* London: E. & S. Livingstone, Ltd., 1959.