From: Department of Orthodontics, The Royal Dental College, Aarhus, Denmark.

A RADIOGRAPHIC CRANIOMETRIC STUDY OF DIMENSIONAL CHANGES IN THE NASAL SEPTUM FROM INFANCY TO MATURITY

by

B MELSEN

INTRODUCTION

The purpose of this study is to give an account of the dimensions of the osseous parts of the nasal septum at various stages of development between full eruption of the deciduous teeth and maturity.

The nasal septum consists of the cartilaginous and the osseous septum, the latter comprising the perpendicular plate of the ethmoid, the vomer, the crest of the sphenoid body and the nasal crests of the maxillae and palatine bones. It is limited below by the floor of the nasal cavity and above by the frontal bone, the cribriform plate of the ethmoid and the crest of the sphenoid body; the anterior and posterior borders are free.

The embryonic development of the nasal septum has been studied by *Mall* (1908), *Fawcett* (1911), *Woo* (1949), *Ford* (1956), *Gilbert* (1958), and *Baume* (1961). Its postnatal growth has been described both histologically and on the basis of measurements. In a histological study of the septum in three 24—42 month old Macaca Rhesus, *Baume* (1963) found active osteogenic processes at the synchondrosis between the perpendicular plate of the ethmoid and the septal cartilage, on the vomer side of the vomerosphenoidal suture and along the posterior border of the vomer. The size of the nasorespiratory area in different age groups was

studied by *Rosenberger* (1934) on profile radiographs of children of 0—19 years. He found in all groups increase of the nasorespiratory area. A direct measurement of the nasal septum was, however, not included in his study. *Scott* (1953, 1959) investigated the role played by the nasal septum in the development of the facial skeleton. He considered the development of the human face to fall into two separate phases — one from birth to the seventh year, and the other thereafter. In the first phase, growth was then mainly determined by the growth of the cartilaginous septum and of the cranial base. In the second phase, growth of the nasal septum and the facial sutures ceased and the development of the facial skeleton was dominated by surface apposition and internal reconstruction.

Takagi (1964) studied the position of the supero-posterior border of the vomer and found a dorsal migration of the vomer in relation to the body of the sphenoid. *Bergland* (1963) made the same observation. *Björk* (1964) found that positional change of the maxilla in relation to the anterior cranial base in males continues until the age of 17. This gives an indirect indication of the growth of the nasal septum, on account of the intimate anatomical relationship of these structures.

The extant literature reveals that the nasal septum and its borders cannot be localized satisfactorily on profile radiographs of living subjects. This excludes an exact longitudinal study of the nasal septum. An investigation of dry skulls of children in different age groups was therefore found to be the best way of obtaining information on development in that region.

MATERIAL AND METHODS

The material consists of 132 skulls from India (purchased for teaching purposes) made available by the Dental Colleges and Universities of Copenhagen and Aarhus. The skulls have not been buried and are well preserved. A racial classification of the skulls has not been possible, owing to lack of information.

Age determination

As an exact determination of age could not be carried out, the skulls were divided into developmental stages according to the development of the dentition, corresponding to dental stages

defined by *Björk, Krebs & Solow* (1964). The stages employed were DS 02, DS 1, DS 2, DS 3, DS 4 and DS M3, defined as follows:

Dental stage 02 Deciduous teeth fully erupted.
1 Permanent incisors erupting.
2 Permanent incisors fully erupted.
3 Canines or premolars erupting.
4 Canines and premolars fully erupted.
M3 3rd molars fully erupted.

The material thus covers the range between fully erupted deciduous teeth and the complete permanent dentition. DS 1 and DS 2, each representing by definition only a small age group, were combined in one group, DS 1—2. *Nanda* (1966) has found that tooth eruption in Indians, especially of a lower socio-economic group, occurs later in relation to chronological and skeletal age than has been stated for children from USA (*Moorrees*, 1963).

Measurements

The measurements were made on profile radiographs. To facilitate localization on the radiographs certain points that are difficult to distinguish were marked on the skulls with gramophone needles. Moreover, the lower border of the vomer and the anterior border of the foramen magnus were marked with 0.5 mm lead wire. The radiographs were taken with the skulls placed in a cephalostat with a film-focus distance of 190 cm, giving an average enlargement of 5.6 %, which was not corrected in the calculations. To obtain the best possible quality of radiographs SINO-film was employed without intensifying screens. The reference points employed were:

spa — Spina nasalis anterior. The tip of the anterior nasal spine.
va — Vomer anterior. The extreme anterior point of the vomer in the median plane.
spp — Spina nasalis posterior. The tip of the posterior nasal spine.
s — Sella. The centre of the sella turcica, with the superior limit of the sella defined as a line joining the tuberculum and the dorsum sellae.
n — Nasion. The most anterior point of the nasofrontal suture.

ba — Basion. The extreme postero-inferior point of the clivus.
ho — Hormion. The extreme dorsal point of contact of the vomer with the body of the sphenoid in the mid-sagittal plane between the alae of the vomer.
vp — Vomer posterior. The vomer's extreme infero-posterior limit (the most dorsal point on the vomer's inferior border on the suture).

With the exception of spa, s and n, all points were marked with pins as described above.

The following dimensions were measured.

Linear dimensions:

No. 1 spa-va	No. 8 s-spp
2 va-spp	9 n-spa
3 spa-spp	10 s-ho
4 s-va	11 ho-vp
5 s-spa	12 va-vp
6 s-n	13 vp-spp
7 s-ba	14 n-va
	15 x (cf. below)

Angles:

No. 16 s-n-spa	No. 19 n-s-ho
17 s-n-va	20 n-s-spp
18 n-s-ba	21 n-s/spa-spp

The linear dimension x is not a single measurement, but an expression of the distance from the lower border of the vomer to the floor of the nasal cavity. As this distance cannot be determined by a single measurement, it is here expressed as the mean of a series of measurements, x being defined as the mean vertical distance between the floor of the nasal cavity and the vomeropalatine suture. It was determined as the distance between the vomeropalatine suture and the most radioopaque part of the nasal floor and was measured perpendicular to the spa-spp line at 1 mm intervals. On an average, 35 such measurements were made on each radiograph. x was then calculated as the mean of these values.

Measurements were made to the nearest tenth of a mm directly on the film, as described by *Björk & Solow* (1964), using a sliding calliper equipped with a dial. The angles were measured to the nearest half degree with the aid of two transparent cellophane sheets, one marked with parallel lines at an interval of 2½ cm, and the other with the two perpendicular midlines.

Error of the method

Error was checked by double measurement of 10 skulls. Approximately one week after the first radiographs were taken, the whole procedure of marking skulls, radiographing and measuring was repeated, and the difference between the two measurements was tested by Student's t-test. In none of the cases was the difference significant, which indicates that there was no systematic error in the method. The size of the random error $s(i) = \sqrt{\frac{(x_1 - x_2)^2}{2N}}$ was then investigated. The results are presented in

Table I.
Table I. *Error of the method*

spa-va	= 0.39 mm	s-n	= 0.77 mm	ho-vp	= 0.64 mm	s-n-va	= 1.62°
va-spp	= 0.25 »	s-ba	= 0.34 »	vp-va	= 0.43 »	n-s-ba	= 1.55°
spa-spp	= 0.19 »	s-spp	= 0.19 »	vp-spp	= 0.19 »	s-n-spa	= 0.83°
s-va	= 0.41 »	n-spa	= 0.19 »	n-va	= 0.33 »	n-s-ho	= 1.24°
s-spa	= 0.24 »	s-ho	= 0.27 »	x	= 0.54 »	n-s-spp	= 0.88°
						n-s/spa-spp	= 0.85°

For several of the variables, it was possible to compare the estimated s(i) with values from earlier studies of cranial material and it was found that they were of the same magnitude (*Lysell & Filipson,* 1958; *Bergland,* 1963).

The above s(i) values are a combined expression of 1) marking error, 2) variation in positioning of the skulls in the cephalostat and 3) measuring error. In measurements of profile X-ray photographs of living subject *Solow* (1966) considered errors of less than 0.5 mm as small and of more than 1.5 mm as large. These errors were an expression of 1) variation in positioning of the patient in the cephalostat and 2) measuring error. For the linear measurements, involving one or two of the marked points, according to *Solow's* classification, the s(i) values in the present

study turned out to be small, indicating perhaps that accuracy increases when points are marked as described. Some of the angular measurements showed a large random error, in particular s-n-va and n-s-ba. Apart from the error in localizing s-n, (s(i) = 0.77 mm), this may be due to the difficulty of locating va and ba, respectively.

Statistical analysis

The distributions of the measurements obtained were analysed and compared with a normal distribution. This analysis employed, apart from the normal statistical parameters x, s, and V, for groups containing 20 or more skulls *b1*, *b2* (*Pearson*, 1931) and *a* (*Geary*, 1935), and for the group of 14 skulls (DS 3) *a* and *Kolmogorov-Smirnov's* test, i. e. calculation of $D\alpha$ (*Massey*, 1954). Definitions of the parameters *b1*, *b2* and *a* correspond to those employed by *Solow* (1966), and tabulation of significance limits has been carried out by *Pearson* and *Hartley* (1954).

$D\alpha$ is defined as the largest absolute deviation from a theoretical distribution; its significance limits have been tabulated by *Owen* (1962). Deviations from normality, significant at 1 % and 5 % levels have been marked in the tables with a double and a single asterisk, respectively. Significance levels for *b2* are not given, as they are not available for small groups.

Finally, the equality of the mean for the various age groups was tested by an analysis of variance. The resulting F values are given in Table VII on the right side, and significance is indicated as described above. All calculations were carried out on an electric computer (GIER).

RESULTS

Distribution form. Tables II—VI.

Only a few distributions showed deviations from the normal distribution significant at the 1 % level. Among the significant deviations, no systematic tendency to skewness, platykurtosis or leptokurtosis was found at the different stages of development, and an explanation of the deviations could not be found.

Dimensional changes. Table VII records the mean values of the linear and angular variables at the different dental stages, while

Table II. *Statistical description of the distributions DS 02 (deciduous teeth fully erupted), 48 skulls*

Variable	Range Min	Max	$\bar{x}$	s	s($\bar{x}$)	V	Skewness b1	Kurtosis b2	a
spa-va	6.0	15.0	8.91	1.91	.275	21.48	1.067**	3.94	.7611
va-spp	27.4	39.5	32.43	2.61	.376	8.04	.118	2.86	.8250
spa-spp	34.9	46.5	40.20	2.71	.392	6.75	.153	2.47	.8150
s-va	51.3	67.9	58.08	3.65	.527	6.29	.196	2.75	.8156
s-spa	58.9	74.5	66.92	3.71	.536	5.55	—.073	2.46	.8124
s-n	51.4	66.9	59.31	3.07	.443	5.17	.158	3.08	.7778
s-ba	27.3	37.2	32.11	2.47	.464	7.69	.048	2.41	.7988
s-spp	31.5	42.0	35.38	2.28	.330	6.46	.474	3.10	.7935
n-spa	32.3	47.7	38.17	3.09	.445	8.09	.520	3.81	.7807
s-ho	14.8	20.4	18.16	1.26	.220	6.95	—.308	3.06	.7907
ho-vp	9.5	21.3	14.94	2.92	.508	19.51	.332	2.43	.8193
vp-va	25.9	38.5	32.66	3.06	.532	9.36	—.211	2.62	.8349
vp-spp	1.6	7.6	4.47	1.34	.234	30.04	.156	2.67	.8239
n-va	29.4	39.9	35.18	2.28	.396	6.47	.096	3.14	.7695
x	0.9	3.2	1.90	0.56	.098	29.72	.522	2.70	.8114
s-n-spa	75.5	90.5	83.83	3.67	.529	..	—.164	2.69	.7905
s-n-va	62.2	78.0	70.34	4.34	.626	..	—.048	2.07	.8331
n-s-ba	123.5	145.0	134.89	4.97	.733	..	—.206	2.75	.8053
n-s-ho	64.0	87.0	76.77	5.32	.830	..	.179	2.63	.8282
n-s-spp	52.5	76.0	64.82	3.80	.554	..	.216	5.06	.7312*
n-s/spa-spp	2.0	14.5	8.91	2.61	.381	..	—.324	3.07	.7805

Table III. *Statistical description of the distributions DS 1--2 (permanent incisors erupting or fully erupted), 20 skulls*

Variable	Range Min	Max	$\bar{x}$	s	s($\bar{x}$)	V	Skewness b1	Kurtosis b2	a
spa-va	7.9	14.4	11.00	1.88	.420	17.07	—.009	2.08	.8321
va-spp	31.0	42.5	35.63	2.73	.611	7.67	.444	3.17	.8214
spa-spp	40.0	50.4	44.45	2.41	.539	5.42	.365	3.27	.8004
s-va	59.7	68.1	63.58	2.45	.547	3.85	.067	1.98	.8724
s-spa	69.6	80.5	74.48	2.67	.598	3.59	.175	3.19	.7346
s-n	58.8	68.4	63.27	2.42	.541	3.82	.242	2.63	.8080
s-ba	32.1	40.0	36.37	2.10	.470	5.77	—.497	2.70	.7625
s-spp	35.5	42.5	39.80	1.93	.433	4.86	—.623	2.56	.8337
n-spa	38.3	47.6	43.83	3.14	.703	7.17	—.490	1.91	.8501
s-ho	18.8	23.1	21.21	1.33	.305	6.28	—.269	1.98	.8571
ho-vp	11.6	20.8	15.89	2.69	.618	16.94	.293	2.05	.8456
vp-va	31.5	43.5	35.68	3.30	.757	9.25	.746*	2.84	.8397
vp-spp	2.0	9.1	5.08	1.93	.443	37.97	.431	2.41	.8372
n-va	34.5	44.7	39.47	3.06	.702	7.75	.023	2.06	.8279
x	1.7	3.7	2.66	0.62	.143	23.37	—.111	2.21	.8037
s-n-spa	82.0	92.0	85.26	2.42	.540	..	.982	4.01	.7823
s-n-va	68.0	82.5	71.56	3.46	.773	..	1.072*	6.07	.7131*
n-s-ba	124.5	138.2	132.17	3.50	.782	..	—.301	2.95	.7882
n-s-ho	71.0	86.5	79.66	4.15	1.039	..	—.340	2.57	.8265
n-s-spp	61.5	75.0	67.27	3.57	.798	..	—.040	2.57	.8111
n-s/spa-spp	5.0	14.0	9.72	2.68	.599	..	.037	1.88	.8717

Table IV. *Statistical description of the distributions DS 3 (canines and premolars erupting), 14 skulls*

Variable	Range Min	Max	$\bar{x}$	s	$s(\bar{x})$	V	Skewness b1	Kurtosis b2	a	Dα
spa-va	9.0	16.5	12.42	2.56	.685	20.63	.214	1.88	.8522	.118
va-spp	31.5	42.0	36.96	3.10	.828	8.38	—.442	2.28	.8295	.170
spa-spp	40.4	52.0	47.22	3.42	.913	7.24	—.351	4.24	.8644	.133
s-va	55.0	72.0	64.86	4.32	1.154	6.65	—.350	3.37	.7668	.132
s-spa	66.5	84.2	77.11	5.01	1.338	6.49	—.360	2.62	.8349	.099
s-n	56.6	70.5	65.39	3.88	1.038	5.94	—.622	2.86	.8288	.093
s-ba	33.3	47.7	39.62	4.61	1.231	11.63	.116	1.85	.8857	.170
s-spp	35.4	48.4	41.56	4.08	1.090	9.81	—.069	2.06	.8215	.128
n-spa	38.1	54.4	46.47	4.70	1.256	10.11	—.214	2.12	.8512	.092
s-ho	18.0	22.6	21.03	1.59	.481	7.58	—.626	2.18	.8482	.120
ho-vp	11.8	23.9	16.94	3.80	1.141	22.42	.487	2.59	.7078	.178
vp-va	29.9	41.8	36.13	3.68	1.110	10.19	—.141	2.03	.8344	.099
vp-spp	3.0	7.3	5.21	1.37	.413	26.29	—.012	2.08	.8013	.151
n-va	33.5	45.8	40.32	3.41	1.028	8.45	—.559	2.35	.7567	.268
x	2.2	5.3	3.15	0.98	.296	31.16	1.019	3.13	.8268	.153
s-n-spa	78.0	98.7	84.59	3.76	1.006	..	—.307	1.86	.8808	.141
s-n-va	64.5	78.0	69.85	4.36	1.165	..	.742	2.32	.8011	.100
n-s-ba	120.0	144.5	131.12	7.19	1.923	..	.129	2.36	.8043	.214
n-s-ho	76.5	90.0	83.82	4.80	1.448	..	—.181	1.67	.8970*	.150
n-s-spp	64.5	75.5	69.36	3.85	1.028	..	.327	1.79	.8482	.137
n-s/spa-spp	5.5	15.0	9.25	2.97	0.793	..	.524	2.06	.8747	.153

Table V. *Statistical description of the distributions DS 4 (canines and premolars fully erupted), 30 skulls*

Variable	Range Min	Max	$\bar{x}$	a	$s(\bar{x})$	V	Skewness b1	Kurtosis b2	a
spa-va	7.8	21.0	12.56	2.57	.469	20.44	.885*	5.39	.6938
va-spp	29.7	43.2	37.97	3.31	.605	8.72	—.569	2.92	.7919
spa-spp	43.6	54.4	48.57	3.17	.578	6.52	.247	1.95	.8584
s-va	62.3	71.4	66.57	2.24	.408	3.36	.386	2.67	.8357
s-spa	72.1	87.1	78.94	3.48	.636	4.41	.450	2.99	.7875
s-n	59.5	73.5	65.88	4.10	.748	6.22	.118	1.96	.8639*
s-ba	30.3	52.5	39.97	3.84	.701	9.61	.654	5.81	.7313*
s-spp	38.0	47.1	42.84	2.22	.406	5.19	—.187	2.46	.8394
n-spa	41.4	53.0	46.91	3.33	.608	7.10	.119	1.97	.8585
s-ho	19.1	24.4	21.68	1.49	.292	6.86	.143	2.17	.8155
ho-vp	11.1	25.7	18.06	3.67	.720	20.33	.386	2.89	.7790
vp-va	27.9	45.7	37.57	4.56	.895	12.15	—.154	2.35	.8196
vp-spp	3.7	12.5	6.37	2.02	.397	31.78	1.085**	4.34	.7802
n-va	38.4	46.3	41.89	2.56	.502	6.12	.079	1.57	.8983**
x	2.0	7.9	4.52	1.11	.217	24.49	.693*	1.23	.7262*
s-n-spa	78.5	99.2	87.00	4.64	.847	..	.272	3.23	.7797
s-n-va	63.5	83.2	72.05	4.66	.851	..	.224	2.71	.7853
n-s-ba	120.0	155.0	133.37	6.70	1.224	..	.701*	5.21	.7183*
n-s-ho	76.0	94.5	83.90	4.75	.883	..	.360	2.77	.7922
n-s-spp	61.0	75.0	69.55	3.65	.667	..	—.401	2.42	.8412
n-s/spa-spp	2.5	14.0	8.50	2.88	.526	..	—.253	2.56	.8115

Table VI. *Statistical description of the distributions DS M3 (3rd molars fully erupted), 20 skulls*

Variable	Range Min	Max	$\bar{x}$	s	$s(\bar{x})$	V	Skewness b1	Kurtosis b2	a
spa-va	8.6	18.8	12.65	2.76	.618	21.84	.612	2.96	.7447*
va-spp	35.7	47.9	41.24	3.54	.791	8.58	—.047	2.23	.8238
spa-spp	46.2	60.3	52.61	4.02	.898	7.64	.294	2.46	.7912
s-va	62.9	75.8	68.93	3.87	.865	5.61	—.027	2.05	.8298
s-spa	74.0	90.3	81.54	4.11	.920	5.05	.293	2.65	.7977
s-n	59.6	72.4	66.38	3.46	.774	5.22	.075	2.22	.8517
s-ba	37.0	46.8	42.27	3.03	.678	7.17	—.158	2.00	.8303
s-spp	38.9	49.2	53.29	3.09	.691	7.14	.459	2.22	.7973
n-spa	41.9	55.5	49.50	3.65	.816	7.37	—.322	2.39	.8337
s-ho	18.5	25.5	21.84	1.90	.425	8.71	.163	2.45	.8148
ho-vp	13.6	22.5	18.91	2.44	.546	12.92	—.320	2.13	.8759*
vp-va	35.6	46.4	40.97	3.23	.722	7.88	—.159	1.85	.8715*
vp-spp	4.5	8.9	6.33	1.47	.330	23.28	.411	1.71	.8940*
n-va	39.0	50.5	45.07	3.00	.671	6.66	—.246	2.37	.8245
x	3.1	5.7	4.68	.79	.176	16.83	—.423	2.11	.8608
s-n-spa	81.5	92.0	87.10	3.05	.683	..	—.049	2.35	.8128
s-n-va	68.5	77.0	73.62	3.02	.467	..	—.718	3.30	.7673
s-n-ba	126.5	139.0	133.27	3.72	.832	..	—.096	1.84	.8814*
n-s-ho	76.5	95.5	88.70	5.01	1.120	..	—.941*	3.68	.7292*
n-s-spp	63.5	78.5	72.05	3.93	.878	..	—.466	2.66	.7826
n-s/spa-spp	5.0	14.0	9.17	2.03	.455	..	.592	3.60	.7703

Table VII. *Means of the variables at the 5 different dental stages*

Variable	DS 02	DS 1—2	DS 3	DS 4	DS M3	F^4_{127}
spa-va	8.91	11.00	12.42	12.56	12.65	17.26**
va-spp	32.43	35.63	36.96	37.97	41.24	38.00**
spa-spp	40.20	44.45	47.22	48.57	52.61	70.86**
s-va	58.08	63.58	64.84	66.57	68.93	51.70**
s-spa	66.92	74.48	77.11	78.94	81.54	86.24**
s-n	59.31	63.27	65.39	65.88	66.38	26.27**
s-ba	32.11	36.37	39.62	39.97	42.27	79.59**
s-spp	35.38	39.80	41.56	42.84	43.29	55.37**
n-spa	38.17	43.83	46.47	46.91	49.50	50.03**
s-ho	18.16	21.21	21.03	21.68	21.84	2.80*
ho-vp	14.94	15.89	16.94	18.06	18.91	6.79**
vp-va	32.66	35.68	36.13	37.57	40.97	17.74**
vp-spp	4.47	5.08	5.21	6.37	6.33	6.13**
n-va	35.18	39.47	40.32	41.89	45.07	45.83**
x	1.90	2.66	3.15	4.52	4.68	59.49**
s-n-spa	83.83	85.26	84.59	87.00	87.10	17.77**
s-n-va	70.34	71.56	69.85	72.05	73.62	2.53*
n-s-ba	134.89	132.17	131.12	132.37	133.27	1.24
n-s-ho	76.77	79.66	83.82	83.90	88.70	23.29**
n-s-spp	69.82	67.27	69.36	69.55	72.05	16.27**
n-s/spa-spp	8.91	9.72	9.25	8.50	9.17	1.41

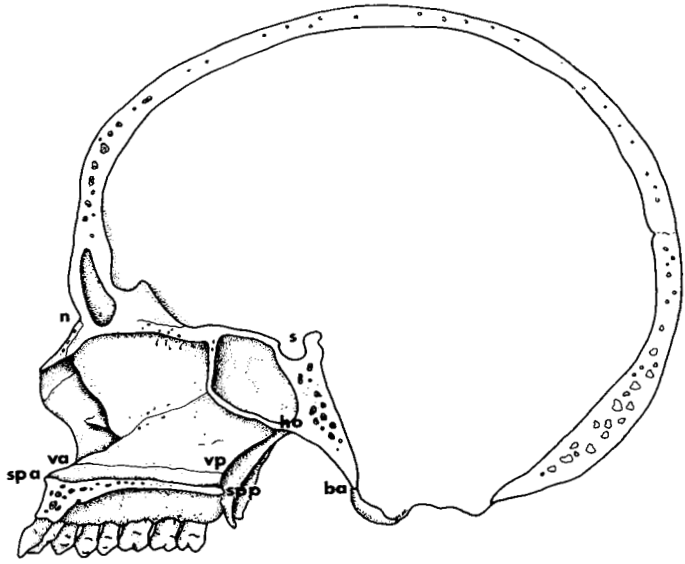

Fig. 1. Reference points employed on profile radiographs.

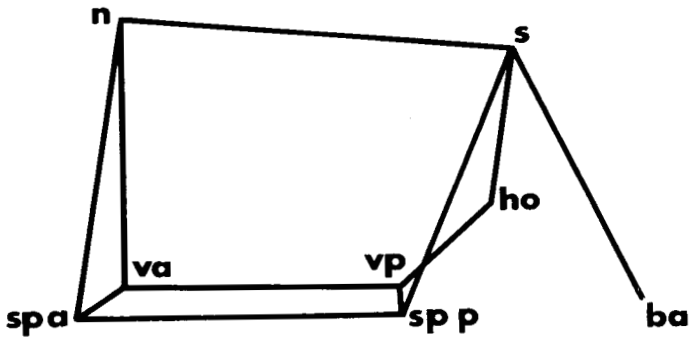

Fig. 2. Diagram showing the linear dimensions determined.

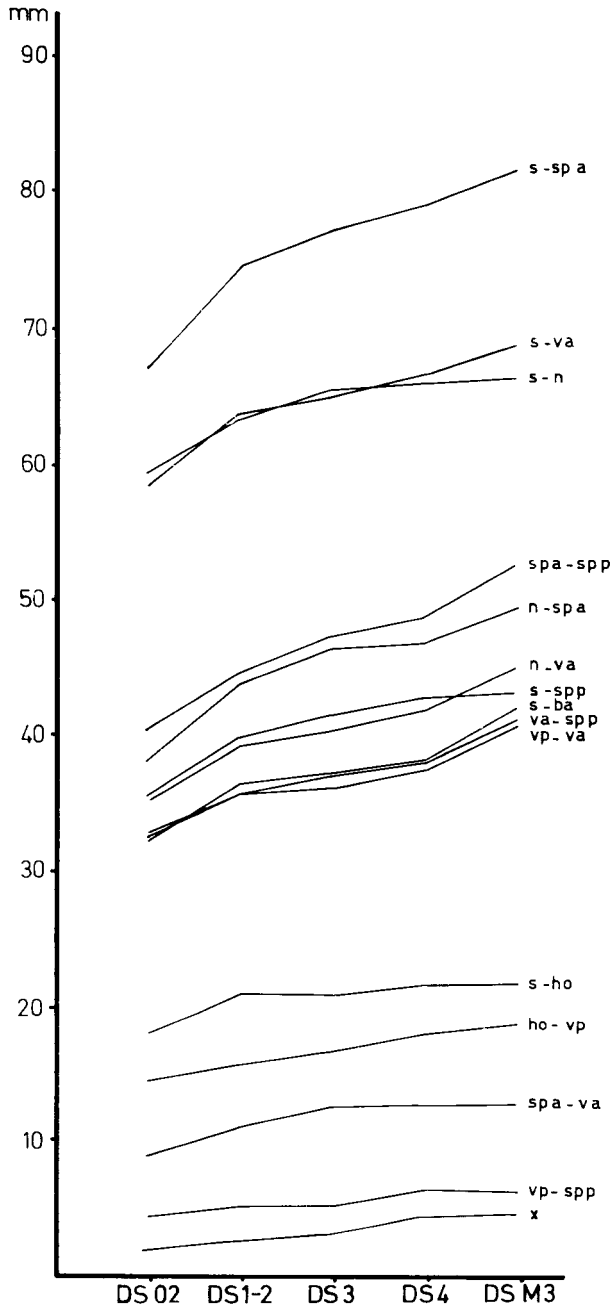

Fig. 3. Growth curves for linear dimensions.

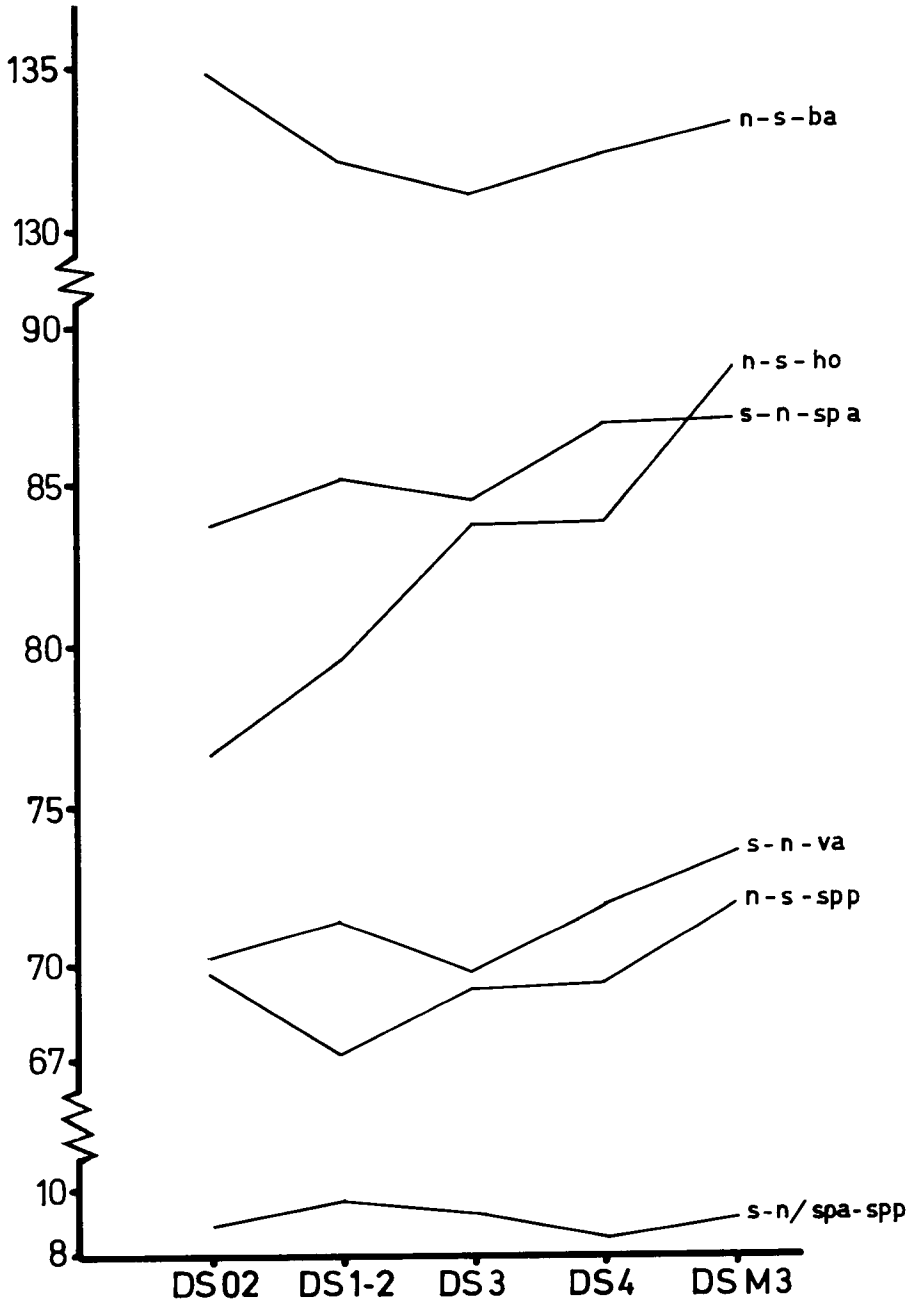

Fig. 4. Growth curves for angles.

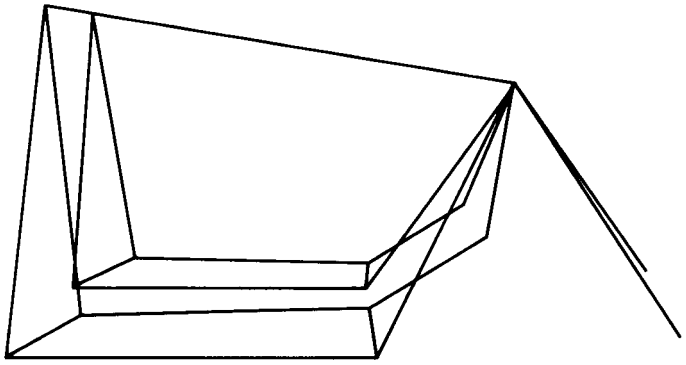

Fig. 5. Mean upper facial diagrams at DS 02 and DS M3 superimposed on s-n and registered on s.

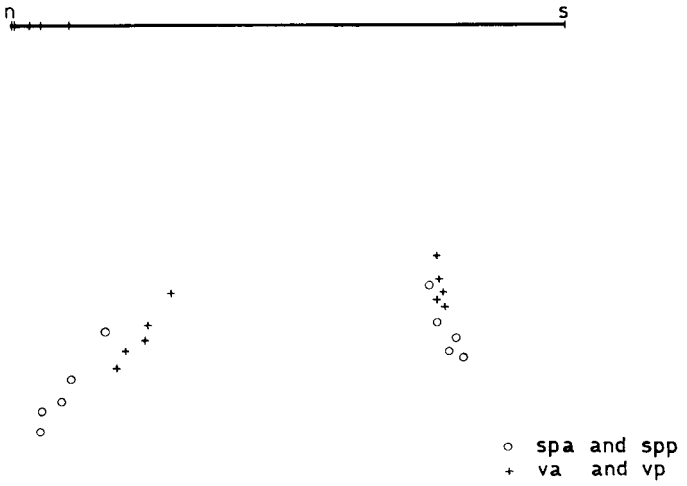

Fig. 6. Mean changes in reference points spa, spp, va, vp in relation to s-n.

Figs. 3 and 4 present these results graphically. Diagrams based on the means were drawn for each dental stage and in Fig. 5 the diagrams for DS 02 and DS M3 are superimposed on s-n registered on s. With s-n as reference line, the positions of the points spa-va, vp and spp at different dental stages are marked in Fig. 6.

The variables could be classified into 5 groups according to the pattern they followed through the different dental stages:

Variables.
1) for which no change can be demonstrated,
2) showing no increase in size after DS 1—2,
3) showing no increase in size after DS 3,
4) showing no increase in size after DS 4,
5) which continue increasing in size until maturity.

See Figs. 3 and 4.

The only measurements for which no change could be demonstrated, were the cranial base angle n-s-ba and the angle between s-n and spa-spp which are apparently constant from the age corresponding to DS 02. The second group includes s-ho, the third consists of a single dimension spa-va, and the fourth of the linear dimensions vp-spp and x and the angle s-n-spa. Among measurements which increase in size until maturity are those indicating anterior facial height n-va and n-spa, posterior facial height s-spp, posterior height of vomer ho-vp and horizontal length of the nasal septum spa-spp, va-spp and va-vp. The angles between the anterior cranial base and the dorsal limit of the septum, n-s-ho and n-s-spp, are also included in this group.

DISCUSSION

The cranial base. No significant changes at different stages were found in the shape of the cranial base, as expressed by the angle n-s-ba. This is in agreement with the findings of *Brodie* (1941) and *Björk* (1947, 1955).

The latter, in a longitudinal study of 12 to 20 years old males, found that the angle n-s-ba might increase or diminish in the individual case, but that the mean angle could be considered to be constant in the group as a whole.

Stamrud (1960), in a cross-sectional study of subjects ranging in age from 3 years to maturity, found small differences in the mean base angle between age groups, but that this angle remains constant as a whole.

The linear dimensions n-s and s-ba continued to increase until maturity, in agreement with the findings of *Björk* (1947, 1955), *Stamrud* (1959) and *Koski* (1960).

The maxillary complex. As a reference line for evaluation of the displacement of the maxillary complex, the s-n line registered on s was employed. The changes accompanying growth of this line in the age group 12 to 20 years have been followed longitudinally by *Björk* (1955). He demonstrated that in spite of marked individual variation, the nasion in its forward movement generally followed the direction of the s-n line at the initial stage of observation.

The growth of the sella turcica is stated by *Björk* to be usually excentric, the sella point generally moving downward and backward. There can be no compensation for this in a cross-sectional study.

The position of the *posterior limit of the maxillary complex* in the mid-sagittal plane in relation to the anterior cranial base, is expressed by the linear dimensions s-ho, s-spp and the corresponding angles n-s-ho and n-s-spp. The increase of the linear dimension s-ho ceased at DS 1—2, but this does not mean that the position of ho was then constant, as it migrated dorsally in relation to the body of the sphenoid, the angle n-s-ho increasing until DS M3. This has also been observed by *Bergland* (1963) and *Takagi* (1964). The lowering of the nasal floor was found to be parallel in relation to the s-n line as the angle s-n/spa-spp remained constant from DS 02 to DS M3. A similar parallel lowering of the nasal floor was observed by *Brodie* (1941) in subjects from 3 months to 8 years and by *Björk* (1947) in subjects from 12 to 20 years. The increase of s-spp was less in relation to the increase found in the anterior part of the maxillary complex — for instance in n-spa. The constant value of the angle s-n/spa-spp and the increase in the angle n-s-spp indicate that the difference was due to a backward movement of spp.

The height of the *anterior part of the maxillary complex* is represented by the dimension n-spa, and its positional relation-

ship to the anterior cranial base by the angle s-n-spa. The height continued to increase until DS M3. This may be due to sutural growth of the maxilla or remodelling lowering of the nasal floor (*Björk* 1955, 1964), as the two processes of growth occur simultaneously.

The direction of downward movement of spa is reflected by change of the angle s-n-spa, which generally increased until DS 4, after which it remained constant. Thus, in the cranial material investigated, there was an average downward and forward movement of the maxillary complex until DS 4, and thereafter a gradual transition to more vertical growth. This is in agreement with the findings of *Björk* (1964), who in implant studies found that the growth of the upper face in 37 boys was generally downward and forward, although there were very large individual variations. He supposed that the most common pattern of growth in the juvenile period was mainly sagittal and in adolescence more vertical.

Measurement of the dimension s-n showed that n moved forward. The angle s-n-spa nevertheless increased until DS 4, and should be taken as an expression of the even greater forward displacement of the maxillary complex in the growth period, causing a general increase in facial prognathism, as shown by *Björk* (1947), *Stamrud* (1959) and *Koski* (1960).

The distance from the sella to the anterior nasal spine continued to increase until maturity. This increase can theoretically occur in three places: First, as sutural growth between vomer and the body of the sphenoid, secondly, as sutural growth between the vomer and maxilla, and thirdly as lowering of spa by resorption. According to observations of the distance s-ho in this study the increase mainly occurred by apposition on the vomer side of the suture. After DS 3, the average distance from va to spa was constant, as was the height expressed by x after DS 4. The average lowering of spa in relation to the anterior cranial base after DS 4 was equal to that of va. In Fig. 6, the height of the figure spa-va-vp-spp at DS 4 is the same as the height at DS 4, the lowering of the nasal floor having ceased, whereas sutural growth continues until maturity. *Björk* made the same observation in subjects up to 17 years of age.

To sum up, it may be stated that the maxillary complex exhi-

bits a downward and forward displacement in relation to the anterior cranial base from DS 02 to DS 4, and thereafter a transition to mainly downward growth at the end of the growth period.

Increase in size of the nasal septum. The size of the nasal septum is expressed by the sagittal dimensions spa-spp, spa-va, va-vp and va-spp and the vertical dimensions ho-vp and vp-spp. The only dimension which ceased to increase at an early stage was spa-va. The other dimensions continued to increase until maturity, and this increase must occur at the posterior border of the septum, as appositional growth anteriorly was excluded at that age, according to the results of implant studies (*Björk* 1955, 1964), and microanatomical studies (*Enlow* 1966). This agrees with the uniform increase in the three dimensions va-spp, va-vp and spa-spp. The height of the vomer, expressed in the dimension ho-vp, continued to increase until adulthood.

The measurement x, which is an expression of the distance of the vomer from the nasal floor, increased until DS 4. How this occurs is not known, but there are two possibilities: 1) Growth of the vomeromaxillary suture and 2) resorption on the floor of the nose and apposition on the palate. *Baume* (1963) has made a histological examination of the suture along the inferior border of the vomer in rhesus monkeys and found that it was narrow and aplastic from an age of 24 months. If the same is true for humans, x, could be taken as an expression of the maximum resorption at the base of the nose. A histological examination of the suture along the inferior border of the vomer is therefore desirable.

SUMMARY

The purpose of this study was to give an account of the dimensional changes of the osseous parts of the nasal septum at different stages of development, from fully erupted deciduous teeth to maturity, and thereby illustrate the growth mechanism in that region. The material consisted of 132 skulls from India. These were grouped according to dental development stages as defined by *Björk, Krebs* and *Solow* (1964). Reference points which could not be seen on profile radiographs were marked with gramophone needles. On standardized profile radiographs, 15 linear and 6

angular dimensions were then determined. Analysis of the measurements revealed the following:

During development, the maxillary complex as a whole moved downward and forward from dental stage DS 02 (fully erupted deciduous teeth) to DS 4 (fully erupted canines and premolars). Thereafter the direction of growth changed to become mainly downward in the last part of the growth period.

The increase in size of the septum continued posteriorly until maturity. Anteriorly it ceased at DS 3 (premolars or canines erupting). The length and height of the vomer increased until maturity. This growth was considered to occur along the superior and posterior border. The distance from the vomer to the nasal floor increased until DS 4.

RÉSUMÉ

ETUDE RADIOGRAPHIQUE CRANIOMÉTRIQUE DES CHANGEMENTS DE DIMENSIONS DANS LA CLOISON NASALE DEPUIS LA PETITE ENFANCE JUSQU'A LA MATURITÉ

Le but de la présente étude est de rendre compte des changements de dimensions des parties osseuses de la cloison nasale à différents stades du développement, depuis la fin de l'éruption des dents temporaires jusqu'à la maturité, et d'illustrer ainsi le mécanisme de la croissance dans cette région.

Le matériel se compose de 132 crânes provenant d'Inde. Ces crânes ont été groupés suivant les stades de développement dentaire définis par Björk, Krebs et Solow (1964). Les points de référence non visibles sur des radiographies de profil ont été marqués au moyen d'aiguilles de phonographe. Sur des radiographies de profil standardisées, 15 dimensions linéaires et 6 dimensions angulaires ont été déterminées. L'analyse des mesures a mis en évidence les faits suivants:

Pendant son développement, le complexe maxilaire supérieur se déplace dans son ensemble vers le bas et vers l'avant depuis le stade dentaire DS 02 (dents temporaires ayant terminé leur éruption) jusqu'au stade DS 4 (canines et prémolaires ayant terminé leur éruption). La croissance changeait ensuite de direction, et devenait principalement dirigée vers le bas pendant la dernière partie de la période de croissance.

L'augmentaton des dimensions de la cloison continuait en

arriére jusqu'à la maturité. En avant, elle cessait au stade DS 3 (prémolaires et canines en éruption). La longueur et la hauteur du vomer augmentaient jusqu'à la maturité. L'auteur considère que la croissance se produisait le long du bord supérieur et du bord postérieur. La distance du vomer au plancher des fosses nasales augmentait jusqu'au stade DS 4.

ZUSAMMENFASSUNG

RADIOGRAPHISCHE UND CRANIOMETRISCHE UNTERSUCHUNGEN ÜBER ALTERSVERÄNDERUNGEN DER NASENSCHEIDEWAND

Der Zweck dieser Arbeit war, eine Schätzung der Ausmasse von den ossösen Komponenten der Nasenscheidewand auf verschiedenen Entwicklungsstufen zu geben, vom voll hervorgebrochenen Milchgebiss bis zum erwachsenen Alter, und somit den Wachstumsmechanismus in dieser Region zu beleuchten.

Das Material bestand aus 132 Schädeln aus Indien. Diese wurden in Entwicklungsstufen eingeteilt entsprechend den Dentalstadien wie von *Björk*, *Krebs* und *Solow* festgelegt (1964).

Auf Röntgenbildern nicht erkennbare Messpunkte wurden mit Metallstiften markiert. Auf standardisierten Profilröntgenbildern der Schädel wurden demnach 15 lineare sowie 6 Winkelmasse bestimmt.

Die Analyse der Messungen ergab folgendes:

Während der Entwicklung verschiebt sich der maxillare Komplex als Ganzes durchschnittlich nach unten und nach vorne vom Dentalstadium DS 2 an (voll hervorgebrochenes Milchgebiss) bis zum DS 4 (voll hervorgebrochene Prämolaren und Eckzähne). Hiernach ändert sich die Wachstumsrichtung darauf hin, dass sie im letzten Teil der Wachstumsperiode überwiegend nach unten gerichtet ist.

Der Grössenzuwachs des Septums setzt sich hinten bis zum erwachsenen Alter Fort. Der Zuwachs vorne hört den Messungen gemäss vermutlich auf entsprechend dem DS 3 (Prämolaren oder Eckzähne im Hervorbrechen begriffen). Die Länge und Höhe des Vomers vergrössern sich bis zum erwachsenen Alter. Dieses Wachstum findet vermutlich längs der oberen und hinteren Leiste des Vomers statt. Der Abstand vom Vomer bis zum Nasenboden vergrössert sich bis zum DS 4.

ACKNOWLEDGEMENT

The author wishes to express her sincere thanks to Professor Arne Björk and Associate Professor Beni Solow for their encouragement and kind help and to The Dental Colleges and Universities of Copenhagen and Aarhus for making the skulls available. This study has been supported in part by grants from "Fonden til fremme af videnskabelig og praktisk odontologi".

REFERENCES

Baume, J. L., 1961: The postnatal growth of the nasal cartilage septum. Helv. odont. Acta. *5:* 9—15.

Bergland, O., 1963: The bony nasopharynx. A roentgen-craniometric study. Acta odont. scand. *21*, suppl. 35.

Björk, A., 1947: The face in profile. An anthropolical x-ray investigation on Swedish children and conscripts. Lund. Svensk tandläk.-T. *40.*

Björk, A., 1950: Some biological aspects of prognathism and occlusion of the teeth. Acta odont. scand. *9:* 1—40.

Björk, A., 1955: Cranial base development. Amer. J. Orthodont. *41:* 198—225.

Björk, A., 1963: Kæbernes relation til det øvrige kranium. p. 115—152. I: A. Lundström, (Ed.) Nordisk lärobok i odontologisk ortopedi. 2. uppl., Stockh.

Björk, A., 1964 a: Sutural growth of the upper face studied by the implant method. p. 49—65. Europ. orthodont. Soc. Trans.

Björk, A., 1964 b: Käkarnas tillväxt och utveckling i relation till kranier i dess helhet. p. 1—44. I: J. J. Holst (Ed.) Nordisk klinisk odontologi 1—I. A/S Forlaget for Faglitteratur, København.

Björk, A. & B. Solow., 1962: Measurements on radiographs. J. dent. Res. *41:* 671—683.

Björk, A., Aa. Krebs & B. Solow., 1964: A method for epidemiological registration of malocclusion. Acta odont. scand. *22:* 27—41.

Brodie, A. G., 1941: On the growth pattern of the human head from third month to eight years of life. Amer. J. Anat. *68:* 209—262.

Brodie, A. G., 1955—56: The behavior of the cranial base and its components as revealed by serial cephalometric roentgenograms. Angle Orthodont. *25:* 148—160.

Enlow, D. H., 1966: A morphogenetic analysis of facial growth. Amer. J. Orthodont. *52:* 283—299.

Fawcett, C. D., 1911: The development of the human maxilla, vomer and paraseptal cartilages. J. Anat. (Lond.). *45:* 378—405.

Ford, H. R., 1956: The growth of the foetal skull. J. Anat. (Lond.). *90:* 63—72.

Geary, R. C., 1935: The ratio of the mean deviation to the standard deviation as a test of normality. Biometrika. *27:* 310—332.

Gilbert, J. G., 1958: Growth of the nose and the septo-rhinoplastic problem in youth. Arch. Otolaryng. *68:* 673—682.

Ilberg, A., 1935: Über die funktionelle Architektur der Nasenknorpel und ihrer knöchernen Umgebung beim Menschen. Z. Laryng. Rhinol. *26:* 239—257.

Koski, K., 1960: Some aspects of the growth of the cranial base and the upper face. Odont. T. *68:* 344—358.

Lysell, L. & R. Filipsson, 1958: A profile-roentgenologic study of a series of medieval skulls from northern Sweden. Odont. T. *66:* 161—174.

Mall, F. P., 1906: On ossification centers in human embryos less than one hundred days old. Amer. J. Anat. *5:* 433—458.

Martin, R., 1928: Lehrbuch der Antropologie. 2. Aufl. Gustav Fischer, Jena.

Massey, F. J., 1951: The Kolmogorov-Smirnov test for goodness of fit. J. Amer. statist. Ass. *46:*

Moorrees, C. F. A., 1959: The dentition of the growing child. A longitudinal study of dental development between 3 and 18 years of age. Cambridge, Mass., Harvard Univ. Press.

Nanda, S., 1966: Growth and development of dentitions in Indian children. Dental College and Hospital, Lucknow, India. Amer. J. Orthodont. in press.

Owen, D. B., 1962: Handbook of statistical tables. Addison-Wesley Publishing Co. Reading, Mass.

Pearsson, E. S., 1931: A further development of tests of normality. Biometrika. *22:* 239—249.

Pearsson, E. S. & H. O. Hartley, 1954: Biometrika Tables for Statisticans. Vol. 1. Cambridge Univ. Press.

Powell, T. V. & A. G. Brodie, 1963: Closure of the spheno-occipital synchondrosis. Anat. Rec. *147:* 15—23.

Rosenberger, H. C., 1934: Growth and development of the naso-respiratory area in childhood. Ann. Otol. (St. Louis). *43:* 512.

Schour, I. & M. Massler, 1941: The development of the human dentition. J. Amer. dent. Ass. *28:* 1153—1160.

Scott, J. H., 1948: Studies on the growth of the upper jaw. Dent. Rec. *48:* 277—291.

Scott, J. H., 1953: The cartilage of the nasal septum. A contribution to the study of facial growth. Brit. dent. J. *95:* 37—43.

Scott, J. H., 1959: The growth of the nasal cavities. Acta orto-laryng. (Stockholm). *50:* 215—224.

Solow, B., 1966: The pattern of cranio-facial association. A morphological and methodological correlation and factor analysis study on young male adults. Acta odont. scand. 24, suppl. 46.

Stamrud, L., 1959: External and internal cranial base. Acta odont. scand. *17:* 239—266.

Takagi, Y., 1964: Human postnatal growth of vomer in relation to base of cranium. Ann. Otol. (St. Louis). *73:* 238—247.

Woo, J. K., 1949: Ossification and growth of the human maxilla, premaxilla and palate bone. Anat. Rec. *105:* 737—753.

Address: *Aarhus Tandlægehøjskole,*
Vennelyst Boulevard,
Aarhus C, Denmark