Hypoplasia of the Middle Third of the Face - A Morphological Study

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Patients with hypoplasia of the middle third of the face are characterized by their striking clinical appearance, namely, a flattening of the facial profile due to a lack of forward development of the nose and maxilla. There is little information to be found in the literature regarding this particular condition. Hopkin[3] carried out a study on six patients with hypoplasia of the middle third. Radiographically he found that the anterior nasal spine was rudimentary in all cases and that the labial plate of alveolar bone overlying the upper central incisors was abnormally thin. In the cephalometric analysis the inclination of the nasal bones was observed to be more vertically orientated when measured in relation to the maxillary plane. Furthermore, there was an over-all reduction of the cranial base dimensions, a shortened maxilla anteroposteriorly and a reduced vertical development of the maxilla as measured from nasion to the region of the anterior nasal spine. Rabe[8] in a case report described the treatment of an eight year-old girl with hypoplasia of the middle third. There being no further reference in the literature to this condition it seemed desirable to carry out a further examination of these patients based on a greater number of cases.

The aim of the present study was to establish a facial pattern in a sample of patients with hypoplasia of the middle third and to provide information regarding their morphological characteristics.

MATERIAL

The patients included in the study consisted of 31 cases of hypoplasia of the middle third of which 17 were boys and 14 were girls between the ages of 8.4-18.1 years. The patients were selected according to the following basic criteria: 1) patients with a straight or concave soft tissue facial profile due to lack of forward development of the nose and maxilla, and 2) absent or rudimentary anterior nasal spine.

All patients were of Swedish extraction. Due to the wide range of age, a subgroup of 15 patients between the ages of 8.4-10.5 years was examined separately. This subgroup consisted of 9 boys and 6 girls. Of the 31 patients in the study group, 7 had undergone plastic surgery in the region of the nose in the form of a "V-Y" lift to the columella and a bone transplantation to the bridge. Consequently measurements involving the length, angulation and prominence of the nose in these patients were omitted from the analysis. Only one patient had received orthodontic treatment prior to registration. Since treatment had been limited to movement of a few teeth in the lower jaw and was not believed to bias the over-all results, it was decided to include this patient in the study.

The control group consisted of 31 patients selected from that used by Linder-Aronson[5] and matched according to age and sex. The prevailing criterion for the selection of the latter group was freedom from a history of nasal obstruction.

METHOD

Lateral skull X-rays were taken of 20 patients using a Philips Rotapractix with a film focus distance of 165 cm and giving an enlargement in the me-

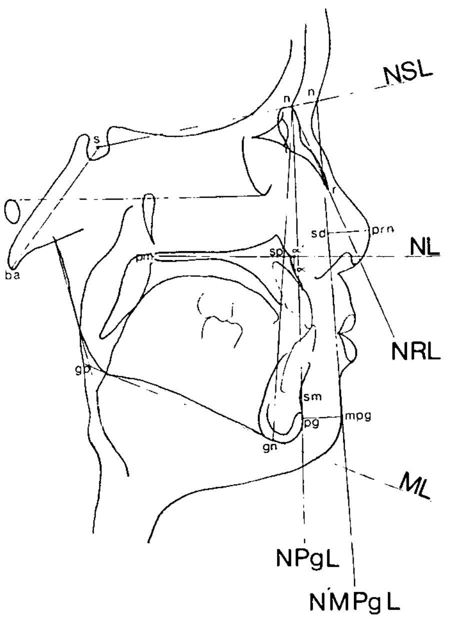

Fig. 1 Cephalometric reference points and lines.

dian plane of 7.1%. The head was orientated with the Frankfurt horizontal plane. The remaining patients were X-rayed using other cephalostats. Length measurements for these patients had therefore to be calibrated accordingly.

Cephalometric landmarks and planes

The analysis was divided into the following eight areas: cranial base, nasal bones, maxilla, mandible, anterior facial height, posterior facial height, pharyngeal depth and convexity. The conventional cephalometric reference points and lines have been detailed elsewhere and are illustrated in Figure 1. For the sake of brevity only those landmarks and lines referring to less common points will be described.

- r Rhinion, the most anterior inferior point on the contour of the nasal bones in the midsagittal plane.[9]
- prn Pronasale, the most anterior point on the contour of the nose.
- α Alpha, the deepest point on the anterior contour of the upper alveolar arch. Where this contour is convex the most anterior point is chosen.[9]
- α' The projection of alpha on the nasal line.
- n' Soft tissue nasion, the point of intersection of the extended nasion—sella line and the soft tissue profile.
- mpg Soft tissue pogonion, the point of intersection of a line drawn perpendicular to NPgL through pg and the soft tissue profile.
- sd The projection of pronasale on the soft tissue facial line (N'MPgL).
- sp' The point of intersection between the nasal line (NL) and the line drawn from nasion-gnathion (n-gn).

Variables studied

AREA	VARIABLE	UNIT
Cranial base	s-n	mm
	ba-n	mm
	s-n-ba	deg.
Nasal bones	n-r	mm
	s-n-r	deg.
	NRL/NL	deg.
Maxilla	s-n-α	deg.
	NL/NSL	deg.
	α-pm	mm
Mandible	s-n-sm	deg.
	ML/NSL	deg.
	ML/NL	deg.
	Gonion angle	deg.
Ant. facial height	n-sp'	mm
	sp'-gn	mm
	$\frac{\text{n-sp'}}{\text{n-gn}}$	%
Post. facial height	s-pm	mm
Pharyngeal depth	ba-pm	mm
Facial convexity	α-NPgL	mm
Nasal prominence	sd-prn	mm

Error of methods

To test the reliability of the analysis technique, duplicate tracings and measurements were made of 15 films randomly selected approximately two weeks after the original data were collected. It was found that, with the exception of the variables listed in Table I, the error variance amounted to less than 3% of the total variance for each variable. This means that, for the majority of variables, the error of the method is of little importance compared with the biological variation.

Statistical analysis

In accordance with the aforementioned analysis the following statistical

TABLE I

Variable	δ^2	S^2_{62}	δ^2 in % of S^2_{62}
n-r*	0.31	9.0	3.5
NL/NSL	0.59	12.3	4.8
$\frac{\text{n-sp}'}{\text{n-gn}}$	0.27	6.8	3.9
α-NPgL	0.33	6.5	5.1

N = 15

*The variance of variable n-r has been calculated for 48 cases.

Variables for which the variance of the error of method > 3% of the variance in all the children (S^2_{62}) in the study. δ^2 is an estimate of the variance of the method in mm for individual measurements on different occasions, determined from double determinations according to the formula $\frac{\Sigma d^2}{2N}$, where d is the difference between two occasions and N is the number of double determinations.

values were calculated for both study and control groups: number of observations, mean, standard deviation, standard error of the mean, variance, and t-values for the difference between two means. Simple correlation analyses were carried out to determine the relationship between ML/NSL and ba-pm and between ML/NSL and s-n-r. Only differences at the 1% and 0.1% levels of significance are accepted as being statistically significant. To check that the material included in the study was normally distributed regarding the variables examined, histograms were constructed for each variable in both study and control groups. No indication of abnormal distribution was found.

Results

Means, standard deviations, and t-values for the difference between two means calculated for the study and control groups are illustrated in Tables II (all cases)and III (cases between 8.4 and 10.5 years).

From Table II the following significant differences at the 1% and 0.1% levels can be noted for patients with hypoplasia of the middle third: anterior cranial base (s-n), cranial base angle (s-n-ba), inclination of the nasal bones (s-n-r) and (NRL/NL), orientation of the maxilla (s-n-α), maxillary base (α′-pm), upper/total facial height ($\frac{\text{n-sp}'}{\text{n-gn}}$), posterior facial height (s-pm), pharyngeal depth (ba-pm), facial convexity (α-NPgL), and nasal prominence (sd-prn).

Excepting NRL/NL all measurements were shorter or smaller for the study group.

From Table III (subgroup of children between 8.4-10.5 years) the following additional information can be noted: posterior facial height (s-pm) significantly smaller at the 5% level; total cranial base (ba-n) shorter than the controls; and upper facial height (n-sp′) less than the controls.

Otherwise, with the exception of posterior facial height, similar results to those summarizing Table II were observed.

Figures 2 and 3 illustrate correlation diagrams for the relation between the mandibular plane angle (ML/NSL) and the sagittal depth of the nasopharynx (ba-pm). It was found that relationship (r = -0.62) was significant at the 0.1% level for the children in the study group (Fig. 2). The relationship was found to be almost significant (r = -0.41) on examination of the control group (Fig. 3). It was thus noted that those children from the study group who demonstrated extremely low values for the sagittal depth of the nasopharynx had, as a rule, extremely high values for the angle between the mandibular line and the anterior cranial base (ML/NSL).

Figures 4 and 5 illustrate correlation diagrams for the relationship between the mandibular plane angle (ML/NSL) and the angulation of the nasal bones s-n-r. From these diagrams it can

Region	Variable		Mean	S.D.
Cranial base	s-n	I	65.0	4.5
	s-n	II	68.2	3.2
	t-score	I-II	-3.20**	
	ba-n	I	99.0	7.4
	ba-n	II	103.4	4.4
	t-score	I-II	-2.48*	
	s-n-ba	I	128.0	4.8
	s-n-ba	II	131.9	4.7
	t-score	I-II	-3.21**	
Nasal bone	n-r	I	22.4	2.7
	n-r	II	22.3	3.3
	t-score	I-II	0.14	
	s-n-r	I	102.6	6.6
	s-n-r	II	109.6	5.5
	t-score	I-II	-3.98***	
	NRL/NL	I	70.3	9.4
	NRL/NL	II	63.4	5.2
	t-score	I-II	3.14**	
Maxilla	s-n-α	I	75.4	3.8
	s-n-α	II	81.8	3.7
	t-score	I-II	-6.76***	
	NL/NSL	I	7.6	3.6
	NL/NSL	II	7.0	3.5
	t-score	I-II	0.74	
	α'-pm	I	40.4	3.9
	α'-pm	II	47.6	3.15
	t-score	I-II	-8.07***	
Mandible	s-n-sm	I	78.7	3.5
	s-n-sm	II	78.0	2.7
	t-score	I-II	0.89	
	ML/NSL	I	35.6	3.19
	ML/NSL	II	33.3	6.68
	t-score	I-II	1.67	
Mandible	ML/NL	I	28.0	6.3
	ML/NL	II	27	5.1
	t-score	I-II	0.73	
	Go angle	I	128.8	7.2
	Go angle	II	127.0	7.7
	t-score	I-II	0.95	
Anterior facial height	n-sp'	I	47.7	4.4
	n-sp'	II	49.8	2.3
	t-score	I-II	-2.42*	
	sp'-gn	I	63.2	5.3
	sp'-gn	II	60.8	5.7
	t-score	I-II	1.72	
	n-gn	I	111.2	8.2
	n-gn	II	110.6	7.3
	t-score	I-II	0.29	
	n-sp' / n-gn	I	42.6	2.1
	n-sp' / n-gn	II	45.1	2.3
	t-score	I-II	-4.55***	
Posterior facial height	s-pm	I	42.8	3.5
	s-pm	II	45.3	3.5
	t-score	I-II	-2.92**	
Pharyngeal depth	ba-pm	I	40.5	5.4
	ba-pm	II	44.7	3.4
	t-score	I-II	-3.64***	
Facial convexity	α-NPgL	I	-3.7	3.7
	α-NPgL	II	+2.9	2.5
	t-score	I-II	-8.04***	
Nasal prominence	sd-prn	I	12.7	3.2
	sd-prn	II	21.3	3.1
	t-score	I-II	-9.71***	

Significant differences: * = $p \leq 0.05$
** = $p \leq 0.01$
*** = $p \leq 0.001$

TABLE II
Means, standard deviations and t-values for the differences between two means for the children in the study group (I) and control group (II) as a whole. Nasal bone and nasal prominence N = 24, others N = 31.

Region	Variable		Mean	S.D.
Cranial base	s-n	I_s	62.5	3.8
	s-n	II_s	67.3	2.6
	t-score	I_s-II_s	-3.54**	
	ba-n	I_s	94.0	4.9
	ba-n	II_s	101.2	3.5
	t-score	I_s-II_s	-4.71***	
	s-n-ba	I_s	126.6	4.9
	s-n-ba	II_s	132.6	5.8
	t-score	I_s-II_s	-3.1**	
Nasal bone	n-r	I_s	21.7	2.3
	n-r	II_s	22.4	3.0
	t-score	I_s-II_s	-0.59	
	s-n-r	I_s	101.3	6.3
	s-n-r	II_s	107.8	3.8
	t-score	I_s-II_s	-3.44**	
	NRL/NL	I_s	70.8	6.0
	NRL/NL	II_s	64.5	4.8
	t-score	I_s-II_s	3.11**	
Maxilla	s-n-	I_s	74.1	4.6
	s-n-	II_s	81.5	3.4
	t-score	I_s-II_s	-4.95***	
	NL/NSL	I_s	7.7	3.6
	NL/NSL	II_s	7.8	3.7
	t-score	I_s-II_s	-0.07	
	α'-pm	I_s	37.6	3.2
	α'-pm	II_s	46.9	2.5
	t-score	I_s-II_s	-8.92***	
Mandible	s-n-sm	I_s	78.7	4.6
	s-n-sm	II_s	77.5	2.4
	t-score	I_s-II_s	0.92	
	ML/NSL	I_s	36.2	7.4
	ML/NSL	II_s	36.2	3.5
	t-score	I_s-II_s	-0.03	

Region	Variable		Mean	S.D.
Mandible	ML/NL	I_s	28.5	7.4
	ML/NL	II_s	28.4	4.6
	t-score	I_s-II_s	0.04	
	Go angle	I_s	129.2	6.0
	Go angle	II_s	131.6	4.8
	t-score	I_s-II_s	-1.21	
Anterior facial height	n-sp'	I_s	44.9	2.9
	n-sp'	II_s	48.5	2.6
	t-score	I_s-II_s	-3.58**	
	sp'-gn	I_s	60.2	4.8
	sp'-gn	II_s	58.4	4.6
	t-score	I_s-II_s	1.03	
	n-gn	I_s	105.8	5.9
	n-gn	II_s	106.9	4.8
	t-score	I_s-II_s	-0.57	
	$\frac{\text{n-sp'}}{\text{n-gn}}$	I_s	42.1	2.0
	$\frac{\text{n-sp'}}{\text{n-gn}}$	II_s	45.4	2.6
	t-score	I_s-II_s	-3.80***	
Posterior facial height	s-pm	I_s	40.4	2.8
	s-pm	II_s	43.3	3.2
	t-score	I_s-II_s	-2.70*	
Pharyngeal depth	ba-pm	I_s	37.9	5.4
	ba-pm	II_s	43.6	2.6
	t-score	I_s-II_s	-3.73***	
Facial convexity	α-NPgL	I_s	-4.3	2.9
	α-NPgL	II_s	+3.5	2.1
	t-score	I_s-II_s	-9.68***	
Nasal prominence	sd-prn	I_s	11.8	2.4
	sd-prn	II_s	20.2	2.3
	t-score	I_s-II_s	-9.71***	

Significant differences: * = $p < 0.05$
** = $p < 0.01$
*** = $p < 0.001$

TABLE III

Means, standard deviations and t-values for the differences between two means for the children in the study group (I_s) and control group (II_s) between the ages of 8.4-10.5 years. Nasal bone and nasal prominence N = 14, others N = 15.

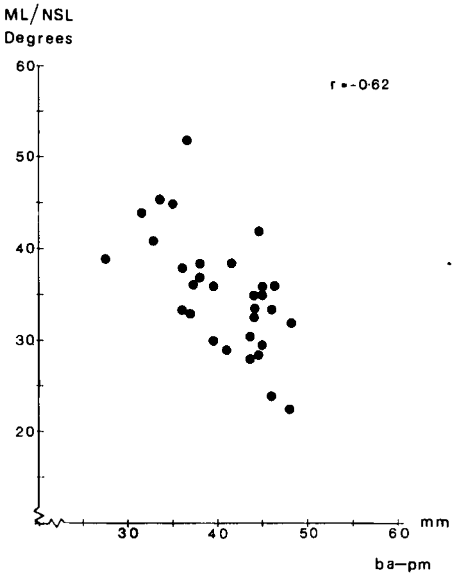

Fig. 2 Correlation diagram for the relation between the angle ML/NSL and the sagittal depth of nasopharynx (ba-ptm) for 31 children in the study group.

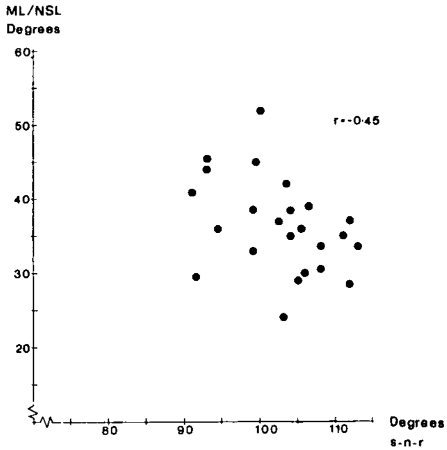

Fig. 4 Correlation diagram for the relation between the angle ML/NSL and the angulation of the nasal bones s-n-r for 31 children in the study group.

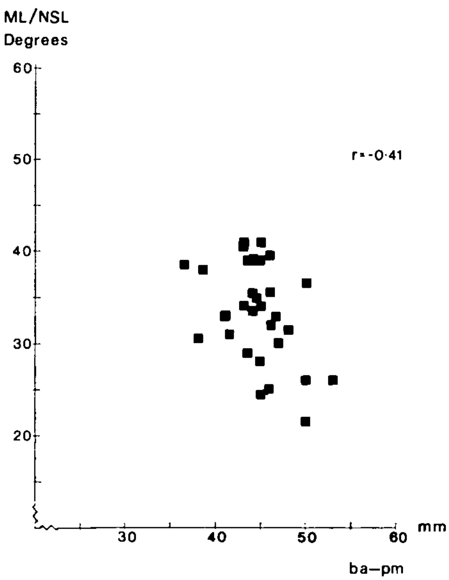

Fig. 3 Correlation diagram for the relation between the angle ML/NSL and the sagittal depth of nasopharynx (ba-ptm) for 31 children in the control group.

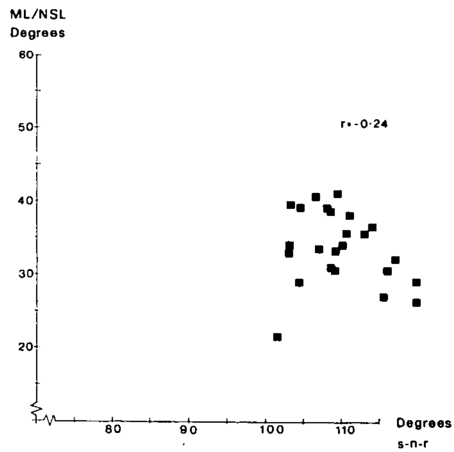

Fig. 5 Correlation diagram for the relation between the angle ML/NSL and the angulation of the nasal bones s-n-r for 31 children in the control group.

be seen that the relationship was almost significant ($r = -0.45$, $p < 3\%$) concerning the children in the study group, whilst not significant for the children in the control group.

Discussion

Only those results which indicated significant differences between control and study cases for both the material as a whole and the subgroup, 8.4-10.5 years, are discussed.

The method error was expressed for each variable as a percent of the variance of the entire material. It was found that those variables which were closely related to the anterior nasal spine gave the greatest method error. This was to be expected since the landmarks around the anterior nasal spine were often difficult to distinguish. Consequently, the results obtained for variables, NL/NSL, $\frac{\text{n-sp}'}{\text{n-gn}}$, and α-NPgL, require some caution as regards interpretation.

In spite of the fact that the number of children included in the study was relatively small, several significant differences were obtained between the children in the study and control groups. These differences describe the following facial morphology in children who are normally diagnosed as having "hypoplasia of the middle third": short anterior cranial base, small cranial base angle, reduced sagittal development of the nose, straight or concave profile, retrognathic maxilla, reduced sagittal depth of the nasopharynx and poor vertical development of the upper face. This descriptive account of the cranial base and development of the maxilla supports the findings of Hopkin.

The straight or concave profile and somewhat underdeveloped nose are characteristics which are easily registered clinically and as such already well-known. The fact that the sagittal depth of the nasopharynx is significantly reduced in these children has not, on the other hand, been previously described. The average difference in depth of the nasopharynx between study and control children was found in this study to be 4.2 mm.

The low figure for the angle between the anterior cranial base and the nasal bones n-s-r can be interpreted as being consistent with a constriction of the outer nose. This, in combination with a sagittally and vertically underdeveloped upper face and a reduced sagittal depth of the nasopharynx, can give reason to believe that children with hypoplasia of the middle third have greater difficulty in nose breathing than children with a well-developed middle third.

Since earlier studies by Harvold[2] and Linder-Aronson[5,6,7] have shown that a change in the mode of breathing can affect the development of the craniofacial complex, correlation analyses were carried out to examine the relationships between the angle ML/NSL and the size of the nasopharynx, and the inclination of the nasal bones. These analyses revealed significant correlations ($3\% > p < 0.1\%$) for the children in the study group. This is in accordance with earlier findings[5] showing that the inclination of the lower border of the mandible in relation to the anterior cranial base is associated with the capacity of the nasopharyngeal airway. Consequently, orthodontic treatment of children with hypoplasia of the middle third should take into consideration not only aesthetic and occlusal-functional factors, but also means for improving the patient's capacity for nose breathing.

Improvement of nasal airflow can be achieved by rapid expansion of the midpalatal suture.[4,11,12] Such a measure can further influence the maxilla in the sagittal plane resulting in an anterior displacement.[10] In cases of hypoplasis of the middle third of the face it would obviously be desirable to accentuate this anterior displacement by, for example, the use of horizontal traction.[1] Should, however, such a form of treatment be undertaken, special consideration must be given to the fact that the alveolar bone labial to the upper incisors can in these patients be dangerously thin.[3]

Summary

The aim of this investigation was to examine the morphological characteristics of patients diagnosed as having hypoplasia of the middle of the face. The study group consisted of lateral skull X-rays of 31 patients, aged 8.4-18.1 years, with hypoplasia of the middle third of the face. A control group of 31 patients matched according to age and sex was used.

The study group showed the following significant differences: short anterior cranial base, small cranial base angle, reduced sagittal development of the nose, straight profile, retrognathic maxilla, short maxilla, reduced sagittal depth of the nasopharynx and reduced vertical growth of the maxilla. These results indicate a reduction in dimensions of the entire nasal airway which, it is suggested, could have an adverse effect on nasal breathing. In addition, correlation analyses for the mandibular plane angle (ML/NSL) in relation to variables of importance in mode of breathing 1) the sagittal depth of the nasopharynx, and 2) the inclination of the nasal bone, have confirmed earlier studies showing that a change in the mode of breathing can affect the development of the entire craniofacial complex. The clinical aspects of these findings are discussed.

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