Mandibular form and position related to changed mode of breathing — a five-year longitudinal study

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Individuals with nasal obstruction of long duration have been shown to have increased lower facial heights.[1-4] Koski and Lähdemäki[2] also observed that the mandible is rotated downwards and backwards in relation to the palate in children with pathologically enlarged adenoids. Following a change in the mode of breathing from oral to nasal, Linder-Aronson et al.[5] showed that the angle between the mandibular and nasal planes (ML/NL) decreased significantly when compared to a control group. A correlation of $r = 0.42$, significant at the 0.1 percent level, was also found between the decrease in ML/NL angle and the change in lower facial height following alteration in the mode of breathing. Linder-Aronson and Woodside[6] described three patients whose lower facial heights did not channelize during the first five years post-adenoidectomy although their upper facial heights did. Consequently, while growth of the upper face in these subjects progressed normally after surgery, growth of the lower face showed a relative reduction in anterior height. A more recent study of Linder-Aronson et al.[5] has shown that the direction of mandibular growth measured at gnathion was more horizontal following adenoidectomy and a change in the mode of breathing. This was noted more often in girls. Furthermore, the amount of growth measured at gnathion was significantly larger ($p<0.01$) in the adenoidectomy children compared to a control group five years postoperatively.

Changes in the mandible following a change in the mode of breathing from oral to nasal are, therefore, described in the literature as being related to a change in growth direction. These changes may indicate a reversal of the backward rotation of the mandible found in children with enlarged adenoids to the more usual forward rotation found in normal subjects without nasal obstruction as shown, for example, by Riolo et al.[7] What is uncertain, however, is whether rotation or remodeling of the mandible is more important as the latter may mask the former, as

Abstract

A five-year follow-up study was performed on 26 children treated for nasal obstruction by adenoidectomy, who exhibited a changed mode of breathing postoperatively. They were compared with a control group matched according to age and sex. Lateral skull radiographs were used to examine mandibular morphology. The mandibular outline was registered using 36 digitized points. This method of portraying growth changes provides a valuable complement to isolated measurements. The technique revealed a more anterior direction of symphyseal growth in the adenoidectomy group following surgery as well as some reversal of the initial tendency to a posterior rotation of the mandible. This article was originally submitted February 1987.

Key Words

Mandibular form • Adenoidectomy

Figure 1

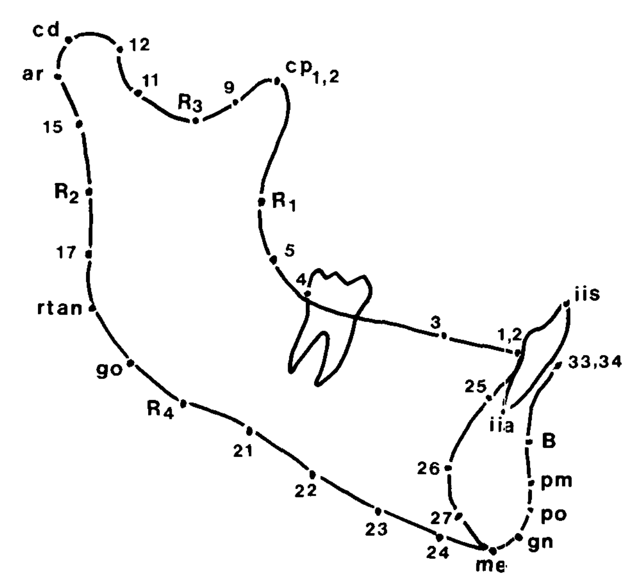


Figure 2

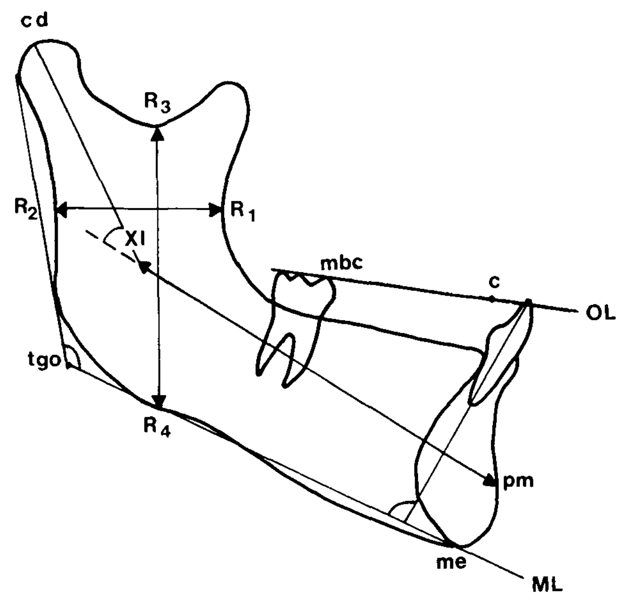


Figure 1
Reference points digitized on the mandibular outline.

Figure 2
Mandibular measurements.

has been demonstrated by Björk and Skeiller.[8]

The aim of the present study was to ascertain the effect of changed mode of breathing on the form and position of the mandible.

Materials and methods

The study was carried out on 52 children, 26 of whom underwent adenoidectomy due to nasal obstruction. The controls consisted of 26 cases free from signs or symptoms of nasal obstruction and matched for age and sex. All the children were from a previous study presented by Linder-Aronson.[9] In each group there were 17 males and nine females. All children were studied before, one year after and five years after adenoidectomy. In order to establish the effect of a changed mode of breathing, the adenoidectomy children included in the study all showed a postoperative return from mouth to nose breathing. The age and sex distributions before, at one year and at five years after operation are shown in Table 1.

Table 1
The distribution of the material with regard to number (N), sex (M,F) and age in years.

	Number		Age (Years)		
			Initial	1 Year	5 Years
	M	F	$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$
Adenoidectomy	17	9	8.2 ± 1.6	9.2 ± 1.6	13.6 ± 1.6
Control	17	9	8.4 ± 1.6	9.2 ± 1.5	13.0 ± 1.7

Radiographic analysis

Lateral skull radiographs, taken before adenoidectomy and at one year and five years postoperatively, were used to digitize the form of the mandible using 36 points recorded on the contour of each mandibular image (Figure 1) as below:

1 and 2	Mandibular incisor lingual bony contact point.
4	Mandibular molar distal cemento-enamel junction.
6	R_1 (Ricketts)
7 and 8	Coronoid process
10	R_3 (Ricketts)
12	Articulare anterior
13	Condylion
14	Articulare posterior
16	R_2 (Ricketts)
17	Where the curvature of the posterior border of the ramus changes from concave to convex.
18	r tan — tangent to the posterior border of the ramus in the region of the angle
19	Gonion
20	R_4 (Ricketts)
21	Antegonial notch
25	Inner border of the mandibular symphysis in the region of the incisor apex
26	Lingual symphyseal point
28	Menton
29	Gnathion
30	Pogonion

Figure 3

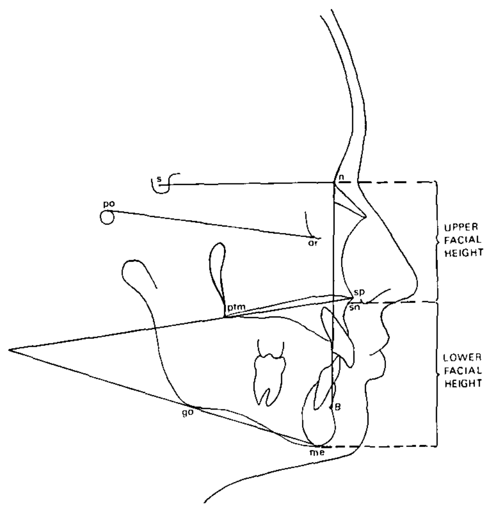


Figure 3
Mandibular spatial relationship measurements.

31	Protruberance menti (Ricketts)
32	B point
33 and 34	Infra dentale
35	iis — mandibular incisal tip
36	iia — mandibular incisal apex

Points 3, 5, 9, 11, 22, 23, 24 and 27 were intermediate points which best described the mandibular contour. With the exception of the Ricketts points, the majority of the remainder can be found in Riolo et al.[7] X_1 point was constructed in the manner described by Ricketts et al.;[10] and nine additional points were recorded as shown in Figures 2 and 3. These points were then used to generate ten linear and ten angular measurements. The mandibular dimensions are shown in Figure 2 and the relationship to the rest of the facial skeleton in Figure 3.

In order to plot the mandibular outline, an algorithm[11] calculating the best fit between successive groups of four points was employed. This allowed a smooth curve to be plotted, thus providing a satisfactory two dimensional hard copy of each mandibular outline. Subsequently, mean outlines were derived for the adenoidectomy and control groups at each examination. These could be superimposed to assess any morphological differences associated with baseline registrations and postsurgical adjustment.

Statistical analysis

Means and standard deviations were calculated for each variable in both the adenoidectomy and control groups. Comparisons of the difference between the two groups were made initially, as well as one year and five years postoperatively using a paired student's "t" test.

Method error

The error of the method was calculated by digitizing 19 randomly selected radiographs on two occasions. Table 2 shows those variables having errors exceeding five percent of the total biological variation of the material examined. With the exception of OL/ML, the greatest error came from those variables constructed from the Ricketts points R_3, R_4 and X_i and these must, therefore, be interpreted with care.

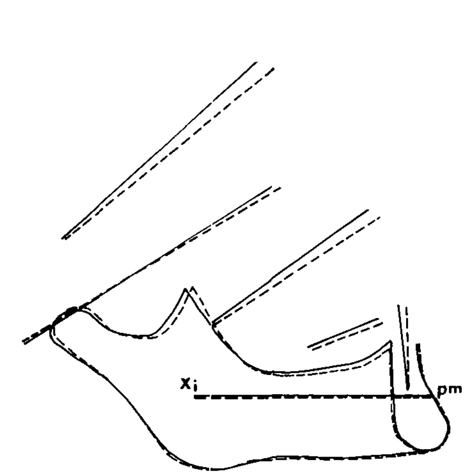
Results

The mean differences between adenoidectomy and control pairs at the three stages are presented in Tables 3 and 4. These show that initially the adenoidectomy group had a significantly smaller SNB angle, a larger mandibular/sella-nasion angle (ML/SNL), more retroclined mandibular incisors, (IL_i/ML) a larger angle between the occlusal and mandibular planes (OL/ML) and larger lower and total facial heights (sn-me, n-me).

With the passage of time, these four angular measurements ceased to differ significantly from the controls while the lower and total facial heights remained significantly larger in the adenoidectomy group, although the mean difference did not increase appreciably. At the same time, some mandibular linear dimensions which initially did not differ significantly, showed significant differences between the groups five years postoperatively. Overall mandibular length (cd-gn), ramus height (R_3-R_4), condylar

Table 2
The effect of repeated tracing and registration of the landmarks used in this investigation. N is the number of double determinations, σ^2 the error variance, S^2 the total biological variance of the material studied and the error as a percentage of the estimated biological variation.

Variable	N	σ^2	S^2_{19}	σ^2 in % of S^2_{19}
n-sn	19	0.81	10.24	7.91
R_3-R_4	19	1.00	13.84	7.23
Rtan-pm	19	1.69	24.25	6.98
Xi-pm	19	1.00	13.82	7.23
cd-R_4	19	2.89	17.73	16.31
cd-Xi	19	2.56	10.68	23.94
cd-Xi/FH	19	3.24	12.92	25.14
cd-Xi/NL	19	3.24	15.78	20.56
cd-Xi/Xi-pm	19	4.41	35.96	12.25
OL/ML	19	6.25	22.79	27.47



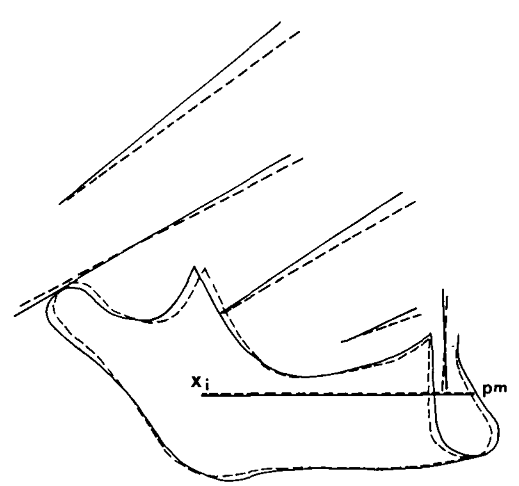


Figure 4
Superimposition on the X_1-pm line of the mean plots of the adenoidectomy and control groups preoperatively.
(______ adenoidectomy group)
(...... control group)

Figure 5
Superimposition on the X_1-pm line of the mean plots of the adenoidectomy and control groups five years postoperatively.
(______ adenoidectomy group)
(...... control group)

length (cd-R_4) and corpus length (X_1-pm) were significantly larger in the adenoidectomy group, while ramus width (R_1-R_2) was significantly smaller, five years postoperatively. The most significant of these ($P<0.01$) was an increase in mean mandibular corpus length (X_1-pm) in the adenoidectomy group. The mandibular arc difference (cd-X_1/X_1-pm) between the adenoidectomy and control groups tended to increase through time, although the difference did not reach the level of statistical significance.

Table 3
Comparisons between the adenoidectomy and control cases for angular measurements (degrees) performed using a paired Student's *t*-test to examine group differences ($\bar{D} \pm SD$) registered at each examination.

Variable	N	Initial $\bar{D} \pm SD$	1 Year $\bar{D} \pm SD$	5 Years $\bar{D} \pm SD$
SNB	26	-1.60 ± 3.61*	-0.78 ± 4.32	0.48 ± 0.43
ML/SNL	26	3.27 ± 6.88*	2.40 ± 7.12	2.30 ± 8.51
ML/NL	26	2.73 ± 8.16	2.81 ± 8.12	2.43 ± 9.19
ML/FH	26	1.02 ± 6.76	1.69 ± 7.64	1.70 ± 9.61
cd-Xi/FH	26	0.57 ± 5.25	0.95 ± 4.75	0.76 ± 6.04
cd-Xi/NL	26	2.31 ± 6.24	2.09 ± 6.18	1.49 ± 5.16
cd-Xi/Xi-pm	26	0.48 ± 6.43	0.98 ± 7.07	1.94 ± 6.15
Gonial Angle	26	2.19 ± 9.01	1.76 ± 8.71	2.24 ± 9.78
IL_i/ML	26	-4.66 ± 6.60**	0.62 ± 7.56	-3.19 ± 8.95
OL/ML	26	2.45 ± 5.31*	4.44 ± 9.96*	3.27 ± 8.56

* $P<0.05$
** $P<0.01$

The superimpositions in Figures 4 and 5, designed to demonstrate changes in mandibular form, show that the initial mean mandibular corpus length was almost identical in both groups, but that five years postoperatively this dimension was larger in the adenoidectomy group. The difference in mandibular incisor inclination was also less five years postoperatively, indicating a greater degree of proclination in the adenoidectomy group. The outlining process also shows some differences in condylar and coronoid form five years postoperatively — chiefly that the condylar process in the adenoidectomy group was more posteriorly positioned in relation to X_1 point.

The corresponding superimpositions on the SN line, registered at S, show the relative spatial position of the mandible in the two groups at the initial registration and five years postoperatively (Figures 5 and 6). The mandible in the adenoidectomy group was initially rotated down and back in relation to the X_1-pm line. Five years postoperatively, although the inclination of the mandible had changed only marginally, the symphyseal outline had advanced more in the adenoidectomy group suggesting a more horizontal pattern of growth following surgery and the change to nasal respiration.

Discussion

While the comparison of mean values for a number of isolated angular and linear measurements provides useful information regarding mandibular morphology, it cannot graphically portray the more subtle morphological changes

Figure 6

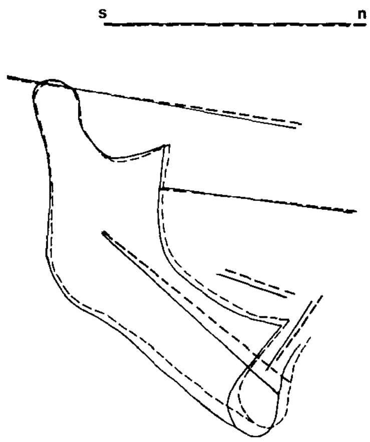


Figure 7

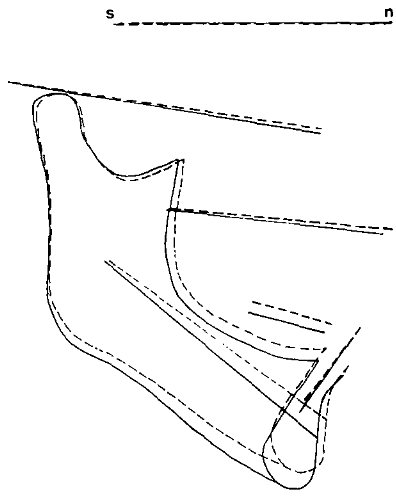


Figure 6
Superimposition on the s-n line of the mean plots of the adenoidectomy and control groups preoperatively.
(______adenoidectomy group)
(...... control group)

Figure 7
Superimposition on the s-n line of the mean plots of the adenoidectomy and control groups five years postoperatively.
(______adenoidectomy group)
(...... control group)

taking place. It is our belief that use of the curve fitting algorithm with more than 30 mandibular landmarks gives a better visual presentation of mean changes encountered. In this way, the comparison between the adenoidectomy and control groups represents the mean plots of entire groups.

The results presented are in agreement with a previous study based on the same material where mandibular growth direction and magnitude, as recorded at gnathion, were found to be similar.[5]

In this study, the angular differences noted presurgically between the adenoidectomy and control groups showed a trend towards normality five years postoperatively, so that the former mouthbreathing group became less dolichocephalic in general facial characteristics. On the other hand, a number of differences in the linear measurements were seen to develop during this postoperative period. The major changes in mandibular form which occurred following adenoidectomy were increases in mandibular corpus and overall length, which from the superimposed outlines would seem to indicate a catch up in the growth of the mandibular corpus. This should be interpreted with care, however, as the constructed point X_1 had an error exceeding five percent of the total biological variation. Nevertheless, the error variance for X_1-pm was one of the smallest.

The non-significant increase in mandibular arc in the adenoidectomy group suggested a change in the relationship of the ramus to the corpus which was too subtle to be shown in the measurements of the gonial angle and probably masked by remodeling.

Consequently, a changed mode of breathing appears to influence both the spatial position of the mandible, by halting the more posterior rotation originally encountered, and mandibular form, by producing a more anterior direction of growth.

Thus, the method demonstrates that morphological differences can be presented effectively

Table 4
Comparisons between the adenoidectomy and control cases for linear measurements (mm) performed using a paired Student's *t*-test to examine group differences ($\bar{D} \pm SD$) registered at each examination.

Variable	N	Initial $\bar{D} \pm SD$	1 Year $\bar{D} \pm SD$	5 Years $\bar{D} \pm SD$
n-sn	26	1.52 ± 4.44	0.77 ± 4.56	1.32 ± 4.84
sn-me	26	2.77 ± 5.99*	3.09 ± 5.70**	3.34 ± 7.62*
n-me	26	4.47 ± 7.02**	4.22 ± 7.44**	5.04 ± 9.54**
R_1-R_2	26	-1.38 ± 3.74	-1.27 ± 3.94	-1.93 ± 4.07*
R_3-R_4	26	1.76 ± 5.79	1.95 ± 4.17	3.07 ± 7.21*
cd-R_4	26	1.02 ± 5.20	0.73 ± 5.27	2.44 ± 4.84*
Xi-pm	26	0.73 ± 3.25	1.14 ± 3.51	2.53 ± 4.27**
cd-gn	26	1.41 ± 6.49	1.42 ± 6.07	3.55 ± 7.10*
cd-Xi	26	0.41 ± 4.17	-0.25 ± 4.07	0.47 ± 3.96
Rtan-pm	26	-0.23 ± 5.92	-0.34 ± 5.54	0.77 ± 6.05

* $P < 0.05$
** $P < 0.01$

by outlining and may well prove useful in other spheres of craniofacial research where longitudinal changes in morphology are sometimes difficult to identify due to the fact that the assessment is based on a few isolated landmarks.

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