Relation Between Height of the Articular Tubercle of the Temporomandibular Joint and Facial Morphology

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The inclination of the path of movement of the condyles and the shift of the condyles on movement of the mandible from intercuspal position to protrusion and maximal opening of the mouth were dealt with in a previous investigation.[1] Since the path of such anterior translation from the intercuspal position corresponds to the outline of the articular tubercle,[2-5] the vertical movement of the condyle is a measure of the height of the tubercle. The height of the tubercle measured in this way has been found to increase from childhood (youngest group 7 years) to adult age.[1] But no clear sex differences in height of the tubercle were found.

Whether the anatomy of the temporomandibular joints varies with facial morphology and type of occlusion is still debatable. Ricketts[6,7] found no difference in anatomy of the temporomandibular joints between persons with normal occlusion and those with Class II malocclusion while the height of the tubercle was less in persons with Class III malocclusion. Lundberg[3] reported a variation in the height of the tubercle and depth of the articular fossa with type of occlusion (normal overbite, deep bite and mandibular prognathism). Several authors have found a correlation between overbite and the height of the tubercle, the height of the tubercle and the inclination of the condylar path being greater in subjects with a deep bite,[13-8] while Lindblom in a later work,[2] like Nevakari[14] and Ingervall,[1] was unable to demonstrate any relation between the inclination of the incisal path and the condylar path.

In most of the above-mentioned investigations analysis of the occlusion and facial morphology was confined to measurement of single characteristics, such as overjet and overbite or classification of the material according to type of occlusion. But since the skeletal morphology can vary considerably among persons with the same type of occlusion, the lack of agreement between the results of investigations of the relation between the anatomy of the temporomandibular joints and facial morphology is not surprising. Since there is often a relation between form and function, which has been shown, for example, between facial morphology and the function of the masticatory muscles,[15,16] one might imagine a relation between facial morphology and the functional anatomy of the temporomandibular joints. The purpose of the present investigation was to find out whether any correlation exists between the inclination of the condylar path and the height of the tubercle and facial morphology, as judged from profile roentgenograms.

MATERIAL AND METHODS

The material consisted of 116 children and 58 adults, which were distributed among three age groups (Table I). Most of the children and adults had normal occlusion and have been described in detail previously.[1] Group II (10 year-old children) in this investigation included 25 children with postnormal occlusion (Class II, Div.

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TABLE I

Number of subjects, sex, mean age and range of variation in age in the three groups examined.

Group	Number of subjects	Sex	Mean age (years)	Range in variation in age (years)
I	38	20 boys	7.8	7.4 — 8.3
		18 girls	7.8	7.3 — 8.3
II	78	22 boys	10.8	10.2 — 11.3
		31 girls	10.7	10.2 — 11.2
		11 boys*	11.1	9.8 — 12.6
		14 girls*	10.8	9.7 — 12.5
III	58	26 men	23.9	20.0 — 29.0
		32 women	21.4	18.4 — 27.0

* Angle Class II, Div. 1 malocclusion

1). The children with a postnormal occlusion had a postnormal intermaxillary relation at the first permanent molars and canines and proclined upper incisors. They filled the following criteria: no crossbite, no extraction of permanent teeth, no previous orthodontic treatment.

Condyle movements

The height of the articular tubercle was determined by recording the position, in profile roentgenograms, of the intercondylar axis in 5 mm protrusion, maximal protrusion and maximal opening of the mouth, and calculating the differences in vertical coordinates between the intercuspal position and the other positions. The maxillary occlusal line was used as reference line. The recording method has been described in detail previously.[1]

The vertical movement of the intercondylar axis to 5 mm protrusion (ProtP) was used for calculating the inclination of the sagittal path of movement of the condyles (variable 1) between intercuspal position and the protruded position. The vertical movement of the intercondylar axis from the intercuspal position to maximal protrusion (MPP, V; var. 2) and between the intercuspal position and maximal opening of the mouth (MOP, V; var. 3) reflects the height of the tubercle (Fig. 1).

Facial morphology

Facial morphology was recorded by analysis of profile roentgenograms with the reference points and lines given in Figures 2 and 3. The definitions and methods have been described previously.[17] The variables recorded are given in Table II.

Statistical methods

The interdependence of variables was studied by calculating rank-correlation coefficients according to Spearman. Stepwise linear regression analysis was performed with the Osiri's program for computer processing (Gothenburg Data Center). The frequency of possibly false significances was cal-

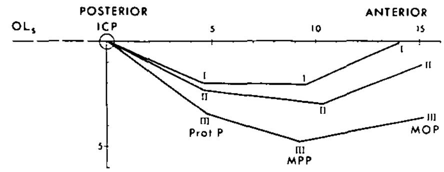

Fig. 1 Average movement of intercondylar axis on change of position of mandible from intercuspal position to 5 mm protrusion (ProtP), maximal protrusion (MPP) and maximal opening of the mouth (MOP) in the three groups studied. OL_S line parallel to maxillary occlusal line. Measurements in millimeters.

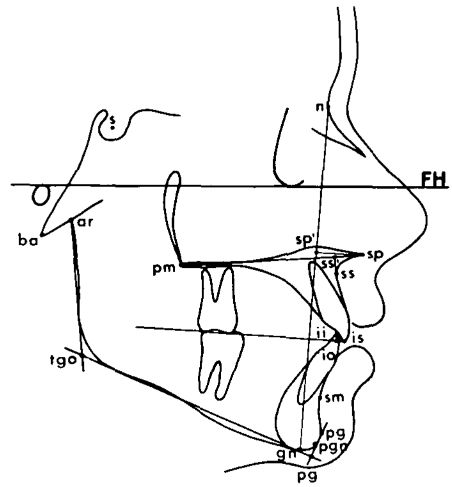

Fig. 2 Reference points for roentgencephalometric analysis.

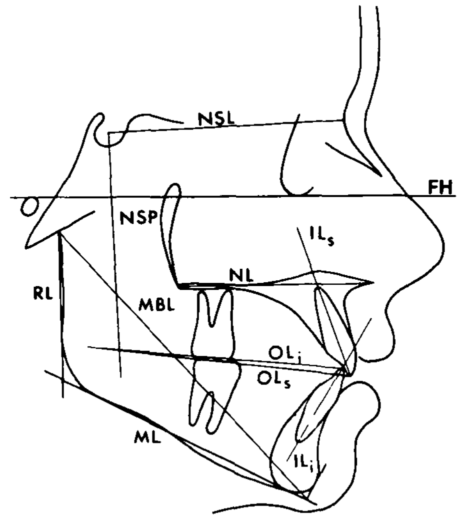

Fig. 3 Reference lines for roentgencephalometric analysis.

TABLE II

Mean, M, standard error of mean, ^{e}M, standard deviation, S.D. and range of variation for movements of intercondylar axis. Linear measurements in mm.

Group	Variable	M	e_M	S.D.	Range
I	1. Inclination of condylar path	23.05°	1.31°	8.10°	1.2° - 44.1°
	2. MPP, V	2.10	0.16	0.99	-0.5 - 3.8
	3. MOP, V	0.09	0.28	1.74	-3.3 - 3.4
II	1. Inclination of condylar path	26.90°	0.81°	7.17°	11.3° - 45.8°
	2. MPP, V	3.00	0.13	1.10	0.2 - 5.6
	3. MOP, V	1.16	0.21	1.82	-3.6 - 5.3
III	1. Inclination of condylar path	36.33°	1.13°	8.58°	17.2° - 59.7°
	2. MPP, V	4.83	0.15	1.13	2.5 - 7.4
	3. MOP, V	3.67	0.24	1.83	-0.5 - 6.9

TABLE III

Significant rank-correlation coefficients between inclination of condylar path and movements of intercondylar axis and variables of facial morphology of Groups I, II and III.

Variable	1. Inclination of condylar path			2. MPP, V			3. MOP, V		
	Group I	Group II	Group III	Group I	Group II	Group III	Group I	Group II	Group III
4. n-s									.30*
5. n-ar			.28*			.35**		-.24*	.38**
6. n-ba			.26*			.33**			.31**
7. s-ar			.31**			.29*		-.27**	.32**
8. s-ba			.40**			.35**			.32**
9. ss´-pm			.36**	.34*		.30*			.31**
10. pm-NSL						.27*			.46**
11. pm-NSP				.32*					
12. n-gn									.27*
13. n-sp´							-.35*		
14. sp´-gn					-.23*				
15. pg´-tgo				.41**					
16. s-tgo			.42**	.38**		.40**			.55**
17. ar-tgo			.38**	.35*		.39**			.55**
18. ar-ss			.29*			.32**			.35**
19. ar-pgn									.30*
20. is-io						.38**			
21. n-s-ar				-.40**			-.41**		
22. n-s-ba			-.33**	-.40**					-.26*
23. s-n-sm				.32*					
24. s-n-pg				.42**					
25. s-ar-tgo				.46**			.47**		
26. NSL/ML	-.35*		-.33**	-.54**					-.29*
27. NL/ML	-.32*			-.42**	-.27**				
28. NSL/OL_s	-.56**		-.37**	-.62**	-.32**		-.41**		-.29*
29. NL/OL_s	-.53**	-.36**		-.56**	-.42**	-.27*		-.26*	
30. ML/RL	-.33*			-.63**			-.34*		-.38**
31. NSL/MBL				-.41**					
32. MBL/ML	.39**		.36**	.62**	.26*	.36**	.34*		.44**
33. IL_i/ML			.31**						

* 0.01 < P < 0.05

** 0.001 < P < 0.01

Variables of facial morphology showing no correlation: ii-io, s-n-ss, ss-n-sm, NSL/NL, OL_i/ML, IL_s/NL, IL_s/IL_i.

Expected number of false significances at 5 % level at most 5-6 (7 %) at 1 % level at most 1 (2 %)

culated according to Eklund and Seeger.[18]

Results

The inclination of the condylar path and the vertical shift of the condyles on maximal protrusion and maximal opening of the mouth are given in Table II. The correlation coefficients among these three variables which express the height of the tubercle and the variables of facial morphology are given in Table III.

In all the groups the vertical movement of the condyle was found to be negatively correlated with the inclination of the mandible (var. 26) and of the maxillary occlusal line (var. 28, 29) as well as with the vertical jaw relation (var. 27) and the gonion angle (var. 30). The vertical shift of the condyle, on the other hand, was positively correlated with the curvature of the mandible (var. 32).

In Group I (7 year-old children) positive correlations were found also with the posterior height of the face (var. 11, 16, 17) and with mandibular prognathism (var. 23, 24) and negative correlations with the curvature of the cranial base (var. 21, 22).

Also in the adults (Group III) the analysis showed positive correlations with the posterior height of the face (var. 16, 17) as well as with the depth of the face (var. 9, 10, 18, 19) and with linear dimensions in the cranial base (var. 4, 5, 6, 7, 8).

To find which variables of facial morphology are the best predictors of the vertical movement of the condyles, stepwise linear regression analyses were performed. As predictors, use was made of those morphological variables which in the calculation of the correlation coefficients were found to be significantly correlated with the respective condylar variables. The results of the regression analyses are given in Tables IV, V and VI. The tables include the variables of the facial morphology up to a limit, where 90 per cent of the variance of the dependent variable explainable by all morphological variables is explained.

In the calculation the predictors are included in the regression equation in the order of their relative significance as predictors for the dependent variable. The determination coefficient denotes that percentage of the variance of the dependent variable that can be explained by the variance of the predictors.

In Group I the inclination of the maxillary occlusal line (var. 28, 29), the curvature of the mandible (var. 32), the angle between the posterior part of the cranial base and the mandibular ramus (var. 25), the mandibular body length (var. 15) and the mandibular prognathism (var. 23) proved to be the most important variables of facial morphology in the prediction of the height of the tubercle. Also in Group II (10 year-old children) the inclination of the maxillary occlusal line and the curvature of the mandible were the most important morphological variables (Table V).

In the adults (Group III) the posterior height of the face (var. 16) and the mandibular ramus height (var. 17) were most important. Other important variables, as in the children, were the inclination of the maxillary occlusal line and the curvature of the mandible.

Discussion

As pointed out in the introduction, several investigations have unequivocally shown that the path of movement of the condyle during protrusion corresponds to the contour of the tubercle. The method for recording the vertical movement of the condyle from the intercuspal position to specified positions anterior to the intercuspal position therefore provides a measure of the

TABLE IV

Multiple correlation coefficients, R, and coefficients of determination, R^2 between inclination of condylar path and variables of facial morphology in Groups I and III.

Group I			Group II			Group III		
Variable	R	R^2x100	Variable	R	R^2x100	Variable	R	R^2x100
28. NSL/OL_s	.61	37	29. NL/OL_s	.44	19	20. is-io	.42	18
25. s-ar-tgo	.70	49	32. MBL/ML	.47	22	17. ar-tgo	.52	27
15. pg′- tgo	.75	56				8. s-ba	.53	28
23. s-n-sm	.82	67				32. MBL/ML	.55	31
						29. NL/OL_s	.57	33

TABLE V

Multiple correlation coefficients, R, and coefficients of determination, R^2 between vertical movement of intercondylar axis to maximal protruded position (MPP, V) and variables of facial morphology in Groups I, II and III.

Group I			Group III		
Variable	R	R^2x100	Variable	R	R^2x100
28. NSL/OL_s	.45	20	16. s-tgo	.36	13
29. NL/OL_s	.48	23	33. IL_i/ML	.51	26
32. MBL/ML	.50	25	28. NSL/OL_s	.56	31
			22. n-s-ba	.58	34
			9. ss-pm	.60	36
			18. ar-ss	.63	40
			8. s-ba	.64	41
			5. n-ar	.64	41
			17. ar-tgo	.65	43

TABLE VI

Multiple correlation coefficients, R, and coefficients of determination, R^2 between vertical movement of intercondylar axis to maximal opening position (MOP, V) and variables of facial morphology in Groups I, II and III.

Group I			Group II			Group III		
Variable	R	R^2x100	Variable	R	R^2x100	Variable	R	R^2x100
25. s-ar-tgo	.50	25	7. s-ar	.27	8	17. ar-tgo	.54	30
28. NSL/OL_s	.58	33				19. ar-pgn	.57	33
						5. n-ar	.67	46
						10. pm-NSL	.70	49
						28. NSL/OL_s	.71	50
						12. n-gn	.72	52
						30. ML/RL	.73	53

height of the tubercle. The height of the tubercle recorded in this way includes the disc, whose thickness can vary somewhat in those parts that are in contact with the tubercle and condyle during anterior translation. There fore, the method does note permit direct determination of the anatomic height of the tubercle but may be regarded as representing the functional anatomy of the tubercle, i.e., the path along which the condyle moves during translation and which influences the movements of the mandible.

In the correlation analysis, the rank-correlation according to Spearman was preferred to the conventional product-moment correlation because it eliminates the influence of nonnormal distributions. That nonnormal distributions occur has been shown regarding the tubercular variables studied here[1] and for variables of facial morphology in previous investigations.[19-21] In regression analysis, however, it is not possible to use nonparametric calculation methods. In the correlation analysis the interdependence between the predictors in the regression analyses and the predicted variable has been proven. A linear combination of predictors therefore also is dependent with the predicted variable. Calculation of the possible number of false significances showed that, of the probably significant correlations, 5-6 (Table III) might be false. The probably significant correlations must therefore be evaluated with caution. Regarding the significant correlations, on the other hand, the risk of false significances is small.

The investigation showed a distinct interdependence between the height of the tubercle and certain facial morphological characteristics. Above all there appeared to be a correlation between the height of the tubercle and the inclination of the face, especially that of the lower face. In persons with a tendency to parallelism between the anterior cranial base, the nasal line, the maxillary occlusal line and the mandibular line, the tubercle tends to be high. Such cases are characterised by rectangular facial form in profile with great posterior height of the face and marked curvature of the mandible and of the cranial base. This form of face is also characterised by considerable depth of the face and total prognathism. The height of the tubercle is small in the opposite type of face, i.e., with triangular facial form in profile, which is seen in persons with a straight cranial base, retrognathism, marked inclination of the face, straight mandible and small posterior facial height.

The variation in the height of the tubercle with this type of face is illustrated by extreme cases from the youngest and oldest age groups (Figs. 4 and 5).

Figure 4 shows the type of face of two girls (B.E. 8.2 years and M.B. 7.8 years) with an extremely large and extremely small tubercular height. B.E. had the greatest and M.B. the smallest inclination of the condylar path and the greatest and smallest height of the tubercle in the girls of this age.

Figure 5 illustrates the type of face of two men (K.W. 23.5 years and S.S. 23.8 years) with the greatest and smallest inclination of the condylar path and with the next greatest and next smallest height of the tubercle in the age group.

The relation between type of face and height of the tubercle proved to be the same in children as in adults. The significant correlations were, however, fewer and weaker in 10 year-old children than in 7 year-old children and in adults. This may be because 10-12 year-old children are in different stages of pubertal growth, for which reason the growth in height of the tubercle may vary with chronological age and thereby tend to mask the cor-

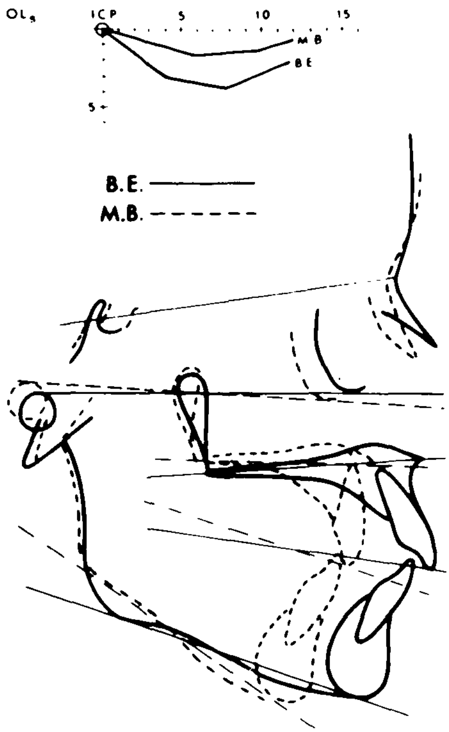

Fig. 4 Facial morphology of two girls in the youngest age group with large and small inclination of the condylar path and tubercular height.

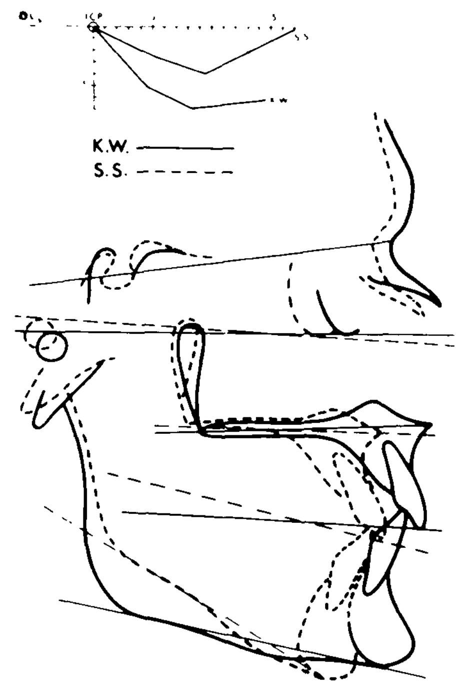

Fig. 5 Facial morphology of two men with large and small inclination of the condylar path and tubercular height.

relation with type of face. That the increase in height of the tubercle is dependent on the general pubertal growth is suggested by the observation that in 10 year-old girls the tubercular height was greater than in boys of corresponding age, while no such difference with sex was demonstrable in children aged 7 or in adults.[1]

The less strong correlation between facial morphology and height of the tubercle in Group II than in Groups I and III is not due to the heterogeneous composition of Group II in respect of type of occlusion. Analysis of Group II, exclusive of children with a postnormal occlusion, did not show any stronger correlation than did analysis of the entire group.

The investigation revealed a clear correlation between the functional anatomy of the tubercle and the form of face and thereby suggests an interplay between form and function during the ontogenetic development of the tubercle. The results are in line with Angel's[12] theoretic discussion of factors that can influence the form of the tubercle during ontogenesis. According to Angel, the shape of the tubercle may be dependent on the direction of pull of the masticatory muscles. A large tubercular height is to be expected if the inclination of the occlusal plane is small and if the posterior height of the face is large as a consequence of a more vertical direction of pull of the lateral pterygoid muscle. Whether muscle function is decisive for the anatomy of the tubercle or whether other factors, such as more direct genetic influence, are the most important cannot, however, be decided on the basis of the present investigation.

SUMMARY

The inclination of the condylar path on movement of the mandible from intercuspal position to 5 mm protrusion and tubercular height in 7 and 10 year-old children and adults were compared with variables of facial morphology for any correlations.

Recording of the condylar path, height of the tubercle and facial morphology was done with profile roentgencephalometry.

A marked inclination of the condylar path and marked height of the articular tubercle of the temporomandibular joint were found to be associated with a rectangular form of the face, i.e., with a tendency to parallelism between the anterior cranial base, nasal line, maxillary occlusal line and the mandibular line, large posterior height of the face, curved mandible and curved cranial base and prognathism. When the shape of the face was triangular in profile, as in persons with a straight cranial base, retrognathism, large inclination of the face, straight mandible and small posterior height of the face, the inclination of the condylar path and the height of the tubercle were found to be small.

The correlations between the inclination of the condylar path, tubercular height and facial morphology were the same in children as in adults.

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