Edgewise Therapy with Cervical and Intermaxillary Traction–Influence on The Position of the Bony Chin

U. Teuscher

Dr. Teuscher is a Senior Lecturer at the Orthodontic Department of the University of Zürich, Switzerland. He is a graduate in Medicine and Dentistry of the State University of Freiburg, West Germany, with Postgraduate education in Orthodontics at Freiburg and Zürich Universities.

Address:
Dr. U. Teuscher
Department of Orthodontics
and Children's Dentistry
Zahnärtzliches Institut
der Universität Zürich
Plattenstrasse 11
CH 8028 Zürich
SWITZERLAND

An evaluation of directional effects of distal-tipping cervical traction applied with a low outer bow in conjunction with Edgewise therapy.

Application of the edgewise technique in conjunction with cervical traction is an accepted procedure for Class II correction.[4,11] The malocclusion is successfully corrected in most growing patients using this approach, but the skeletal and profile results may sometimes be unsatisfactory. One adverse change that may occur is an opening rotation of the mandible.[6,13] Retardation of the forward development of the midface, reflected by a significant decrease in the S-N-A angle,[3,5,22] is often accompanied by significant inhibition of forward movement of the lower face as well.[5,7,16,18] A simultaneous tendency to posterior rotation of the palatal plane,[1-3,6,9,10,18,22] the occlusal plane[1,14] and the mandible[2,5,6,17,18,22] may result in an unwanted increase in anterior facial height.[5,13,18] Thus the growth of the mandible cannot become fully effective in the horizontal development of the face.[18]

Cross[6] has reported finding the mandibular response to Class II treatment to be "clockwise in nature." Any inhibition of the forward movement of pogonion[20] is of considerable disadvantage in those Class II cases where the profile as well as the occlusion is in need of improvement. The adverse treatment response described above has also been attributed to mere banding,[8] intermaxillary elastics,[7,12] tipback bends,[12] flattening of the curve of Spee[8,12] and to extrusion of upper molars by cervical traction.[16,19]

The objective of this evaluation is to relate the treatment response described above, especially as reflected in movement of pogonion, to therapeutic changes in the positions of other facial structures by identifying parameters which are directly influenced by therapy and at the same time have a strong influence on the movement of the bony chin.

Material and Method

Cephalometric changes in a group of treated patients were compared with a control sample (Table 1).

In all patients the casts and radiographs displayed a Class II condition before treatment and correction to a Class I occlusal relationship. The treatment sample contained no high mandibular angles. In 4 of the 16 patients, four bicuspids had been extracted because of severe crowding.

No differences were found between girls and boys or between extraction and non-extraction cases in any of the cephalometric parameters tested (rank-sum-test of each parameter). Therefore the treatment sample, in spite of its inhomogeneity, was analyzed as a unit.

The malocclusions were corrected using Tweed Edgewise technique augmented by low cervical and intermaxillary traction. During the first phase of treatment, light class III elastics were applied for a short period, followed by class II elastics.

The outer arms of the facebow were bent to pass slightly below the occlusal plane, applying a posterior rotating moment.

The randomized control sample consisted of untreated children 9, 10 and 11 years of age. Of the 51 children, 23 showed a Class II malocclusion (mean A-N-B angle 4.1°, interdigitation of the first molars 4.5mm distal) and 28 were Class I (mean A-N-B angle 2.5°, interdigitation of the first molars Class I).

No differences were found between girls and boys or between Class I and Class II subjects in the cephalometric parameters tested. The age range was between 10 and 13.7 years, with linear differences converted to one-year increments.

Frankfort Horizontal (FH) and a vertical through the center of the condyle (C) were selected as the reference base for recording longitudinal

TABLE 1
Sample Distribution

	N	*M*	*F*	*Extraction*	*Age I (Mean)*	*Age II (Mean)*	*Interval (Mean)*	*Treatment Time*
Treatment	16	6	10	4	8.05-13.08 (11.24)	11.54-16.62 (13.66)	1.24-4.04 (2.42)	1.0-3.7 (2.0)
Control	51	29	22	0	8.98-11.80 (10.04)	12.42-15.25 (13.72)	3.43-3.98 (3.68)	

changes (Fig. 1). In order to test their reproducibility, Frankfort horizontal and the center of the condyle were determined twice by two tracers after a one-week interval, and all were within 0.5° or 1mm.

In contrast to the other landmarks, the lower first molars were localized using a mandibular reference system (Fig. 2). Changes in linear dimensions were converted to a one-year time interval; angles and angular differences were used without transformation.

Results

Comparing the treated and the control samples (Tables 2-4; Figs. 3-5), no significant difference was found in the annual condyle growth rate (C-Pg). The treated group showed more vertical displacement of pogonion ($P<.01$). In contrast, no difference was found in the average vertical descent of ANS, PNS or the upper molars.

In the horizontal dimension, the anterior movement of the upper molars was considerably less in the treatment group ($P<.001$). ANS, PNS and pogonion also displayed lower anterior displacements ($P<.01$). The angle C-Pg/FH, opened an average of 1.2°, whereas a slight closing tendency was found in the control sample ($P<.01$). The palatal plane angle (ANS-PNS/FH) showed no significant difference between groups.

No statistically significant difference was found between treatment and control samples in the mean intramaxillary movement of lower molars. (Table 3, Fig. 4).

With reference to Frankfort hori-

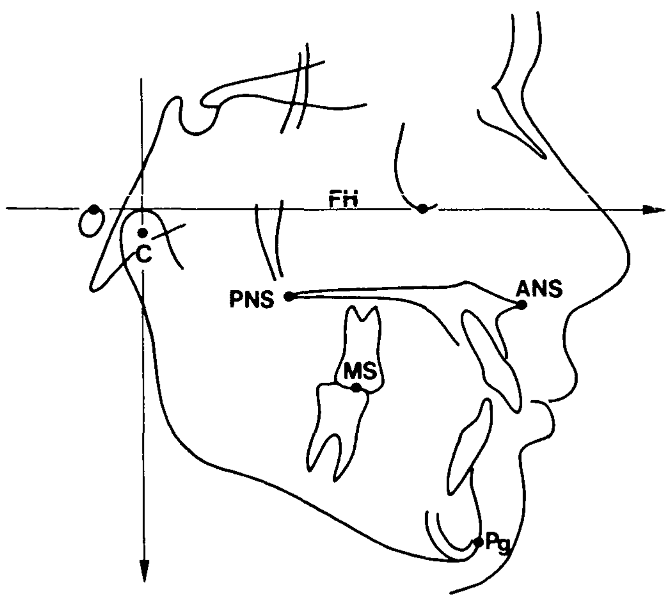

Fig. 1 Reference system consisting of Frankfort Horizontal (FH) and a vertical through the center of the condyle (C). Measured points are anterior nasal spine (ANS), posterior nasal spine (PNS) and upper molar (MS).

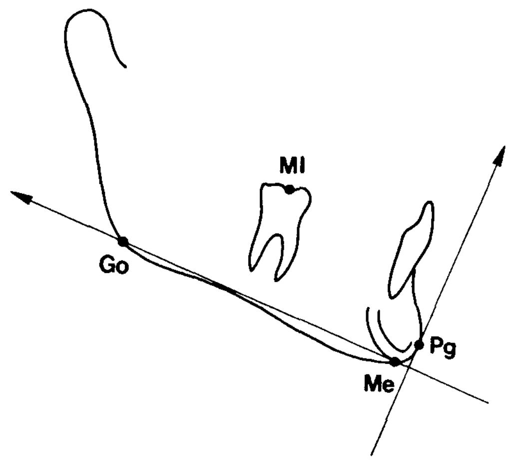

Fig. 2 Mandibular reference system consisting of the menton-gonion (Me-Go) line and a vertical through pogonion (Pg). Measured point: Lower molar (MI).

TABLE 2
Linear and angular changes

	Treatment		*Control*		*Rank Sum Test*			
	Mean	*±SD*	*Mean*	*±SD*	T_1	T_2	*p*	
C—Pg (mm/year)	2.73	1.10	2.52	0.74	584	1694	.28	n.s.
Vertical* (mm/yr)								
ANS	0.93	0.87	0.81	0.42	589	1689	.25	n.s.
PNS	0.50	0.69	0.62	0.33	462	1816	.11	n.s.
MS	1.73	0.84	1.53	0.49	603	1675	.19	n.s.
Pg	2.66	1.06	1.77	0.61	732	1546	.00	**
Horizontal* (mm/yr)								
ANS	0.97	1.20	1.52	0.64	353	1925	.00	**
PNS	0.23	0.82	0.66	0.54	371	1907	.01	**
MS	0.12	2.02	1.73	0.62	286	1992	.00	***
Pg	1.15	1.42	1.78	0.98	383	1895	.01	**
Angles								
CPg/FH	1.23	1.64	0.00	1.54	717	1561	.01	**
NL/FH	1.21	1.81	0.84	1.90	576	1702	.32	n.s.

ANS: anterior nasal spine, PNS: posterior nasal spine, MS: upper molar, Pg: pogonion, CPg/FH: Angulation of line C-Pg (center of the condyle—pogonion) to FH, NL/FH: angulation of ANS-PNS to FH.

* Measurements based on coordinate axes shown in Fig. 1.

TABLE 3
Lower molar (MI) movement.

* *Diff. (mm/year)*	*Treatment* *Mean*	*±SD*	*Control* *Mean*	*±SD*	*Rank Sum Test* T_1	T_2	*p*	
MI vert.	0.19	1.06	0.46	0.45	437	1841	.06	n.s.
MI horiz.	0.06	1.01	—0.18	0.41	630	1648	.10	n.s.

* Measurements based on coordinate axes shown in Fig. 2.

TABLE 4
Growth directions of ANS, Pg and MS

Angle to FH (degrees)	*Treatment* *Mean*	*±SD*	*Control* *Mean*	*±SD*	*Rank Sum Test* T_1	T_2	*p*	
ANS_1-ANS_2	43.10	44.01	29.66	18.03	659	1619	.05	*
Pg_1-Pg_2	67.13	22.18	46.69	21.33	742	1536	.00	**
MS_1-MS_2	82.21	45.65	42.24	14.23	783	1495	.00	***

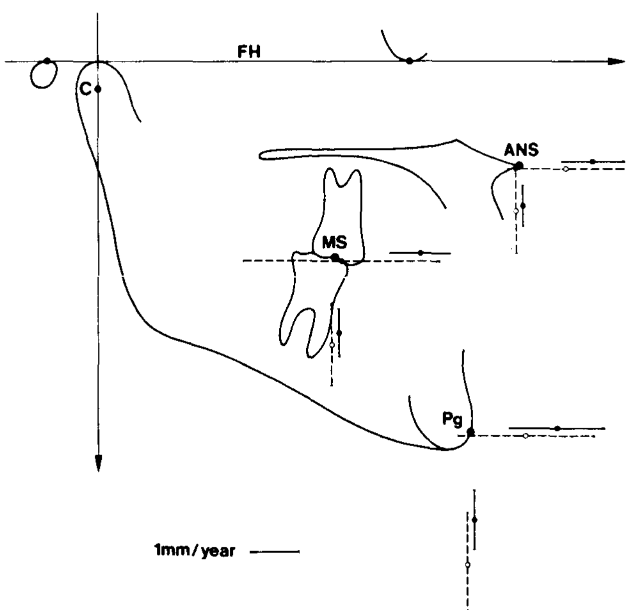

Fig. 3 Horizontal and vertical movements of anterior nasal spine, upper molar and pogonion. Short lines represent standard deviations, with small dots at mean annual movement (note scale). Dashed lines show treatment sample, solid lines control.

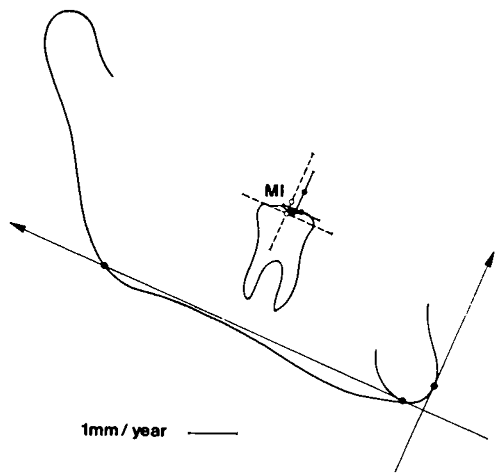

Fig. 4 Lower molar movement in relation to the mandibular reference system.

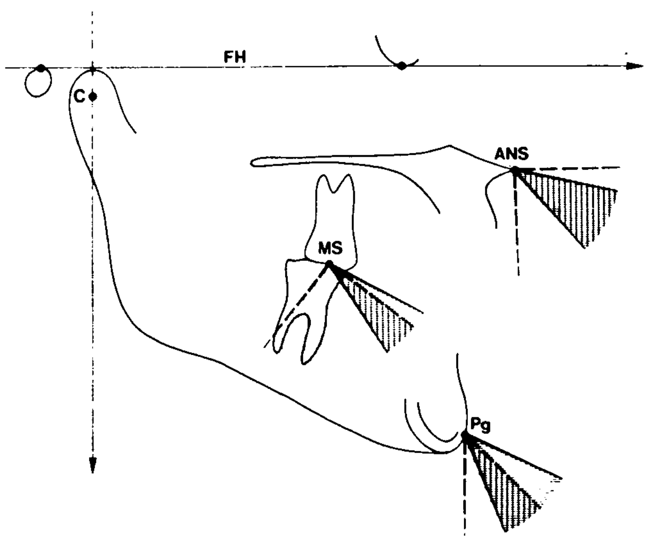

Fig. 5 Directions of movements of anterior nasal spine, upper molar and pogonion. Vertically striped area shows first standard deviation for the treatment sample, horizontally striped area the first standard deviation for the controls.

zontal, the direction of movement of ANS, upper molars and pogonion was significantly more downward among the treatment sample than in the controls (Table 4, Fig. 5). The most marked difference was in the direction of upper molar movement, which averaged 82.2° in the treatment sample compared to 42.2° in the control ($P<.001$). Movement of pogonion also differed significantly (67.1° and 46.7°, $p<.01$). Differences at ANS (43.1° and 29.7°) were not statistically significant.

With the exception of the change in palatal plane inclination (ANS-PNS/FH), all of the parameters tested displayed higher standard deviations in the treatment sample.

Correlations of the parameters were comparable in both groups (Table 5, Figs. 6-11). The direction of upper molar movement in relation to Frankfort was similarly correlated with the directions of movement of pogonion and ANS, change in the angle C-Pg/FH and the anterior displacement of pogonion.

Relating these parameters to the horizontal movement of the upper molars, correlation coefficients of comparable significance were found in patients and controls. For example, the coefficient between the horizontal movement of the upper molars and of pogonion was 0.73 in the treatment sample and 0.76 in the control sample.

In complete contrast, no relation was found in either of the groups between the vertical movement of the upper molars and the horizontal displacement of pogonion.

As expected, a very close relation between anterior displacement of pogonion and condyle growth rate was recorded in both the treatment and control group.

Discussion

Comparison of both samples revealed that Class II correction using Tweed Edgewise technique in conjunction with low cervical traction did not affect the average condyle growth rate, eliminating this as a possible cause of adverse treatment responses. This is in agreement with Oedegard,[15] who supposed that "treatment probably causes a change in the position of the mandible and not in mandibular morphology."

Increased variability of the parameters within the treatment sample was indicative of the very individual reaction to therapy. Once more, the reaction to treatment seems to be highly unpredictable on an individual basis.[21]

Posterior mandibular rotation has been attributed to vertical force components from cervical traction on upper molars.[13,16] Surprisingly, no significant increase of average downward movement of either the upper molars, ANS or PNS was recorded within the treatment sample; nor was the posterior rotation of the palatal plane[9,22] considered sufficient to be significant.

The considerable and significant increase in the angle C-Pg/FH, accompanied by a significant increase in the vertical and decrease in the horizontal movement of pogonion, reflects a posterior rotation of the mandible. This must be attributed to factors other than upper molar extrusion.

The question that arises is which of the parameters show significant differences between both samples, caused directly and undoubtedly by treatment, and have at the same time a similarly close relation to pogonion movement within both of the samples?

The most noticeable difference between the two samples is in the anterior movement of the upper molars, precisely the location where the cervical traction is applied. Anterior molar movement was considerably inhibited in the treatment group.

ANS and PNS displayed corresponding inhibition. This decrease in anterior movement of the maxilla, together with a very slight increase in its vertical displacement, resulted in a steeper path of movement of the upper molars and ANS.

The altered movement of maxillary structures must be seen as a direct consequence of cervical traction. The movement of pogonion, also deflected in a more downward direction in the treatment group (Table 4), can only be explained indirectly by statistical correlation.

Pogonion movement becomes a dependent variable. The direction of pogonion movement on the one hand and the direction of upper molar movement and their anterior displacement on the other, all of them quite different if we compare the two samples, showed practically the same correlation within their respective groups (Table 5).

It is evident, therefore, that posterior rotation of the mandible may be explained as an indirect consequence of therapeutic inhibition of anterior displacement of the midfacial structures.

In the age period evaluated, correlation of the parameters tested demonstrated a harmonious overall behavior of the different parts of the growing face. In both treatment and control samples, the directions of movements of the midfacial structures and of the mandible corresponded to each other. Consequently, any deviation of midfacial displacement in a more downward direction, as may be induced by therapy, will result in a more downward movement of pogonion.

The influence of a deflected direction of upper molar movement on the change in the position of pogonion is illustrated in Fig. 12. Starting from an average facial pattern and a 7° angulation of the occlusal plane to Frankfort Horizontal as found in the treatment sample, the average annual increments and corresponding directions of upper molar movements are traced for the treatment and control samples.

If all other parameters of facial development are held constant, the molar movements 1 (control) and 2 (treatment) lead to the indicated positions 1 and 2 of pogonion. In spite of its shorter length, molar movement 2, by pure geometric consequence, initiates a more downward and posterior position of the chin.

If the position of pogonion is to be kept in accordance with normal development during treatment, inhibition of the anterior movement of the upper molars must be accompanied by corresponding inhibition of their downward movement.

However, the steeper path of the upper molars in the treated sample was not accompanied by the full theoretical effect on the position of pogonion. In relation to Frankfort Horizontal, the average angle of upper molar movement was 82° and of pogonion movement 67°. In the control sample these angles were 42° for upper molar movement and 47° for pogonion movement (Table 4).

It might be speculated that the steeper path of movement of the upper molars in the treatment group

TABLE 5a

Correlations of angles and of angular and linear differences within the treatment group.
Subscript $_s$ = anterior movement, $_v$ = downward movement, Δ = difference.

	Δ C-Pg	Δ Pg_v	Δ Pg_s	Pg_1-Pg_2/FH°	ANS_1-ANS_2/FH°	Δ NL/FH°	Δ CPg/FH°	Δ MS_v	Δ MS_s	MS_1-MS_2/FH°
MS_1-MS_2/FH°	−0.491*	0.248	−0.657**	0.652**	0.821***	0.402	0.631**	0.342	−0.912***	
Δ MS_s	0.456*	−0.386	0.733***	−0.723***	−0.772***	−0.363	−0.695**	−0.271		
Δ MS_v	0.349	0.477*	0.071	0.078	0.429*	−0.166	0.060			
Δ CPg/FH°	−0.462*	0.574*	−0.877***	0.936***	0.589**	0.635**				
Δ NL/FH°	−0.472*	0.131	−0.542*	0.458*	0.424					
ANS_1-ANS_2/FH°	−0.190	0.439*	−0.441*	0.510*						
Pg_1-Pg_2/FH°	−0.509**	0.527**	−0.908***							
Δ Pg_s	0.783***	−0.225								
Δ Pg_v	0.422									
Δ C-Pg										

$P \leq 0.05$*
$P \leq 0.01$**
$P \leq 0.001$***

TABLE 5b

Correlations of angles and of angular and linear differences within the control group.

	Δ C-Pg	Δ Pg_V	Δ Pg_S	Pg_1-Pg_2/FH°	ANS_1-ANS_2/FH°	Δ NL/FH°	Δ CPg/FH°	Δ MS_V	Δ MS_S	MS_1-MS_2/FH°
MS_1-MS_2/FH°	−0.192	0.467***	−0.481***	0.658***	0.783***	0.538***	0.664***	0.567***	−0.678***	
Δ MS_S	0.680***	−0.010	0.758***	−0.596***	−0.624***	−0.492***	−0.612***	0.184		
Δ MS_V	0.497***	0.653***	0.148	0.246*	0.341**	0.183	0.246*			
Δ CPg/FH°	−0.398**	0.618***	−0.834***	0.963***	0.791***	0.576***				
Δ NL/FH°	−0.178	0.402**	−0.457***	0.573***	0.747***					
ANS_1-ANS_2/FH°	−0.320*	0.501***	−0.671***	0.803***						
Pg_1-Pg_2/FH°	−0.378**	0.616***	−0.826***							
Δ Pg_S	0.814***	−0.126								
Δ Pg_V	0.459***									
Δ C-Pg										

$P \leq 0.05$*
$P \leq 0.01$**
$P \leq 0.001$***

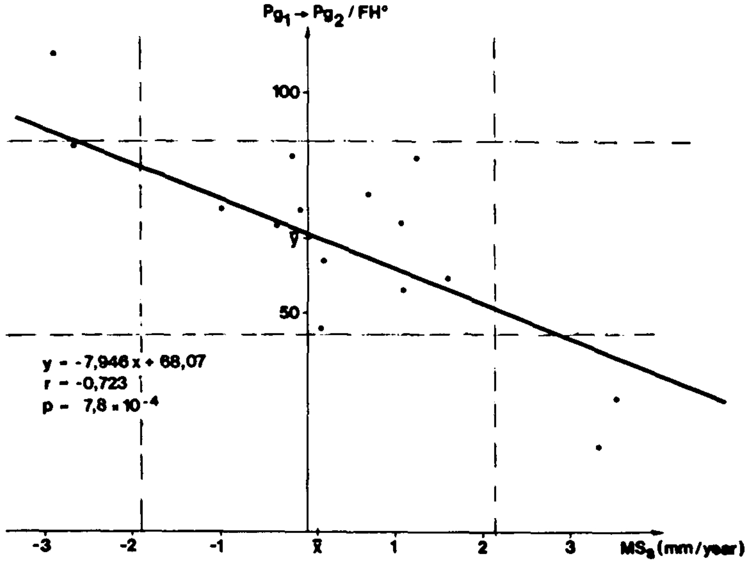

Fig. 6 Linear regression for treatment sample between annual anterior movement of the upper molars and the direction of movement of pogonion.

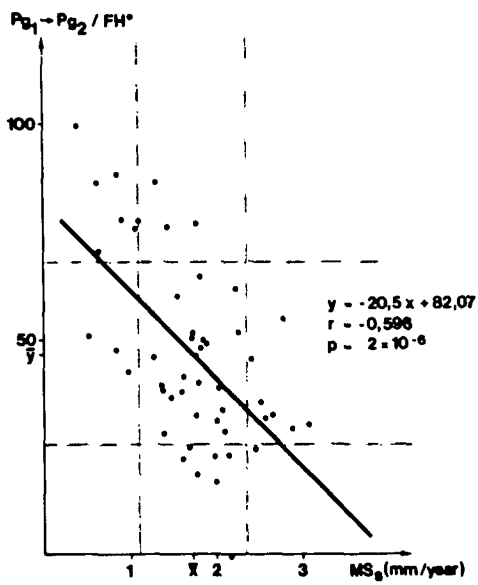

Fig. 7 Linear regression for control sample between annual anterior movement of the upper molars and the direction of movement of pogonion.

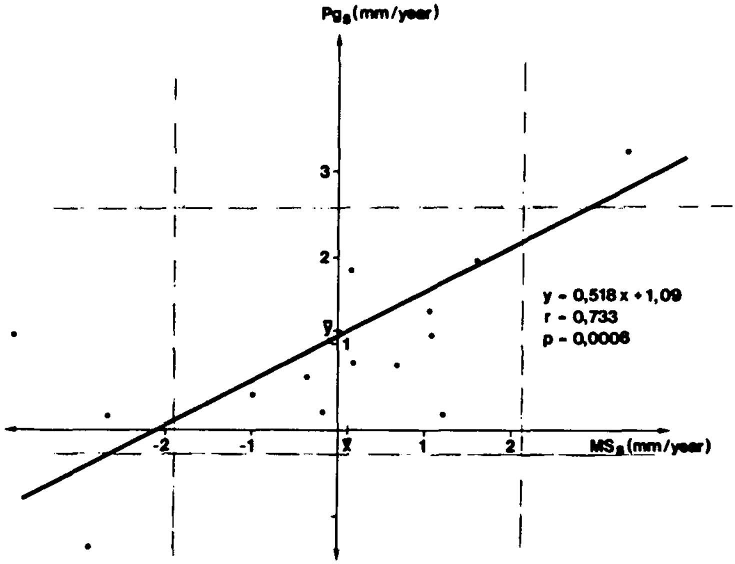

Fig. 8 Linear regression for treatment sample between annual anterior movements of the upper molars and pogonion.

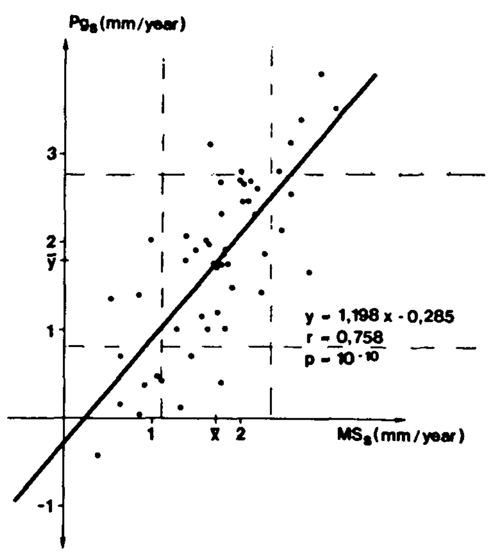

Fig. 9 Linear regression for control sample between annual anterior movements of the upper molars and pogonion.

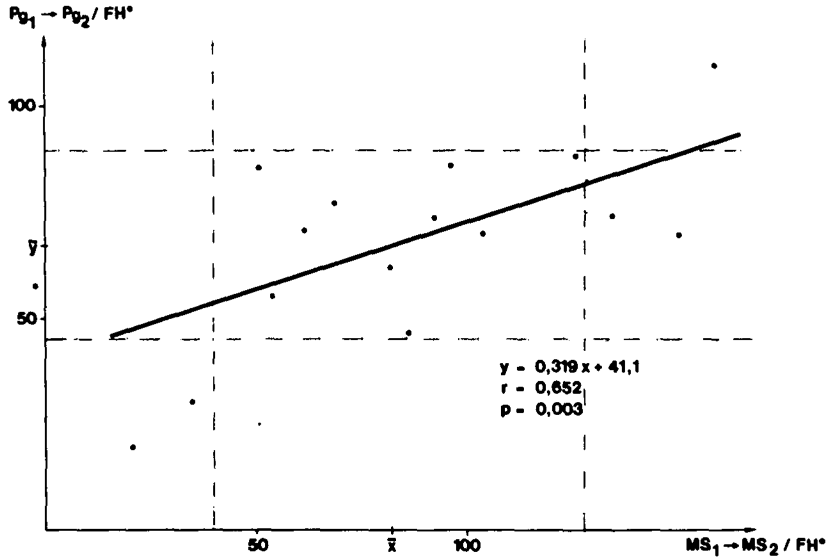

Fig. 10 Linear regression for treatment sample between the directions of movement of upper molars and pogonion.

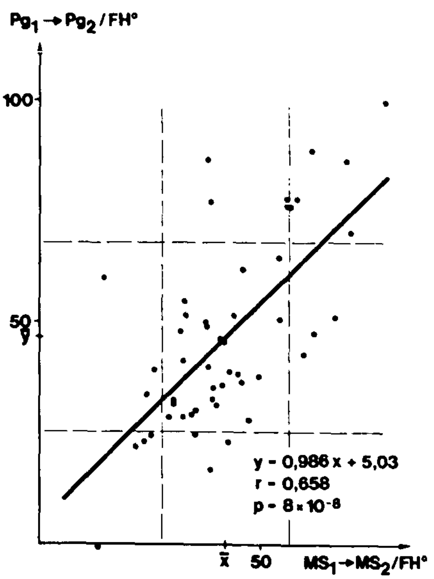

Fig. 11 Linear regression for control sample between the directions of movement of upper molars and pogonion.

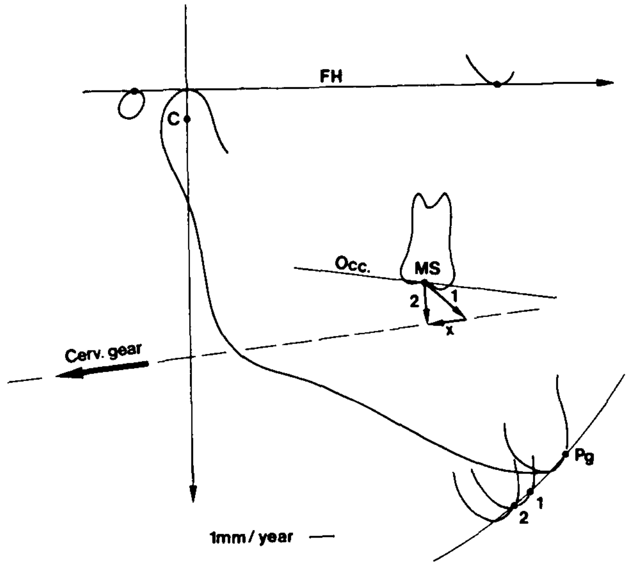

Fig. 12 Influence of two different directions of molar movement on mandibular rotation. Skeletal configuration, upper molar position and angulation of the occlusal plane to Frankfort Horizontal show mean values of the treatment sample. 1 = mean control sample change, 2 = mean treatment sample change, x = treatment effect.
If all other parameters of facial growth are maintained at a zero level for illustration purposes, the molar movements 1 and 2 lead to the corresponding positions 1 and 2 of pogonion.

caused some decrease of vertical movement of the lower molars. There was a corresponding difference of vertical lower molar movement between the groups (Table 3), but in view of the large standard deviation within the treated sample this difference failed to demonstrate the consistency necessary for statistical significance at the $P<.01$ level.

Apart from the amount of anterior movement of the upper molar, the condyle growth rate exerted the greatest influence on the horizontal position of the chin. The inhibition of anterior movement of midfacial structures and the amount of condyle growth thus determine to a large extent the quality of the skeletal and profile result in Class II correction. Posterior rotation of the mandible is most likely to occur where condyle growth rates are small and major inhibition of anterior movement of the maxilla must be effected.

Summary

Comparison of treatment and control samples was intended to reveal those factors which, during Class II correction using Tweed Edgewise technique in conjunction with intermaxillary traction and low cervical traction to upper molars, may lead to undesirable posterior rotation of the mandible.

Both samples exhibited similar condyle growth rates.

Increased variability of the parameters tested was found within the treatment group.

No significant difference was found in the vertical movement of the upper molars, while anterior movement of the upper molars was significantly inhibited in the treatment sample.

The treatment sample displayed increased vertical and decreased anterior movement of pogonion, accompanied by posterior rotation of the mandible.

Close and similar correlations were found in both samples between the anterior movements of the upper molars and pogonion, between the angles of upper molar and pogonion displacement in relation to Frankfort Horizontal, and between both of the upper molar parameters and changes of mandibular rotation.

In the treated sample it was inhibition of anterior movement of the upper first molars, not enhancement of vertical movement that appeared to cause posteroinferior rotation of the mandible and displacement of pogonion through a geometric interdependence.

The direction of upper molar movement and condyle growth rate both exert important influences on changes in position of the growing mandible and thus on the nature of profile changes in Class II correction.

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