Original Article

Comparative Long Term Post-Treatment Changes in Hyperdivergent Class II Division 1 Patients With Early Cervical Traction Treatment

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Abstract: This was a retrospective study of 45 Class II division 1 hyperdivergent patients treated in the mixed dentition with cervical traction and an incisor biteplane. The interjaw or ''B'' angle (mandibular plane to palatal plane angle) was used to determine hyperdivergency. The treated sample was subdivided into 2 groups reflecting whether the mandibular or palatal plane contributed the greatest amount to the more than 1 standard deviation of the ''B'' angle from the mean value of the ''B'' angle present in the 89 untreated Class I controls. Complete records including lateral cephalometric head films were acquired at the start of treatment and 18 to 91 months after discontinuing all retention. Null hypotheses were designed to determine if any significant changes in the ''B'' angle, mandibular plane angle, or palatal plane angle occurred in the control group or the treated group. Thirty-two angular, linear, and proportional data were accumulated to determine the presence or absence of significant differences. The only significant angular differences found were in the group in which the palatal plane inclination was increased relative to Frankfort Horizontal. In this group, the palatal plane became more nearly parallel to Frankfort Horizontal than in the control group, and showed an increase instead of a decrease in the Y-axis. Proportional and linear data indicated the palatal plane change was a lack of descent of Posterior Nasal Spine while the descent of Anterior Nasal Spine was equal to that of the control group. The increase in the Y-axis was not the result of bite opening, but a lack of mandibular horizontal development as indicated by less of an increase in the Facial Angle. Of the 45 patients, only 4 (9%) required 2 phases of treatment and 1 of those required extraction. Thirty patients (67%) completed treatment with alignment and retraction of the maxillary anterior segment and 11 (24%) had additional alignment of the mandibular anterior segment. (*Angle Orthod* 2002;72:5–14.)

Key Words: Interjaw angle; Biteplane; Parallelism; Significant difference; Growth changes

INTRODUCTION

There is an abundance of literature on both the adverse and beneficial results achieved when utilizing extraoral cervical traction in the treatment of patients with Class II division 1 malocclusions. Some claim that cervical traction is contra-indicated in hyperdivergent patients, contending there is an accompanying extrusive force producing elongation of the maxillary molars.[1–7] As a result, different types of extraoral appliances have been designed and described to counteract possible extrusive forces. Despite these claims, throughout the years, other authors detected no elongation and demonstrated successful results.[8–47]

Investigators have noted variations in vertical facial relationships as an expression of different growth patterns. Various methods have been used to determine vertical facial types, including cant of the mandibular plane,[48–50] cant of the palatal plane,[51–53] interjaw angle,[1,52] and ratios of anterior and posterior face heights.[54–56] Descriptive terms have been used to categorize facial types including short, average, long, poor, and good facial patterns, forward and backward rotators, hyperdivergent, neutral, and hypodivergent growth patterns.[44–55]

Post-treatment changes in the vertical parameters of treated and growing patients not only reflect the effects of residual growth, varying facial type responses, tissue rebound, and clockwise or counter-clockwise mandibular rotation, but also the clinician's understanding of the appliance's functional design. Physiologic response to the short and long outer face bow in cervical traction will vary. The

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Accepted: July 2001. Submitted: April 2001.
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clinician cannot equate the physiologic response of a short outer bow to that of a long outer bow.

The purpose of this investigation was to test several null hypotheses in patients presenting with a Class II division 1 Angle malocclusion and hyperdivergent facial patterns all of which were treated with a cervical headgear and an incisor biteplane in the mixed dentition. The hyperdivergent facial patterns were determined by the ‘‘B’’ or interjaw angle[51,52] formed by the intersection of the mandibular and palatal planes. The hypotheses were:

1. The mean growth changes in the ‘‘B’’ angle will not differ in Class I untreated and hyperdivergent cervical traction treated Class II division 1 patients at the time of acquisition of final records;
2. The mean growth changes in the mandibular plane angle will not differ between Class I untreated and hyperdivergent cervical traction treated Class II division 1 patients at the time of the acquisition of final records;
3. The mean growth changes in the palatal plane angle will not differ between Class I untreated and hyperdivergent cervical traction treated Class II division 1 patients at the time of acquisition of final records;
4. The responses to cervical traction treatment of Class II division 1 patients will not vary, whether the palatal or mandibular plane was the etiology, at the time of acquisition of final records.

MATERIAL AND METHODS

Each lateral cephalometric radiograph was traced with a 4H graphite pencil on a 0.008″ matte acetate tracing paper. Both midline and bilateral images were traced with all bilateral images bisected and thereafter treated as midline structures. Linear measurements were read to the nearest 0.5 mm, and all angular measurements were obtained with a standard protractor and read to the nearest 0.5 degree. A right angle coordinate system as described by Coben[54] was used to determine proportions.

The control group consisted of 89 untreated Class I cases of which 53 came from the files of the Mooseheart Foundation Cephalometric Growth Study of the University of Illinois, 33 from the Philadelphia Center for Research in Child Growth and 3 from the family of Dr Allan G. Brodie.[56]

The criteria used in selection of patients were: (1) all patients had a Class II division 1 malocclusion in the mixed dentition with sagittal correction starting with a cervical headgear; (2) all the patients had an interjaw ‘‘B’’ angle 1 standard deviation greater than the mean of the Class I untreated control; (3) no patients had congenital anomalies, significant facial asymmetries or congenitally missing teeth; (4) records for each patient included dental casts, facial photographs, full mouth or panorex x-rays, and lateral cephalometric head films obtained just prior to treatment, at the time of debanding, and a minimum of one and a half years following removal of all retainers; and (5) all patients were treated to an acceptable occlusion (ie, a Class I molar and canine relationship with a well-aligned interdigitated dentition).

These criteria had the disadvantage of limiting the number of patients, but conversely, increased the homogeneity of the sample by including only the most severe vertical discrepancy cases. We believe the size of the sample is not as significant as the quality of the sample. Selection was based solely on the severity of the deformity; therefore, gender differences were not considered.

A total of 45 patients were selected from an initial sample of 345 patients who met all the criteria. They were then divided into 2 groups based on whether the patient’s palatal or mandibular plane deviated from the mean of the control by more than 1 standard deviation. In cases where both deviated by more than 1 standard deviation, the plane that deviated the most determined which category the records would be placed. The length of treatment was determined from the time the initial appliance was placed until debanding. The length of retention was calculated from the date of placement of retainers until removal of the last retainer. Length of post-retention was evaluated from the date of discontinuing all retainers, fixed and removable, to the date of acquisition of the final records. One clinician treated all the patients.

An analysis of variance (ANOVA) was conducted to determine if there was a difference in mean change from baseline to retention to final records in the 3 groups. For those that were significant (alpha $=.05$) a 2-tailed (paired) *t*-test was then conducted using a Bonferroni correction to determine which mean differences were significant. In some instances, an apparent significant data ($P < .05$) was not registered because, in this case, a corrected alpha value for *t*-tests should be .0083 (.025/3).

The headgear was a Kloehn cervical[32,33] with approximately 400 g of force per side with slight expansion across the 0.045 inner E arch that fit into 0.045 tubes placed occlusally on banded maxillary first permanent molars. The outer face bow was initially tipped up posteriorly 15° and extended to the tragus of the ears.[12,31–33] The patient was instructed to wear the headgear 10 to 14 hours per day (mostly sleep time). As treatment progressed, the angulation of the outer bow was either increased or decreased depending upon the molar angulation. If the molar tipped distally, as indicated by impingement of the face bow on the lower lip, the angulation was increased. Impingement into the upper lip would indicate distal root tipping, thus directing a reduction of the angle.

Twenty-seven of the patients had deep bites, while 12 had no more than a 3 mm overbite. Six patients had mild open bites (2–4 mm) due to persistent thumb sucking or tongue thrusting habits, as revealed in each patient’s history. For these patients, a removable maxillary acrylic pal-

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atal appliance was fabricated. Three vertical loops were placed, extending from cuspid to cuspid, lingually along the lower incisors and inferior to the cingulum with the mouth closed. However, the loops would still extend inferior to the incisal edge of the mandibular incisors and cuspids with the mouth open. The palatal acrylic extended only to the distal edge of the maxillary cuspid, freeing the maxillary anterior segment of the restrictive influence of the acrylic. With the appliance in place, the thumb or any finger could not enter the mouth. When the tongue was thrust, the appliance would be dislodged giving a negative message of, ''don't swallow this way.'' Elevating the tongue, with an up and backward movement, would replace the appliance and evoke a positive message of, ''swallow this way.'' Typically, the habits would be broken and the bite closed within 3 to 4 months.

An acrylic incisal biteplane was utilized in deep bite cases before starting cervical traction.[25,34] It was determined early that cooperation was difficult to achieve by asking the patient to adjust to 2 appliances simultaneously. The biteplane portion of the appliance extended anteriorly to the level of the maxillary incisal edge and posteriorly to the incisal edge of the mandibular incisors with the mouth closed. Cervical headgear was initiated only when maximum occlusion of the buccal segments was achieved with the biteplane in place and the patient was fully comfortable with the biteplane. This usually took 3 to 4 months of 24-hour wear. The initial force placed on the headgear was only sufficient to keep it in place. The force was to be increased at 4- to 6-week intervals until 400 g was reached and checked thereafter at 6-week intervals.

As the bite closed and excessive overbite returned, a new biteplane was fabricated and inserted since anterior-posterior correction had not yet been achieved. This appliance was designed to reopen the bite and to reestablish full palatal coverage. There was an increase in maxillary dental arch width due to both the expanded inner bow (E arch) and the loss of facial musculature constrictive forces on the buccal segments from the 10- to 14-hour shielding effect of the inner bow. Three to 4 mm spaces developed between the dental bearing edge of the acrylic palate and the lingual surface of the maxillary buccal segments. In some cases, an additional side effect of the newly expanded maxillary arch form enabled the elevation of the tongue from an initial low position. Elms et al[16,17] demonstrated that increased maxillary and mandibular arch widths post-treatment and post-retention remained stable. The mean ages of the individuals at the different stages of treatment and the mean treatment, retention, and post-retention times are presented in Table 1.

TABLE 1. Mean Ages of Subjects at Different Stages of Treatment and Mean Averages of Treatment, retention, and Postretention Time

	Control[a] (n = 89)		Class II[a] PPG (n = 22)		Class II[a] MPG (n = 23)	
	x	SD	x	SD	x	SD
Pretreatment age (T1)	8.3	1.3	8.6	1.3	9.7	1.1
End of treatment (T2)			12.3	1.4	13.1	1.6
Postretention (T3)	16.0	1.9	18.0	2.1	19.0	1.6
Treatment time (y)[b]			3.7	1.6	3.4	1.5
Retention time (y)[b]			3.0	1.2	2.3	0.8
Postretention time (y)[b]			2.7	1.3	3.6	1.6

[a] PPG indicates patients with palatal plane angles greater than 1 standard deviation from the mean of the controls; MPG, patients with mandibular plane angles greater than 1 standard deviation from the mean of the controls; n, number of patients; x, mean age; SD, standard deviation.

[b] Treatment time is calculated from the date treatment started until date of debanding. Retention time is calculated from the insertion of retainers until full removal date. Postretention time is calculated from the removal of all retainers to date of final examination.

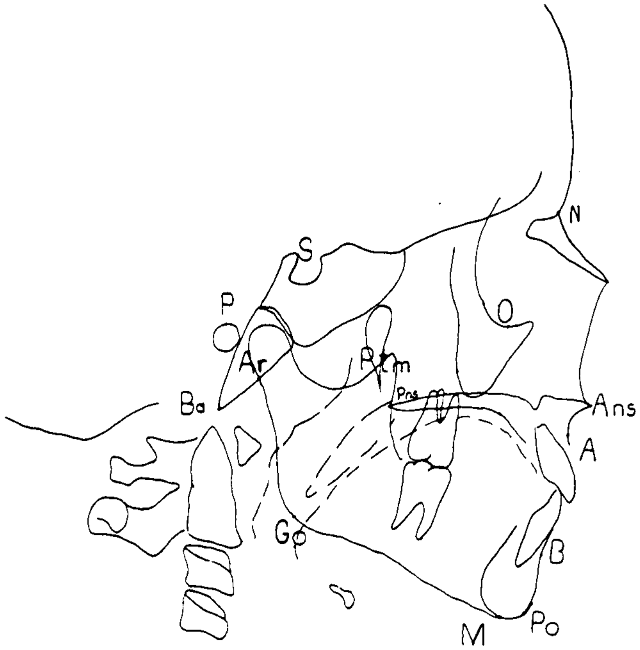

FIGURE 1. Cephalometric landmarks.

Cephalometric landmarks and measurements

The planes and landmarks employed are presented in Figures 1 and 2. Thirty-two angular, linear, and proportional measurements were determined for each patient prior to treatment and at the acquisition of final records. The angular measurements were as follows: FH:NPO, BaSN, FH:ANSPNS, FH:MGO, ANSPNS:MGO, FH:SGN.

The horizontal linear measurements were: A-NPO, U1-APO, L1-APO, ULIP-E, L LIP-E and Ba-N. The vertical linear measurements were: U1-L1, N-M, N-ANS, ANS-M, N-S, S-PNS, S-AR, AR-GO and S-GO. A right angle coordinate system was used to determine proportional data.[54] The proportional measurements (Figures 3–5) were NM%BaN, NANS%NM *(UAF%NM)*, ANSM%NM

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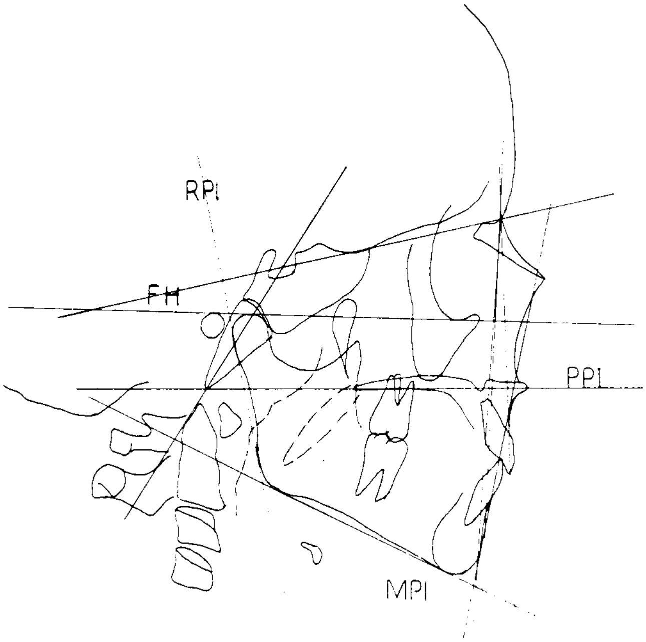

FIGURE 2. Cephalometric planes: MPL indicates Mandibular Plane; PPL, Palatal plane; FH, Frankfort Horizontal; and RPL, Ramal Plane.

(LAF%NM), NS%NM, SPNS%NM, SAR%NM, SGO%NM, NANS%ANSM *(UAF%LAF)*, SPNS%SGO (UPF/LPF X 100), and SPNS%ARGO *(PMX/PMA X 100).* All horizontal landmarks except A-NPGO, U1-APG, L1-APO, U LIP-E and L LIP-E were determined by projecting the landmarks at right angles to Frankfort Horizontal. The exceptions to the above dimensions were projected at right angles to the mentioned reference planes. All vertical landmarks were determined by projecting the landmarks at right angles to a line perpendicular to Frankfort Horizontal. Proportions are determined from these measurements.[54]

RESULTS

Table 1 shows 45 patients had interjaw ‘‘B’’ angles greater than 1 standard deviation from the control mean. Twenty-two of these patients had palatal plane angles that were greater than 1 standard deviation from the mean of the controls (PPG) while 23 patients had mandibular planes that were greater than 1 standard deviation from the mean of the controls (MPG).

In the PPG group, 16 patients (73%) had only 1 phase of treatment while 6 (27%) had alignment of the lower anterior segment from cuspid to cuspid. In the MPG sample, 4 patients (17%) required full or 2-phase treatment. Only 1 patient (a male) in this group of 4 required the extraction of maxillary and mandibular first bicuspids. Five (22%) of the MPG sample had alignment of the same mandibular segment while the remaining 14 (60%) were completed, as in the PPG subdivision, with alignment and retraction of the maxillary anterior segment from cuspid to cuspid.

Tables 2–4 show a reduction of the ‘‘B’’ palatal and mandibular plane angles in all 3 groups from the start of treat-

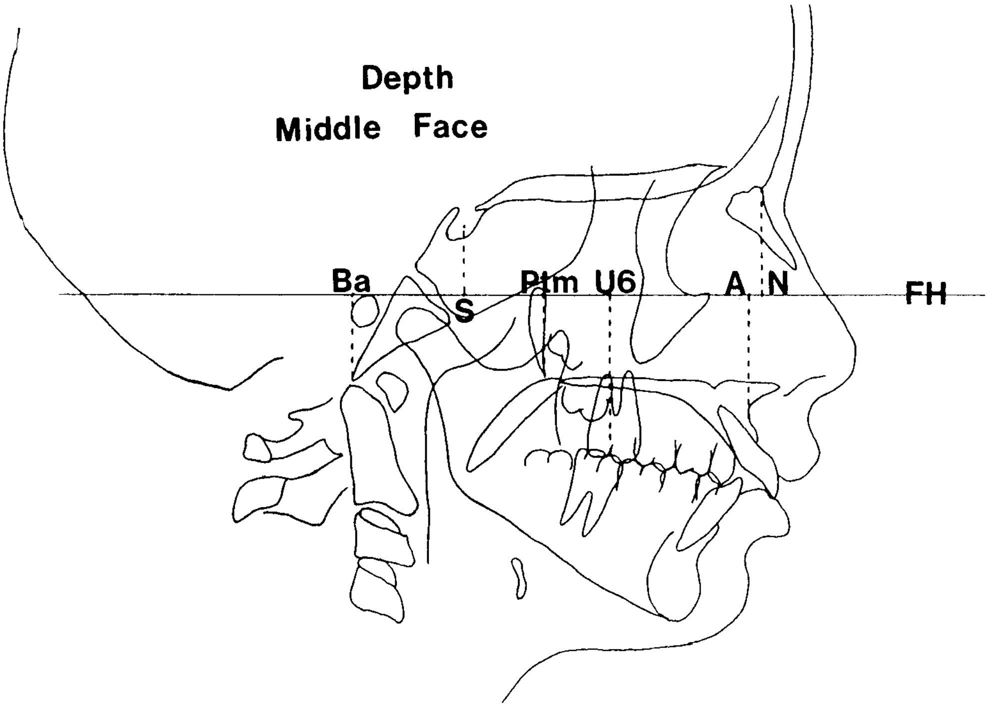

FIGURE 3. Middle Face Depth: Ba indicates Basion; S, Sella Turcica; Ptm, Pterygo maxillary fissure; U6, Mid buccal groove maxillary first molar; A, Point A; N, Nasion; FH, Frankfort Horizontal.

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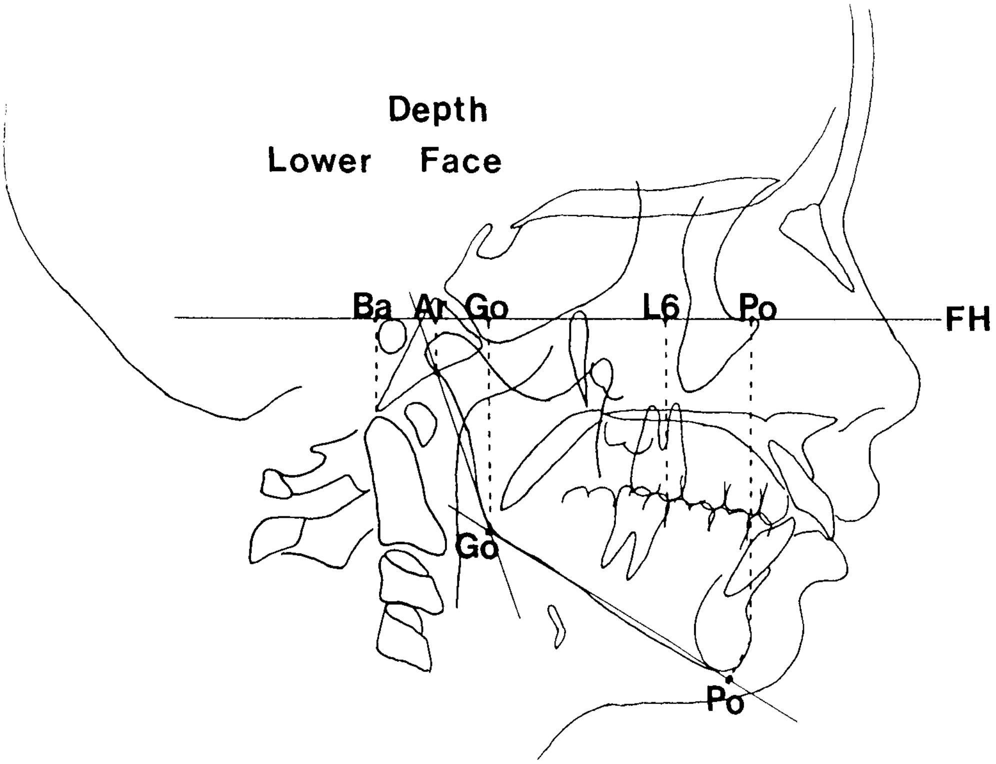

FIGURE 4. Lower Face Depth: Ar indicates Articulare; Go, Gonion; L6, mesial contact mandibular first permanent molar; and Po, Pogonion.

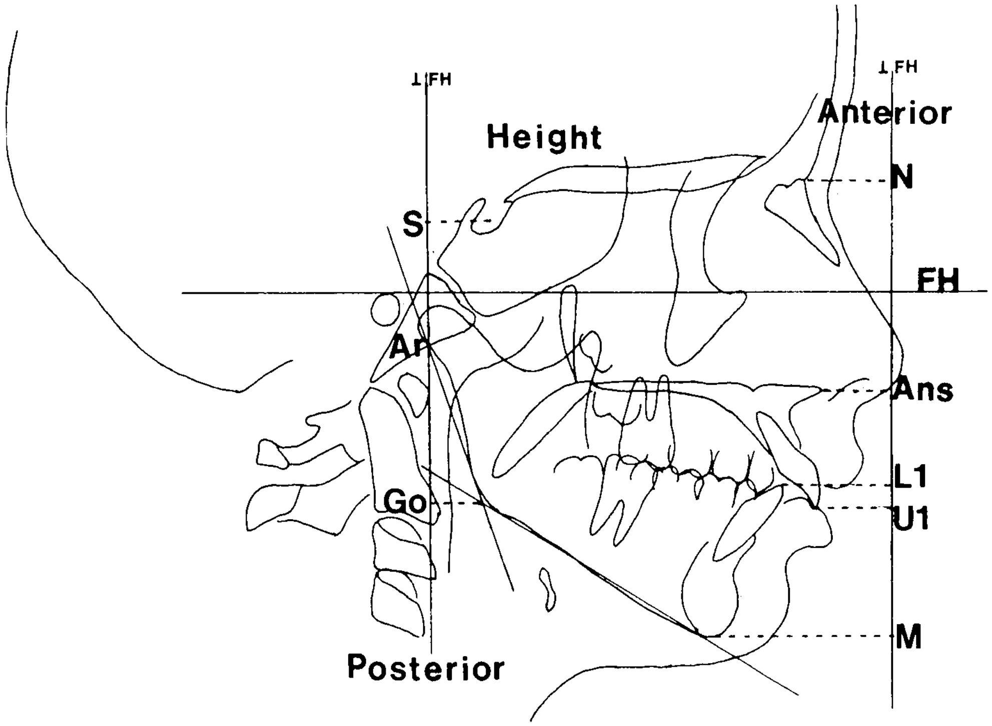

FIGURE 5. Anterior and Posterior Face Height: Ans indicates Anterior Nasal Spine; M, Menton; L1, Incisal edge mandibular incisor; and U1, incisal edge maxillary incisor.

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TABLE 2. B Angle in All 3 Groups from Start of Treatment to Final Records

	Class I	PPG[a]	MPG[a]
Start	25.9 ± 5.1	31.0 ± 2.6	33.9 ± 3.2
Retention	24.3 ± 5.1	29.0 ± 3.7	32.1 ± 3.6
Final	22.0 ± 5.8	27.6 ± 4.7	31.2 ± 3.5

[a] PPG indicates patients with palatal plane angles greater than 1 standard deviation from the mean of the controls; and MPG, patients with mandibular plane angles greater than 1 standard deviation from the mean of the controls. PPG indicates patients with palatal plane angles greater than 1 standard deviation from the mean of the controls; and MPG, patients with mandibular plane angles greater than 1 standard deviation from the mean of the controls.

TABLE 3. Palatal Plane Angle in All 3 Groups from Start of Treatment to Final Records

	Class I	PPG[a]	MPG[a]
Start	1.6 ± 2.5	6.7 ± 2.1	3.0 ± 2.5
Retention	1.5 ± 2.5	4.7 ± 2.5	2.2 ± 2.6
Final	1.4 ± 3.1	4.5 ± 2.5	2.5 ± 2.2

[a] PPG indicates patients with palatal plane angles greater than 1 standard deviation from the mean of the controls; and MPG, patients with mandibular plane angles greater than 1 standard deviation from the mean of the controls.

TABLE 4. Mandibular Plane Angle in All 3 Groups from Start of Treatment to Final Records

	Class I	PPG[a]	MPG[a]
Start	24.4 ± 4.9	24.4 ± 2.1	30.9 ± 2.7
Retention	22.9 ± 4.9	24.3 ± 2.5	29.9 ± 3.4
Final	20.6 ± 5.4	23.1 ± 4.9	28.7 ± 4.2

[a] PPG indicates patients with palatal plane angles greater than 1 standard deviation from the mean of the controls; and MPG, patients with mandibular plane angles greater than 1 standard deviation from the mean of the controls.

ment to final records. The control groups' retention data were extrapolated according to the average age of the 2 treated groups.

Table 5 demonstrates a significant difference between the control and the PPG patients in both the palatal plane angle ($P = .004$) and the Y-axis ($P < .001$). The palatal plane approached parallelism with Frankfort Horizontal more in the treated patients than in the controls, while this treated sample had a significant increase in the Y-axis. No significant differences were present in the facial, cranial base, "B" or mandibular plane angles between these 2 groups. No significant differences were present in the angular changes between the control and the MPG division and between the 2 treated groups.

Table 6 indicates a significant proportional increase in anterior face height (NM%BaN) relative to cranial base depth for both treated groups when compared to the control. There were no other significant proportional differences between the control and the treated groups or between the 2 treated groups.

Table 7 indicates many statistically significant linear changes between the treated divisions and the control and between the 2 treated groups. The treated samples exhibited statistically significant changes from the control in a reduced cranial base length (BaSN), less of an increase in Sella to Posterior Nasal Spine, more of a retraction of point A to Nasion-Pogonion line, a retraction of the maxillary central incisor to the A- Pogonion line, an advancement of the mandibular central incisor to the same line, and a reduction of the overbite instead of an increase. All were significant at the $P < .001$ levels.

The MPG treated portion differed from both the control and the PPG portion at a significance level of $P = .007$ with less of an increase in anterior face height (N-ANS) and less of an increase in cranial base length at a level of $P < .001$. The ramal length (AR-GO) increase was significantly less than the control ($P = .002$) and although insignificant, it was still less when compared to the PPG portion.

DISCUSSION

This was a retrospective study of comparative growth in 45 treated patients with Class II division 1 severe hyperdivergent facial patterns to a normal control. The interjaw or "B" angle as described by both Schwartz[51] and later Sassouni[52] was used to determine a hyperdivergent pattern in preference to the Y-axis or mandibular plane as used by others.[26,43,49,50,65,70] A downward or upward tipping of the palatal plane could well compensate for an equal amount

TABLE 5. Average Angular Changes and Significance Levels from Start of Treatment to Final Records

	Change		Significance	Change		Significance	Change		Significance
	Control	PPG[a]	*P*-value	Control	MPG[a]	(*P*-value)	PPG	MPG	(*P*-value)
Fac Ang	3	2.3		3	2.8		2.3	2.8	
BaSN	0.2	0.1		0.2	−1		0.1	−1	
B ANG	−4	−3.4		−4	−2.7		−3.4	−2.7	
PP Ang	−0.2	−2.2	.004	−0.2	−0.6		−2.2	−0.6	
MP Ang	−3.5	−1.2		−3.5	−2.1		−1.2	−2.1	
Y AXIS	−1	1.7	.001	−1	−0.1		1.7	−0.1	

[a] PPG indicates patients with palatal plane angles greater than 1 standard deviation from the mean of the controls; and MPG, patients with mandibular plane angles greater than 1 standard deviation from the mean of the controls.

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TABLE 6. Average Proportional Changes and Significance Levels

Proportional Measurements[a]	Change			Change			Change		
	Control	PPG[b]	Significance	Control	MPG[b]	Significance	PPG	MPG	Significance
NM % Ba	6.2	10.6	$P < .001$	6.2	10.9	$P < .001$	10.6	10.9	
UAF%NM	0.3	1.1		0.3	0		1.1	0	
LAF%NM	−0.3	−1.1		−0.3	0		−1.1	0	
NS%NM	−0.2	−1.5		−0.2	−0.5		−1.5	−0.5	
SPNS%NM	0.3	0.2		0.3	−0.1		0.2	−0.1	
SAR%NM	0.4	0.1		0.4	0.9		0.1	0.9	
ARGO%NM	3	2.7		3	3.4		2.7	3.4	
SGO%NM	3.4	2.6		3.4	3.1		2.6	3.1	
UAF/LAF	1.4	1.8		1.4	0		1.8	0	
UPF/LPF	−5.3	−7.8		−5.3	−6.3		−7.8	−6.3	
PMX/PMA	−2.2	−2.7		−2.2	−2.7		−2.7	−2.7	

[a] UAF = NANS; LAF = ANSM; UPF = SPNS; LPF = ARGO; PMX = SPNS; PMA = SGO.
[b] PPG indicates patients with palatal plane angles greater than 1 standard deviation from the mean of the controls; and MPG, patients with mandibular plane angles greater than 1 standard deviation from the mean of the controls.

TABLE 7. Average Proportional Changes and Significance Levels[a]

	Change			Change			Change		
	Control	PPO	Significance	Control	MPO	Significance	PPO	MPO	Significance
BaSN	8.3	6.1	$P < .001$	8.3	3.6	$P < .001$	6.1	3.6	$P < .001$
NM	16.1	14.9		16.1	12.9		14.9	12.9	
NANS	7.7	7.7		7.7	5.9	$P = .007$	7.7	5.9	$P = .007$
ANSM	8.3	8		8.3	7.7		8	7.7	
NS	1.6	0.4		1.6	1		0.4	1	
SPNS	5.8	4.5	$P < .001$	5.8	4.6	$P < .001$	4.5	4.6	
SAR	4.6	4		4.6	4.6		4	4.6	
ARGO	9.5	8.4		9.5	6.9	$P = .002$	8.4	6.9	
SGO	14.2	13		14.2	11		13	11	
ANPO	−1.7	−3.8	$P < .001$	−1.7	−3	$P < .001$	−3.8	−3	
U1APO	0.5	−1.4	$P < .001$	0.5	−2.1	$P < .001$	−1.4	−2.1	
L1APO	0	2.5	$P < .001$	0	1.9	$P < .001$	2.5	1.9	
U LIPE	−4	−5.4		−4	−4.8		−5.4	−4.8	
L LIPE	−3	−3.6		−3	−3		−3.6	−3	
OB	1.8	−1.6	$P < .001$	1.8	−0.9	$P < .001$	−1.6	−0.9	

[a] PPG indicates patients with palatal plane angles greater than 1 standard deviation from the mean of the controls; and MPG, patients with mandibular plane angles greater than 1 standard deviation from the mean of the control.

of variation in the mandible resulting in a balanced interdigitation of the mandibulo-maxillary complex.[52]

The corrected Class II division 1 malocclusion patient is in a Class I interdigitation and no longer represents a malocclusion. Bishara[10,45] found that a treated group of Class II division 1 patients had ‘‘a normalization’’ in the growth potential and dentofacial characteristics at the end of a 5-year period. It was decided to compare the skeletal and anterior dental changes occurring in the treated patient from the start of treatment to the acquisition of final records with the untreated Class I normal over the same time period.

Patient treatment was started in the mixed dentition in an attempt to avoid the need for full banding and, if unsuccessful, to reduce the possible need for extraction and shorten full treatment time.[38,46] Angle believed in the attainment of normal occlusion as soon as possible. He felt the sooner he could obtain a normal coupling of the incline planes, the sooner the face would be beautiful and the jaw would develop around the corrected dentition. The younger patient appears to be more compliant to instruction than the older teenager.[35,46,57] The older patient, having a reduced growth potential, minimizes growth as a contributing factor to successful treatment. Allowing abnormal function and deleterious habits to persist could contribute to the severity of a malocclusion as well as increase the loss of leeway space needed for arch length.[13] Some authors report large overjets as significant predictors of teasing affecting a child’s self concept while others found that self concept was not a factor at the start of treatment and did not improve during early treatment.[60]

Tulloch[37,38] found that the time in fixed appliance was shorter for those patients that had early treatment even if the total treatment time was longer due to observation prior to starting the second phase. Interestingly, she found that

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there were more extraction cases in children that used functional appliances in the first phase than in the headgear group. The proceedings of the workshop on early treatment concluded that the final result with early treatment was better.[46]

Why would anyone use an incisor biteplane in a hyperdivergent patient? The successful and stable results on these 45 extremely hyperdivergent cases give credence to the following thought processes. It was and still is the opinion of the clinician that a complete, palatally impinging, overbite in a 9-year-old child is not the result of incisor supraeruption, but over-closure and infraeruption of buccal segments.

Ricketts,[61,62] using cephalometric laminagraphy of the temporomandibular joints, reported that two-thirds of the Class II division 1 patients he studied carried their condyles down and forward against the articular eminence at rest. The condyles demonstrated greater up and backward movement while going into occlusion. Following correction, condylar movement from rest to occlusion was reduced with the condyles now occupying a more up and backward position in the fossa in occlusion. Ricketts[61–63] concluded that upward and backward growth of the condyle contributed to a downward movement of the chin and not a forward movement. He found up and forward condylar growth was consistent with an increase in posterior face height and a forward growth tendency of the chin. He surmised that up and forward growth of the condyles forces the muscles of mastication to move the chin forward with an increase in ramal length and posterior face height.[62–65] He found this to agree with the implant work of Bjork.[66]

In accordance, the treating clinician believed that placement of an incisor biteplane would free the condyles' anterior superior border and permit growth at that border. The resultant action of the masticatory musculature would then thrust the chin forward in contrast to the reaction on the masticatory musculature by growth at the posterior superior border rotating the mandible down and backward. Keeling et al,[27] using headgear and a biteplane, found that a year after treatment was completed the headgear (90 patients) was more effective in enhancing mandibular growth than the activator (81 patients). Hellsong[25] used a maxillary biteplane to open the bite from 4 to 7 mm and Kondo[34] used a biteplane to overcorrect the incisal area to an edge-to-edge relationship.

The significant ($P = .004$) flattening of the palatal plane in the PPG portion, as seen in other studies,[12,63,64] is explained by the proportional changes in Table 6 and the linear changes in Table 7. The linear increase in the Nasion to Anterior Nasal Spine distance was the same in both the treated and control groups. Simultaneously, the Sella to Posterior Nasal Spine linear change was significantly less ($P < .001$) in the treated PPG sample. As additional conformation, although insignificant, upper posterior face height to lower posterior face height (UPF/LPF) proportionally decreased more in the PPG patients than in the controls. In synchrony, upper anterior face height proportion to lower (UAF/LAF) was almost identical to the controls. The approaching parallelism of the palatal plane to Frankfort Horizontal is, therefore, the result of a reduced descent of Posterior Nasal Spine and not an excessive dropping of Anterior Nasal Spine since its descent was equal to that of the controls. This orthopedic skeletal variation in growth results in a dental modification.

The significant ($P < .001$) increase in the Y-axis with the PPG portion in Table 5 indicates a significant increase in anterior face height. This is apparently confirmed in Table 6 by the significant increase ($P < .001$) in anterior face height as a proportion of cranial base depth (NM%BaN). However, Table 7 denotes that the cranial base increase (BaSN) was significantly less ($P < .001$) than the controls. Therefore, the increase in the Y-axis was not totally due to an increase in anterior face height or bite opening. The Y-axis is reflective of 2 planes in space, horizontal and vertical. The reduced increase in the Facial angle, seen in Table 5, could indicate that a lack of horizontal mandibular development may have also contributed to the increased Y-axis.

The absence of significant angular changes, when comparing the control to the MPG segment, appears contradictory to the linear and proportional data. The lack of a significant difference in palatal plane change in Table 5 is attributed to linear data seen in Table 7. In contrast to the PPG patients, there was a significant compensatory ($P = .007$) reduced vertical development of upper anterior face height (N.ANS). Simultaneously, the posterior face height (SPNS) change was almost equal to the PPG portion, thereby preventing the rotation of the maxilla seen in the other treated group and maintaining the maxillary molars' position in the face.

Table 6 shows a significant ($P < .001$) proportional increase in anterior face height (NM%BaN) without an expected significant change relative to the controls in either the mandibular plane or Y-axis in both treated groups. A significant lack of cranial base length increase ($P < .001$) relative to the control for both the MPG and PPG group, seen in Table 7, again indicates the change was not an increase in anterior face height or bite opening, but a lack of increase in cranial base length.

The almost identical lack of change in the cranial base angle (BaSN) in all 3 groups (Table 5) denotes this linear difference to be predominantly a quantity disparity. The significant differences in skeletal and dental profile and overbite linear readings ($P < .001$) in Table 7 are indicative of treatment objectives. Advancement of lower incisors was dictated in some of the cases by the restrictive action of deeply excessive overbites. Although the ramal length (AR-GO) increase was significantly less in the MPG segment relative to the control, the mandibular plane difference was insignificant. When compared with the short increase in

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cranial base and upper anterior and posterior face heights, it appears the MPG sample was just skeletally smaller.

The fallacy of utilizing angles to study changes occurring in a single plane of space and basing findings on a limited amount of data is exemplified by the above discussion. The creation of an angle is dependent upon 2 lines in space. Pythagorean trigonometric function states that the sine of the apex angle of a right triangle is equal to its base divided by the hypotenuse. Therefore, the greater the vertical length, the more acute the angle becomes.

CONCLUSIONS

No significant mean growth differences in the ‘‘B’’ and mandibular plane angles were found between the treated hyperdivergent Class II division 1 patients and the controls. The palatal plane in the PPG sample paralleled Frankfort Horizontal significantly more than in the controls. Even though there were no significant differences between the 2 treated groups, the palatal plane flattened more in the PPG patients than the MPG patients, while the mandibular plane flattened more in the latter. We might presume, from this study, that cervical traction action is the etiologic offending component.

ACKNOWLEDGMENTS

Mario Del Signore, MS, Biostatistics Department, Medical University of South Carolina, did the statistical analysis.

REFERENCES

1. Armstrong MN. Controlling magnitude, direction and duration of extraoral forces. *Am J Orthod.* 1971;59:217–243.
2. Braun S, Johnson BE, Hnat WP, Gomes JA. Evaluation of vertical forces generated by the cervical biteplane facebow. *Angle Orthod.* 1993;63:119–126.
3. Creekmore TD. Inhibition or stimulation of the vertical growth of the facial complex, its significance to treatment. *Angle Orthod.* 1967;37:285–296.
4. Kuhn R. Control of anterior vertical dimension and proper selection of extraoral anchorage. *Angle Orthod.* 1968;38:340–349.
5. Merrifield L. Directional forces. *Am J Orthod.* 1970;57:435–464.
6. Poulton DR. The influence of extraoral traction. *Am J Orthod.* 1967;53:8–18.
7. Ucem TT, Yuksel S. Effects of different vectors of forces applied by combined headgear. *Am J Orthod Dentofacial Orthop.* 1998; 113:316–323.
8. Artun J, Garol JD, Little RM. Long-term stability of mandibular incisors following successful treatment of Class II division 1 malocclusions. *Angle Orthod.* 1996;66:229–238.
9. Baumrind S. Mandibular plane changes during maxillary retraction. *Am J Orthod.* 1978;74:32–40.
10. Bishara SE, Zaher AR, Cummins DM. Effects of orthodontic treatment on the growth of individuals with Class II division 1 malocclusion. *Angle Orthod.* 1994;64:221–230.
11. Boecler PR, Riolo ML, Keeling SD. Skeletal changes associated with extraoral appliance therapy: an evaluation of 200 consecutive treated cases. *Angle Orthod.* 1989;69:63–270.
12. Cook AH, Selke TA, BeGole ED. Control of the vertical dimension in Class II correction using cervical headgear and lower utility arch in growing patients. Part 1. *Am J Orthod Dentofacial Orthop.* 1994;106:376–388.
13. Dugoni SA, Lee JS, Varela J, Dugoni AA. Early mixed dentition post-retention evaluation of stability and relapse. *Angle Orthod.* 1995;65:311–320.
14. Dugoni SA, Lee JS. Mixed dentition report. *Am J Orthod Dentofacial Orthop.* 1995;107:239–244.
15. Efstratiadas SS, Cohen G, Ghafari J. Evaluation of differential growth and orthodontic treatment outcome by regional cephalometric superpositions. *Angle Orthod.* 1999;69:225–230.
16. Elms TN, Buschang PH, Alexander RG. Long term stability of Class II division 1 nonextraction cervical bow therapy: II Cephalometric analysis. *Am J Orthod Dentofac Orthop.* 1996;109:386–392.
17. Elms TN, Buschang PH, Alexander RG. Long term stability of Class II division 1 nonextraction cervical bow therapy: I. Model analysis. *Am J Orthod Dentofacial Orthop.* 1996;109:271–276.
18. Fidler BC, Artun J, Joondeph DR, Little RM. Long-term stability of Angle Class II division 1 malocclusions with successful occlusal results at the end of treatment. *Am. J Orthod Dentofac Orthop.* 1995;107:276–285.
19. Graber TM. Dentofacial orthopedics. In: Graber TM, ed. Current Orthodontic Concepts and Techniques. Philadelphia, Penn: WB Saunders; 1969:2;919–988.
20. Graber TM. Extraoral forces, facts and fallacies. *Am J Orthod.* 1955;41:490–505.
21. Graber TM. Dentofacial orthopedics versus orthodontics. *J Am Dent Assoc.* 1967;75:1145–1166.
22. Graber TM. Extrinsic control factors influencing craniofacial growth: In: McNamara JA Jr, ed. *Control mechanisms in craniofacial growth.* Monograph 3, Craniofacial Growth Series, Ann Arbor, MI: Center for Human Growth and Development, University of Michigan; 1975: 75–100.
23. Haas AJ. Palatal expansion: Just the beginning of dentofacial orthopedics. *Am J Orthod.* 1970;57:219–255.
24. Harris EH, Gardner RZ, Vaden JL. A longitudinal study of post orthodontic craniofacial changes. *Am J Orthod Dentofacial Orthop.* 1999;115:77–82.
25. Hellsong E, Hellsong G, Eliasson S. Effect of fixed anterior biteplane therapy. A radiographic study. *Am J Orthod Dentofacial Orthop.* 1996;110:61–68.
26. Hering K, Ruf S, Pancherz H. Orthodontic treatment of openbite and deepbite high- angle malocclusions. *Angle Orthod.* 1999;69: 470–477.
27. Keeling SD, Wheeler TT, King GJ, Garvan CW, Cohen DA, Cabassa S, McGorray SP, Taylor MG. Anteroposterior skeletal and dental changes after early Class II treatment with bionators and headgear. *Am J Orthod Dentofacial Orthop.* 1998;113:40–50.
28. Jakobson S. Cephalometric evaluation of treatment effect of early treatment for Class II malocclusions. *Am J Orthod.* 1967;53:446–456.
29. King EB. Cervical anchorage in Class II division 1 treatment: a cephalometric appraisal. *Angle Orthod.* 1957;27:98–104.
30. King GJ, Keeling SD, Hocevar RA, Wheeler TT. The timing of treatment in Class II malocclusions in children: a literature review. *Angle Orthod.* 1991;60;87–98.
31. Kirjavainen M, Kirjavainen T, Haavikko K. Changes in dental arch dimensions by use of an orthopedic cervical headgear in Class II correction. *Am J Dentofac Orthop.* 1997;111:59–66.
32. Kloehn SJ. Guiding alveolar growth and eruption of teeth to reduce treatment time and produce a more balanced denture and face. *Angle Orthod.* 1947;17:10–33.
33. Kloehn SJ. Orthodontics-Force or persuasion. *Angle Orthod.* 1953;23:56–65.
34. Kondo E. Occlusal stability in Class II division 1 deep bite cases

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followed up for many years after orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 1998;114:611–630.
35. Kopecky GR, Fishman LS. Timing of cervical headgear treatment based on skeletal maturation. *Am J Orthod Dentofacial Orthop.* 1993;104:162–169.
36. Tulloch JF, Phillips WR, Koch G, Profitt WR. The effect of early intervention on skeletal pattern in Class II malocclusion: A randomized clinical trial. *Am J Orthod Dentofacial Orthop.* 1997;111:391–400.
37. Tulloch JF, Profitt WR, Phillips C. Influences on the outcome of early treatment for Class II malocclusion. *Am J Orthod Dentofacial Orthop.* 1997;111:533–542.
38. Tulloch JF, Phillips C, Profitt WR. Benefit of early Class II treatment: progress report of a two phase randomized clinical trial. *Am J Orthod Dentofacial Orthop.* 1998;113:62–72.
39. Wieslander L. Long term effect of treatment with headgear-Herbst appliance in the early mixed dentition: stability or relapse? *Am J Orthod Dentofacial Orthop.* 1993;104:319–329.
40. Zaher AR, Bishara SE, Jakobson JR. Post treatment changes in different facial types. *Angle Orthod.* 1994;64:425–436.
41. Jacobson A. Extraoral forces. *Am J Orthod.* 1979;75:361–386.
42. Badell MV. An evaluation of extraoral combined high pull traction and cervical traction to the maxilla. *Am J Orthod.* 1976;69:431–446.
43. Betzenberger D, Ruf S, Pancherz H. The compensatory mechanism in high-angle malocclusions: a comparison of subjects in the mixed and permanent dentition. *Angle Orthod.* 1999;69:27–32.
44. Bishara SE. Mandibular changes in persons with untreated and treated Class II division 1 malocclusion. *Am J Orthod Dentofacial Orthop.* 1998;113:661–673.
45. Bishara SE, Bayati P, Jakobsen JR. Longitudinal comparison of dental arch changes in normal and untreated Class II division 1 subjects and their clinical implications. *Am J Orthod Dentofacial Orthop.* 1996;110:483–489.
46. Bishara SE, Justus R, Graber TM. Proceedings of the Workshop Discussion on Early Treatment. *Am J Orthod Dentofacial Orthop.* 1998;113:5–6.
47. Ghafari J, Brinh I, Kelly MB. Mandibular rotation and lower face height indicators. *Angle Orthod.* 1989;59:31–36.
48. Karlsen AT, Krogstad O. Morphology and growth in convex profile patterns: a longitudinal study. *Angle Orthod.* 1999;69:334–343.
49. Karlsen AT. Craniofacial growth differences between low and high MP-SN angles males: a longitudinal study. *Angle Orthod.* 1995;65:341–350.
50. Schudy FF. Vertical growth versus anteroposterior growth as related to function and treatment. *Angle Orthod.* 1964;34:75–93.
51. Schwartz AM. Roentgenostatics. *Am J Orthod.* 1961;47:561–585.
52. Sassouni V. *The Face in Five Dimensions. Facial Typing.* Morgantown, WV: School of Dentistry Publication, West Virginia University; 1962:67–72.
53. Nahoun HI. Vertical proportions and the palatal plane in anterior openbite. *Am J Orthod.* 1971;59:273–282.
54. Coben SE. The integration of facial skeletal variants. *Am J Orthod.* 1955;41:407–434.
55. Coben SE. Growth and Class II treatment. *Am J Orthod.* 1971;59:470–487.
56. Andria LM. *Facial Convexity. A serial cephalometric roentgenographic study of variables affecting middle face protrusion* [master's thesis]. Chicago, Ill: University of Illinois; 1970.
57. Arystas MG. The rationale for early orthodontic treatment. *Am Orthod Dentofac Orthop.* 1998;113:15–18.
58. Dugoni SA. Comprehensive mixed dentition treatment. *Am J Orthod Dentofacial Orthop.* 1998;113:75–84.
59. Kilpelinen PV, Phillips C, Tulloch JF. Anterior tooth position and motivation for early treatment. *Angle Orthod.* 1993;63:171–174.
60. Dann C, Phillips C, Broder HL, Tulloch JF. Self concept, Class II malocclusion, and early treatment. *Angle Orthod.* 1995;65:411–416.
61. Ricketts RM. Variations of the teMPGromandibular joint as revealed by cephalometric laminaraphy. *Am J Orthod.* 1950;36:877–897.
62. Ricketts RM. A study of changes in teMPGromandibular relations associated with the treatment of Class II malocclusion (Angle). *Am J Orthod.* 1952;38:1–16.
63. Ricketts RM. Facial and denture changes during orthodontic treatment as analyzed from the teMPGromandibular joint. *Am J Orthod.* 1955;41:163–179.
64. Ricketts RM. Influence of orthodontic treatment on facial growth and development. *Angle Orthod.* 1960;30:103–133.
65. Ricketts RM. Clinical implications of the teMPGromandibular joint. *Am J Orthod.* 1966;52:416–439.
66. Bjork A. The use of metallic implants in the study of facial growth in children. Method and application. *Am J Phys Anthrop.* 1959;29:45–83.
67. Burke M, Jacobson A. Vertical changes in high-angle Class II division 1 patients treated with cervical or occipital pull headgear. *Am J Orthod Dentofacial Orthop.* 1992;102:501–508.
68. Fields HW, Profitt WR, Nixon WL, Phillips C, Stanek E. Facial pattern differences in long- faced children and adults. *Am J Orthod Dentofacial Orthop.* 1984;85:217–223.
69. Funk AC. Mandibular response to headgear therapy and its clinical significance. *Angle Orthod.* 1967;53:182–216.
70. Nelson BG. Extraoral anchorage in treatment of Class II division 1 malocclusions—its possibilities and limitations. *Angle Orthod.* 1953;23:121–133.

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