Original Article

First or Second Premolar Extraction Effects on Facial Vertical Dimension

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Abstract: If the concept of mesial movement of molars to reduce the ''wedge effect'' and decrease facial vertical dimension (FVD) is valid, it is important to investigate the effect of first (P1) and second premolar (P2) extraction on FVD. This study compares the mesial movement of molars and changes in FVD between P1 and P2 extraction groups in Class I malocclusion with a hyperdivergent facial type. We compared 27 cases with maxillary and mandibular P1 extractions (group 1) and 27 cases with maxillary and mandibular P2 extractions (group 2). To determine FVD changes due to treatment and to compare differences between two groups, paired *t*-test and independent *t*-test were performed, respectively. Group 2 showed more mesial movement of the maxillary and mandibular first molars and less retraction of the maxillary and mandibular central incisors than group 1 ($P < .05$). Both groups showed increased anterior facial height ($P < .05$), but there were no statistically significant differences in angular and proportional measurements between pre- and posttreatment. There was no significant difference in the amount of FVD change between groups 1 and 2 except in the maxillomandibular plane angle and SN to palatal plane angle ($P < .05$). These results suggest that there is no decrease in FVD regardless of the maxillary and mandibular P1 or P2 extraction. Therefore, the hypothesis that P2 extraction in hyperdivergent facial types will result in mesial molar movement and decrease FVD by reducing the wedge effect is invalid. (*Angle Orthod* 2005;75:177–182.)

Key Words: Vertical dimension; Premolar extraction; Wedge effect

INTRODUCTION

Schudy[1–3] described facial types as ''hypo- and hyperdivergence'' and recommended a nonextraction approach in the treatment of hypodivergent facial types and an extraction approach ''to close down the bite'' in hyperdivergent types. Sassouni and Nanda[4] concurred with this treatment philosophy. However, there is great controversy concerning the effects of premolar extractions on facial vertical dimension (FVD). Some authors speculate that first premolar (P1) extractions cause temporomandibular joint disorder (TMD) by reducing FVD[5–8] and overretracting maxillary anterior teeth.[9] However, many other reports offer data to disprove this hypothesis.[10–15]

Because the indications for P1 extraction are usually severe anterior crowding or lip protrusion,[16] most of the extraction space is used for alleviating crowding and retracting incisors. The remaining space is closed by reciprocal movement of anterior and posterior teeth. The amount of mesial molar movement can be very little if anchorage is well maintained.[17,18] It has not been shown that the bite is closed in P1 extraction treatments by mesial movement of the molars. The changes in FVD occurring with the extraction of maxillary and mandibular P1 were reported to be no different than the changes in FVD occurring in nonextraction cases.[17–20]

It has been shown that in borderline cases with moderate crowding, fairly well-aligned incisors, and a relatively acceptable profile, second premolars (P2) can be extracted.[16,21–28] According to the ''wedge effect'' concept, it is hypothesized that P2 extraction permits the molar to move more mesially than P1 extraction, resulting in a greater decrease of the FVD by reducing the wedge effect.[2,3,5,7,8] To investigate the concept that the bite and FVD can be closed

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TABLE 1. Comparison of Arch Length Discrepancy and Anterior Bolton Tooth Ratio in the Pretreatment Measurements Between Groups 1 and 2[a]

Parameters	Group 1		Group 2		Significance
	Mean	SD	Mean	SD	
Upper arch length discrepancy (mm)	2.3	2.7	2.4	2.1	NS
Lower arch length discrepancy (mm)	2.0	1.6	2.3	1.8	NS
Anterior Bolton tooth ratio (%)	77.6	2.8	77.9	2.7	NS

[a] Independent *t*-test between groups 1 and 2; NS, not significant.

by mesial movement of the molars, it is more appropriate to evaluate P2 extraction cases than P1 extraction cases.

To observe changes in FVD, it is appropriate to study hyperdivergent facial type because it is in this group that excess FVD is of greatest concern. In addition, according to the wedge effect concept, even small changes in mesial movement of molars result in a pronounced effect on the mandibular plane angle and FVD in this group. Class I maloccusions were selected to study in order to eliminate excessive molar movement during treatment of Class II and III malocclusions.

The null hypothesis is that there is a significant difference in changes of FVD between P1 and P2 extraction groups with Class I malocclusion and a hyperdivergent facial type. Therefore, this study investigates FVD change by orthodontic treatment with P1 or P2 extraction and compares the effects of P1 and P2 extractions on FVD change.

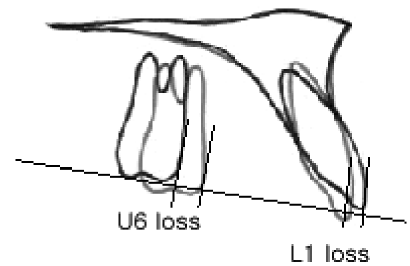

FIGURE 1. Measurement of the amount of incisor and molar movement in the maxilla. To measure the amount of incisor and molar movement, the maxilla was superimposed at ANS with palatal plane and distance change such as retraction of maxillary central incisor (U1 loss) and mesial movement of maxillary first molar (U6 loss) were measured on the posttreatment occlusal plane from the projection point of the maxillary central incisor edge (U1E) and the mesial contact point of the maxillary first molars (UM) from pre- and posttreatment lateral cephalograms.

MATERIALS AND METHODS

The sample consisted of a total of 54 Class I hyperdivergent type malocclusion cases (32° < SN-MP < 45°, 24° < FMA < 35°). The hyperdivergent type was selected because it is easy to identify vertical dimensional changes. They did not have severe anteroposterior (0° < ANB < 4°) and vertical discrepancies (0 mm < overbite < 4 mm) or TMD symptoms.

Group 1 was composed of 27 cases (6 male and 21 female cases, pretreatment age: 15.6 ± 3.9 years, treatment period: 2.3 ± 0.6 years) with maxillary and mandibular P1 extractions. Group 2 was composed of 27 cases (6 male and 21 female cases, pretreatment age: 16.2 ± 4.0 years, treatment period: 2.5 ± 0.7 years) with maxillary and mandibular P2 extractions. To compare the amount of mesial movement of the molar, the cases with moderate to severe crowding were not selected for group 1. Therefore, the arch length discrepancy of the maxilla and mandible did not show statistically significant differences (Table 1). The anterior Bolton tooth ratio also did not show statistically significant differences (Table 1).

All cases were diagnosed and treated by one operator (Dr J.-T. Kim) with a 0.022-inch slot preadjusted edgewise appliance (SWA, Ormco Corp., West Collins Orange, Calif) and closing loop mechanics. Confounding mechanics that could influence molar extrusion, such as extraoral anchorage and interarch elastics, were not used. Any expansion appliance, such as a quad helix or intraoral anchorage such as a Nance appliance or transpalatal arch, was not used to avoid significant vertical dimensional change. The pre- and posttreatment lateral cephalograms were taken on the same radiographic unit (Panex-EC, J. Morita Corporation, Osaka, Japan) and traced and digitized by another operator (Dr T.-K. Kim). A Graphtec Digitizer KD4300 (Graphtec Corporation, Yokohama, Japan) and IBM compatible computer were used for digitization and measurements.

The amount of incisor and molar movement was determined by superimposing the maxilla on ANS and the palatal plane[19] and the mandible by the structural method.[29] Retraction of maxillary (U1 loss) and mandibular central incisor (L1 loss) and mesial movement of maxillary (U6 loss) and mandibular first molar (L6 loss) were measured on the posttreatment occlusal plane from the projection point of the maxillary (U1E) and mandibular central incisor edge (L1E) and mesial contact point of the maxillary (UM) and mandibular first molars (LM) from pre- and posttreatment lateral cephalograms (Figures 1 and 2). Because the amount of incisor retraction depends on the angulation of maxillary and mandibular incisors, the angulation of the upper incisor (U1 to FH plane and U1 to SN plane) and lower incisor (IMPA) at the beginning of the treatment and angulation changes were measured (Figure 3). Fourteen angular (defined in Figure 3) and seven linear and propor-

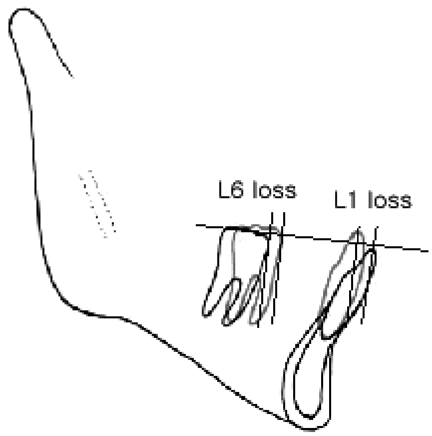

FIGURE 2. Measurement of the amount of incisor and molar movement in the mandible. To measure the amount of incisor and molar movement, the mandible was superimposed by structural method, and distance change such as retraction of mandibular central incisor (L1 loss) and mesial movement of mandibular first molar (L6 loss) were measured on the posttreatment occlusal plane from projection point of mandibular central incisor edge (L1E) and mesial contact point of mandibular first molars (LM) from pre- and posttreatment lateral cephalograms.

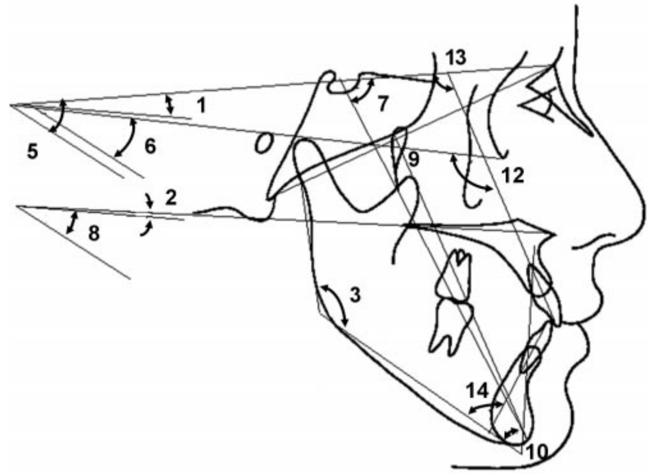

FIGURE 3. Angular measurements. 1, SN to palatal plane angle (SN-PP, °); 2, FH to palatal plane angle (FH-PP, °); 3, gonial angle (°); 4, Björk sum (°); 5, SN to mandibular plane angle (SN-MP, °); 6, FH to mandibular plane angle (FMA, °); 7, y-axis angle (°); 8, maxillomandibular plane angle (MMA, °); 9, facial axis angle (FAX, °); 10, AB to mandibular plane angle (AB-MP, °); 11, ODI (2 + 10) (°); 12, U1 to FH plane (°); 13, U1 to SN plane (°); and 14, IMPA (°).

tional measurements (defined in Figure 4) were selected to evaluate vertical dimensional changes.

To determine FVD changes with treatment, pre- and posttreatment parameters from groups 1 and 2 were evaluated by the paired *t*-test. To compare differences in FVD change between groups 1 and 2, independent *t*-tests were done.

RESULTS

U1-FH and U1-SN did not show statistical differences in the pre- and posttreatment measurements between groups 1 and 2. However, there were statistical differences in the IMPA in the pre- (a $<$ .05) and posttreatment (b $<$ .01) measurements between groups 1 and 2 (Table 2).

Group 2 showed more mesial movement of the maxillary and mandibular first molars and less retraction of the upper and lower central incisors than group 1 (* indicates $<$.05, Table 3). Comparison of incisor angulation change according to treatment between groups 1 and 2 showed no significant differences (Table 3).

Differences in the pretreatment FVD between groups 1 and 2 were analyzed by the independent *t*-test. Although SN-MP angle and AB-MP angle showed differences (* indicates $<$.05, Table 4), there were no differences in other pretreatment measurements of FVD between groups 1 and 2.

Parameters of facial height in group 1 were significantly increased after treatment ($P < .05$), but angular and proportional measurements were not statistically different before and after treatment (Table 5). Group 2 showed similar results. Facial height measurements were significantly increased after treatment ($P < .05$) (Table 5). Although the

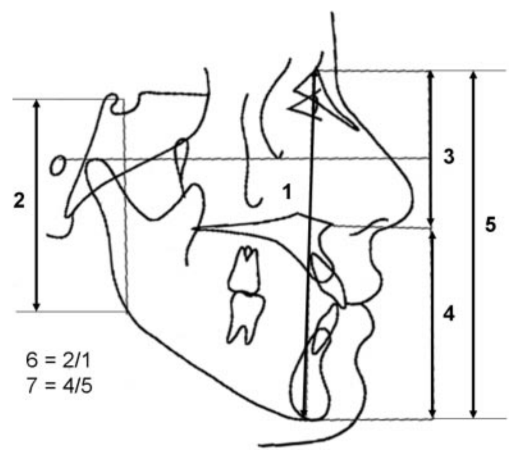

FIGURE 4. Linear and proportional measurements. 1, Anterior facial height (AFH; N-Me, mm); 2, posterior facial height (PFH; S-Go, mm); 3, upper anterior facial height (UAFH; N′-ANS′, mm) (N′ means the projection of N on N-perpendicular line, and ANS′ means the projection of ANS on N-perpendicular line); 4, lower anterior facial height (LAFH; ANS′-Me′, mm) (Me′ means the projection of Me on the N-perpendicular line); 5, total facial height (TFH; N′-Me′, mm) (3 + 4); 6, anteroposterior facial height ratio (APFHR; S-Go/N-Me, %) (2:1); and 7, lower facial height ratio (LFHR; ANS′-Me′/N′-Me′, %) (4:5).

maxillomandibular plane angle (MMA) and lower facial height ratio (LFHR) were statistically different in group 2 ($P < .05$), the amount of increase was too small to have clinical significance (Table 5). There were no significant differences in other angular and proportional measurements before and after treatment (Table 5).

When the amount of change in FVD during treatment between groups 1 and 2 were compared, there were no sig-

TABLE 2. Comparison of Incisor Angulation in the Pre- and Posttreatment Measurements Between Groups 1 and 2

	Korean Norms[a]		Group 1				Group 2				
			Pretreatment		Posttreatment		Pretreatment		Posttreatment		
Parameters	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Significance[b]
U1 to FH	116.02	5.78	118.33	7.31	107.96	7.17	117.43	5.60	110.94	5.36	NS
U1 to SN	107.81	5.94	110.26	7.99	99.57	6.91	108.02	6.06	101.56	5.65	NS
IMPA	95.91	6.35	99.61	8.37	89.96	7.50	92.78	6.13	84.67	6.16	a, b

[a] Korean norms[30].

[b] Independent *t*-test between groups 1 and 2; NS, not significant; a $<$ .05, pretreatment measurements between groups 1 and 2; b $<$ .01, posttreatment measurements between groups 1 and 2.

TABLE 3. Comparison of the Amount of Incisor Retraction and Molar Mesial Movements and Incisor Angulation Change According to Treatment Between Groups 1 and 2

	Group 1		Group 2		
Parameters[a]	Mean	SD	Mean	SD	Significance[b]
U1 loss (mm)	4.71	1.42	2.33	1.32	*
L1 loss (mm)	5.13	1.34	3.01	1.53	*
U6 loss (mm)	2.72	1.41	3.84	1.22	*
L6 loss (mm)	2.14	1.03	3.62	1.31	*
Change of U1 to FH (°)	10.37	8.27	6.48	6.24	NS
Change of U1 to SN (°)	10.69	8.37	6.46	6.15	NS
Change of IMPA (°)	9.65	7.32	8.11	5.72	NS

[a] U1 and L1 loss, amount of incisor retraction; U6 and L6 loss, amount of molar mesial movements.

[b] Independent *t*-test; NS, not significant; * indicates $<$ .05.

nificant differences in linear and proportional measurements. Although SN to palatal plane angle (SN-PP) and MMA showed significant changes (** indicates $<$.05, Table 5), the amount of increase was too small to have clinical significance. There were no differences in other angular measurements between groups 1 and 2 (Table 5).

DISCUSSION

Previous reports on the relationship between extraction with orthodontic treatment and FVD have shown that the former does not significantly change the latter. Staggers[17] showed that there was no significant difference in the vertical dimension changes between P1 extraction and nonextraction groups, and orthodontic treatment produced increases in the cephalometric vertical dimensions in both groups. Chua et al[20] examined the effect of extraction and nonextraction on lower anterior facial height (LAFH, ANS-Me) with a standardized score to account for effects due to growth and concluded that nonextraction treatment was associated with a significant increase in LAFH, but extraction treatment was not associated with any significant changes in LAFH. Cusimano et al[19] found that there were no differences in facial height of hyperdivergent patients with first premolar extraction treatment when pre- and posttreatment results were compared.

This study showed a significant increase of linear measurements after orthodontic treatment in group 1 (Table 5), corroborating the findings of Staggers[17] and Kocadereli[18]

TABLE 4. Comparison of Pretreatment Measurements in Facial Vertical Dimension Between Groups 1 and 2

	Korean Norms		Group 1		Group 2		
Parameters	Mean	SD	Mean	SD	Mean	SD	Significance[a]
Anterior facial height	131.70	7.08	125.03	4.90	127.71	5.38	NS
Posterior facial height	90.24	7.82	81.77	7.78	81.02	6.58	NS
Facial height ratio	68.52	4.78	65.31	5.01	63.38	4.13	NS
Upper anterior facial height	58.53	6.11	56.09	3.03	57.63	3.28	NS
Lower anterior facial height	73.19	5.14	67.85	4.62	69.09	3.37	NS
Total facial height	131.72	7.08	123.94	5.15	126.72	5.17	NS
Lower facial height ratio	55.54	1.87	54.65	2.29	54.47	1.64	NS
SN to palatal plane	9.39	3.38	9.82	3.28	10.34	2.58	NS
FH to palatal plane	1.05	3.12	2.00	2.11	1.07	2.71	NS
Gonial angle	117.90	6.38	123.54	7.76	125.00	5.20	NS
Björk sum	391.82	5.54	397.80	5.53	400.14	4.67	NS
SN to mandibular plane angle	31.80	5.53	37.70	5.56	40.15	4.83	*
FH to mandibular plane angle	23.50	5.01	29.81	5.20	30.99	3.86	NS
Y-axis angle	61.36	2.92	71.48	3.38	72.81	2.84	NS
Maxillomandibular plane angle	22.45	5.13	27.78	5.30	29.92	4.64	NS
Facial axis angle	86.28	3.49	87.03	6.25	91.09	8.55	NS
AB to mandibular plane angle	71.68	4.58	69.17	4.63	65.57	4.37	*
ODI	72.75	5.73	71.20	5.37	66.65	6.45	NS

[a] Independent *t*-test; NS, not significant; * indicates $<$ 0.05.

TABLE 5. Comparison of Pre- and Posttreatment Measurements in Facial Vertical Dimension of Groups 1 and 2 and Changes in Facial Vertical dimension Between Groups 1 and 2

	Comparison of Pre- and Posttreatment Measurements in Facial Vertical Dimension of Group 1					Comparison of Pre- and Posttreatment Measurements in Facial Vertical Dimension of Group 2					Comparison of Changes in Facial Vertical Dimensions Between Group 1 and 2				
	Pretreatment		Posttreatment		Signifi-	Pretreatment		Posttreatment		Signifi-	Group 1		Group 2		Signifi-
Parameters	Mean	SD	Mean	SD	cance[a]	Mean	SD	Mean	SD	cance	Mean	SD	Mean	SD	cance
Anterior facial height	125.03	4.90	128.42	4.89	*	127.71	5.38	131.04	6.18	*	3.39	2.92	3.33	3.05	NS
Posterior facial height	81.77	7.78	83.71	6.59	*	81.02	6.58	83.23	7.01	*	1.94	2.31	2.21	2.37	NS
Facial height ratio	65.31	5.01	65.17	4.77	NS	63.38	4.13	63.49	4.22	NS	−0.14	1.35	0.11	1.06	NS
Upper anterior facial height	56.09	3.03	57.47	3.39	*	57.63	3.28	58.33	3.13	*	1.39	1.66	0.70	1.66	NS
Lower anterior facial height	67.85	4.62	69.91	4.36	*	69.09	3.37	71.74	4.01	*	2.06	2.39	2.65	2.24	NS
Total facial height	123.94	5.15	127.38	4.75	*	126.72	5.17	130.07	6.11	*	3.44	3.06	3.35	3.14	NS
Lower facial height ratio	54.65	2.29	54.82	2.38	NS	54.47	1.64	55.09	1.38	*	0.17	1.07	0.62	0.88	NS
SN to palatal plane angle	9.82	3.28	10.72	3.60	NS	10.34	2.58	10.17	2.87	NS	0.90	1.49	−0.17	1.63	**
FH to palatal plane angle	2.00	2.11	2.40	2.35	NS	1.07	2.71	1.04	3.25	NS	0.41	1.38	−0.03	1.36	NS
Gonial angle	123.54	7.76	123.67	7.60	NS	125.00	5.20	125.62	5.24	NS	0.13	1.56	0.02	1.71	NS
Björk sum	397.89	5.53	398.45	5.46	NS	400.14	4.67	400.35	4.79	NS	0.56	1.70	0.22	1.34	NS
SN to mandibular plane angle	37.70	5.56	38.26	5.48	NS	39.89	4.65	40.15	4.83	NS	0.56	1.70	0.26	1.35	NS
FH to mandibular plane angle	29.81	5.20	29.94	5.30	NS	30.60	3.68	30.99	3.86	NS	0.13	1.81	0.39	1.66	NS
Y-axis angle	71.48	3.38	71.98	3.45	NS	72.52	2.84	72.81	2.84	NS	0.50	1.35	0.29	1.12	NS
Maxillomandibular plane angle	27.78	5.30	27.44	5.05	NS	29.45	4.55	29.92	4.64	*	−0.33	1.58	0.47	1.15	**
Facial axis angle	87.03	6.25	87.54	6.54	NS	90.63	8.39	91.09	8.55	NS	0.52	5.28	0.46	3.57	NS
AB to mandibular plane angle	69.17	4.63	69.12	5.09	NS	66.07	4.63	65.57	4.37	NS	−0.06	2.23	−0.50	1.95	NS
ODI	71.20	5.37	71.56	5.94	NS	67.17	6.17	66.65	6.45	NS	0.36	2.60	−0.52	2.28	NS

[a] NS, not significant.
* $P < .05$, paired *t*-test.
** $P < .05$, independent *t*-test.

but disagreeing with those of Chua et al.[20] P1 extraction did not significantly change angular and proportional measurements (Table 5), supporting the results of Kocadereli,[18] Cusimano et al,[19] and Chua et al.[20]

Taner-Sarisoy and Darendeliler[31] reported that treatment with fixed appliances and premolar extractions did not significantly alter the growth pattern. Yet, LAFH can be significantly influenced by orthodontic treatment. The net increase of LFHR is due to extrusion of molars by treatment mechanics and residual vertical growth of the patients. It is possible that mesial molar movement may help accommodate these effects and work to maintain LFHR.

Group 2 had more cases with increased LFHR (74.1% vs 51.9%) and fewer cases with decreased LFHR (14.8% vs 40.7%) than group 1. It has been shown that molars can be extruded when extraction space is closed.[17,19] Extrusion appears to maintain or even increase the FVD. Therefore, greater mesial movements can possibly allow for more molar extrusion due to the chosen mechanics of space closure. If extrusion of the posterior teeth keeps pace with the increase in anterior facial height, SN-MP will be maintained and the bite-closing effect of mesial molar movement will be nullified.[19] If the vertical growth of the ramus or posterior alveolar bone do not compensate extrusion of molars, LFHR can be increased. In this study, increases of LFHR in group 2 could be due to less compensation for molar extrusion compared with group 1.

Residual growth has to be considered because it can influence LAFH. In female individuals the growth is nearly over at 14 years. The average ages of groups 1 and 2 were 15.6 ± 3.9 years and 16.2 ± 4.0 years, respectively, so we cannot talk about the influence of residual growth because it is very limited at these ages. However, in this study all linear measurements increased after treatment. This result suggests that some residual growth as well as treatment effects took place. This finding is similar to the studies of Staggers[17] and Kocadereli[18] with growing children. Because the mean age of two groups was similar in this study, the effect of growth on LAFH between groups 1 and 2 can be expected to be the same. Thus, the effect of growth on LAFH in this study can be eliminated.

In this study the effects of P1 and P2 extractions on change of FVD were compared in relation to the concept that mesial molar movement will close FVD by reducing the wedging effect. However, the results showed that there were no significant differences in FVD changes between groups 1 and 2 except for MMA and SN-PP (Table 5). The reason why SN-PP and MMA showed significant differences might be due to differences in skeletal characteristics and arch length discrepancy between groups 1 and 2, even though these met the sample selection criteria such as orthognathic Class I malocclusions within the same range of vertical and anteriorposterior measurements.

Garlington and Logan[32] observed a significant decrease in LAFH in the mandibular second premolar enucleation cases due to forward rotation of the mandible, but they found no significant differences in total facial height and the MMA. This suggests that there were compensatory changes in the maxillary vertical growth.

The results indicate that the null hypothesis is invalid and suggest that the FVD is maintained or even increased regardless of amount of mesial molar movement. Further studies are required on the biological response to treatment effects as well as compensatory mechanisms, particularly those affecting vertical facial dimensions. It would be of interest to study these patients in the long term to determine how LAFH changes with time.

CONCLUSIONS

Regardless of maxillary and mandibular P1 or P2 extraction treatments, there was no decrease of FVD and no significant difference in FVD changes in the patients with a Class I malocclusion and hyperdivergent facial type. Therefore, the wedge effect concept that the bite is closed by extraction of P2 and forward movement of molars seems invalid. In these patients premolar extraction decisions could be based on other criteria, such as incisor retraction, area of crowding, tooth sizes, and condition of teeth, rather than on a desire to change FVD.

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