Original Article

Vertical Changes in Class II division 1 Malocclusion after Premolar Extractions

Kazem S. Al-Nimri

Abstract: The purpose of this study was to compare changes in the facial vertical dimension in patients with Class II division 1 malocclusion after the extraction of either mandibular first premolars or mandibular second premolars. The records of two groups of patients were used: one group was treated with extraction of mandibular first premolars (age: 13.2 ± 1.5 years) and the other group with extraction of mandibular second premolars (age: 13.4 ± 1.4 years). Each group consisted of 26 subjects (16 boys and 10 girls). Maxillary first premolars were extracted in both groups. The two groups were matched by sex, age (within six months), and facial divergence measured by maxillary-mandibular plane angle (MM angle) and ratio of posterior facial height to the total anterior facial height. Student's *t*-test was used to compare the two groups. Significance was predetermined at $P < .05$. Second premolar extraction was associated with more forward movement of the mandibular molars, but there was no significant difference in vertical facial growth between the two groups. In both groups, there was no significant change in the mandibular plane angle and the MM angle. The results of this study do not support the hypothesis that mandibular premolar extraction is associated with mandibular overclosure or reduction in the vertical dimension, or both, in subjects with Class II division 1 malocclusion. (*Angle Orthod* 2006;76:52–58.)

Key Words: Vertical facial growth; Facial divergence

INTRODUCTION

The extraction of premolars as a practical form of orthodontic therapy has been accepted for many years, but there remains a controversy regarding the effect of premolar extraction on the facial vertical dimension. Some believe that premolar extraction permits the posterior teeth to move forward resulting in decrease in the vertical dimension of occlusion.

Few studies have reported on the effect of first premolar extraction on the vertical dimension in Class I malocclusion. Chua et al[1] found that premolar extraction was not associated with any significant change of the lower anterior facial height (LAFH), whereas nonextraction treatment was associated with a significant increase in LAFH. On the other hand, Staggers[2] and Kocadereli[3] found that the vertical changes that occurred after the extraction of first premolars were not different from those that occurred in the nonextraction cases. However, in these two studies, it was pointed out that there was minimal need for protraction of posterior teeth because most of the extraction space was used to relieve crowding or to retract the anterior teeth. It was suggested that the absence of posterior teeth protraction could explain the comparable changes in the vertical dimension between extraction and nonextraction groups.

In contrast, in Class II malocclusion, some protraction of the mandibular molars is expected because mandibular premolar extraction space is usually used, at least in part, to correct the Class II molar relationship. Nevertheless, it had been reported that the extraction treatment of Class II malocclusion does not cause a diminution of the LAFH, whereas nonextraction method tends to increase the LAFH.[1]

The protraction of the mandibular molars is expected to be greater in cases treated with second premolar extraction than those treated with first premolar extraction.[4] If mesial movement of mandibular molars is associated with mandibular overclosure and decreases in the vertical facial dimension, subjects treated with second premolar extraction should have more re-

[a] Associate Professor, Orthodontic Department, School of Dentistry, Jordan University of Science and Technology, Irbid, Jordan.

Corresponding author: Kazem S. Al-Nimri, BDS, PhD, M.Orth.RCS (Ed), Orthodontic Department, School of Dentistry, Jordan University of Science and Technology, PO Box 3030, Irbid, Jordan 22110
(e-mail: kazemnimri@hotmail.com).

Accepted: March 2005. Submitted: December 2004.

duction in the vertical dimension than those treated with first premolar extraction. However, the literature does not contain any study comparing changes in facial height between cases treated with first premolar extraction and those treated with second premolar extraction.

The purpose of this study is to compare the vertical changes occurring in Class II division 1 patients treated orthodontically with mandibular first premolar extraction with those occurring in Class II division 1 patients treated orthodontically with mandibular second premolar extraction.

MATERIALS AND METHODS

The materials for this study were selected from the records of 52 subjects (32 boys and 20 girls) treated in the Orthodontic Department of Sligo General Hospital or Letterkenny General Hospital, Republic of Ireland, by fixed appliance therapy. The orthodontic treatment of half of these subjects (16 boys and 10 girls) involved the extraction of two mandibular first premolars (first premolar extraction group). The average age of this group was 13.2 ± 1.5 years. Each of these subjects was matched according to sex, age (within six months), and facial divergence with a case treated by fixed appliance therapy that involved the extraction of two mandibular second premolars (second premolar extraction group). The group average age was 13.4 ± 1.4 years. Facial divergence was determined on the basis of the maxillary-mandibular plane angle (MM angle) and the ratio of posterior facial height to the total anterior facial height (PTH/TAFH). The difference between each two matched cases did not exceed 2° in the MM angle and 3% in PTH/TAFH. All subjects had Class II division 1 malocclusion and were treated by the same consultant using the preadjusted Edge-Wise appliance (Roth prescription, slot size 0.022 × 0.028 inch). Sliding mechanics were used to close the residual extraction spaces.

The subjects were selected on the basis of the following criteria:

- Class II division 1 malocclusion without bimaxillary protrusion
- The availability of full records, including pretreatment and posttreatment models, lateral cephalograms, and clearly documented orthodontic treatment mechanics
- The treatment involved the extraction of the maxillary first premolars
- No headgear was used before or during the fixed appliance therapy
- No functional appliance was used before or with the fixed appliance

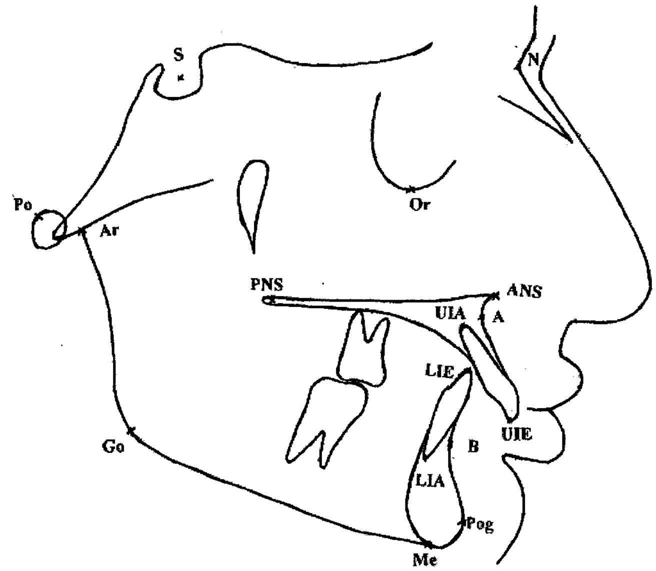

FIGURE 1. Hard tissue landmarks used in this study: sella (S); nasion (N); anterior nasal spine (ANS); posterior nasal spine (PNS); point A (A); point B (B); apex of maxillary central incisor (UIA); tip of maxillary central incisor (UIE); apex of mandibular central incisor (LIA); tip of mandibular central incisor (LIE); pogonion (Pog); menton (Me); gonion (Go); orbital (Or); porion (Po). The following parameters were used in this study: SNA; SNB; ANB; maxillary-mandibular plane angle, MM angle; mandibular plane angle, MP angle; total anterior facial height, TAFH; lower anterior facial height, LAFH; posterior facial height, PFH; the ratio of the lower anterior facial height to the total anterior facial height, LAFH/TAFH; the ratio of the posterior facial height to the total anterior facial height, PFH/TAFH. Interincisal angle; maxillary incisors angle to maxillary plane (Ui–Max°); mandibular incisors angle to mandibular plane (Li–Mand°); mandibular incisors distance to N-Pog line (LIE to N-Pog mm); overjet; overbite; crowding in the lower arch; residual space in the mandibular arch after initial alignment; duration of Class II intermaxillary traction; duration of reverse curve of Spee in the mandibular archwire; duration of orthodontic treatment.

- Space in the mandibular arch was completely closed at the end of treatment
- Space closure was carried out on 0.019 × 0.025 inch stainless steel archwires
- Mandibular intercanine and intermolar widths maintained
- Class I incisor and molar relationships achieved at the end of orthodontic treatment.

The lateral cephalometric films were traced by the same investigator, and 15 landmarks were identified (Figure 1). All cephalometric measurements (Table 1) were made with the Quick Ceph program (Quick Ceph System, San Diego, Calif) on a computer. On the pretreatment and posttreatment cephalometric tracings, a perpendicular line was drawn from the tip of the mesial cusp of the mandibular molar to the corpus axis. The pretreatment and posttreatment mandibular tracings were then superimposed on the corpus axis at suprapogonion. The distance between the two lines mea-

TABLE 1. Cephalometric Measurements[a]

No.	Measurement	Definition
1	SNA°	Angle formed by the intersection of nasion-sella and nasion- A point lines
2	SNB°	Angle formed by the intersection of nasion-sella and nasion- B point lines.
3	ANB°	Angle formed by the intersection of nasion-A point and nasion- B point lines.
4	MM angle	Angle formed by the intersection of anterior nasal spine-posterior nasal spine and menton-pogonion lines.
5	MP angle	Angle formed by the intersection of menton-gonion and orbital-porion lines.
6	TAFH	The distance between nasion and menton.
7	LAFH	The distance between anterior nasal spine and menton.
8	PFH	The distance between sella and gonion.
9	LAFH/TAFH	Ratio of the distance between anterior nasal spine and menton to the distance between nasion and menton.
10	PFH/TAFH	Ratio of the distance between sella and gonion to the distance between nasion and menton.
11	Interincisal angle	Angle formed by the intersection of long axis of the upper and mandibular incisors.
12	Ui to max°	Angle formed by the intersection of the long axis of upper incisor and anterior nasal spine-posterior nasal spine line.
13	Li to mand°	Angle formed by the intersection of the long axis of mandibular incisor and menton-gonion line.
14	LIE to N-Pog (mm)	Horizontal distance from the mandibular incisor tip to nasion-pogonion line.

[a] MM angle indicates maxillary-mandibular plane angle; MP angle, mandibular plane angle; TAFH, total anterior facial height; LAFH, lower anterior facial height; PFH, posterior facial height; LAFH/TAFH, the ratio of the lower anterior facial height to the total anterior facial height; PFH/TAFH, the ratio of posterior facial height to the total anterior facial height; LIE, tip of mandibular central incisor; Ui to Max°; maxillary incisors angle to maxillary plane; and Li to Mand°; mandibular incisors angle to mandibular plane.

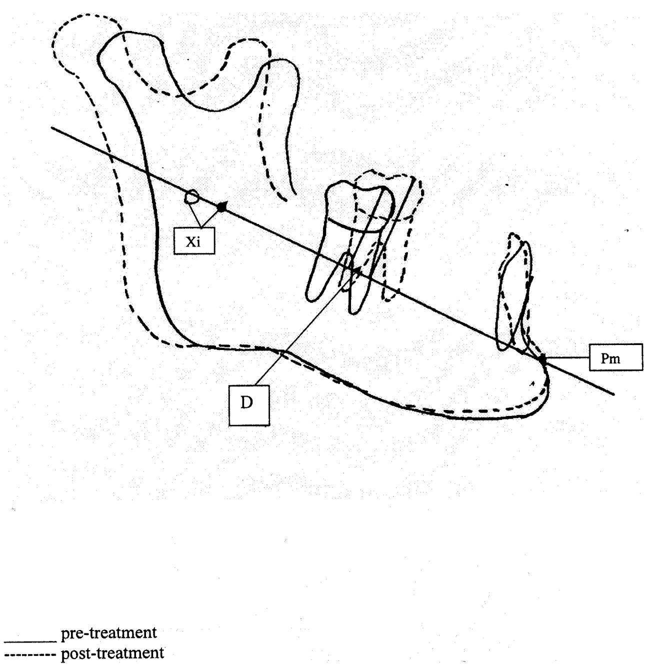

FIGURE 2. Mandibular molars changes. (Superimposition on corpus axis at suprapogonion). (D) Anteroposterior component of the change in the mandibular molar position.

sured at the corpus axis determined the anteroposterior component of the change in the mandibular molar position (Figure 2).

The residual space in the mandibular arch was calculated by subtracting the amount of mandibular arch crowding from the mesiodistal width of the extracted mandibular premolars (Residual space = mesiodistal width of extracted teeth − crowding), where crowding is total tooth size minus arch perimeter. Arch perimeter was measured by dividing the dental arch into four straight-line segments; each segment was measured individually. To calculate the total tooth size, the mesiodistal width of each tooth was measured from contact point to contact point. All model measurements were carried out using a sharpened Boley gauge.

All model and cephalometric measurements were made at least twice. If there was a difference between the two measurements, a third reading was made, and the aberrant one was discarded. The mean of the two closest measurements was used in the calculations.

The measurement error was calculated according to Dahlberg's double determination method.[5] For model measurements, the results of the measurement error were 0.32 mm for arch perimeter and 0.30 mm for the total tooth size. For the angular and linear cephalometric measurements, the error ranged from 0.34° to 1.05° and 0.20 to 0.41 mm, respectively.

Statistical analysis

Means and standard deviations for the two extraction groups were calculated for all the variables with SPSS for Windows (Chicago, Ill). The differences between the two groups were determined with student's *t*-test. *P* values less than .05 were considered significant.

RESULTS

At the start of the orthodontic treatment, the two groups were comparable in all parameters except for the overjet and lower arch residual space, which were

TABLE 2. Comparison Between First and Second Premolar Extraction Cases at the Start of the Treatment[a]

Independent Variable	First Premolar Extraction	Second Premolar Extraction	Difference	Significance (*P* Value)
SNA°	80.0	79.8	0.2	.883
SNB°	74.6	74.1	0.5	.337
ANB°	5.4	5.7	−0.3	.649
MM angle	31.8	31.7	0.1	.990
MP angle	29.3	27.5	1.8	.453
TAFH (mm)	119.1	122.1	−3.1	.112
LAFH (mm)	69.3	71.6	−2.3	.141
PFH (mm)	72.4	74.5	−2.1	.189
LAFH/TAFH	58.2	58.6	−0.4	.408
PFH/TAFH	60.8	61.0	−0.2	.901
Interincisal angle	125.9	122.8	3.1	.270
Ui to max°	113.3	116.0	−2.7	.153
Li to mand°	91.4	90.9	0.5	.810
LIE to N-Pog (mm)	3.4	2.1	1.3	.202
Overjet (mm)	9.1	11.4	−2.3*	.019
Overbite (mm)	1.7	0.8	0.9	.249
Lower arch crowding (mm)	6.6	3.9	2.7*	.021
Lower arch residual space (mm)	8.5	10.9	−2.4*	.045
Class II traction (months)	4.0	5.5	−1.5	.130
Reverse curve of Spee (months)	2.3	4.2	−1.9	.112
Age (years)	13.2	13.4	0.2	.685
Treatment period (months)	27.3	28.4	−1.0	.766

[a] MM angle indicates maxillary-mandibular plane angle; MP angle, mandibular plane angle; TAFH, total anterior facial height; LAFH, lower anterior facial height; PFH, posterior facial height; LAFH/TAFH, the ratio of the lower anterior facial height to the total anterior facial height; PFH/TAFH, the ratio of the posterior facial height to the total anterior facial height; LIE, tip of mandibular central incisor; N-Pog, nasion-pogonion; Ui to Max° maxillary incisors angle to maxillary plane; and Li to Mand°, mandibular incisors angle to mandibular plane.

* $P < .05$.

greater in the second premolar extraction group ($P = .019$ and $P = .045$, respectively), and for the lower arch crowding, which was greater in the first premolar extraction group ($P = .021$). The duration of reverse curve of Spee in the mandibular archwire and the duration of Class II intermaxillary elastics used in first premolar extraction group were not significantly different from those used in the second premolar extraction group. The orthodontic treatment period was nearly the same in both groups (Table 2).

The mean changes resulting from treatment reflected an increase in TAFH, LAFH, and PFH in both groups (Table 3). This increase was greater in male subjects ($P < .01$). In the first premolar extraction group, there was virtually no change in the mandibular plane angle (MP angle), MM angle, or PFH/TAFH. In the second premolar extraction group, the MP angle and the MM angle were reduced by an average of 0.8° during orthodontic treatment; however, this reduction was not statistically significant ($P = .441$ and $P = .483$, respectively), whereas the PFH/TAFH increased by an average of 1.0%. This increase was statistically significant ($P = .019$).

The average increase in the LAFH in the cases treated with first premolar extractions was 4.2 mm, whereas in those treated with second premolar extractions it was 3.8 mm (Table 4). The difference was not significant ($P = .610$). In the first premolar extraction group, the mandibular molars were protracted by 2.9 mm during orthodontic treatment, whereas in the second premolar extraction group, the mandibular molars were protracted by 4.7 mm. This difference was statistically significant ($P = .002$).

DISCUSSION

The aim of this study was to evaluate the effect of premolar extraction on the facial vertical dimension in orthodontically treated Class II division 1 malocclusion. Functional appliances and cervical headgear were considered to have an extrusive effect on the posterior teeth[6] that could mask any possible vertical dimension loss resulted from premolar extraction. Therefore, cases with functional appliances or headgears were excluded. The reason for not including a nonextraction group in this study was that nonextraction treatment of Class II division 1 malocclusion invariably involves headgear or functional appliance (or both). Moreover, it was not possible to find a nonextraction group matched to the two extraction groups by facial divergence because nonextraction treatment is carried out more frequently in subjects with reduced facial divergence.

The two groups were selected to have a comparable

TABLE 3. Vertical Changes in the First Premolar and Second Premolar Extraction Groups[a]

	First Premolar				Second Premolar			
	Female	Male	Total	Sig[b]	Female	Male	Total	Sig[b]
TAFH (mm)	4.2	9.6	7.5**	.000	3.8	7.4	6.0**	.000
LAFH (mm)	2.7	5.2	4.2**	.000	3.1	4.2	3.8**	.000
PFH (mm)	2.2	6.7	5.0**	.000	2.0	6.0	4.2**	.000
MP angle	0.3	−0.6	−0.3	.815	−0.6	−1.0	−0.8	.240
MM angle	0.4	−0.2	0.0	.988	−0.6	−0.9	−0.8	.459
LAFH/TAFH	0.3	−0.4	−0.1	.706	0.9	−0.1	0.3	.469
PFH/TAFH	0.2	0.6	0.4	.494	0.8	1.1	1.0*	.019

[a] TAFH indicates total anterior facial height; LAFH, lower anterior facial height; PFH, posterior facial height; MP angle, mandibular plane angle; MM angle, maxillary-mandibular plane angle; LAFH/TAFH, the ratio of lower anterior facial height to the total anterior facial height; and PFH/TAFH, the ratio of posterior facial height to the total anterior facial height.

[b] Significance of the total changes.

* $P < .05$.

** $P < .01$.

TABLE 4. Comparison of the Treatment Changes Between First and Second Premolar Extraction Groups[a]

	First Premolar	Second Premolar	Difference	Sig
Change in TAFH (mm)	7.5	6.0	1.5	.184
Change in LAFH (mm)	4.2	3.8	0.4	.610
Change in PFH (mm)	5.0	4.2	0.9	.441
Change in MP angle	−0.3	−0.8	0.5	.483
Change in MM angle	0.0	−0.8	0.8	.362
Change in LAFH/TAFH	−0.1	0.2	−0.4	.426
Change in PFH/TAFH	0.4	1.0	−0.6	.636
Mandibular molar protraction (mm)	2.9	4.7	1.8**	.002

[a] TAFH indicates total anterior facial height; LAFH, lower anterior facial height; PFH, Posterior facial height; MP angle, mandibular plane angle; MM angle, maxillary-mandibular plane angle; LAFH/TAFH, the ratio of lower anterior facial height to the ratio of total anterior facial height; and PFH/TAFH; the ratio of posterior facial height to total anterior facial height.

** $P < .01$.

facial divergence because it has been reported that there is a significant difference in the vertical growth (TAFH and LAFH) between mesiodivergent and hyperdivergent facial types, with the latter showing more vertical growth.[7] Moreover, Chung and Wong[8] reported that low-angle skeletal Class II–untreated subjects had significantly more mandibular forward rotation (less increase in the vertical dimension) than did the high-angle subjects.

The degree of upper arch crowding, the postalignment residual space in the upper arch, and the degree of mesial movement of the upper molars were not taken into consideration because most of the upper arch extraction space would have been used to retract the upper incisors rather than to protract the upper molars. Anchorage in the upper arch was mainly maintained by the use of Class II intermaxillary traction and a transpalatal bar. In contrast, in the lower arch, and because cases with bimaxillary protrusion were excluded, part of the mandibular extraction space was used to align the incisors in crowded dentitions and the remaining residual space was used to correct the Class II molar relationship by mesial movement of the mandibular molars.

The residual space in the mandibular arch was calculated by subtracting the amount of crowding from the extraction space. Assuming that there was no alteration in the arch dimensions or in the depth of the curve of Spee, the calculated residual space is an accurate representation for the space to be closed after initial alignment. Although preserving the arch dimensions was one of the criteria for patient selection, the change in the depth of curve of Spee was not taken into consideration. However, nearly all cases included in this study had normal or reduced overbite at the start of the treatment (Table 2), which indicated a flat or shallow curve of Spee. Therefore, the change in the depth of curve of Spee was considered insignificant.

The significant difference in the lower arch crowding between the two extraction groups is explained by the fact that first premolars are extracted in cases with severe crowding, whereas second premolars are extracted when the crowding is not severe to obtain Class I molar relationship.

The increase in the average TAFH and LAFH in this study is explained by the fact that most of the studied subjects had growth potential. As the mandible develops, it is displaced forward and downward.[9]

Rothstein and Phan[10] reported an average increase in LAFH of 1.9 mm in girls and 2.9 mm in boys and an average increase in TAFH of 6.5 mm in girls and 6.2 mm in boys in a group of untreated subjects with Class II division 1 malocclusion between the ages of 10 and 14 years. In the current study, the increase in LAFH in both extraction groups was greater than that reported in the untreated subjects. This could be attributed to the fact that the two extraction groups had more than average facial divergence at the start of the orthodontic treatment and consequently more vertical growth. In addition, the use of Class II traction for four and 5.5 months in the first and second premolars extraction groups, respectively, could have generated more vertical alveolar growth.

Schudy[11] advocated extraction of teeth ''to close down the bite.'' Sassouni and Nanda[12] concurred with such treatment philosophy. In this study, the fact that there was virtually no change in the MP angle, MM angle, and PFH/TAFH in the first premolar extraction group and that the changes in the MP and MM angles in the second premolar extraction group were statistically and clinically insignificant does not support the hypothesis that premolar extraction is associated with mandibular overclosure in cases with Class II division 1 malocclusion. Although there was a statistically significant increase in PFH/TAFH in the second premolar extraction group, the clinical significance of this increase (1.0%) is questionable.

The forward movement of the mandibular molars was greater in the second premolar extraction group. This is attributed to the larger residual space in the lower arch after initial alignment in this group and to the difference in the distribution of the anchorage values in the lower arch within each extraction group.

Extraction orthodontic treatment is carried out more frequently in cases with a hyperdivergent facial type,[13] a pattern which is usually associated with more than average vertical facial growth, whereas nonextraction treatment is more likely to be performed in low-angle cases, which usually have less than average vertical facial growth. The previous reports that compared the changes in the vertical dimension between extraction and nonextraction groups did not take into account the pretreatment difference in the facial divergence between the groups.[2,3] Therefore, finding similar vertical growth in the extraction and nonextraction groups does not necessarily indicate that premolar extraction does not affect the vertical dimension.

In the current study, the two groups were comparable in the pretreatment facial divergence, orthodontic mechanics, and the duration of orthodontic treatment (Table 2). However, there was a significant difference in the lower arch residual space and subsequently the forward movement of the mandibular molars, which were greater in the second premolar extraction group. Nevertheless, the increase in LAFH in the two groups was not different. This comparable change in vertical dimensions in the two groups despite the greater forward movement of the mandibular molars in the second premolar extraction group suggests that molar protraction does not result in the reduction of the vertical dimension of the occlusion.

The results of this study do not support the hypothesis that mandibular premolar extraction is associated with mandibular overclosure or reduction in the facial vertical dimension, or both, in cases with Class II division 1 malocclusion.

CONCLUSIONS

- Mandibular premolar extraction in Class II division 1 subjects was not associated with a significant reduction of the facial divergence measured by the MM angle and the MP angle.
- Second premolar extraction was associated with more forward movement of the mandibular molars; nevertheless, there was no significant difference in the facial vertical growth between first and second premolars extraction groups.

ACKNOWLEDGMENT

The author expresses his gratitude to Mr Bryan Johns, consultant orthodontist at Sligo and Letterkenny General Hospitals, Republic of Ireland, for his valuable help in providing the data for this research.

REFERENCES

1. Chua A, Lim JYS, Lubit EC. The effect of extraction versus nonextraction orthodontic treatment on the growth of the lower anterior face height. *Am J Orthod Dentofacial Orthop.* 1993;104:361–368.
2. Staggers JA. Vertical changes following first premolar extractions. *Am J Orthod Dentofacial Orthop.* 1994;105:19–24.
3. Kocadereli I. The effect of first premolar extraction on vertical dimension. *Am J Orthod Dentofacial Orthop.* 1999;116:41–45.
4. Saelens NA, De Smit AA. Therapeutic changes in extraction versus non-extraction orthodontic treatment. *Eur J Orthod.* 1998;20:225–236.
5. Dahlberg G. *Statistical Methods for Medical and Biological Students.* London, UK: George Allen and Unwin Ltd; 1940.
6. Nanda SK. Patterns of vertical growth in the face. *Am J Orthod Dentofacial Orthop.* 1998;93:103–116.
7. Taner-Sarisoy L, Darendeliler N. The influence of extraction orthodontic treatment on craniofacial structures: evaluation according to two different factors. *Am J Orthod Dentofacial Orthop.* 1999;115:508–514.
8. Chung C, Wong WW. Craniofacial growth in untreated skeletal Class II subjects: a longitudinal study. *Am J Orthod Dentofacial Orthop.* 2002;122:619–626.
9. Enlow DH. *Handbook of Facial Growth.* Philadelphia, Pa: WB Saunders; 1990:58–148.
10. Rothstein T, Phan XL. Dental and skeletal characteristics and growth of females and males with Class II division 1

malocclusion between the ages of 10 and 14 (revisited). Part II. Anteroposterior and vertical circumpubertal growth. *Am J Orthod Dentofacial Orthop.* 2001;120:542–555.

11. Schudy FF. The control of vertical overbite in clinical orthodontics. *Angle Orthod.* 1968;38:19–39.
12. Sassouni V, Nanda S. Analysis of dentofacial vertical proportions. *Am J Orthod.* 1964;50:801–823.
13. Bennett JC, McLaughlin RA. *Orthodontic Treatment Mechanics of Preadjusted Appliance.* St Louis, Mo: CV Mosby; 1994:121.