

Incisal and Soft Tissue Effects of Maxillary Premolar Extraction in Class II Treatment

Nevenka Tadic^a; Michael G. Woods^b

ABSTRACT

Objective: This retrospective study was designed to show likely upper incisal and soft tissue lip changes accompanying Class II fixed appliance treatment with only two upper premolar extractions and to assess whether the lips, especially, are predictably and directly affected with such treatment.

Materials and Methods: Pretreatment and posttreatment lateral cephalograms and study casts from 61 growing Class II patients (aged 11 to 18 years; 39 division 1 and 22 division 2) were assessed. Upper and lower lip curve depths, nasolabial angle, and upper incisal position and angulation were all assessed and compared with changes in other cephalometric variables.

Results: A wide range of individual response in both lip and upper incisor behavior were noted. The observed soft tissue lip changes were most likely to be related to the preexisting morphology of the lips themselves, while upper incisal changes were mainly related to their own pretreatment positions and changes occurring with treatment in the underlying bony structures.

Conclusion: Orthodontic treatment involving the extractions of only two upper premolars is likely to result in a wide range of variation in lip and upper incisor behavior. The preexisting soft tissue morphology is likely to be the greatest determinant of lip behavior.

KEY WORDS: Class II; Premolar extractions; Lip changes

INTRODUCTION

A major orthodontic treatment goal is to improve facial esthetics and maintain or improve the labial contours of the upper and lower lips. Previous researchers have therefore investigated the anteroposterior lip changes associated with incisor retraction during orthodontic treatment.

The upper lip has been reported to respond to upper incisor retraction with a mean movement ratio of approximately 1 : 3. The corresponding value for the lower lip to lower incisor relation varies between 1 : 0.4 and 1 : 0.59.¹⁻⁶ Recently, various researchers have begun to investigate the depth and regularity of the lip tissue contours and their importance in the overall perception of the lateral facial profile.⁷⁻¹¹ They have

shown that with wide individual variation in lip curve changes, premolar extractions do not necessarily lead to direct or even predictable changes in lip curve depth. It has been concluded that it is the combined effects of the lip response to various dental and skeletal changes and the competent clinical management of extraction spaces that apparently affect the ultimate shape of the lips in the profiles of individual orthodontic patients.⁷⁻¹¹

The extraction of upper premolars is often chosen as an alternative to orthognathic surgery for nongrowing Class II patients, for some patients with significant overjet, or in cases in which there has been failure of attempted headgear or functional appliance treatment to achieve Class I canine relationships.¹² This dentoalveolar approach to treatment, however, is often assumed to result in negative facial profile effects. Interestingly, there have been only a few previous reports of soft tissue treatment effects in Class II cases with only two upper premolar extractions.¹³⁻²⁰

This present study was undertaken to evaluate the effects of upper premolar extractions in males and females with Class II division 1 or 2 malocclusions. It has been designed to assess the likely ranges of changes in the soft tissue lip profile and upper incisor

^a Former graduate student, Department of Orthodontics, University of Melbourne, Melbourne, Australia.

^b Professor and Chair of Orthodontics, Department of Orthodontics, University of Melbourne, Melbourne, Australia.

Corresponding author: Professor Michael G. Woods, School of Dental Science, University of Melbourne, 720 Swanston Street, Victoria 3010, Australia.

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Table 1. Age at Commencement of Treatment (in Years)

Group	n	Mean	Minimum	Maximum	SD
Total sample	61	13.9	9.7	19.0	2.1
Division 1	39	13.3	9.7	17.0	1.9
Division 1, females	18	13.0	9.7	16.8	2.1
Division 1, males	21	14.0	12.0	17.0	1.5
Division 2	22	14.5	10.5	19.1	2.4
Division 2, females	12	14.5	10.5	18.0	2.5
Division 2, males	10	15.5	12.1	19.1	2.8

positions and angulations and to search for factors that might be associated with those changes.

MATERIALS AND METHODS

Study Sample

The sample consisted of 61 Class II patients all treated with fixed appliances and only upper premolar extractions (Table 1). In all patients, the mesiobuccal cusps of both upper first molars occluded at least 5 mm anterior to the midbuccal grooves of the lower first molars. All patients exhibited minimal crowding in both upper and lower arches, were between the ages of 11 and 18 years, and were treated by one experienced orthodontist using consistent biomechanical principles. High quality pretreatment and posttreatment lateral cephalometric radiographs were available. All radiographs had been taken with the same cephalostat, showing good soft tissue definition with lips relaxed and teeth in occlusion.

Cephalometric Analysis

All pretreatment and posttreatment cephalograms were traced by one examiner and digitized with the aid of Westcef cephalometric software (customized cephalometric analysis software by Geoffrey West). Transfer of both sphenothoidale and the inferior pterygomaxillary point from the first to the second tracing was undertaken to provide a consistent frame of reference (the PM vertical line) for the subsequent evaluation of horizontal changes in study landmarks.^{7-11,21,22} Cephalometric measurements used in this study are listed in Table 2 and illustrated in Figures 1 and 2.

Patients were classified as division 1 if the upper incisors were greater than or equal to 18° relative to the N-A line. They were classified as division 2 if the upper incisors were less than 18° relative to the N-A line. From this measurement, 39 patients were classified as division 1 and 22 were classified as division 2.

The depths of the upper and lower lip curves were

measured from upper and lower anterior reference lines, constructed from the most anterior points of the nose and chin to those on the upper and lower lips, respectively (Figure 2). To determine the range of lateral soft tissue changes occurring with treatment, three main cephalometric measurements were made: nasolabial angle and upper and lower lip curve depths. To determine the range of upper incisal changes with treatment, two measurements were made: upper incisor angulation and position in relation to the N-A line. All other listed measurements were used for calculations of Pearson's correlation coefficients (Table 2).

Study Cast Analysis

Study cast measurements used in this study are listed in Table 2 and illustrated in Figure 3. An electronic digital sliding caliper (Mitutoyo Corporation, Tokyo, Japan) was used to measure distances between occlusal landmarks (to the nearest 0.1 mm). The amount of crowding was calculated using the segmental method of Proffit and Fields²³ by subtracting the pretreatment segmental total from the posttreatment segmental total and then adding back in the mesiodistal widths of the two extracted upper premolars. The residual space following initial alignment was calculated by subtracting the amount of crowding from the sum of the mesiodistal widths of the extracted maxillary premolars.^{9,10}

Statistical Analysis

All cephalometric and study cast measurements were transferred to an Excel spreadsheet (Excel Office 2000; Microsoft Corp, Seattle, WA.). Mean changes occurring during treatment were then calculated, and the data were statistically analyzed using a commercially available statistical software package (Statistical Software Release; Minitab, State College, PA.). Analysis of variance was used to search for statistically significant differences in the mean measurements for division 1 and 2 groups and between the males and females within each group. Finally, Pearson's correlation coefficients and associated levels of significance were calculated to search for significant correlations among all variables.

Error Measurement

To evaluate the tracing and measurement error associated with the method, 20 radiographs from 10 patients were selected at random and then traced and measured twice 4 weeks apart. Results of the paired *t*-test showed that there were no clinically significant differences between the two sets of measurements at the 95% confidence level (Table 3).

Table 2. Lateral Cephalometric and Study Cast Measurements

Lateral Cephalometric Measurement	Definition
Facial axis, °	The posterior-inferior angle between the lines basion-nasion and Pt-gnathion
ANB angle, °	The difference between the SNA and SNB angles
Mandibular length (Co-Gn), mm	The distance between condyilion and gnathion point
Nasolabial angle, °	The angle between the tip of the nose, subnasale, and the upper vermillion of the lip
Point A to N-perp, mm	The horizontal distance between point A and the nasion-perpendicular
Pogonion to N-perp, mm	The distance between pogonion and nasion-perpendicular
Pogonion soft tissue thickness, mm	Distance between hard tissue pogonion and the outline of the chin, drawn perpendicular to PM line
Menton soft tissue thickness, mm	Distance between hard tissue menton and the point of intersection with the outline of the inferior surface of the menton drawn parallel to the PM line
Upper incisor angulation to N-A line, °	The angle between the upper incisor and the N-A line
Upper incisor distance to N-A Line, mm	The distance from the most labial point of the upper incisor and the N-A line
Lower incisor distance to N-B line, mm	The distance from the most labial point of the lower incisor to the N-B line
Upper lip curve depth, mm	Distance to soft tissue point A measured perpendicular to a line joining the nasal tip and the upper vermillion point
Lower lip curve depth, mm	Distance to soft tissue point B measured perpendicular to a line joining the lower vermillion point and soft tissue pogonion
Upper lip thickness, mm	Distance between hard tissue point A and point of intersection with the outline of the upper lip drawn perpendicular to Pm line
Soft tissue point A	
Vermillion	Distance between vermillion point of the upper lip and inner aspect of the lip, drawn perpendicular to PM line
Lower lip thickness, mm	Distance between hard tissue point B and point of intersection with the outline of the lower lip drawn perpendicular to Pm line
Soft tissue point B	
Vermillion	Distance between vermillion point of the lower lip and inner aspect of the lip, drawn perpendicular to PM line
Study cast measurements	
Overbite, mm	Vertical overlap of the upper and lower incisors measured perpendicular to the occlusal plane
Overjet, mm	Horizontal distance between the upper and lower incisors measured parallel to the occlusal plane
Crowding, mm	Space required for crowding relief and leveling, calculated using Proffit's segmental method, by subtracting the pretreatment segmental total from the posttreatment segmental total, then adding back in the mesiodistal widths of the two extracted premolars
Arch depth, mm	Perpendicular distance from the line joining the mesial contact points of the upper first molars to the contact point of the upper central incisors
Arch segments, mm	Distance between the lines perpendicular to the contact points of a segment of teeth; between the first molar and the distal surface of the lateral incisor and between that distal surface and the mesial surface of the central incisor
Molar relationship, mm	Distance between the mesiobuccal cusp tip of the upper first molar and the buccal groove of the lower first molar measured parallel to the occlusal plane

RESULTS

Mean Changes in Soft Tissue and Upper Incisor Measurements

There was a mean increase in the nasolabial angle of 3.65° for the total sample (Table 4; Figure 4). Since there was wide variation among the subjects in all groups, differences in group means were not significantly different ($P = .49$).

There were mean decreases of only 0.06 mm and 0.28 mm, respectively, in the upper and lower lip curve depths. Once again, differences in group means were not significantly different ($P = .75$; Tables 5 and 6; Figures 5 and 6).

There was a mean increase in upper incisor angulation relative to the N-A line of 1.03° for the total sample. While there was wide variation among the subjects in all groups, differences in the means for the overall division 1 (−3.00°) and division 2 (+8.00°) groups were significant ($P \leq .001$). Similar significant differences were also found for all division 1 and 2 gender groups (Table 7; Figure 7). There was a mean decrease of 0.82 mm in the upper incisor distance to the NA line for the total sample. While there was wide individual variation among the subjects in all groups, the differences in the means for the division 1 (−1.88 mm) and division 2 (+1.30 mm) male groups were significant ($P \leq .01$; Table 8; Figure 8).

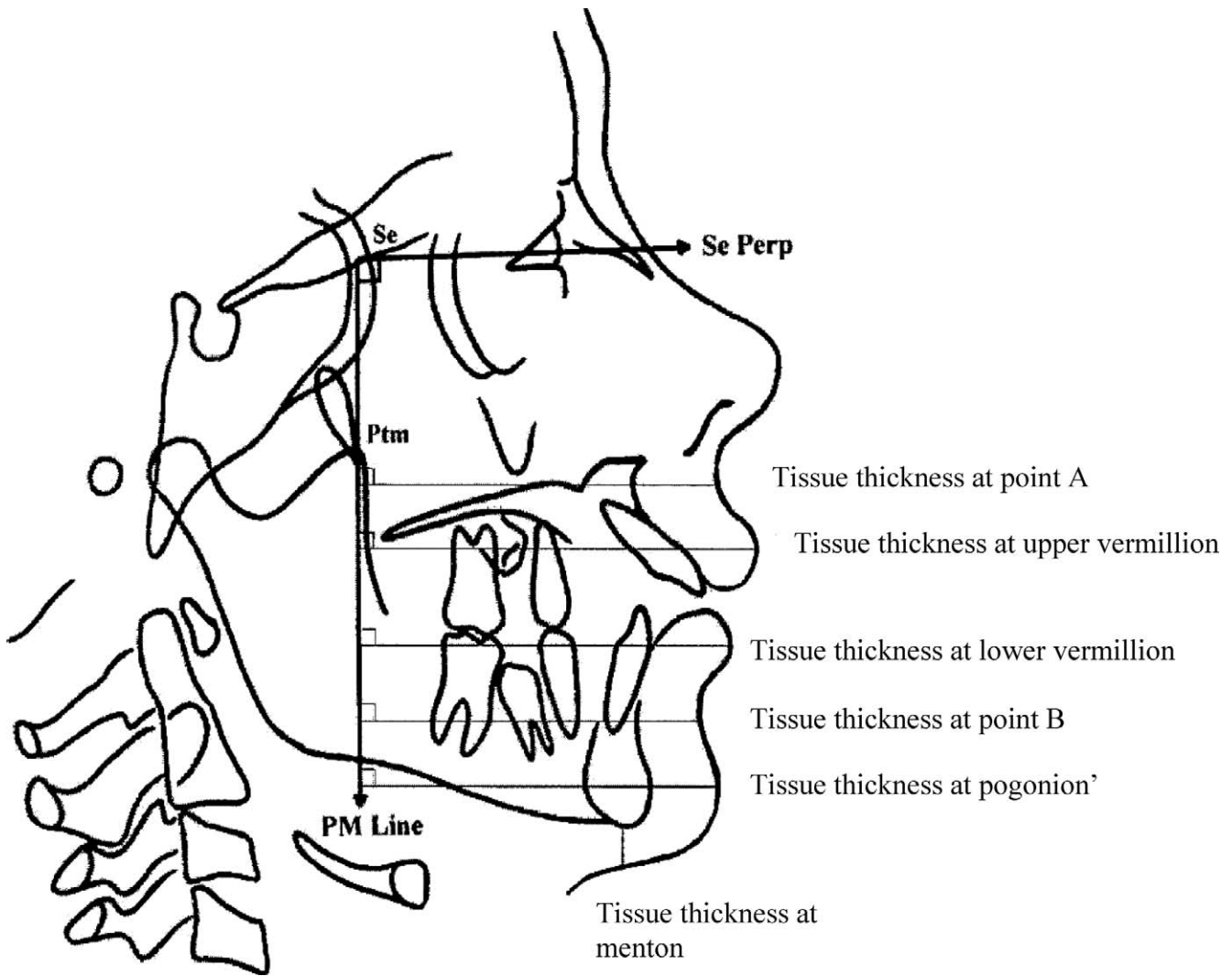


Figure 1. Lips and pogonion tissue thickness.

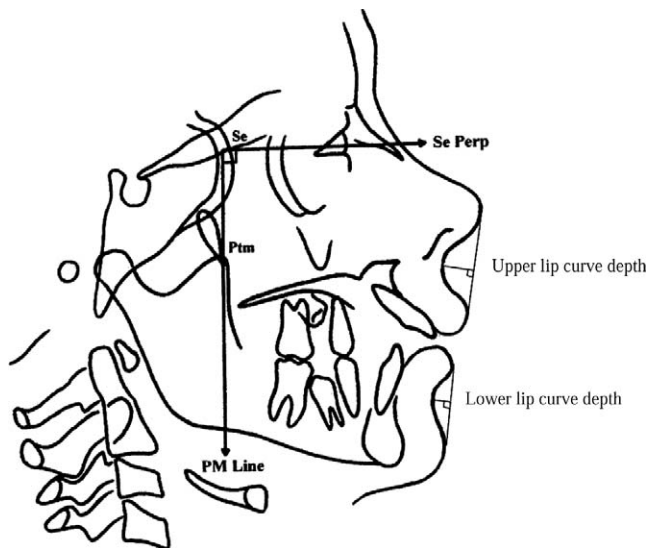


Figure 2. Location of upper and lower lip curve depths in relation to anterior soft tissue lines.

Calculation of Pearson's Coefficients of Correlation

Pearson's coefficients of correlation (r values at a significance level of $P \leq .01$) were calculated for the five main study variables and other cephalometric and arch-dimensional measurements and changes. Changes in the nasolabial angle were correlated only with changes in both upper lip thickness and upper lip curve depth ($r = -.340$). This means that an increase in nasolabial angle is likely to occur whenever there is a decrease in upper lip thickness or lip curve depth.

Similarly, changes in upper lip curve depth were found to correlate with changes in upper lip thickness and nasolabial angle ($r = -.340$). This means that a decrease in upper lip curve depth is likely to occur whenever there is a decrease in upper lip thickness or an increase in nasolabial angle. Changes in upper lip curve depth were also found to correlate with mandib-

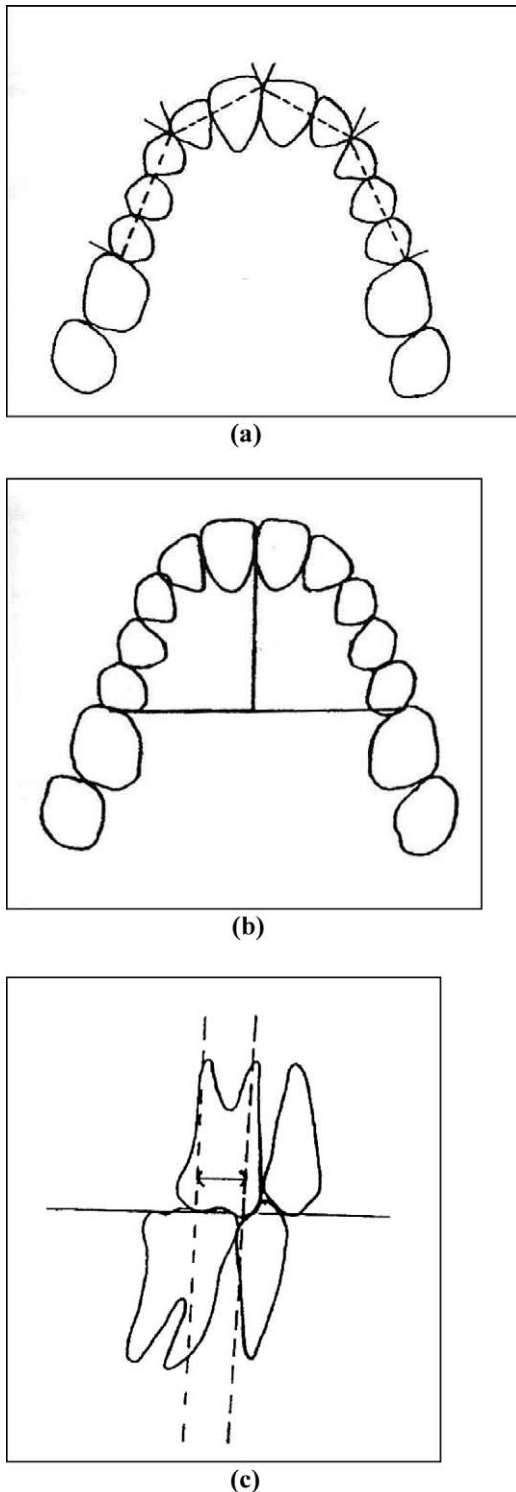


Figure 3. (a) Arch segment measurements. (b) Arch depth measurement. (c) Molar relationship measurement.

ular length changes ($r = -.65$). This means that the greater the increase in mandibular length, the less likely there is to be a decrease in upper lip curve depth. Changes in lower lip curve depth were found to correlate only with changes in lower lip thickness at both

the vermillion level ($r = -.590$) and soft tissue menton ($r = -.261$). This means that whenever these thicknesses increase, it is likely that there will be a decrease in the depth of the lower lip curve, that is, less lower lip roll.

Changes in upper incisor angulation were found to correlate with the amount of pretreatment incisor protrusion ($r = -.502$), the amount of pretreatment incisal overjet ($r = -.627$), and the change in ANB angle ($r = -.526$). This means that the greater the pretreatment incisal protrusion or overjet, the greater the likely need for reduction in upper incisor angulation. It also means that the greater the decrease in the ANB angle, the less there is a need for reduction in upper incisor angulation. The same correlations were found to apply to changes in upper incisor protrusion.

DISCUSSION

The aim of this study was not only to provide means for change but also to recognize the likely wide individual variation, and also to then study the factors that might influence the changes observed with such treatment. In this case, untreated control subjects would not have provided any further information than that gained in the study. Two frames of reference were used in this study to permit assessment of changes in the skeletal hard tissues as well as the soft tissues in the nasal region. The skeletally defined PM line of Enlow et al²⁴ was used as the principal reference line for the hard tissue components. Anterior reference lines were then constructed using the most protrusive points on the nose and upper lip and soft tissue pogonion and lower lip. This is in accordance with the recommendation of Zierhut et al,²⁵ Foley and Duncan,²⁶ and Meng et al,²⁷ who emphasized the need to also consider the effects of nasal changes on the total facial profile as well as changes in total facial convexity.

The mean overall increase in nasolabial angle of 3.65° for the Class II patients in this study is consistent with increases reported previously for treatment involving only two upper premolar extractions.^{15,20} The observed wide individual variation is also consistent with all these studies. It is interesting to note that, once again, the strongest associations for change in nasolabial angle were seen with inherent soft tissue factors, such as pretreatment lip thickness and lip curve depth. This is also consistent with the strong associations that have been reported previously between thinner, flatter, pretreatment upper lips and increasing lower facial height and greater increases in nasolabial angle during treatment.⁴

As with the nasolabial angle, there was wide individual variation in upper lip curve depth change with treatment, with the only real correlations being with

Table 3. Cephalometric Measurements and Error Study

Variable	n	Mean	SD	SE Mean	T	P Value
Facial axis	20	0.19	0.54	0.12	1.60	.13
ANB	20	-0.08	0.70	0.16	-0.54	.60
Mandibular length Co-Gn	20	0.52	0.97	0.22	2.38	.02
Nasolabial angle	20	1.55	5.38	1.20	1.28	.22
Point A-Nperp	20	0.28	1.23	0.28	1.02	.32
Pog-NPerp, mm	20	0.42	1.46	0.33	1.27	.22
Upper inc-NA (angle)	20	-0.04	1.68	0.38	-0.10	.92
Upper inc-palatal plane	20	-0.00	1.64	0.37	-0.00	.10
Labial point of upper incisor to NA	20	-0.12	0.86	0.19	-0.61	.55
Labial point of lower incisor to NB	20	-0.12	0.76	0.17	-1.17	.26
Lower incisor to NB angle	20	0.53	2.78	0.62	0.84	.41
Soft tissue at A point	20	0.19	0.84	0.18	1.03	.32
Upper vermilion thickness	20	0.33	0.70	0.16	2.12	.05
Lower vermilion thickness	20	-0.23	1.10	0.25	-1.21	.24
Soft tissue at B point	20	-0.04	0.72	0.16	-0.25	.81
Pogonion soft tissue thickness	20	0.10	1.14	0.26	0.40	.70
Soft tissue thickness at menton	20	-0.15	1.03	0.23	-0.64	.53

Table 4. Mean Changes in Nasolabial Angle (in °)^a

	n	Mean	Minimum	Maximum	SD
Total	61	3.65	-14.55	25.23	7.92
Division 1					
Total	39	4.28	-14.55	25.23	8.39
Female	18	4.78 (NS)	-11.96	22.44	7.37
Male	21	3.86 (NS)	-14.55	25.23	9.34
Division 2					
Total	22	2.53	-8.27	16.06	7.03
Female	12	0.55 (NS)	-8.27	16.06	7.43
Male	10	4.91 (NS)	-2.43	14.20	6.05

^a NS indicates not statistically significant.

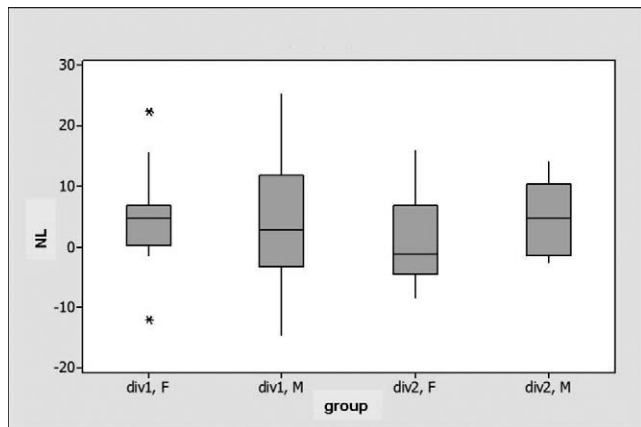


Figure 4. Mean changes in nasolabial angle.

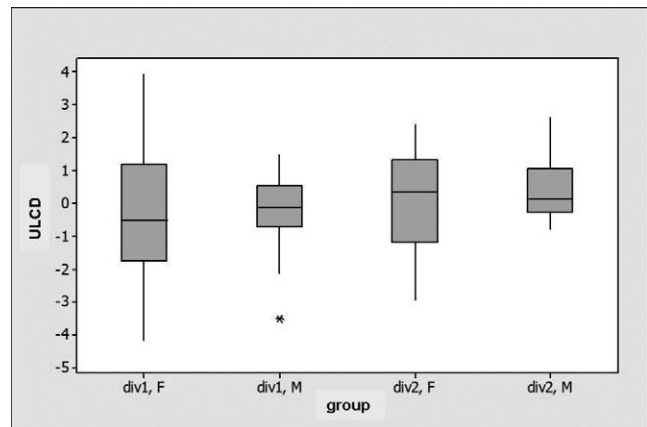


Figure 5. Mean changes in upper lip curve depth.

other changes in soft tissues. This is consistent with previously published findings that the soft tissues themselves are in fact the ultimate compensators in the facial profile and that the inherent characteristics of the lips will greatly influence any response to orthodontic treatment.^{7,8,11,28,29}

Historically, it has been accepted that the positions of soft tissue points A and B are strongly related to those of the underlying hard tissue points A and B, as

well as to the upper incisors.^{15,30} Some authors have, however, highlighted the more complex functional anatomy and behavior of the upper lip.^{4,7,8,11,19} The fact that upper lip behavior is so complex would help to explain the present findings as well as the previously proposed contention that the behavior of the midfacial tissues shows considerably greater independence of the underlying hard tissue changes than those within the lower face.³¹

Table 5. Mean Changes in Upper Lip Curve Depth (mm)

	Group	n	Mean	Min	Max	SD
Total		61	-0.06	-4.17	3.93	1.60
Division 1	Total	39	-0.21	-4.17	3.93	1.70
	Female	18	-0.18 (NS)	-4.17	3.93	2.20
	Male	21	-0.23 (NS)	-3.52	1.49	1.18
Division 2	Total	22	0.19	-2.95	2.63	1.39
	Female	12	0.01 (NS)	-2.95	2.39	1.67
	Male	10	0.42 (NS)	-0.78	2.63	1.02

NS indicates not statistically significant.

Table 6. Mean Changes in Lower Lip Curve Depth (mm)

	Group	n	Mean	Min	Max	SD
Total		61	-0.28	-3.37	2.85	1.37
Division 1	Total	39	-0.18	-3.37	2.85	1.51
	Female	18	0.58**	-1.57	2.85	1.40
	Male	21	-0.81**	-3.37	1.40	1.32
Division 2	Total	22	-0.46	-2.07	2.10	1.09
	Female	12	-0.46	-2.07	2.10	1.30
	Male	10	-0.45	-1.73	0.36	0.84

** $P \leq 0.01$.

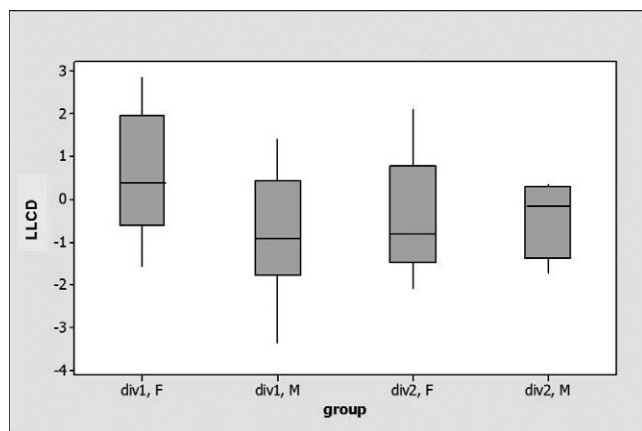


Figure 6. Mean changes in lower lip curve depth.

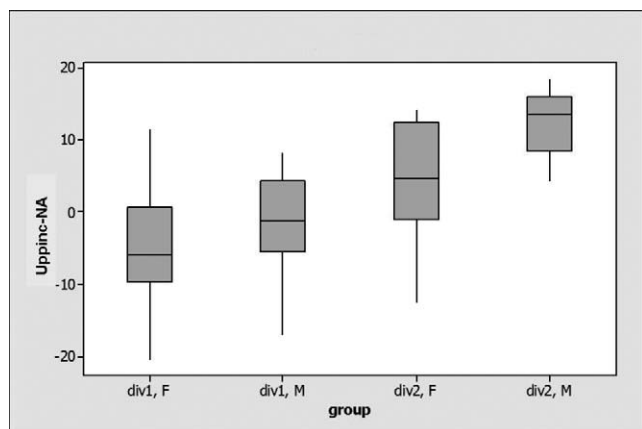


Figure 7. Mean changes in upper incisor angulation to the N-A line.

Table 7. Mean Changes in Upper Incisor Angulation to the N-A Line (degrees)

	Group	n	Mean	Min	Max	SD
Total		61	1.03	-20.36	18.51	9.12
Division 1	Total	39	-2.90	-20.36	18.51	7.43
	Female	18	-5.06**	-20.36	11.50	7.81
	Male	21	-1.04***	-17.00	8.28	6.73
Division 2	Total	22	7.80	-12.52	18.51	7.65
	Female	12	4.33**	-12.52	14.22	7.85
	Male	10	12.40***	4.36	18.51	4.64

** $P \leq 0.01$; *** $P \leq 0.001$.

Table 8. Mean Changes in Upper Incisor Distance to the N-A Line (mm)

	Group	n	Mean	Min	Max	SD
Total		61	-0.82	-5.87	5.65	2.35
Division 1	Total	39	-1.67	-5.87	5.65	1.91
	Female	18	-1.43	-5.87	2.11	2.17
	Male	21	-1.88**	-4.03	2.90	1.67
Division 2	Total	22	0.70	-2.86	5.65	2.34
	Female	12	0.19	-2.86	5.65	2.62
	Male	10	1.30**	-1.22	5.35	1.92

** $P \leq 0.01$.

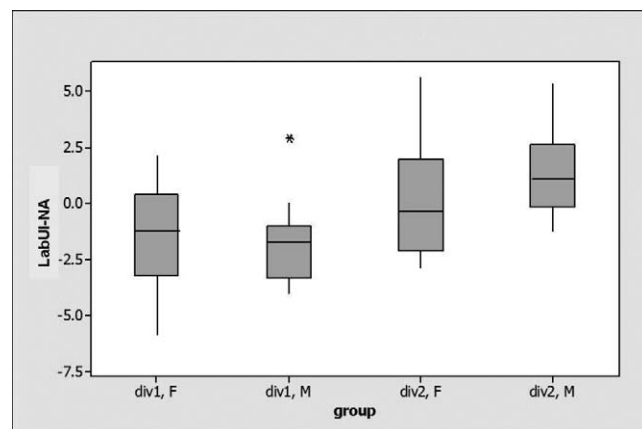


Figure 8. Mean changes in the upper incisor distance to the N-A line.

Despite the fact that it has previously been accepted that considerable upper lip retraction will necessarily follow upper incisor retraction,^{18,25,32-34} it is now widely recognized that the complex functional musculoskeletal anatomy of the nose/upper lip complex contributes to the observed wide variability of upper lip change with premolar extraction treatment.^{5,6,16,30} Simplistic ratios of lip response to upper incisor movement would therefore seem to be of limited value for application to treatment planning in individual subjects.

The fact that there were significant differences in overall average incisal angulation changes for division 1 and division 2 groups would be expected given that, by definition, there were different treatment needs

within each group. In fact, this is highlighted by the observation that changes in upper incisal angulation were largely correlated with pretreatment incisal positions. In the context of incisal overjet reduction, it obviously means that the greater the pretreatment incisal proclination or protrusion and the greater the pretreatment overjet, the greater the likely reduction in upper incisal angulation with treatment.

When putting all this together, it seems that the lips may be affected by anteroposterior tooth movements, but the degree to which this occurs is likely to be variable, depending on the treatment mechanics used, the various extraction or nonextraction decisions, the final angulations of the upper and lower incisors, the pretreatment lip thickness, and the underlying vertical and anteroposterior facial patterns. Furthermore, individual variation in the growth of the nose and chin and the direction of overall facial growth make it difficult, if not impossible, to accurately predict changes in the nasolabial angle and lip curve depths from previously published averages and ratios.

In light of these findings, one should perhaps accept that the upper lip curve and nasolabial angle are more likely to be negatively affected during upper premolar extraction treatment in those patients presenting with thin pretreatment upper lips, increased pretreatment nasolabial angles, expected vertical mandibular growth direction, or of limited continued pubertal growth potential.

CONCLUSIONS

- Class II orthodontic treatment involving the extractions of only two upper premolars is likely to result in a wide range of variation in nasolabial angle, upper and lower lip curve depths, and upper incisor positions and angulations.
- It is likely that any soft tissue changes accompanying such treatment will be largely related to the pre-existing morphology of the soft tissues themselves.
- Upper incisal changes accompanying such treatment are likely to be related to both their own pretreatment positions and changes occurring in the ANB angle.

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