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Effect of upper premolar extractions on the position of the upper lip

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Background: It has been suggested that Class II division 1 malocclusions treated with extractions result in detrimental changes in the facial profile. This study investigates changes in the position of the upper lip following upper arch extractions only.
Objective: To investigate changes in the position of the upper lip following extraction of the upper first premolars and retraction of the upper incisors.
Methods: The sample consisted of 35 Class II division 1 patients with overjets of least 5 mm whose malocclusions were corrected with upper first premolar extractions and full fixed appliances. Twelve patients in the sample had overjets ≥ 9 mm. There were no extractions in the lower arch. Pre- and post-treatment lateral cephalograms were used to determine the changes in the position of the upper lip.
Results: At the end of treatment the upper lip was 0.46 mm less protrusive than at the start of treatment. In patients with overjets ≥ 9 mm the upper lip was approximately 1 mm less protrusive at the end of treatment (Mean pre- and post-treatment difference: 0.92 mm). There were no significant gender differences in the positions of the upper lip.
Conclusion: Minimal changes occur in the position of the upper lip following extraction of the upper premolars and retraction of the upper incisors. Factors other than the position of the upper incisors may determine the post-treatment position of the upper lip.
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Introduction

Of particular interest to orthodontists is the response of the soft tissues to orthodontic tooth movement, particularly treatment involving premolar extractions and the retraction of the upper incisors. There is a belief among some orthodontists, general dentists and the lay public that premolar extractions result in detrimental changes in facial appearance, particularly 'flattening' of the profile. As a result the antero-posterior position of the upper lip and the nasolabial angle have attracted the attention of clinical researchers due to their presumed contribution to a harmonious soft tissue profile.[1,2] However, given the subjective nature of aesthetic assessment, it is not surprising that opinion differs and changes as to what constitutes an 'ideal' profile.

Upper first premolars may be extracted to facilitate retraction of the upper canines and incisors and alignment the teeth within the dental arches. In a non-extraction lower arch the lower incisors limit the extent to which the upper incisors can be retracted. Upper first premolars combined with lower second premolar extractions are often utilised in cases with significant lower arch crowding.[3,4] Functional appliances have also been used to provide Class II correction by 'stimulating' mandibular growth. However, the current evidence suggests that although functional appliances are effective in reducing overjets, the degree of long-term growth stimulation is only minor.[5–9] Headgear and molar distalising appliances are also advocated. The former is generally used in the mixed dentition period to move the upper molars distally, and the latter often results in some lower and upper incisor proclination.[10–12] Orthognathic surgery is generally used to correct severe Class II dentoskeletal discrepancies.

Scientific studies designed to specifically identify the impact of upper first premolar extractions on the facial profile are rare. However, several authors have examined the effects of four premolar extractions on

the soft tissue profile.[13–23] For example, lay people judged the aesthetics of both the profile[13] and anterior smile[18] in extraction cases to be equally favourable to nonextraction cases. Similarly, neither dentists nor orthodontists could discriminate between extraction and nonextraction post-treatment soft tissue profiles.[14] It has also been reported that extraction therapy compared with nonextraction therapy is not associated with unfavourable changes in the facial profile[16,17,19,20,23] and lip position.[22] The rate of undesirable facial changes is reported to be similar in extraction and nonextraction patients, and that it is over-simplistic to blame undesirable facial changes on premolar extractions.[15]

Lower premolar extractions have the potential for the lower incisors to be retracted, though this is not always observed.[21] In cases where the lower incisors are retracted, the upper incisors may be 'over-retracted' and an unfavourable soft tissue profile can result. Bishara *et al.*[24] reported an increased pretreatment protrusiveness of the lips relative to the aesthetic plane in Class II division 1 patients eventually treated with four premolar extractions, indicating this was an important parameter in the extraction decision. They acknowledged there are other factors to be considered besides lip protrusion, including different biases between clinicians. Bishara *et al.*[25,26] concluded that the extraction decision, if properly exercised, has no deleterious effect on the facial profile.

To date no studies have specifically examined the effect of upper premolar extractions on the position of the upper lip in moderate to severe Class II division 1 malocclusions. The aim of this study was to determine in subjects with Class II division 1 malocclusions the effect of upper first premolar extractions and retraction of the upper incisors on the position of the upper lip.

Materials and methods

The sample consisted of the pre- and post-treatment records of 35 consecutively treated patients (16 male, 19 female) with Class II division 1 malocclusions. The following criteria were used:

1. All patients had a pretreatment overjet of 5 mm or greater and lower arch crowding of 4 mm or less. Twelve (6 males, 6 females) of these patients had pretreatment overjets ≥ 9 mm.

2. Patients were treated with upper first premolar extractions alone to enable the Class II incisors to be corrected and any upper arch crowding relieved. The lower arch was managed on a nonextraction basis with interproximal stripping to resolve any crowding. Thus, the amount of upper incisor retraction was largely determined by the pretreatment positions of the lower incisors. Intermaxillary traction such as Class II elastics or bite jumping appliances were not used, thereby minimising the possibility of treatment-induced lower incisor proclination contributing to the overjet reduction.

3. No patients had received any previous orthodontic treatment.

4. All patients were treated by the same orthodontist using preadjusted 0.018 inch slot edgewise appliances. Anchorage support such as headgear, Nance buttons, and transpalatal arches were used as required.

5. Pretreatment and post-treatment lateral cephalograms of each patient, taken with the teeth together and lips relaxed, were available.

6. Patients were judged by the treating orthodontist to have a clinically acceptable lip morphology and nasolabial form.

The average age of the sample at the start of treatment was 13.05 years (SD: 0.35 years) and at the completion of treatment it was 16.47 years (SD: 0.35 years). The mean pretreatment age of the 12 subjects with severe overjets (≥ 9 mm) was 12.94 years (SD: 0.36 years) and the mean post-treatment age of this subgroup was 16.33 years (SD: 0.40 years). Of the 35 patients, 34 are Caucasian and one is an Eurasian.

Patients were assessed as being suitable for treatment by means of upper premolar extractions. This assessment was based on clinical and radiographic examination of the hard and soft tissue profiles, without using predefined numerical limits, and thus contained a significant subjective component.

Cephalometric analysis

All pretreatment and post-treatment lateral cephalograms were traced by one examiner (TC). The upper lip soft tissue analysis described by Moseling and Woods,[22] was used with the addition of the nasolabial angle. Bjork superimpositions using cranial base landmarks were constructed on the pretreatment tracing. Sphenoethmoidale (Se) and inferior pterygomaxillary point (Ptm) were transferred from the

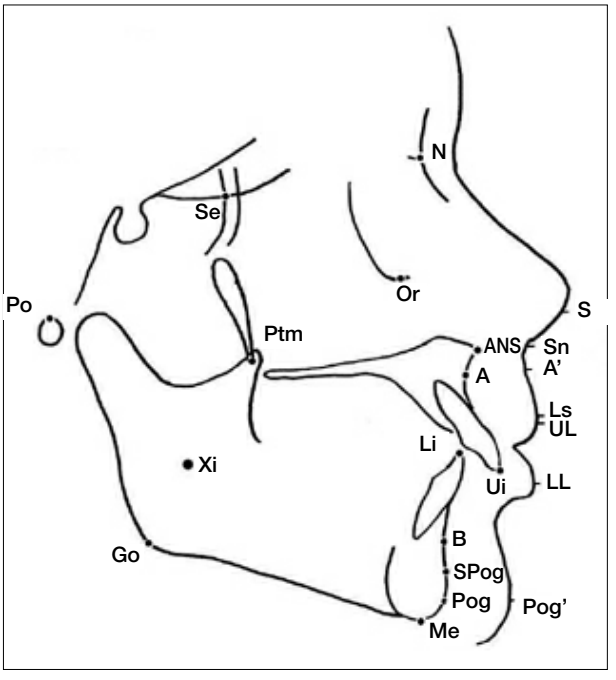

Figure 1. Cephalometric landmarks and measurements.
Se: sphenoethmoidale. Ptm: inferior pterygomaxillary point. N: nasion. A: point A. B: point B. ANS: anterior nasal spine. Xi: Xi point. Po: porion. Pog: pogonion. Pog': soft tissue pogonion. SPog: suprapogonion. Me: menton. Go: gonion. Or: orbitale. Sn: subnasale, point of maximum concavity on soft tissue outline between nose and upper lip. S: mid-point of columella of nose. Ls: labrale superius, superior point of upper lip. A': deepest point on outline of upper lip. UL: anterior point of upper lip. LL: anterior point of lower lip. Ui: upper incisor tip. Li: lower incisor tip. UVP: upper vermillion point, most anterior point of upper lip (not shown).

LFH: lower facial height, ANS-Xi-Spog. MPA: mandibular plane angle, FH (Po-Or) to Me-Go. ANB: point A-nasion-point B. Ui to APog: upper incisor tip to APog line. Li to APog line: lower incisor tip to APog line. E Plane: soft tissue nasal tip to Pog'. LL to E Plane: Lower lip to E Plane. UL to E Plane: upper lip to E Plane. NLA: nasolabial angle, S-Sn-Ls. UL PM: upper lip curvature relative to PM line: x axis coordinate distance PM to soft tissue Point A' subtracted from PM to upper vermilion point. UL depth: upper lip depth to anterior soft tissue line, perpendicular distance from soft tissue Point A' to anterior soft tissue line (nasal tip-upper vermilion point). PM: pterygomaxillary line, Se-Ptm.

Table I. Comparison of pre- and post-treatment measurements following upper first premolar extractions and upper incisor retraction (N = 35).

	Pretreatment		Post-treatment		Difference		*p*	95 per cent CI
	Mean	SD	Mean	SD	Mean	SD		
LFH (degrees)	46.54	4.69	47.11	4.63	0.57	1.36	0.02	0.11, 1.04
MPA (degrees)	27.31	5.10	27.60	5.20	0.29	1.36	0.20	-0.18, 0.75
ANB (degrees)	5.51	1.82	4.40	1.94	-1.11	1.21	<0.001	-1.53, -0.70
Overjet (mm)	7.71	1.74	2.89	0.72	-4.82	1.52	<0.001	-5.53, -4.31
Ui to APog (mm)	9.31	2.29	5.11	1.88	-4.20	1.94	<0.001	-4.87, -3.53
Li to APog (mm)	1.80	1.89	2.34	1.68	0.54	1.07	0.005	0.18, 0.91
LL to E Plane (mm)	0.06	2.47	-2.43	3.12	-2.49	2.16	<0.001	-3.23, -1.74
UL to E Plane (mm)	-1.49	2.73	-4.43	3.05	-2.94	1.80	<0.001	-3.56, -2.33
NLA (degrees)	115.54	6.44	117.06	6.46	1.52	2.25	<0.001	0.74, 2.29
UL PM (mm)	3.40	1.75	2.94	1.43	-0.46	1.22	0.03	-0.88, -0.04
UL depth (mm)	6.89	1.16	7.60	1.38	0.71	1.10	0.001	0.34, 1.09

pretreatment tracing to the post-treatment tracing to ensure a consistent plane of reference.[22] Cephalometric landmarks and measurements are described in Tables I, II and III, and Figure 1. All linear measurements were multiplied by a factor of 0.92 to compensate for radiographic enlargement.

Statistical analysis

The effect of treatment on the cephalometric variables was assessed by examining the difference between the pretreatment and post-treatment measurements using a paired sample *t*-test. To assess the changes between two groups, for example between the male and female subjects, an independent sample *t*-test was used.

Error measurement

To assess the tracing and measurement errors 10 randomly selected pretreatment and post-treatment radiographs were remeasured eight weeks apart.

Table II. Comparison of the pre- and post-treatment measurements in the 12 patients with severe pretreatment overjets (≥ 9 mm).

	Pretreatment		Post-treatment		Difference		*p*	95 per cent CI
	Mean	SD	Mean	SD	Mean	SD		
LFH (degrees)	45.42	5.02	46.25	5.46	0.83	1.40	0.06	-0.06, 1.73
MPA (degrees)	26.58	5.47	26.83	5.77	0.25	1.42	0.60	-0.65, 1.15
ANB (degrees)	5.50	1.73	4.08	2.23	-1.42	1.00	<0.001	-2.05, -0.78
Overjet (mm)	9.67	0.98	3.25	0.87	-6.42	1.08	<0.001	-7.11, -5.73
Ui to APog (mm)	10.42	2.75	4.75	1.91	-5.67	1.56	<0.001	-6.66, -4.68
Li to APog (mm)	1.08	2.02	1.75	1.66	0.67	0.89	0.03	0.10, 1.23
LL to E Plane (mm)	0.00	2.13	-2.41	3.92	-2.41	2.84	0.01	-4.22, -0.61
UL to E Plane (mm)	-0.83	2.12	-4.08	3.20	-3.25	1.42	<0.001	-4.15, -2.35
NLA (degrees)	113.17	7.33	115.25	7.10	2.08	2.50	0.02	0.49, 3.67
UL PM (mm)	4.17	1.99	3.25	1.48	-0.92	1.38	0.04	-1.79, -0.04
UL depth (mm)	7.42	1.16	7.92	1.16	0.50	0.90	0.08	-0.07, 1.07

Table III. Soft Tissue measurements in the male (N = 6) and female (N = 6) patients with severe overjets (≥ 9 mm).

	Change (Females)		Change (Males)		Difference		*p*	95 per cent CI
	Mean	SD	Mean	SD	Mean	SD		
LL to E Plane (mm)	-2.33	2.34	-2.50	3.51	0.17	2.98	0.9	-3.67, 4.00
UL to E Plane (mm)	-3.67	1.21	-2.83	1.60	-0.84	1.42	0.3	-2.66, 0.99
NLA (degrees)	1.50	1.87	2.67	3.08	-1.17	2.55	0.4	-4.44, 2.11
UL PM (mm)	-0.50	1.05	-1.33	1.63	0.83	1.37	0.3	-0.93, 2.60
UL depth (mm)	0.33	0.82	0.67	1.03	-0.34	0.93	0.5	-1.53, 0.86

A paired sample *t*-test was used to test the null hypothesis that the mean measurement error was equal to zero. Only the nasolabial angle (NLA: Mean difference 1.45 degrees, $p < 0.003$) and upper lip depth (UL depth: Mean difference 0.70 mm, $p < 0.001$) showed significant measurement errors. The errors in both measurements are considered to be due to the difficulty in locating the three soft tissue points used in each measurement.

Results

Of the three skeletal measurements, both ANB and lower facial height demonstrated statistically significant changes with treatment (Table I). The ANB decreased by 1.11 degrees, the lower facial height increased by 0.57 degrees, but there was no significant treatment change in the mandibular plane angle. The incisal edges of the upper incisors relative to the APog line were retracted 4.2 mm and the incisal edges of the lower incisors were proclined 0.54 mm.

A subgroup (N = 12) consisting of patients with pretreatment overjets ≥ 9 mm was also assessed (Table II). In the subgroup the nasolabial angle (NLA), the position of the upper lip relative to the PM line (UL to PM) and E plane (UL to E plane) showed statistically significant change. The nasolabial angle increased, on average, by 2.08 degrees, but the significance of this change is negated when the measurement error is considered. The position of the upper lip relative to the vertical reference line (UL PM) decreased by 0.92 mm. Both the upper (UL to E Plane) and lower lips (LL to E Plane) became more retrusive with respect to the E Plane. In the severe overjet subgroup, the upper lip depth (UL depth) was not significantly different.

There were no significant gender differences for the soft tissue measurements (Table III).

Discussion

The present study assessed the soft tissue changes associated with upper first premolar extractions in Class II division 1 cases. Upper lip protrusiveness was reduced to small, but clinically insignificant, amount following this form of treatment. Even in the severe overjet subgroup there were only modest changes in the position of the upper lip. Claims that upper premolar extractions result in a flattening of the facial profile are not supported by the present study.

In common with other retrospective studies this study has a number of shortcomings. Firstly, the pretreatment diagnostic criteria were not precisely defined and it was not possible to retrieve them. Future studies should ideally be prospective with defined criteria for assigning patients to either extraction, nonextraction or orthognathic surgical based treatment groups. Secondly, the patients were treated by a single clinician, which may have introduced bias. Another clinician or group of clinicians treating the same patients may have obtained different results. Thirdly, an untreated group with identical malocclusions was not available and as a result it was not possible to separate the changes due to growth. In adolescents it would be reasonable to expect that growth of the nose, lips and differential growth between the cranial base and maxilla might contribute to some of the changes we observed. On balance, growth changes, particularly in the nose, lips and chin, would be likely to increase the changes we observed.[2,27–29] If so, the changes we have attributed to treatment may be even less than those we have reported. Finally, because of the small sample size the data were not age corrected, nor the sample divided into age groups.

All patients had pretreatment overjets of 5 mm or greater, 4 mm or less of lower arch crowding and the treatment mechanics were aimed at minimising lower incisor proclination. Thus, it could be argued that this group provides a good sample for examining the effects of upper premolar extractions and upper incisor retraction on the overlying soft tissues. Of the skeletal measurements, the ANB angle decreased by about 1 degree in both the sample and the severe overjet subgroup. This change is not surprising considering that A point is a dentoalveolar landmark and the upper incisors were retracted approximately 5 mm. A statistically significant increase in the lower facial height (LFH) of 0.57 degrees occurred during treatment, but this is not considered to be clinically significant.

Even in the severe overjet subgroup with greater anchorage requirements the lower incisal edges relative to APog plane moved forward a small, but statistically significant, amount. One would expect little forward movement of the lower incisors because there was only mild pretreatment crowding, Class II mechanics were not used, and headgear, Nance buttons, and transpalatal arches were used to support anchorage as required. Furthermore, if A point moved palatally as the upper incisors were retracted the APog plane would tip palatally and contribute to the increase in Li to APog distance.

The upper incisors (Ui to APo) were retracted, on average, approximately 4 mm in the sample and almost 6 mm in the severe overjet subgroup. The post-treatment overjet in the severe subgroup was slightly larger than for the overall sample (2.89 mm *vs.* 3.25 mm), which is consistent with the greater anchorage requirements in the latter group. The severe overjet group was slightly younger because some of these patients had been seen before 12 years of age when other options, such as early intervention or later surgery, had been outlined to them. A number had declined mixed dentition treatment and then returned, electing for non-surgical treatment.

In the present study, the upper and lower lips were more retrusive with respect to the E Plane following treatment. Given the age of the patients in the study sample, it seems likely that the relative lip retrusion also resulted from nose and chin growth.[2,19,27–29] It has been reported that both extraction and nonextraction treatments result in acceptable facial profiles in growing subjects.[16,19]

We found a small, but statistically significant, increase in the nasolabial angle. Whilst it may be reasonable to expect this angle to increase in cases with large overjets following retraction of the upper incisors in our hands this angle had a significant measurement error. The post-treatment nasolabial angle of 115 degrees, falls within the range (90 to 120 degrees) considered to be 'ideal' for this angle.[16] Previous authors have reported increases in this angle following upper incisor retraction. For example, Talass *et al.*[30] reported increases of 0.8 degrees per mm of incisor retraction, whilst Lo and Hunter[31] reported increases of 1.6 degrees per mm. The latter

authors also noted that the nasolabial angle did not change with growth in untreated subjects, that the amount of nasolabial angle change was variable and that it could not be reliably predicted.[30,31] Lo and Hunter[31] and Waldman[32] also reported that there was no consistent relationship between the change in nasolabial angle and horizontal movement of the upper incisor edge. Drobocky and Smith's[16] finding that the nasolabial angle fell in over 25 per cent of their patients underlines the variablity in this measurement.

The change in the position of the upper lip following premolar extraction therapy was of the order of 0.5 mm. The retrusiveness doubled in patients with overjets equal to or greater than 9 mm, but was still less than 1 mm. The variability we encountered was similar to that that reported in previous studies examining soft tissue changes.[16,33–36]

Lip thickness can influence positional changes in the lips. It has been reported that the response of the upper lip following retraction of the upper incisors varies according to the thickness of the underlying soft tissues. Significant correlations have been reported in persons with thin lips and weak correlations have been found in individuals with thick lips.[37] In the present study patients with 'thin' lips would be underrepresented because one of the criteria used in selecting patients for upper premolar extractions was the thickness of the upper lip.

In view of the relatively small change in the position of the upper lip following upper premolar extractions and incisor retraction it could be postulated that factors other than the position of the upper incisors may determine the lip form.[16,30,34,35,38–40] It would appear that the pretreatment lip morphology is a reasonably reliable predictor of post-treatment lip morphology, at least in cases with moderate overjets and following modest changes in the positions of the incisors. Increases in the nose and chin may increase midface protrusion over time.

Conclusion

Our findings suggest that minimal changes occur in the position of the upper lip following upper premolar extractions and retraction of the upper incisors. Indirect evidence suggests that factors such as the lip morphology may determine the behaviour of the upper lip following upper premolar extractions and retraction of the upper incisors.

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