sciendo

DOI: 10.2478/aoj-2013-0021

Effects of four premolar extractions on vermilion height and lip area during a posed smile in patients with bimaxillary protrusion

Nety Trisnawaty, Hideki Ioi, Toru Kitahara, Akira Suzuki and Ichiro Takahashi
Section of Orthodontics, Faculty of Dental Science, Kyushu University, Fukuoka, Japan

Objective: The purpose of this study was to evaluate the effects of four premolar extractions and orthodontic treatment on changes to the lips and vermilion height during a posed smile.
Methods: Fifteen female patients who were diagnosed with bimaxillary protrusion and treated with four premolar extractions were selected. The control group consisted of 25 female volunteers with a normal occlusion. Frontal photographs of the patients during a posed smile were taken before and after orthodontic treatment. Thirty-five landmarks on the upper and lower lips were identified and used to generate measurements of lip area and vermilion height. Linear and angular cephalometric measurements were also obtained.
Results: The mean values for vermilion height and lip form before orthodontic treatment were significantly larger in the treatment group compared with those of the control group. Following treatment, values significantly decreased to the extent that there was no significant difference in the vermilion height and lip form between the post-treatment and control groups. Only three and four significant correlations were found between the changes in incisor position and changes in vermilion height and lip area for the upper and lower lips, respectively.
Conclusions: The vermilion height and lip area in patients with bimaxillary protrusion approached comparative and normal values as a result of four premolar extractions and orthodontic retraction.
(Aust Orthod J 2013; 29: 176-183)

Received for publication: January 2013
Accepted: August 2013

Nety Trisnawaty: netytrisnawaty@yahoo.com; Hideki Ioi: ioi@dent.kyushu-u.ac.jp; Toru Kitahara: kitahara@dent.kyushu-u.ac.jp; Akira Suzuki: suzuki@dent.kyushu-u.ac.jp; Ichiro Takahashi: takahashi@dent.kyushu-u.ac.jp

Introduction

The face plays a key role in communication and interaction in the context of human social behaviour.[1-3] The mouth and teeth are considered fundamental in the appreciation of facial aesthetics.[4,5] A smile influences perceived attractiveness and is pivotal in social interaction which mainly focuses on the eyes and mouth.[6] Recent research has demonstrated that vermilion height plays an important role in determining smile aesthetics.[7] It has been stated[7] that the vertical thickness of the upper lip is an aesthetic determinant for orthodontists and laypersons, while the vertical thickness of the lower lip is an aesthetic determinant only for laypersons. The reported conclusion suggested that vertical lip thickness is an important factor in the determination of smile attractiveness.

Patients with a malocclusion characterised by a bimaxillary protrusion exhibit dentofacial features related to a protruded lower facial profile, difficulty in establishing a lip seal, and an increased vermilion height due to labially inclined anterior teeth. Dentally protrusive patients have long been treated via premolar extractions to straighten their profile and to facilitate a lip seal.[7] However, this treatment modality has the potential to decrease vermilion height which has been reported to be aesthetically detrimental. Contemporary attractive faces have been shown to have relatively large mouths, with a full vermilion dominating the orolabial

area.[8] Although numerous studies have examined the relationship between anterior tooth retraction and changes in facial profile,[9-15] to date, none have reported on the effects of premolar extractions on vermilion height in a smiling face.

As the relationship between incisor protrusion and lip thickness is an important consideration when planning orthodontic treatment, the purpose of the present study was to evaluate the effects of orthodontic treatment involving the extraction of four premolars on changes to vermilion height and lip area during smiling. The hypotheses to be examined were: (1) the vermilion height and lip form in patients with bimaxillary protrusion would be larger compared with patients with a normal occlusion, (2) the orthodontic retraction of anterior teeth would decrease the vermilion height and the surface areas of the upper and lower lips, and (3) the amount of anterior retraction would correlate with a decrease in vermilion height and the area of the lips.

Material and methods

Samples

The examination group was selected from the patient files of the Section of Orthodontics, Faculty of Dental Science, Kyushu University, Fukuoka, Japan. Case records contained pre- and post-treatment frontal facial photographs of a posed smile, cephalograms, dental photographs, panoramic radiographs, dental casts and accompanying descriptions of diagnoses, treatment plans, and summaries of treatment. The selection criteria for the patient group included:

1. Japanese female adults, whose minimum ages at the beginning of treatment were at least 18 years old.
2. Orthodontic treatment consisting of the extraction of four premolars, with subsequent retraction of the anterior teeth.
3. Pre- and post-treatment cephalometric radiographs of adequate diagnostic quality.
4. A skeletal Class I pattern and an Angle Class I molar relationship.
5. Pretreatment upper incisor protrusion (U1-point A vertical line to the occlusal plane) more than 6.0 mm.
6. Pretreatment lower incisor protrusion (L1-APog) more than 4.9 mm.
7. A pretreatment overjet less than 4.0 mm.
8. An absence of craniofacial anomalies.

The present study identified fifteen female patients (age range: 18 to 31 years, mean age ± standard deviation (SD): 23.1 ± 4.1 years), all of whom were treated with edgewise appliances.

A control group was selected from dental students and staff members at Kyushu University. Twenty-five female volunteers (age range: 20 to 30 years, mean age ± SD: 23.5 ± 3.0 years) with a normal occlusion were recruited. Further inclusion criteria were an Angle Class I occlusion with minor or no crowding, the presence of all teeth except third molars and no previous orthodontic treatment. All volunteers in the control group were healthy and free from any oral, dental and craniofacial anomalies.

The research protocol was approved by the Kyushu University Institutional Review Board for Clinical Research.

Facial photograph analysis

The frontal photographs of the sample group were taken with a posed smile in a seated position with the head orientated and fixed by ear rods at a distance of 1.5 metres from the camera. The subject's head was positioned so that Frankfort horizontal (FH) was parallel to the floor, while the mid-sagittal plane was aligned with the centre of the camera lens. The posed smile was taken in a relaxed, but smiling lip position. The smiling frontal photographs were taken before and immediately after orthodontic treatment. All were scanned at a resolution of 300 dpi, printed on A4 size paper, hand traced and 35 facial landmarks identified and marked (Figure 1).

An X-axis was drawn parallel to the line connecting the right and left irises through the subnasal point (Sn). A Y-axis was drawn perpendicular to the X-axis through the Sn point following which, two vertical lines were drawn through the right and left superior vermilion points (9, 11). The distance from the superior vermilion point to the right (6) and left (14) corners of the mouth was divided into three equal parts. Four additional vertical lines were drawn through points 7, 8, 12 and 13. Landmarks numbered 6 to 21 (Figure 1) were allocated to the upper lip, whereas the corresponding landmarks numbered 22 to 35 were allocated to the lower lip. Vermilion height was defined as the distance between the superior and inferior vermilion borders. Upper lip area was defined as the area bounded by the landmarks numbered

6–21. The lower lip area was defined as the area bounded by the landmarks numbered 22–35. The vermilion heights (points 7-15, 8-16, 9-17, 10-18, 11-19, 12-20, 13-21, 22-29, 23-30, 24-31, 25-32, 26-33, 27-34, 28-35) were measured and the areas of both lips calculated using software programs Winceph 5.5 (Rise, Sendai, Japan) and Adobe Photoshop 7.0 (Adobe systems, San Jose, CA, USA). All landmarks were digitised into X and Y coordinates, and statistical analysis was performed on these values. Facial size differences were evaluated between the treatment group and the control group by the Mann-Whitney U test which indicated that there was no significant difference in the facial size between groups. Therefore, the two groups could be confidently compared.

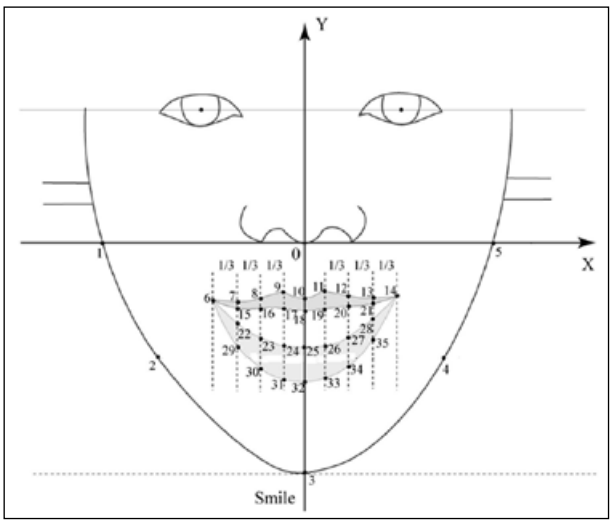

Figure 1. Facial photograph analysis:
Upper vermilion height 7-15, 8-16, 9-17, 10-18, 11-19, 12-20, 13-21.
Lower vermilion height 22-29, 23-30, 24-31, 25-32, 26-33, 27-34, 28-35.

Cephalometric analysis

Lateral cephalograms before and after orthodontic treatment were taken with the lips in a relaxed position and teeth in occlusion.[16,17] The radiographs were taken with a DR-155-23HC (SSR-2B, Hitachi Medical Corporation, Tokyo, Japan) and exposed at 100 kV, 200 mA at the Dental Radiology Clinic of Kyushu University Hospital. All cephalometric radiographs were traced by hand on matte acetate sheets by one author (NT) to avoid inter-investigator variability.

A reference X axis was constructed parallel to the occlusal plane through sella, while a reference Y axis was drawn through sella and perpendicular to the X axis on the pretreatment tracings (Figure 2). The X and Y axes were transferred to post-treatment tracings by superimposing on sella-nasion lines registering at sella. Six linear measurements and three angular measurements were used to evaluate horizontal dental changes (Figure 2).

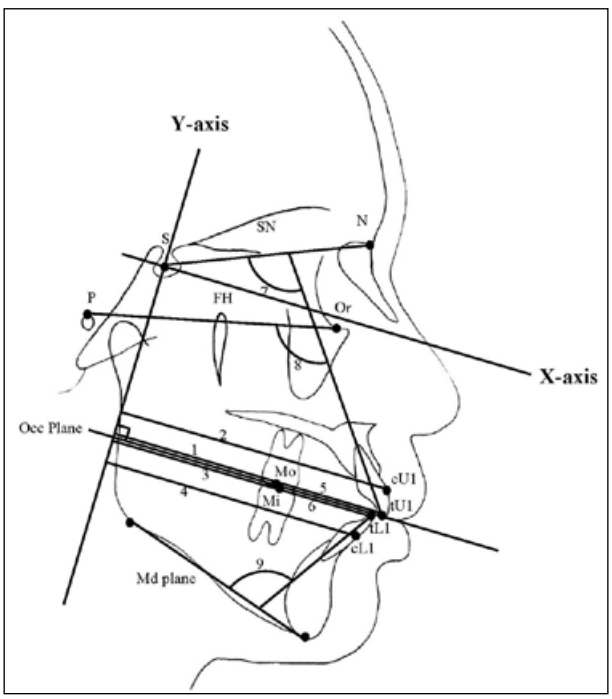

Figure 2. Horizontal dental and angular measurements:
1. H-tU1 (distance from the tip of the maxillary incisor to the Y-axis) (mm)
2. H-cU1 (distance from the cervical point of the maxillary incisor to the Y-axis)
3. H-tL1 (distance from the tip of the mandibular incisor to the Y-axis)
4. H-cL1 (distance from the cervical point of the mandibular incisor to the Y-axis)
5. tU1-Mo (distance between the tip of the maxillary incisor and the centre of the maxillary first molar)
6. tL1-Mi (distance between the tip of the mandibular incisor and the centre of the mandibular first molar)
7. U1 to SN (angle between the maxillary incisor long axis and the sella-nasion line)
8. U1 to FH (angle between the maxillary incisor long axis and the Frankfort horizontal plane)
9. L1 to Md (angle between the mandibular incisor long axis and the mandibular plane).

Statistical analysis

The Kolmogorov-Smirnov test indicated that the measurements used in this study were not normally distributed and so the pretreatment and post-treatment values were compared using the Wilcoxon signed-rank test. The Mann-Whitney U test was used to indicate the differences between the treatment group and the control group. Spearman correlation coefficients were calculated to assess the association between changes in incisor position compared with vermilion height or lip area. The minimum level of statistical significance was set at $p < 0.05$.

Sample size

A sample size calculation was undertaken using the nQuery Adviser software package (Version 6.01, Statistical Solutions, Cork, Ireland). The pilot study estimated that the effect size was 1.245. On the basis of a significance level of alpha = 0.050, the sample size was calculated to achieve 90% power. The sample size calculation showed that 15 subjects were necessary to detect a significant difference.

Reliability

All facial photographs were traced and digitised on two separate occasions and intra-class correlation coefficients (ICC) for vermilion height and lip area measurements were used to detect intra-observer error. Because all ICC were greater than or equal to 0.94, the method error was considered to be negligible.

Facial photographs of 10 female volunteers were taken three times at one-week intervals to assess test-retest consistency. The photographs were traced and digitised by one observer (NT) and the Friedman test, followed by the Dunn test, were applied to evaluate the reliability of the method. There were no statistically significant differences in the vermilion height and lip area between the three facial photographs.

Results

Lip morphological changes

The photographs of the vermilion area in the patient group before and after treatment are shown in Figure 3. The upper vermilion height change during a posed smile in the patients who received orthodontic treatment are shown in Figure 4. The height of the pretreatment upper vermilion was significantly larger than those of the post-treatment and control groups. Moreover, there was no significant difference between the post-treatment and control groups. On average, every 1 mm of maxillary incisor tip retraction produced a 0.18 mm decrease in upper vermilion height (Up 10-18). The changes in lower vermilion height in patients who received orthodontic treatment are shown in Figure 5. The values of pretreatment lower vermilion height were significantly larger than those of the post-treatment and control groups. There was no significant difference between the post-treatment and control groups. Every 1 mm of mandibular incisor tip retraction produced a 0.24 mm decrease in lower vermilion height (Lo 25-32). The individual change variations in vermilion height due to orthodontic treatment are shown in Figure 6. On average, similar decreasing tendencies in the upper and lower vermilion heights were found but individual variations were evident. The lip area changes in orthodontic treatment are shown in Figure 7. The values of the pretreatment lip area were significantly larger than those of the post-treatment and control groups for the upper and lower lips, except between the pretreatment and control groups for the lower lip. Moreover, there was no significant difference between the post-treatment and control groups for the upper and lower lip areas. Every 1 mm of maxillary incisor tip retraction produced a 6.39 mm^2 decrease in upper lip area. In addition, every 1 mm of mandibular incisor tip retraction produced an 8.16 mm^2 decrease in lower lip area. The individual changes in lip area due to orthodontic treatment are shown in Figure 8. Similar decreasing tendencies in the upper and lower lip areas were found, with noted individual variations.

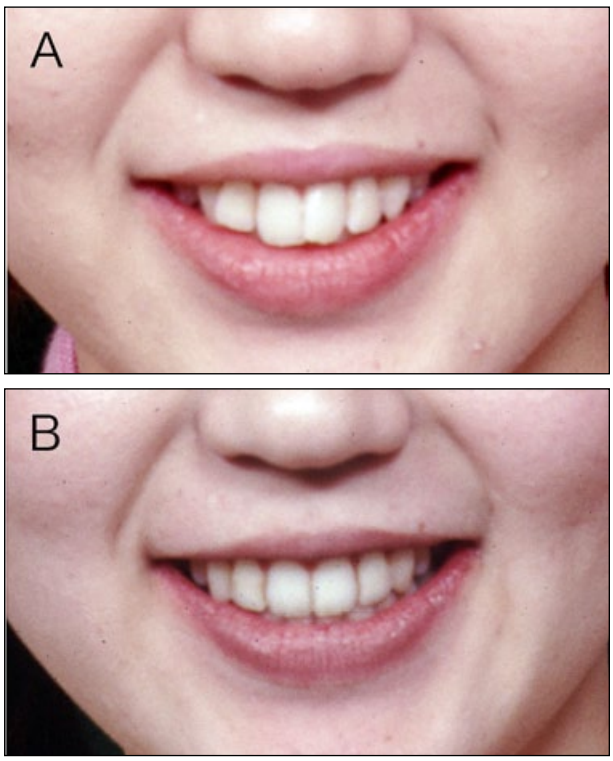

Figure 3. Actual photographs of the vermilion in the patient group before (A) and after treatment (B).

Cephalometric analysis

The cephalometric analysis revealed that the upper and lower incisors moved significantly posteriorly

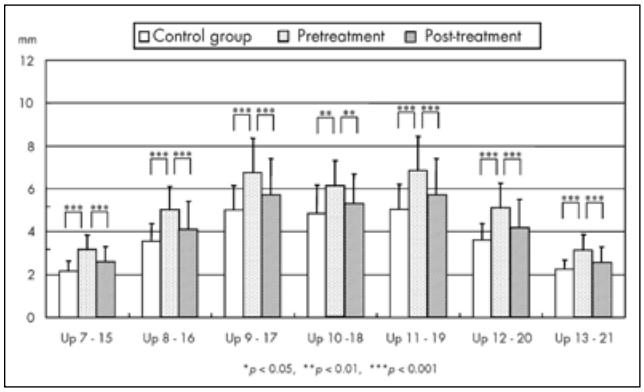

Figure 4. Upper vermilion height changes in the orthodontic treatment: Up 7-15, the upper vermilion height 7-15; Up 8-16, the upper vermilion height 8-16; Up 9-17, the upper vermilion height 9-17; Up 10-18, the upper vermilion height 10-18; Up 11-19, the upper vermilion height 11-19; Up 12-20, the upper vermilion height 12-20; Up 13-21, the upper vermilion height 13-21

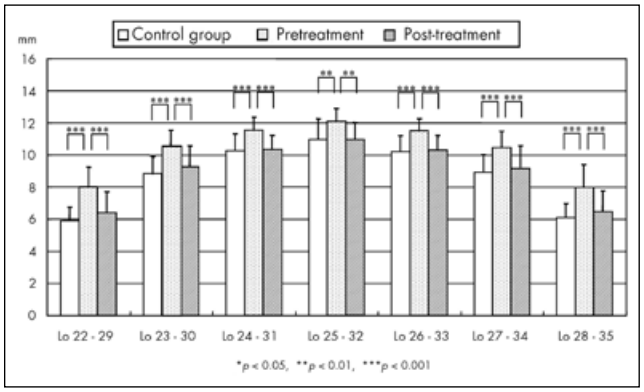

Figure 5. Lower vermilion height changes in the orthodontic treatment: Lo 22-29, the lower vermilion height 22-29; Lo 23-30, the lower vermilion height 23-30; Lo 24-31, the lower vermilion height 24-31; Lo 25-32, the lower vermilion height 25-32; Lo 26-33, the lower vermilion height 26-33; Lo 27-34, the lower vermilion height 27-34; Lo 28-35, the lower vermilion height 28-35.

and lingually based on measurements found in Table I (H-tU1, H-cU1, H-tL1, H-cL1, U1-SN, U1-FH, L1-Md, tU1-Mo, and tL1-Mi).

Relationship between incisor position and lip morphology

The changes in incisor position and changes in vermilion height or lip area for the upper lip revealed three significant correlations (Table II). The changes in vermilion height at Up9-17 and Up11-19 were significantly correlated with the changes of L1-Md plane angle. The change in vermilion height at Up11-19 was also significantly correlated with the changes at tL1-Mi. The changes in incisor position and changes in vermilion height or lip area for the lower lip revealed four significant correlations (Table III). The change of vermilion height at Lo28-35 was significantly correlated with the changes of H-tL1 or L1-Md plane angle. Lower lip area was significantly correlated with changes of H-tU1 or H-cU1.

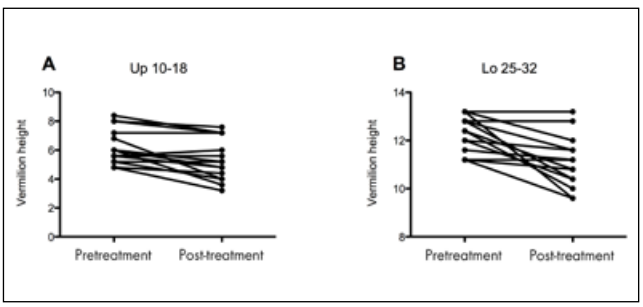

Figure 6. Individual variations in the changes of vermilion height due to the orthodontic treatment. A, Upper vermilion height (Up 10-18); B, Lower vermilion height (Lo 25-32).

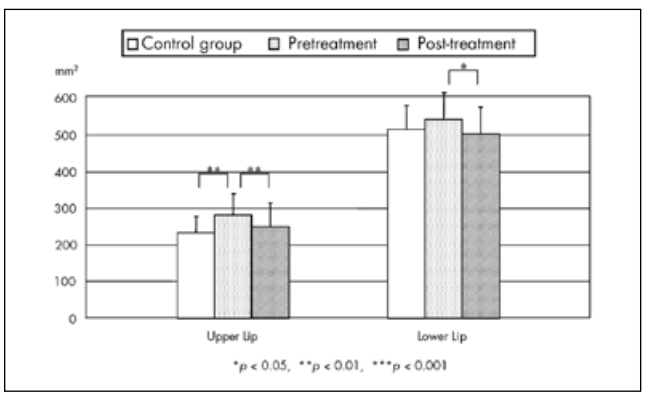

Figure 7. Lip area changes in the orthodontic treatment.

Discussion

The present report is the first study to evaluate the effects of orthodontic treatment involving the extraction of four premolars and accompanying changes in vermilion height and lip area during a posed smile.

The values of the pretreatment vermilion height and lip area for the upper and lower lips were significantly larger than those of the control group. The extraction of four premolars resulted in significant decreases

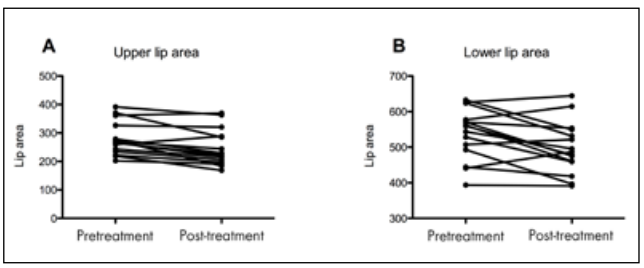

Figure 8. The individual variations in the changes of lip area due to the orthodontic treatment. A, Upper lip area; B, Lower lip area.

Table I. Incisor position changes in the orthodontic treatment.

	Pretreatment Mean ± SD	Post-treatment Mean ± SD	*p* value
H-tU1 (mm)	89.4 ± 4.1	84.3 ± 3.1	< 0.001
H-cU1 (mm)	85.2 ± 3.6	82.3 ± 2.9	< 0.001
H-tL1 (mm)	85.7 ± 4.2	80.9 ± 3.2	< 0.001
H-cL1 (mm)	83.4 ± 3.4	80.1 ± 3.3	< 0.001
U1-SN (°)	112.0 ± 6.2	99.6 ± 8.2	< 0.001
U1-FH (°)	119.4 ± 4.6	107.6 ± 7.4	< 0.001
L1-Md (°)	100.8 ± 9.5	93.5 ± 9.7	< 0.01
tU1-Mo (mm)	36.7 ± 2.1	29.9 ± 1.6	< 0.001
tL1-Mi (mm)	31.2 ± 2.4	25.1 ± 1.5	< 0.001

Table II. Spearman correlation coefficients between changes of incisor position and vermilion height or lip area in upper lip.

	Up7-15	Up8-16	Up9-17	Up10-18	Up11-19	Up12-20	Up13-21	Upper lip area
H-tU1 (mm)	-0.216	-0.241	-0.254	-0.242	-0.171	-0.198	-0.480	-0.064
H-cU1 (mm)	-0.324	-0.075	0.121	0.062	0.172	0.007	-0.436	0.018
H-tL1 (mm)	-0.041	-0.136	-0.122	-0.091	0.002	-0.032	-0.158	-0.013
H-cL1 (mm)	-0.278	-0.320	-0.348	-0.264	-0.343	-0.499	-0.428	-0.306
U1 to SN (°)	0.072	-0.084	-0.257	0.042	-0.287	-0.345	-0.238	-0.096
U1 to FH (°)	-0.019	-0.263	-0.342	-0.052	-0.313	-0.381	-0.279	0.014
L1 to Md plane (°)	-0.101	0.385	0.541*	0.326	0.616*	0.451	0.127	0.066
tU1-Mo (mm)	-0.208	0.034	0.109	-0.065	0.198	0.198	-0.432	0.086
tL1-Mi (mm)	0.278	0.258	0.428	0.186	0.564*	0.471	0.368	0.375

*$p < 0.05$

Table III. Spearman correlation coefficients between changes of incisor position and vermilion height or lip area in lower lip.

	Lo22-29	Lo23-30	Lo24-31	Lo25-32	Lo26-33	Lo27-34	Lo28-35	Lower lip area
H-tU1 (mm)	0.477	0.134	0.070	0.025	0.083	0.196	0.491	0.668**
H-cU1 (mm)	0.492	0.082	0.205	0.305	0.264	0.063	0.498	0.564*
H-tL1 (mm)	0.481	0.296	0.098	-0.203	0.057	0.280	0.679**	0.411
H-cL1 (mm)	0.095	0.321	0.094	-0.071	0.071	0.333	0.322	0.356
U1 to SN (°)	0.055	0.085	-0.016	0.056	-0.038	0.147	0.246	0.364
U1 to FH (°)	0.108	0.036	-0.105	-0.164	-0.128	0.101	0.234	0.507
L1 to Md plane (°)	0.454	0.382	0.453	0.222	0.416	0.293	0.607*	0.186
tU1-Mo (mm)	0.504	-0.064	0.002	0.033	0.029	-0.011	0.451	0.407
tL1-Mi (mm)	0.356	0.200	0.280	-0.109	0.227	0.176	0.468	0.104

*$p < 0.05$, **$p < 0.01$

in vermilion height and lip area which approached control group values. However, post-treatment values were not less than those of the control group. The success of orthodontic treatment is often measured by smile aesthetics and the orthodontic literature has identified factors which contribute to an aesthetic smile. These include the display and condition of the teeth and gingiva, as well as arch size and shape, symmetry and width, skeletal base relationship, and smile arc.[18-22] However, little attention has been paid to the lips and their relation to smile aesthetics. Scott et al. assessed smiling lip attractiveness and reported that thick and medium upper and lower lip vermilions were rated as significantly more attractive than thin vermilions for both lips. This finding is in agreement with McNamara et al.,[7] who speculated that a great deal of current advertising in the mass media is aimed at self-improvement. This included a focus on fuller lips and presented plastic surgery and other cosmetic treatments to enhance lip size. It therefore seems reasonable to recommend that clinicians pay close attention to changes in the vermilion height and lip area in the frontal view, especially when treatment planning involves posterior movements of the anterior teeth. Treatment involving extractions of four premolars can be beneficial in patients with bimaxillary protrusion who want to straighten their profiles.[23] The current results suggest that clinicians could decrease vermilion height toward normal values while simultaneously improving the patients' facial appearance.

Three and four significant correlations were found between the horizontal changes in incisor position and changes in vermilion height and lip area for the upper and lower lips, respectively. McNamara et al.[7] stated that the vertical thickness of the upper lip was significantly related to maxillary incisor protrusion, while the vertical thickness of the lower lip was related to lower anterior facial height. The results of the present study revealed changes in upper vermilion height were weakly related to the horizontal position of the incisors. The poor correlations might be individual response variations in vermilion height or lip area relative to the positional changes of incisors. Further studies considering additional variables which might affect vermilion height would be necessary.

The possibility of a standardised, repeatable, and reproducible method in analysing lip morphology was evaluated. The reliability test showed that on separate occasions, ICC values were greater than or equal to 0.94 for vermilion height and lip area measurements. Moreover, morphological differences were minimal over the three separate examinations. Therefore, the measuring system utilised in this research protocol proved to be reliable, and the vermilion height and lip area appeared to be consistent variables in the evaluation of lip morphology.

The present study demonstrated that post-treatment vermilion height and lip area displayed during a posed smile decreased and approximated control group values after treatment which involved the extraction of four premolars. However, no evidence exists regarding specific vermilion height values preferred by orthodontists and their patients. Generally, orthodontic treatment is planned so that post-treatment cephalometric values lie within the average range provided that physiological function is not impaired. Using cognitive averaging theory, Principe and Langlois[24] speculated that an average face is preferred because it is closer to a central tendency and is more prototypical than a less attractive face. Therefore, an average vermilion height would be desirable as an objective of orthodontic treatment. Additional research which evaluates perceptions and desirable values of vermilion height and lip area is therefore warranted.

Conclusions

1. Pretreatment vermilion height and lip area for the upper and lower lips were significantly larger than those of a control group.
2. Vermilion height and lip area showed significant decreases toward control group values as a result of orthodontic treatment.
3. Few significant correlations were established between the observed horizontal changes in incisor position and the changes in vermilion height or lip area for the upper and lower lips.
4. The present study suggests that a clinical decrease in vermilion height and a simultaneous improvement in facial profile are beneficial in patients with pretreatment bimaxillary protrusion.

Acknowledgment

We thank Dr Ze'ev Davidovitch for his valuable help with this manuscript.

Corresponding author

Dr Hideki Ioi
Section of Orthodontics
Graduate School of Dental Science
Kyushu University
3-1-1 Maidashi, Higashi-ku
Fukuoka 812-8582
Japan

Email: ioi@dent.kyushu-u.ac.jp

References

1. Ferrario VF, Sforza C, Serrao G, Ciusa V, Dellavia C. Growth and aging of facial soft-tissues: a computerized three-dimensional mesh diagram analysis. Clin Anat 2003;16:420-33.
2. Matoula S, Pancherz H. Skeletofacial morphology of attractive and nonattractive faces. Angle Orthod 2006;76:204-10.
3. Van der Geld P, Oosterveld P, Van Heck G, Kuijpers-Jagtman AM. Smile attractiveness. Self-perception and influence on personality. Angle Orthod 2007;77:759-65.
4. Shaw WC, Rees G, Dawe M, Charles CR. The influence of dentofacial appearance on the social attractiveness of young adults. Am J Orthod 1985;87:21-6.
5. Peck S, Peck L. Selected aspects of the art and science of facial esthetics. Semin Orthod 1995;1:5-26.
6. Miller AG. Role of physical attractiveness in impression formation. Psychon Sci 1970;19:241-3.
7. McNamara L, McNamara JA Jr, Ackerman MB, Baccetti T. Hard- and soft-tissue contributions to the esthetics of the posed smile in growing patients seeking orthodontic treatment. Am J Orthod Dentofacial Orthop 2008;133:491-9.
8. Scott CR, Goonewardene MS, Murray K. Influence of lips on the perception of malocclusion. Am J Orthod Dentofacial Orthop 2006;130:152-62.
9. Oliver BM. The Influence of lip thickness and strain on upper lip response retraction. Am J Orthod 1982;82:141-9.
10. Rains MD, Nanda R. Soft-tissue changes associated with maxillary incisor retraction. Am J Orthod 1982;81:481-8.
11. Drobocky OB, Smith RJ. Changes in facial profile during orthodontic treatment with extraction of four first premolars. Am J Orthod Dentofacial Orthop 1989;95:220-30.
12. Bravo LA. Soft tissue facial profile changes after orthodontic treatment with four premolars extracted. Angle Orthod 1994;64:31-42.
13. Kusnoto J, Kusnoto H. The effect of anterior tooth retraction on lip position of orthodontically treated adult Indonesians. Am J Orthod Dentofacial Orthop 2001;120:304-7.
14. Yasutomi H, Ioi H, Nakata S, Nakashima A, Counts AL. Effects of retraction of anterior teeth on horizontal and vertical lip positions in Japanese adults with the bimaxillary dentoalveolar protrusion. Orthod Waves 2006;65:141-7.
15. Hayashida H, Ioi H, Nakata S, Takahashi I, Counts AL. Effects of retraction of anterior teeth and initial soft tissue variables on lip changes in Japanese adults. Eur J Orthod 2010;33:419-26.
16. Ricketts RM. A foundation for cephalometric communication. Am J Orthod 1960;46:330-57.
17. Burstone CJ. Lip posture and its significance in treatment planning. Am J Orthod 1967;53:262-84.
18. Betts NJ, Vanarsdall RL, Barber HD, Higgins-Barber K, Fonseca RJ. Diagnosis and treatment of transverse maxillary deficiency. Int J Adult Orthodon Orthognath Surg 1995;10:75-96.
19. Kokich VG. Esthetics and vertical tooth position: orthodontic possibilities. Compend Contin Educ Dent 1997;18:1225-31.
20. Kokich VO Jr, Kiyak HA, Shapiro PA. Comparing the perception of dentists and lay people to altered dental esthetics. J Esthet Dent 1999;11:311-24.
21. Padwa BL, Kaiser MO, Kaban LB. Occlusal cant in the frontal plane as a reflection of facial asymmetry. J Oral Maxillofac Surg 1997;55:811-6.
22. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. Am J Orthod Dentofacial Orthop 2001;120:98-111.
23. Bills DA, Handelman CS, BeGole EA. Bimaxillary dentoalveolar protrusion: Traits and Orthodontic Correction. Angle Orthod 2005;75:333-9.
24. Principe CP, Langlois JH. Faces differing in attractiveness elicit corresponding affective responses. Cogn Emot 2011;25:140-8.