Original Article

Lip Morphology Changes Following Orthognathic Surgery for Class III Malocclusion

Rafiqul Islam[a]; Toru Kitahara[b]; Lutfun Naher[c]; Atsushi Hara[d]; Shunsuke Nakata[e]

ABSTRACT

Objectives: To test the hypothesis that there is no difference in the morphology of the lips and to determine the degree of improvement in the smile after orthognathic surgery for Class III malocclusion.

Materials and Methods: The sample subjects included 30 adult female patients with dento-skeletal Class III malocclusion and 28 adult female volunteers with normal occlusion. Frontal facial photographs were taken before and after treatment, and 35 landmarks were placed on each tracing made from the frontal facial photograph. Thereafter, the landmarks were digitized into an x and y coordinate system with the subnasal point as the origin. The pretreatment rest and smile conditions were compared with the posttreatment conditions, respectively, using paired *t*-tests. In addition, two sample *t*-tests were used to test for differences between groups.

Results: Both the upper and lower lips in the smiles of the Class III pretreatment group were positioned downward, and the upward movement of the upper lip and commissure points were smaller compared with the control group. When smiling, the horizontal direction of the mouth corners was statistically significantly different between the pretreatment and posttreatment conditions, whereas these were wider in the posttreatment than in the pretreatment conditions. These characteristics of the Class III smile improved after orthognathic treatment, but the differences with the control group remained unchanged immediately after treatment.

Conclusion: The hypothesis is rejected. The soft tissue morphology of patients with dento-skeletal Class III malocclusion shows a significant improvement after orthognathic surgery. (*Angle Orthod* 2010;80:344–353.)

KEY WORDS: Smile esthetics; Soft tissue; Class III Malocclusion; Orthognathic surgery

INTRODUCTION

The objective of orthognathic surgical treatment is to achieve a harmonious relationship between the skeletal, dental, and soft tissue for the improvement of function and facial esthetics. In most cases, the treatment is carried out not only to correct the malocclusion involving the stomatognathic function but also to improve the facial esthetics. Therefore, it is important for the clinician to be able to accurately predict the soft tissue changes resulting from alterations of hard tissue.

Arnett and Bergman,[1] Arnett et al,[2] and Proffit[3] emphasized the importance of esthetics in the frontal view, and orthodontists shift the focus from the sagittal plane to the frontal plane when evaluating their patients and planning and assessing orthodontic treatment.[4] At present, orthodontic patients are concerned with their dynamic appearances during conversation and smiling, in addition to their static appearances.[5]

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The smile is an important form of facial expression. Facial expression and physical attractiveness in general form essential parts of social interaction. Frequently, "smile designing" in orthodontic treatment involves the posed smile, which is known to be repeatable and reproducible.[6–10] Most orthognathic surgical procedures involve functional and often marked esthetic changes. Surgeons generally assume that these changes are beneficial to the patient, both physically and psychologically. However, the soft tissue response after mandibular setback osteotomies is subject to individual variation, and the predictability of soft tissue changes remains an important topic.[11–13]

Cunningham et al[14] and Finlay et al[15] reported that a dento-skeletal Class III malocclusion can result in esthetic deformities and facial asymmetry, with consequent psychological relational distress for the patients. Therefore, success in dento-skeletal Class III surgical treatment now includes achieving both correct functionality and excellent esthetics. Improving normal jaw function and achieving optimal facial esthetics are the goal of a successful orthognathic treatment. The clinical assessment should always include an evaluation of the soft tissue at rest and during function.[16]

The objective of this study is to determine morphologic changes in the lips and to determine the degree of improvement in the smile after orthognathic surgery for Class III malocclusions. Therefore, a statistical evaluation was conducted of the morphologic changes in the lips and soft tissues of the perioral region after orthognathic treatment.

MATERIALS AND METHODS

The sample subjects included 30 adult female Angle Class III patients (age range, 18–32 years; mean, 23.8 ± 4.7 years) with mandibular prognathism who underwent an orthognathic surgical treatment. Surgical treatments were performed with sagittal split ramus osteotomy (SSRO, 17 patients) or intraoral vertical ramus osteotomy (IVRO, 13 patients) without genioplasty surgery, 25 subjects were treated with tooth extraction, and 5 subjects were treated without extraction. All of the patients were treated at the Kyushu University Hospital Orthodontic Clinic from 2001 to 2007. The control group consisted of 28 adult female volunteers (age range, 20–30 years; mean, 25 years) with Angle Class I normal occlusion, with both an overbite and overjet of 1.5 mm. This study was carried out in accordance with the regulations of the Ethical Committee of the Faculty of Dentistry of Kyushu University, and informed consent was obtained from each subject before data collection.

The photographic procedure was described previously.[17] The frontal photographs of the patients were taken at the start of the surgical orthodontic treatment and immediately after surgical treatment in a normal seated posture with the head fixed by ear rods, at a distance of 1.5 m between the camera lens and the subject at rest in a posed smiling condition. The subjects wore no facial cosmetics/makeup. The subject's head was positioned so that the Frankfort horizontal plane was parallel to the floor, and the midsagittal plane of the head was aligned with the center of the camera lens.

Criteria for inclusion in the study were the availability of a standardized facial photograph of adequate quality and resolution taken according to a strict data collection protocol. Frontal photographs of the control group were taken in the same manner as for the patients of Class III group. Each subject was coached and asked to achieve the same lip position at least twice in succession before a photograph was taken. During the posed smile, subjects kept their molars lightly close, and the perioral soft tissues and mandibular posture were unstrained at rest. The frontal photographs were printed on A4 size paper, and tracings were made and 35 facial landmarks were added using tracing paper (Figure 1). This study fixed the subnasal (Sn) point as the origin. A line was drawn through the center of the eyeball. A horizontal plane was drawn through the Sn point parallel to the eyeball distance line, and this plane was designated as the x axis. A vertical line was drawn perpendicular to the x axis through the Sn point, which was designated as the y axis. Next, another line was drawn parallel to the x axis through the lower border of the chin and divided into two equal halves. Then, two vertical lines were drawn through the right and left superior vermilion point (numbered 9, 11 in Figure 1). From the superior vermilion point of the lip to the corners of the mouth, both the right (numbered 6 in Figure 1) and left (numbered 14 in Figure 1) sides were divided into three equal parts.

Every landmark was digitized into x- and y-coordinate values, and a statistical analysis was performed using these values. The landmarks numbered 6–14 and 15–21 in Figure 1 indicated the upper lip area, and those numbered 22–28 and 29–35 indicated the lower lip area. Differences in facial size were examined by measuring the distance between the center of the right and left eyeballs of the Class III and control groups. There were no statistically significant differences between the two groups with different facial patterns. The pretreatment rest and smile conditions were compared with the posttreatment conditions using paired *t*-tests and the Microsoft Excel software program (Microsoft Corporation, Redmond, WA). In

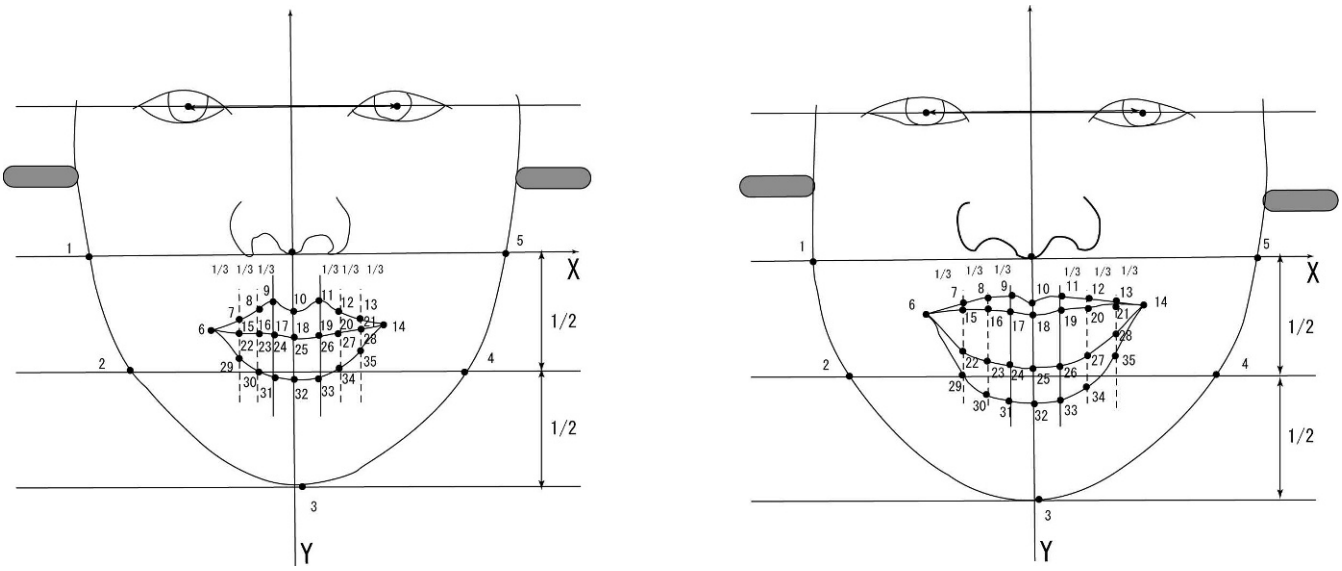

Figure 1. 1. Zygion (right) 3. Soft tissue Pogonion 5. Zygion (left) 6. Commissure (right) 9. Christa Philtri (right) 10.Vermillion Superior 11. Christa Philtri (left) 14. Commissure (left) 32. Vermillion Inferior 6~14, 15~21 Upper Lip 22~28,29~35 Lower lip.

addition, two sample *t*-tests were used to test for differences between the patients in the Class III group and the control group. Differences with a value of $P <$ .05 were considered statistically significant.

Error of Methods

Systematic and accidental errors of analysis were evaluated by duplicate determinations of 25 photographs selected at random. Selected photographs were retraced and recalculated by the same person about one month after the initial data were recorded. The error variance was calculated according to the Dahlberg formula,[18] and systematic error between the first and second measurements was calculated using the paired *t*-test. Most of the accidental errors were smaller than 1 mm, and the errors did not exceed 0.59 mm. In addition, coefficients of reliability values were high, thus indicating the sufficient accuracy of the measurements (Table 1).

The same facial photograph was traced 30 times to evaluate the intraexaminer error. The means of the errors in the x- and y-coordinate values, expressed by the coefficient of variation, were .05 and .01, respectively.

RESULTS

Lip Morphology at Rest and on Smiling for the Normal Occlusion in Control Subjects

Table 2 shows the control group upper lip area to be smaller than the lower lip area at rest, and the upper lip area decreased and the lower lip area increased when smiling. The upper and lower lip ratio (U/L ratio) was 80% at rest and 40% on smiling.

Table 3 shows the landmark coordinates and Figure 2 displays the lip morphology of the control group at rest and on smiling. On smiling, both the mouth corners moved to a superior position. The upper lip moved to a superior position, and the lower lip and facial outline moved to an inferior position. The movement of the mouth corners and the upper lip was remarkable laterally and superiorly.

Lip Morphology at Rest and on Smiling for Class III Pretreatment

Table 2 shows that, in the pretreatment group, both lip areas were significantly larger than those of the control group at rest and while smiling. The U/L ratio was 80% at rest and 60% on smiling.

Landmark coordinates between the Class III pretreatment and the control group (Table 4, Figure 3) in rest show few significant differences in horizontal direction, but there were clear significant differences in the vertical direction ($P <$ .05, $P <$ .01), where the facial outline is placed in an inferior position ($P <$ .01). When smiling, the Class III pretreatment group shows significant ($P <$ .05, $P <$ .01, $P <$ .001) differences in both the vertical and horizontal direction, where the mouth corners, lips, and facial outline were moved toward an inferior position compared with those of the control group.

Lip Morphology at Rest and on Smiling for Class III Posttreatment

Table 2 shows that, in the posttreatment group, both lips area in the rest and smiling positions were larger than those of the control group. But the lower lip at rest

Table 1. Error of the Merthod Assessed From Duplicate Tracings of 25 Photographs

Point		Dahlberg's Calculation	Houston's Coefficient of Reliability	Systematic Error: *t*-test (*P* Value)	Dahlberg's Calculation	Houston's Coefficient of Reliability	Systematic Error: *t*-test (*P* Value)
Outline	1	0.485	0.995	0.00005*	–	–	–
	2	0.499	0.994	0.660	0.492	0.962	0.284
	3	–	–	–	0.504	0.991	0.270
	4	0.594	0.994	0.004*	0.496	0.966	0.185
	5	0.448	0.987	0.927	–	–	–
Upper lip	6	0.356	0.991	0.311	0.396	0.995	0.118
	7	0.349	0.987	0.302	0.459	0.989	0.811
	8	0.263	0.993	0.876	0.448	0.983	0.580
	9	0.286	0.994	0.810	0.564	0.974	0.104
	10	–	–	–	0.458	0.981	0.451
	11	0.365	0.993	0.202	0.456	0.984	0.057
	12	0.398	0.988	0.918	0.522	0.979	0.854
	13	0.369	0.989	0.213	0.462	0.991	0.014*
	14	0.193	0.998	0.355	0.488	0.994	0.581
	15	0.305	0.990	0.928	0.435	0.993	0.188
	16	0.247	0.994	0.616	0.435	0.990	0.211
	17	0.294	0.993	0.744	0.414	0.989	0.127
	18	–	–	–	0.358	0.991	0.116
	19	0.286	0.996	0.128	0.489	0.987	0.021*
	20	0.378	0.989	0.585	0.410	0.992	0.036*
	21	0.335	0.990	0.712	0.395	0.994	0.108
Lower lip	22	0.278	0.992	0.083	0.480	0.994	0.136
	23	0.257	0.994	0.957	0.311	0.997	0.627
	24	0.223	0.996	0.666	0.409	0.994	0.065
	25	–	–	–	0.358	0.995	0.212
	26	0.361	0.994	0.077	0.460	0.995	0.953
	27	0.384	0.989	0.694	0.565	0.990	0.526
	28	0.305	0.992	0.364	0.460	0.995	1.000
	29	0.280	0.992	0.961	0.597	0.992	0.963
	30	0.315	0.990	0.271	0.484	0.994	0.116
	31	0.234	0.996	0.443	0.390	0.995	0.140
	32	–	–	–	0.495	0.992	0.007*
	33	0.414	0.995	0.0004*	0.417	0.994	0.138
	34	0.442	0.985	0.533	0.532	0.993	0.239
	35	0.392	0.987	0.305	0.528	0.994	0.247

* $P < .05$.

and the upper and lower lip during smiling were significantly larger. The U/L ratio was 70% at rest and 50% on smiling. The lip ratio of the Class III posttreatment group in smiling was the same as that of the control group. This indicated that the orthognathic treatment improved upper and lower lip balance.

Table 5 and Figure 4 illustrate that there was only a slight difference between the pretreatment and post-treatment at-rest conditions. The facial outlines were positioned significantly superior to those in the pretreatment ($P < .001$). When smiling, the mouth corners ($P < .001$) and upper and lower lips ($P < .05$, $P < .01$, $P < .001$) moved significantly laterally and superiorly. The facial outline showed significant difference ($P < .05$) only in the vertical direction, where the lower part of the face decreased. This indicated that

Table 2. Area measurements

		Control		Pretreatment		Posttreatment	
Rest							
Upper lip	mm^2	325.9	58.9	353.5	67.3*	362.3	69.4*
Lower lip	mm^2	432.5	66.4	471.0	76.3*	498.2	61.9***
Ratio of upper to lower lip		0.8	0.1	0.8	0.1	0.7	0.1
Smile							
Upper lip	mm^2	217.5	71.6	314.1	64.8***	303.6	63.7***
Lower lip	mm^2	513.1	93.8	550.4	72.4*	583.4	61.6***
Ratio of upper to lower lip		0.4	0.1	0.6	0.1***	0.5	0.1**

* Indicated significant different in Class III group from control group.* $P < .05$; ** $P < .01$;*** $P < .001$.

Table 3. Landmark coordinates and measurements in the control group

		Rest		Smile	
		X	Y	X	Y
Point		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Outline, mm	1	−77.1 ± 4.1	0.0 ± 0.0	−79.4 ± 3.8	0.0 ± 0.0
	2	−61.3 ± 3.9	−38.0 ± 2.7	v61.3 ± 3.8	−39.4 ± 2.3
	3	0.3 ± 1.0	−75.8 ± 4.9	0.3 ± 1.7	−79.0 ± 4.4
	4	61.0 ± 3.9	−38.1 ± 2.6	61.2 ± 3.5	−39.6 ± 2.4
	5	76.4 ± 4.0	0.0 ± 0.0	78.9 ± 3.8	0.0 ± 0.0
Upper lip, mm	6	−28.2 ± 2.2	−25.2 ± 3.3	−37.5 ± 3.6	−15.1 ± 3.6
	7	−21.4 ± 1.8	−21.3 ± 2.9	−29.3 ± 3.0	−12.7 ± 2.8
	8	−14.7 ± 1.7	−17.9 ± 2.6	−20.9 ± 3.2	−11.3 ± 2.2
	9	−7.5 ± 2.3	−15.3 ± 2.4	−12.4 ± 3.9	−10.6 ± 2.1
	10	0.0 ± 0.0	−17.3 ± 2.4	0.0 ± 0.0	−11.4 ± 2.2
	11	8.0 ± 1.8	−15.5 ± 2.1	13.5 ± 3.1	−10.8 ± 2.3
	12	14.6 ± 1.8	−17.7 ± 2.2	21.2 ± 2.4	−11.3 ± 2.5
	13	21.6 ± 2.2	−21.2 ± 2.8	29.4 ± 2.8	−12.6 ± 2.8
	14	28.3 ± 3.0	−24.3 ± 3.3	37.0 ± 3.3	−14.0 ± 3.7
	15	−21.5 ± 1.8	−25.1 ± 2.9	−29.3 ± 3.0	−14.5 ± 3.1
	16	−14.7 ± 1.8	−24.9 ± 2.7	−20.9 ± 3.2	−14.6 ± 2.7
	17	−7.5 ± 2.2	−24.9 ± 2.6	−12.4 ± 3.9	−14.7 ± 2.5
	18	0.0 ± 0.0	−25.1 ± 2.3	0.0 ± 0.0	−15.8 ± 2.1
	19	8.1 ± 1.8	−24.8 ± 2.4	13.5 ± 3.1	−14.8 ± 2.3
	20	14.7 ± 1.8	−24.7 ± 2.5	21.2 ± 2.5	−14.1 ± 2.6
	21	21.4 ± 2.2	−24.6 ± 2.8	29.4 ± 2.8	−14.2 ± 3.0
Lower lip, mm	22	−21.5 ± 1.8	−25.3 ± 3.1	−29.2 ± 3.0	−21.8 ± 3.5
	23	−14.7 ± 1.8	−25.3 ± 2.9	−20.9 ± 3.1	−27.1 ± 3.6
	24	−7.6 ± 2.2	−25.3 ± 2.8	−12.5 ± 3.8	−30.3 ± 3.9
	25	0.0 ± 0.0	−25.6 ± 2.5	0.0 ± 0.0	−32.0 ± 4.0
	26	8.1 ± 1.9	−25.3 ± 2.6	13.4 ± 2.9	−30.2 ± 3.9
	27	14.6 ± 2.0	−25.1 ± 2.7	21.2 ± 2.5	−27.2 ± 3.6
	28	21.5 ± 2.2	−24.9 ± 2.8	29.3 ± 2.8	−21.7 ± 3.3
	29	−21.6 ± 1.7	−29.9 ± 3.6	−29.3 ± 3.0	−26.1 ± 4.2
	30	−14.7 ± 1.5	−33.8 ± 4.0	−21.0 ± 3.0	−34.4 ± 4.2
	31	−7.6 ± 2.1	−36.7 ± 3.9	−12.5 ± 3.8	−39.5 ± 4.3
	32	0.0 ± 0.0	−37.8 ± 3.5	0.0 ± 0.0	−42.3 ± 4.4
	33	7.9 ± 1.9	−37.1 ± 3.6	13.5 ± 3.0	−39.7 ± 4.5
	34	14.7 ± 2.0	−34.8 ± 4.0	21.3 ± 2.6	−35.2 ± 4.0
	35	21.5 ± 2.4	−30.4 ± 3.9	29.4 ± 2.9	−27.1 ± 4.1

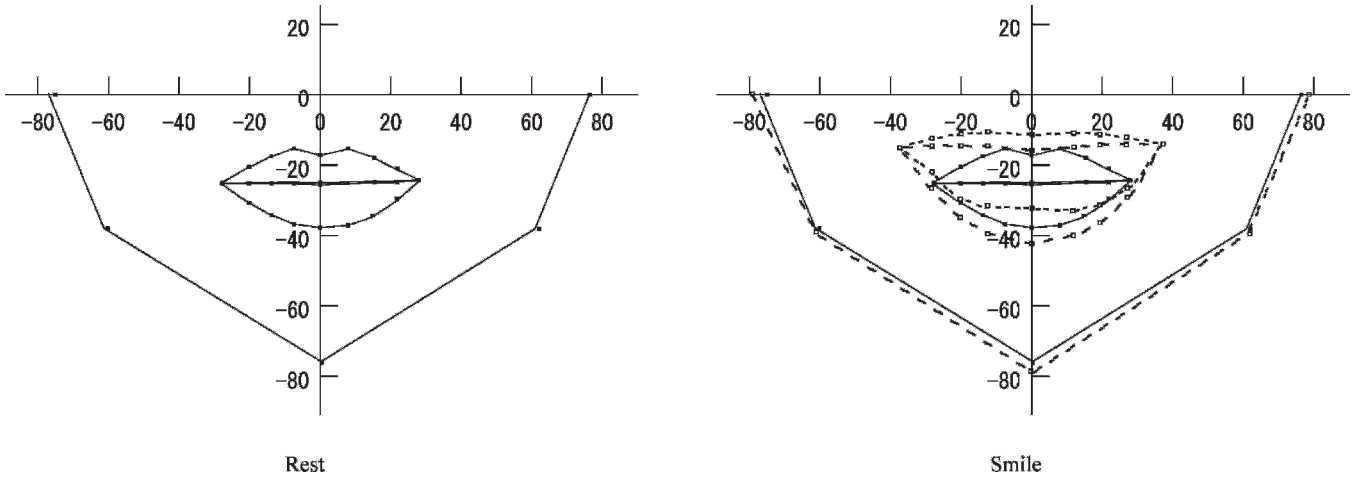

Figure 2. Mean value of landmarks for the control group rest (black) and smile (dotted).

Table 4. Landmark coordinates and measurements in the class III pretreatment group[a]

		Rest		Smile	
		X	Y	X	Y
Point		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Outline, mm	1	−77.7 ± 5.2	0.2 ± 0.4**	−79.4 ± 4.6	0.2 ± 0.5*
	2	−61.8 ± 6.4	−39.8 ± 2.7**	−63.1 ± 6.1	−41.3 ± 2.8**
	3	0.0 ± 0.0	−79.8 ± 5.3**	0.0 ± 0.0	−82.4 ± 5.5**
	4	62.2 ± 5.9	−40.1 ± 2.6**	62.9 ± 6.2	−41.4 ± 2.8**
	5	78.2 ± 4.5	−0.1 ± 0.4	79.1 ± 4.7	−0.1 ± 0.5
Upper lip, mm	6	−28.1 ± 3.0	−24.8 ± 3.1	−33.5 ± 3.6***	−19.4 ± 5.9***
	7	−21.0 ± 2.4	−20.0 ± 2.7	−25.5 ± 3.1***	−15.3 ± 4.2**
	8	−13.9 ± 1.9	−16.3 ± 2.7	−18.0 ± 3.2***	−12.7 ± 3.4*
	9	−6.5 ± 1.9	−14.0 ± 2.7	−10.2 ± 3.7*	−11.1 ± 3.2
	10	0.0 ± 0.0	−15.3 ± 2.6	0.0 ± 0.0	−12.1 ± 3.2
	11	7.4 ± 1.7	−13.9 ± 2.5*	11.5 ± 4.4*	−11.0 ± 3.2
	12	14.3 ± 2.0*	−16.2 ± 2.8*	18.7 ± 3.7**	−12.6 ± 3.7
	13	21.6 ± 2.4*	−20.2 ± 3.1*	25.9 ± 3.4***	−15.2 ± 4.7**
	14	28.7 ± 2.9	−24.5 ± 3.8**	33.5 ± 3.9***	−19.2 ± 6.4***
	15	−21.0 ± 2.4	−24.4 ± 2.9**	−25.5 ± 3.2***	−18.9 ± 4.7***
	16	−13.8 ± 2.0	−24.0 ± 2.7*	−18.0 ± 3.3***	−18.2 ± 4.0***
	17	−6.6 ± 1.9	−23.8 ± 2.6	−10.2 ± 3.6*	−17.8 ± 3.6***
	18	0.0 ± 0.0	−24.1 ± 2.8	0.0 ± 0.0	−18.3 ± 3.5***
	19	7.5 ± 1.7	−24.0 ± 2.8	11.5 ± 4.3*	−17.8 ± 3.9***
	20	14.3 ± 2.0*	−24.0 ± 2.9	18.7 ± 3.6**	−18.3 ± 4.5***
	21	21.6 ± 2.4*	−24.7 ± 3.3	25.9 ± 3.4***	−19.0 ± 5.3***
Lower lip, mm	22	−21.0 ± 2.4	−24.3 ± 2.9	−25.5 ± 3.1***	−25.4 ± 5.5**
	23	−13.8 ± 2.0	−24.0 ± 2.7	−18.0 ± 3.2***	−29.1 ± 5.3*
	24	−6.6 ± 1.8	−23.9 ± 2.6	−10.2 ± 3.7*	−31.3 ± 5.1
	25	0.0 ± 0.0	−24.1 ± 2.7	0.0 ± 0.0	−32.3 ± 4.8
	26	7.4 ± 1.7	−24.0 ± 2.8	11.5 ± 4.4*	−31.0 ± 5.1
	27	14.3 ± 2.0*	−24.0 ± 3.0	18.7 ± 3.7**	−29.1 ± 5.6
	28	21.5 ± 2.3*	−24.6 ± 3.2	25.9 ± 3.4***	−25.4 ± 6.6**
	29	−21.0 ± 2.4	−30.5 ± 3.3	−25.4 ± 3.2***	−33.6 ± 6.3***
	30	−13.8 ± 1.9	−34.6 ± 3.4	−17.9 ± 3.2***	−39.3 ± 5.8***
	31	−6.6 ± 1.8	−36.5 ± 3.3	−10.2 ± 3.7*	−42.2 ± 5.2
	32	0.0 ± 0.0	−37.2 ± 3.2	0.0 ± 0.0	−43.5 ± 4.7
	33	7.4 ± 1.6	−36.5 ± 3.3	11.6 ± 4.4*	−41.6 ± 5.4
	34	14.2 ± 1.9*	−34.8 ± 3.2	18.7 ± 3.7**	−38.6 ± 6.1**
	35	21.6 ± 2.3	−31.1 ± 3.5	25.9 ± 3.4***	−33.1 ± 7.2***

[a] Indicates significant different in the class III pretreatment group from the control group; *$P < .05$; **$P < .01$; ***$P < .001$.

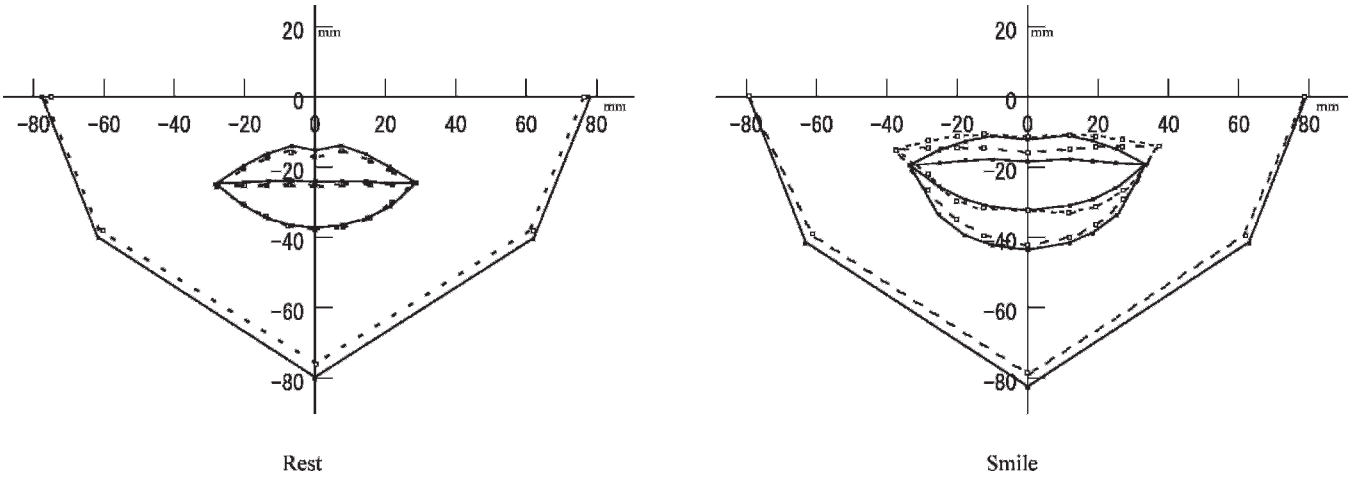

Figure 3. Mean value of landmarks for the Class III pretreatment (black) and control group (dotted).

Table 5. Landmark coordinates and measurements in class III posttreatment group

		X	Y	X	Y
Point		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Outline, mm	1	−76.9 ± 5.4	0.2 ± 0.4**	−78.9 ± 5.1	0.1 ± 0.5
	2	−61.3 ± 6.2	−38.7 ± 2.5##	−62.8 ± 6.7	−40.4 ± 2.5#
	3	0.0 ± 0.0*	−77.7 ± 5.2##	0.0 ± 0.1	−80.7 ± 4.5#
	4	61.4 ± 5.7	−38.9 ± 2.5##	63.4 ± 5.8*	−40.5 ± 2.5#
	5	76.9 ± 5.0##	−0.1 ± 0.5	79.5 ± 5.0	0.1 ± 0.5
Upper lip, mm	6	−29.3 ± 2.4## *	−24.8 ± 3.3	−36.4 ± 2.8###	−16.6 ± 4.6###
	7	−21.7 ± 2.0#	−20.5 ± 3.0	−27.2 ± 2.8###**	−13.8 ± 3.5##
	8	−14.3 ± 1.6	−17.0 ± 2.8#	−19.0 ± 3.2#*	−11.9 ± 3.0#
	9	−7.1 ± 1.4	−14.9 ± 2.7##	−10.7 ± 3.8*	−10.8 ± 2.9
	10	0.0 ± 0.1	−16.0 ± 3.1#*	0.0 ± 0.1	−11.8 ± 2.7
	11	7.4 ± 1.5	−14.7 ± 2.8##	12.9 ± 3.8##	−10.6 ± 2.9
	12	14.5 ± 2.0	−16.8 ± 3.0#	20.6 ± 3.2###	−11.8 ± 3.3#
	13	21.9 ± 2.2	−20.6 ± 3.1	28.3 ± 2.9###	−13.8 ± 3.8#
	14	29.3 ± 3.0#	−24.2 ± 3.1	36.3 ± 3.0###	−16.0 ± 4.6###*
	15	−21.7 ± 2.0 #	−24.7 ± 2.9	−27.2 ± 2.9##**	−16.7 ± 3.7##**
	16	−14.4 ± 1.7	−24.6 ± 2.4	−19.0 ± 3.2#*	−16.7 ± 3.3#**
	17	−7.0 ± 1.4	−24.7 ± 2.2#	−10.7 ± 3.7*	−16.7 ± 3.0#**
	18	0.0 ± 0.0	−24.9 ± 2.2#	0.0 ± 0.1	−17.5 ± 3.0#**
	19	7.3 ± 1.5 *	−24.7 ± 2.3	12.9 ± 3.7#	−16.8 ± 3.3#**
	20	14.5 ± 1.9	−24.6 ± 2.4	20.6 ± 3.2###	−16.7 ± 3.4##***
	21	22.0 ± 2.2	−24.7 ± 2.5	28.2 ± 2.9###	−16.8 ± 3.7###**
Lower lip, mm	22	−21.7 ± 2.0 #	−24.8 ± 2.8	−27.1 ± 2.8**	−24.1 ± 4.2*
	23	−14.4 ± 1.6	−24.8 ± 2.5	−19.0 ± 3.1#*	−28.8 ± 3.9*
	24	−7.0 ± 1.4	−24.8 ± 2.2#	−10.7 ± 3.7*	−31.3 ± 4.1
	25	0.0 ± 0.0	−25.0 ± 2.3#	0.0 ± 0.0	−32.4 ± 3.7
	26	7.3 ± 1.4***	−24.8 ± 2.4#	13.0 ± 3.8##	−30.7 ± 4.2
	27	14.5 ± 1.9	−24.8 ± 2.4	20.6 ± 3.2###	−28.4 ± 4.3
	28	22.0 ± 2.2	−24.8 ± 2.5	28.3 ± 2.9###	−23.9 ± 4.3#*
	29	−21.7 ± 2.1#	−31.2 ± 2.8	−27.2 ± 2.8###**	−31.8 ± 5.5#***
	30	−14.4 ± 1.6#	−35.4 ± 2.4*	−19.0 ± 3.1#**	−38.3 ± 4.7***
	31	−7.2 ± 1.4	−37.5 ± 2.4#	−10.6 ± 3.7*	−42.0 ± 4.0*
	32	0.0 ± 0.0	−38.2 ± 2.4#	0.0 ± 0.1	−43.8 ± 3.3
	33	7.3 ± 1.4	−37.5 ± 2. #	13.0 ± 3.8 ##	−41.0 ± 4.1
	34	14.4 ± 1.9	−35.5 ± 2.5	20.6 ± 3.3 ###	−37.4 ± 4.5*
	35	22.1 ± 2.0	−31.2 ± 2.7	28.3 ± 3.0 ###	−30.8 ± 5.0 # ***

# Indicates significant different in the Class III posttreatment group from pretreatment group. # $P < .05$; ## $P < .01$; ### $P < .001$.
* Indicates significant different in the Class III posttreatment group from the control group. * $P < .05$; ** $P < .01$;*** $P < .001$.

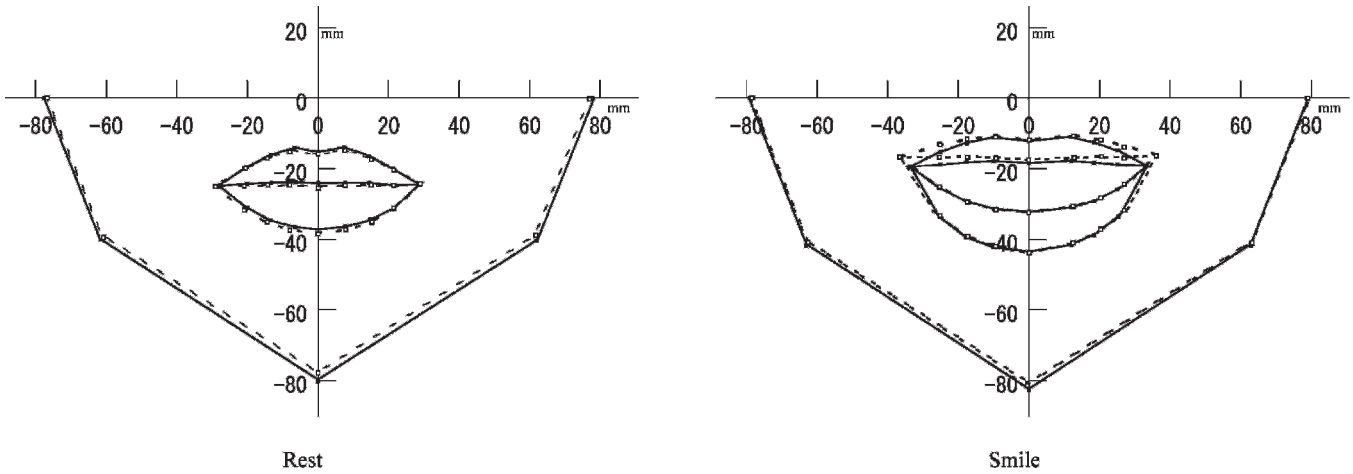

Figure 4. Mean value of landmarks for the Class III pretreatment (black) and posttreatment smile (dotted).

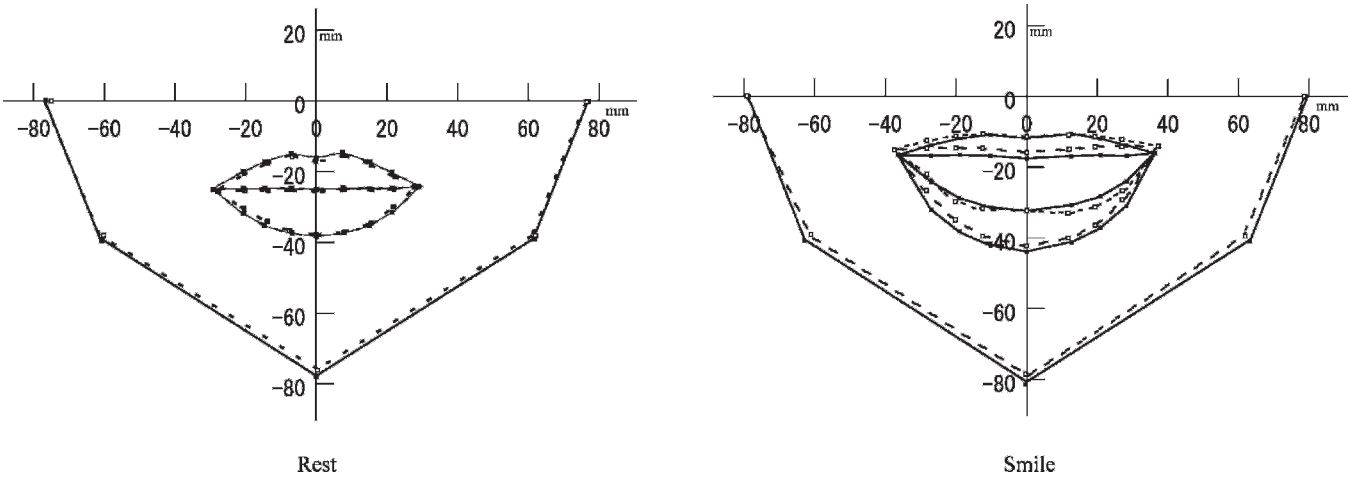

Figure 5. Mean value of landmarks for the Class III posttreatment (black) and control group (dotted).

the mandible became shorter after orthognathic treatment.

Table 5 and Figure 5 show the difference between the posttreatment and the control groups. At rest, there was no significant difference either horizontally or vertically. When smiling, the posttreatment group showed that both lips and the lower facial outline were positioned significantly ($P < .05$, $P < .01$) inferiorly to those of the control group.

Fewer significant differences between the Class III posttreatment and the control group were observed in the horizontal direction than in the vertical direction after the treatment. This shows that, when smiling, both the upper and lower lips and the mouth corners of the Class III group changed to almost the same location as the control group.

DISCUSSION

The smile is even more important because of its increasing role in the esthetic ideal. A bright smile is associated with intelligence, sympathy, extroversion, and attractiveness. Moreover, in studies with photographs, higher intellectual and social abilities were attributed to people with esthetically pleasing smiles, who were also judged to be more attractive than the same people with modified lower-level esthetic smiles. Because the mouth is the center of communication in the face, the esthetic appearance of the oral region during smiling is a conspicuous part of facial attractiveness. Lip position and the amount of tooth and gingival displayed during smiling and speech are important diagnostic criteria in orthodontics, dentofacial surgery, and esthetic dentistry.

Many studies have reported[19–22] various results in evaluating facial soft tissue changes after orthognathic surgery. A lateral cephalograph has been the conventional tool used to evaluate the profile changes, especially in hard tissue, but it is not the best imaging technique for soft tissues. It may be inaccurate because of the poor image and inherent errors. Soft tissue may not be observed clearly because of the low resolution of the radiographic image and the superimposition of bony structures on soft tissues, thus resulting in landmark digitization errors.[22] Furthermore, a lateral cephalograph is costly and radiation is also required. On the other hand, the standard frontal photograph technique is easy, repeatable, and cost-effective.

Regarding standardized photography of the facial profile, Claman et al[23] stated that an identical lens focal distance, constant distance from the camera to the object, and a camera fixed to a stand are needed. In addition, the line from the center of the lens to the eye of the subject should be parallel to the horizontal plane. In the current study, the camera was fixed to a stand, and the distance between the camera lens and the subject was fixed at 1.5 m.

Holberg et al[24] reported a high displacement measured around the corners of the mouth, the lower lip, cheek, and nasal wings. Therefore, it is important to assess the soft tissue changes in the smile, especially in the lip area after orthodontic treatment, and it is essential for achieving a successful orthodontic treatment goal. In general, posterior repositioning of the mandible by ramus procedures yields a 90% soft tissue change at the chin, labiomental fold, and lower lip relative to the anteroposterior bone change and in contrast with the 20% posterior movement of the upper lip.[17,25] This study quantitatively evaluated the morphologic changes in the lips and determined the degree of improvement in the smile after orthognathic surgery for Class III malocclusion using A-P facial photographs.

In Class III pretreatment, the upper lip area and the upper and lower lip ratio are larger than in control

subjects' smiles. It may be attributable to the protrusive mandible in the Class III malocclusion, which makes the lower lip loose and everted. A reverse overbite may also evert the lower lip. It is possible that the abnormal overjet and overbite may increase the lip area, thus resulting in a loss of upper and lower lip balance.[26] After treatment, the angle of the mouth corners in the smile became wide and close to that of the control subjects. In addition, in the posttreatment smile both mouth corners are wider than those in the pretreatment smile. Ishikawa et al[27] performed a three-dimensional dynamic analysis of the smile in Class III malocclusion and reported that both lips showed a larger downward displacement. Cummins et al[28] showed that in the posttreatment assessment of Class II division 1 malocclusion, the mouth corners were wider than before treatment. However, the present study shows that the posttreatment smiles of Class III malocclusion were not the same as the standard smile using the subjects with normal occlusion, and they were similar to the result in the previous study for Class II malocclusions.[17]

The overall analysis of the study indicates that improvements were achieved in the features of the smile for the patients who have undergone orthognathic treatment for Class III malocclusion. After treatment, the lips and both mouth corners in the Class III subjects were close to those seen in the smiles of control subjects. This study, therefore, can be used in future research regarding soft tissue analysis. This method of analysis represents a new, dynamic approach to assessing the soft tissue changes associated with orthognathic treatment.

CONCLUSIONS

- In the smiles of the Class III pretreatment group, both the upper and lower lips moved to an inferior position, and the upward movement of the upper lip and mouth corners was smaller compared with those of the control group.
- The soft tissue morphology shows a significant improvement after orthognathic surgery for Class III malocclusion.

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