*Original Article*

# Lip Morphological Changes in Orthodontic Treatment

***Class II division 1 Malocclusion and Normal Occlusion at Rest and on Smiling***

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**ABSTRACT**

**Objective:** To evaluate the morphological changes in the lips and to determine the degree of improvement in the smile after orthodontic treatment for Class II division 1 malocclusion.

**Materials and Methods:** The sample subjects were divided into two groups: a group that consisted of 20 adult female patients with Angle Class II division 1 malocclusion and a control group that consisted of 28 adult female volunteers with normal occlusion. Frontal photographs were taken before and after orthodontic treatment, and 35 landmarks were placed on each tracing made from the photograph. Thereafter, landmarks were digitized into an x- and y-coordinate system with the subnasal point as the origin. The comparisons between pretreatment and posttreatment at rest and on smiling, and the comparisons between Class II division 1 and control group were made using Student's *t*-test.

**Results:** Both the upper and lower lips in the smile of patients in the Class II division 1 pretreatment group were positioned downward, and the upward movement of the upper lip and mouth corners was smaller in comparison with the control group. These characteristics of the Class II smile improved after orthodontic treatment, but the differences with the control group remained unchanged immediately after treatment.

**Conclusion**: The soft tissue morphology shows a relative improvement after orthodontic treatment.

**KEY WORDS:** Lip position; Smile; Soft tissue

## INTRODUCTION

In the field of orthodontic treatment, the improvement of the facial esthetics is considered an intellectual study and is the cornerstone of orthodontics. The smile emanates from the facial movements and is the clear manifestation of the facial structures. One of the most important opportunities of orthodontic treatment is to improve the esthetic and morphological harmony as well as the function of the oral and maxillofacial region. For this reason, we have studied the statistical evaluation of the morphological changes in the lips and soft tissues of the perioral region after orthodontic treatment.

Recently, the relationship among such factors as occlusion, function, and esthetics is emerging. What kind of harmony occurs as each part of the hard and soft tissues changes is one of the interesting topics in orthodontics.

The appearance of the smile is of substantial clinical importance[1–3] and one of the key criteria by which patients judge the success of their own orthodontic treatment. This is why the smile is an integral part of the diagnosis and planning, and a key point in the treatment objectives[4] in orthodontic care. The main effort of contemporary evidence-based orthodontics is to create a clear-cut treatment paradigm[5] out of diffuse subjective, scientific, and anecdotal esthetic values that quite often differ between the patient and the orthodontist. By placing a grid over the smile photo-

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graph, Hulsey[6] measured a sample of orthodontically treated patients and compared them with a sample of untreated orthodontic patients with normal occlusion. He concluded that a key component present in an esthetic smile was a consonance between the arcs formed between the incisal edges of the maxillary anterior teeth and the curvature of the lower lip.

Moseling and Woods[7] reported no significant differences in the changes in the depth of the upper or lower lip curves associated with either premolar extraction or nonextraction treatment. During smile animation, the landmarks[8] on the mid and lower facial regions (infraorbital, zygomatic, lateroalar, nasolabial, commissure, upper lip, lower lip, and chin) showed the greatest movement.

Prior to orthodontic treatment, the clinical assessment should always include an evaluation of the soft tissue at rest and during function because the morphology of the soft tissues themselves is a major factor in determining the overall facial profile.[9] Usually, the patients undergoing orthodontic surgery and cleft lip surgery have been assessed at rest, but it is now recognized that it is also important to evaluate their expressions both before and after treatment.[8] At present, there is little reliable information regarding how much of the change in the facial expression is due to orthodontic treatment.

The purpose of this study was to evaluate the morphological changes in the lips and to determine the degree of improvement in the smile after orthodontic treatment of patients with Class II division 1 malocclusion.

## MATERIALS AND METHODS

The subjects were divided into two groups. The patient group consisted of 20 women (age range 18–35 years; mean 22.2 years) with Angle Class II division 1 malocclusion and a mean overjet of 7.4 mm and overbite of 3.8 mm. Seventeen subjects were treated with extraction of the premolars, and three subjects were treated without extraction. All patients came to the Kyushu University Hospital, Orthodontic Clinic from 1996 to 2003. 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 overbite and overjet of 1.5 mm. All subjects in the volunteer group were healthy and free from any craniofacial anomalies. 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 prior to data collection.

The frontal photographs were taken 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. The subjects wore no facial cosmetics/make-up. 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. The criteria for inclusion in the study was the availability of a standardized facial photograph of adequate quality and resolution, taken according to a strict data collection protocol.

The frontal photographs of the patients in the Class II group were taken before and immediately after orthodontic treatment, in the same manner as for the control subjects. Each subject was coached and asked to achieve the same lip position at least twice in succession before a photograph was taken. While photographed, they kept their teeth slightly apart, and the perioral soft tissues and mandibular posture were unstrained at rest. At maximum smile, the teeth were closed. 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 the x-axis to the lower border of the chin was divided into two equal halves. Then, two vertical lines were drawn through the right and left superior vermilion point (9, 11). From the superior vermilion point of the lip to the corners of the mouth both the right (6) and left (14) 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 indicated the upper lip area, and 22–28 and 29–35 indicated the lower lip area. We examined the differences in the facial size by measuring the distance between the center of the right and left eyeballs of the Class II and control groups. There were no significant differences in the facial size between the two groups. The pretreatment rest and smile conditions were compared with the posttreatment conditions using paired *t*-tests within the Microsoft Excel software program (Microsoft Corporation, Redmond, Wash). In addition, two sample *t*-tests were used to test for differences between the patients in the Class II group and the control group. Differences with a $P < .05$ were considered statistically significant.

### Error of the Method

The error of the method was evaluated by measuring the same facial photograph 30 times by the same

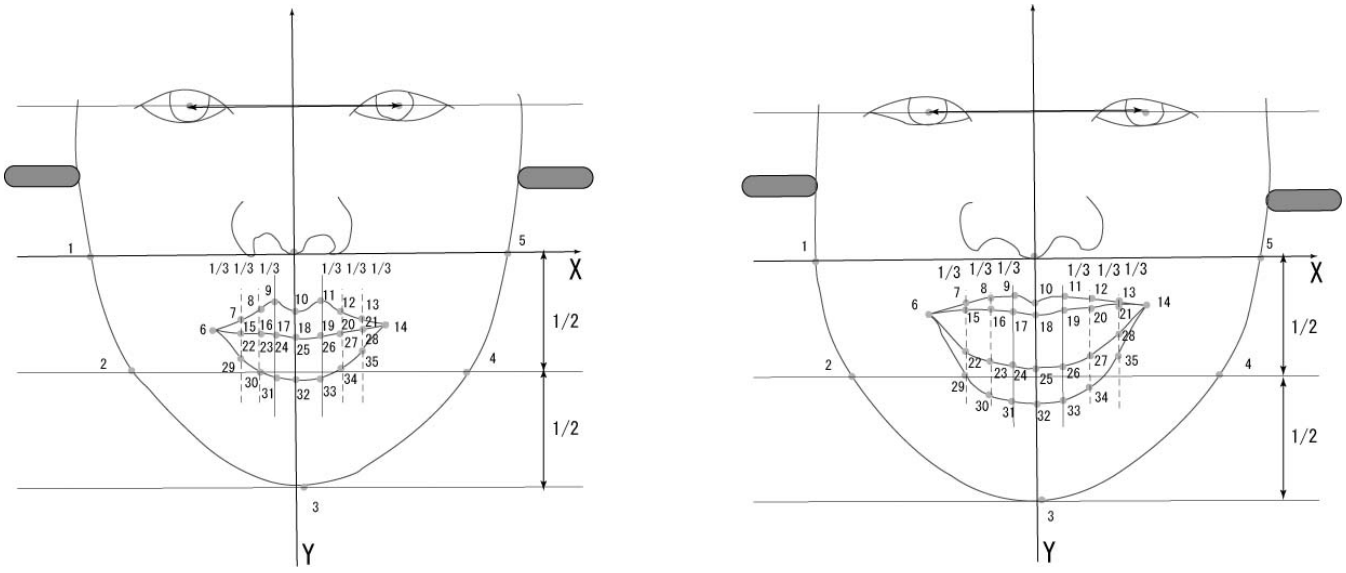


**Figure 1.** Facial landmarks. (1) Zygion (right). (3) Soft tissue pogonion. (5) Zygion (left). (6) Commissure (right). (9) Christa philtri (right). (10) Vermillion superior. (11) Christa philtri (left). (14) Commissure (left). (32) Vermillion inferiore. 6~14, 15~21 Upper Lip 22~28, 29~35 Lower Lip.

**Table 1.** Area Measurements

| | Units | Control | Pretreatment Class II | Posttreatment Class II |
|---|---|---|---|---|
| Rest | | | | |
| Upper lip | $mm^2$ | 325.86 ± 58.93 | 348.09 ± 64.30 | 322.89 ± 70.28 |
| Lower lip | $mm^2$ | 432.52 ± 66.40 | 487.38 ± 123.27* | 502.34 ± 68.60*** |
| U/L lip ratio[a] | | 0.76 ± 0.12 | 0.82 ± 0.59 | 0.65 ± 0.15** |
| Smile | | | | |
| Upper lip | $mm^2$ | 217.52 ± 71.64 | 277.97 ± 83.19** | 263.88 ± 85.18* |
| Lower lip | $mm^2$ | 513.07 ± 93.84 | 553.60 ± 102.75 | 595.33 ± 89.78** |
| U/L lip ratio[a] | | 0.43 ± 0.14 | 0.51 ± 0.17* | 0.45 ± 0.15 |

[a] U/L indicates upper and lower.
* Indicates significant difference between Class II division 1 group and control group.
* $P < .05$; ** $P < .01$; *** $P < .001$.

tracer and by calculating the standard error of the x- and y-coordinate values for all 35 landmarks. Consequently, the mean of the error in the x- and y-coordinate values, expressed by the coefficient of variation, was .05 and .01, respectively.

## RESULTS

### Lip Morphology at Rest and on Smiling for Normal Occlusion in the Controls

Table 1 shows the control group upper lip area to be smaller than the lower lip area in the rest condition, while the upper lip area decreased and the lower lip area increased in the smile condition. The upper and lower lip ratio (U/L ratio) was 76% at rest and 43% on smiling.

Table 2 shows the landmark coordinates, and Figure 2 displays the lip morphology at rest and on smiling of the control group. When smiling, both 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.

### Lip Morphology at Rest and on Smiling for Class II Pretreatment

Table 1 shows that, in the Class II pretreatment group, both lip areas were larger than in the control group, where the lower lip area at rest and the upper lip area in the smiling condition were larger than those of the control group. The upper and lower lip ratios were 82% at rest and 51% on smiling, where the lower lip was significantly larger than the control.

Table 3 and Figure 3 show significant differences in the landmark coordinates between the Class II pretreatment and the control groups in the rest condition,

**Table 2.** Landmark Coordinates and Measurements in the Control Group

| | | Rest | | Smile | |
|---|---|---|---|---|---|
| Point | | X Mean ± SD | Y Mean ± SD | X Mean ± SD | Y 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 | −61.3 ± 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 |

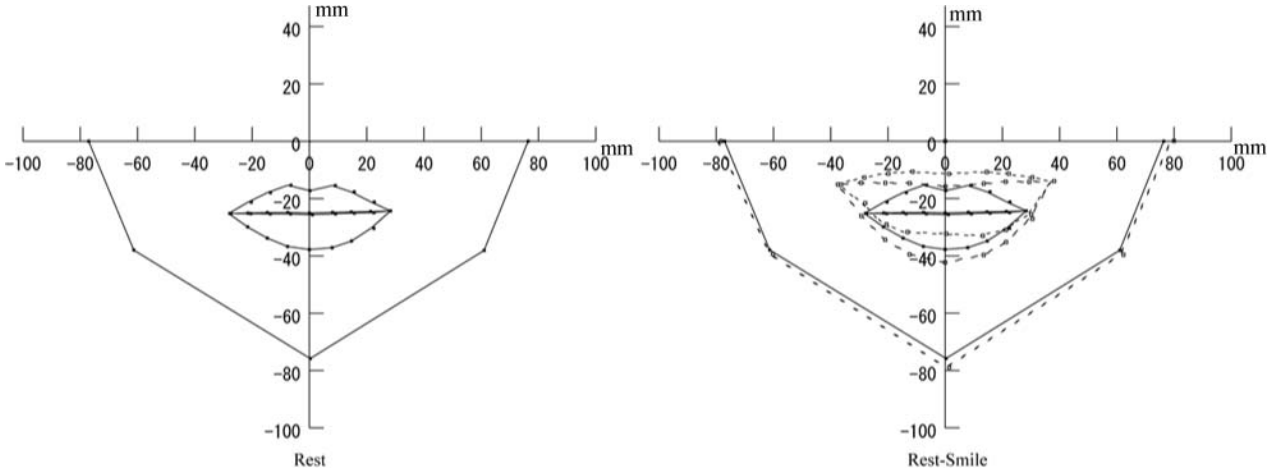


**Figure 2.** Graphics of mean value of landmarks for the control group.

where both lips moved to an inferior position in the Class II group ($P < .05$, $P < .01$). However, no significant differences were observed in the horizontal coordinates of the mouth corners.

In the smile condition, the landmark coordinates of the Class II pretreatment group were positioned significantly inferior to those of the control group ($P < .05$, $P < .01$). The movement of the mouth corners and the upper lip in the Class II group was less than that in the control group.

### Lip Morphology at Rest and the Smile of Class II Posttreatment

Table 1 shows, in the Class II posttreatment group, the lower lip area in the rest condition, and both the lower and upper lips in the smile condition were significantly larger than those of the control group. The upper and lower lip ratios were 65% at rest and 45% on smiling. The lip ratio of the Class II group in the smile condition was the same as that in the control group. This indicated the improvement of the upper and lower lip balance by the orthodontic treatment.

Table 4 and Figure 4 show that there was a slight difference between the pretreatment and posttreatment at rest condition. When smiling, only the horizontal direction of the mouth corners and the upper and lower lips were statistically significantly different, whereas these were wider in the Class II posttreatment smile than in the pretreatment smile.

Table 4 and Figure 5 show the differences between the posttreatment of the Class II and control groups in the rest condition. In the Class II group, the lips moved to a more inferior position than those of the control group, and there were no significant differences in the horizontal coordinates of the mouth corners and others, and these findings were identical with the pretreatment lip position. In the smile condition, posttreatment observations showed that both lips of the Class II group were positioned significantly inferior to those of the control group ($P < .001$).

Less significant differences between the Class II posttreatment and the control group were observed in the horizontal direction than in the vertical direction after the treatment, thus showing that in the smile condition, both the upper and lower lips and the mouth corners of the Class II group changed near to those of the control group.

## DISCUSSION

At present, patients believe that they will become more attractive, better liked, and more successful in their social[10] and occupational life after orthodontic treatment, and the facial esthetic is one of the important social concerns in current society. Eighty percent of patients seek orthodontic treatment for esthetic reasons.[11] Facial attractiveness influences mating success, kinship opportunities, personality evaluations, performance, and employment prospects.[12] Therefore, orthodontic treatment has gained momentum in modern society, and therefore, will attract even more attention in the future. The success of orthodontic treatment is routinely assessed by smile esthetics, and the lips are the controlling factor in the smile. Wylie[13] emphasized that the goal of orthodontic treatment should be the attainment of the best possible esthetic result, dentally and facially.

Most of the previous research[14–16] regarding soft tissue morphology and behavior analysis was done by a lateral cephalometric or videographic method. On the other hand, the facial soft tissue has not yet been sufficiently studied, and an analysis based on the anterior-posterior (AP) facial photograph is very rare. Holberg et al[17] reported a high displacement to be 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 lips area after orthodontic treatment, and it is essential to the achievement of the successful orthodontic treatment goal.[18–20] Mackley[21] stated that there was a definite improvement of the smile in the average scores because of orthodontic treatment. In this study, we quantitatively evaluated the morphological changes of the lips, using AP facial photographs of the Class II division 1 patients.

The advantage of this facial photograph–based study is that the procedure is simple and economical, and the number of samples is easily increased. In addition, these photographs are usually available in the orthodontic office, and they are rated as more attractive than the profile views.[22] In the measurement and analysis of the smile, however, there is one limitation in the methodology because of the reproducibility of a natural smile. Some reports[23,24] showed that an imitative smile rehearsing the phrase ''cheese'' was more reproducible than a natural smile. However, according to our pilot study, Ishikawa et al[25] reported that significant differences were found between the coordinates obtained in the smile while saying cheese and the coordinates of the natural smile. Another limitation is the difficulty in collecting a natural smiling photograph, because before orthodontic treatment, the patients have an unusual alignment and occlusion. In addition, they might feel shy about smiling.

In Class II division 1 pretreatment, the upper lip area and the upper and lower lip ratio are larger than in the control in the smile. It may be due to the protrusive upper incisors in the Class II division 1 which make the upper lip loose and everted. On the other hand, a deep overbite may also evert the lower lip. It is pos-

**Table 3.** Landmark Coordinates and Measurements in the Class II Division 1 Pretreatment Group

| | | Rest | | Smile | |
|---|---|---|---|---|---|
| Point | | X Mean ± SD | Y Mean ± SD | X Mean ± SD | Y Mean ± SD |
| Outline, mm | 1 | −77.4 ± 3.7 | 0.0 ± 0.0 | −78.6 ± 3.2 | 0.0 ± 0.0 |
| | 2 | −62.0 ± 4.7 | −38.0 ± 2.3 | −62.1 ± 4.0 | −39.0 ± 2.8 |
| | 3 | 0.0 ± 3.1 | −76.1 ± 4.4 | −1.1 ± 2.4** | −78.3 ± 5.4 |
| | 4 | 60.5 ± 5.0 | −38.4 ± 2.1 | 60.2 ± 5.1 | −39.3 ± 2.6 |
| | 5 | 75.6 ± 4.6 | 0.0 ± 0.0 | 76.1 ± 4.1* | 0.0 ± 0.0 |
| Upper lip, mm | 6 | −28.6 ± 2.9 | −27.6 ± 2.6** | −34.1 ± 3.7*** | −20.1 ± 4.9*** |
| | 7 | −21.7 ± 2.4 | −23.3 ± 2.7** | −26.2 ± 2.8*** | −16.4 ± 4.0*** |
| | 8 | −14.7 ± 1.9 | −19.3 ± 2.8* | −17.7 ± 2.4*** | −14.3 ± 3.4*** |
| | 9 | −7.4 ± 1.6 | −16.9 ± 2.8* | −9.3 ± 2.1*** | −13.1 ± 3.0*** |
| | 10 | 0.0 ± 0.0 | −18.5 ± 2.7* | 0.0 ± 0.0 | −14.4 ± 3.1*** |
| | 11 | 7.0 ± 2.0* | −16.8 ± 2.5* | 9.3 ± 3.2*** | −13.0 ± 3.2** |
| | 12 | 14.4 ± 2.0 | −19.1 ± 2.6* | 17.2 ± 3.1*** | −14.3 ± 3.7*** |
| | 13 | 21.7 ± 2.2 | −22.8 ± 2.5* | 25.0 ± 3.8*** | −16.5 ± 4.3*** |
| | 14 | 28.3 ± 2.7 | −26.9 ± 2.7** | 32.3 ± 4.5*** | −19.6 ± 5.4*** |
| | 15 | −21.7 ± 2.5 | −27.4 ± 2.6** | −26.2 ± 2.8*** | −19.3 ± 4.7*** |
| | 16 | −14.7 ± 1.9 | −26.8 ± 3.0* | −17.7 ± 2.3*** | −19.1 ± 4.2*** |
| | 17 | −7.5 ± 1.6 | −26.5 ± 3.4* | −9.3 ± 2.1*** | −19.2 ± 3.8*** |
| | 18 | 0.0 ± 0.0 | −26.9 ± 3.3* | 0.0 ± 0.0 | −20.4 ± 3.4*** |
| | 19 | 7.0 ± 2.1* | −26.5 ± 3.4* | 9.3 ± 3.1*** | −19.5 ± 3.9*** |
| | 20 | 14.4 ± 2.2 | −26.5 ± 2.8* | 17.1 ± 3.1*** | −19.3 ± 4.4*** |
| | 21 | 21.7 ± 2.3 | −26.8 ± 2.5** | 24.9 ± 3.8*** | −19.3 ± 5.2*** |
| Lower lip, mm | 22 | −21.8 ± 2.5 | −27.5 ± 2.6** | −26.2 ± 2.7*** | −25.5 ± 3.5*** |
| | 23 | −14.7 ± 2.0 | −27.3 ± 2.7* | −17.7 ± 2.3*** | −29.5 ± 3.8* |
| | 24 | −6.9 ± 2.5 | −27.2 ± 2.7* | −9.3 ± 1.9*** | −32.1 ± 4.7 |
| | 25 | 0.0 ± 0.0 | −27.6 ± 2.9** | 0.0 ± 0.0 | −33.0 ± 5.0 |
| | 26 | 7.1 ± 2.1 | −27.3 ± 2.7** | 9.4 ± 3.2*** | −31.7 ± 4.9 |
| | 27 | 14.4 ± 2.0 | −27.1 ± 2.5** | 17.1 ± 3.2*** | −29.5 ± 4.6* |
| | 28 | 21.7 ± 2.3 | −27.0 ± 2.5** | 24.9 ± 3.8*** | −25.3 ± 4.5*** |
| | 29 | −21.8 ± 2.4 | −33.2 ± 3.8** | −26.2 ± 2.7*** | −31.8 ± 4.4*** |
| | 30 | −14.8 ± 1.8 | −37.7 ± 4.3** | −17.8 ± 2.2*** | −39.6 ± 4.7*** |
| | 31 | −7.6 ± 1.6 | −40.3 ± 4.6** | −9.4 ± 2.1*** | −43.6 ± 5.3** |
| | 32 | 0.0 ± 0.0 | −41.2 ± 4.5** | 0.0 ± 0.0 | −45.0 ± 5.6* |
| | 33 | 6.9 ± 2.0* | −40.4 ± 4.4** | 9.3 ± 3.2*** | −43.5 ± 5.9** |
| | 34 | 14.3 ± 2.2 | −37.7 ± 4.3* | 17.0 ± 3.2*** | −39.9 ± 5.9*** |
| | 35 | 21.6 ± 2.2 | −32.9 ± 3.9* | 24.9 ± 3.9*** | −32.4 ± 6.1*** |

* Indicates significant difference between Class II division 1 pretreatment group and control group.
* $P < .05$; ** $P < .01$; *** $P < .001$.

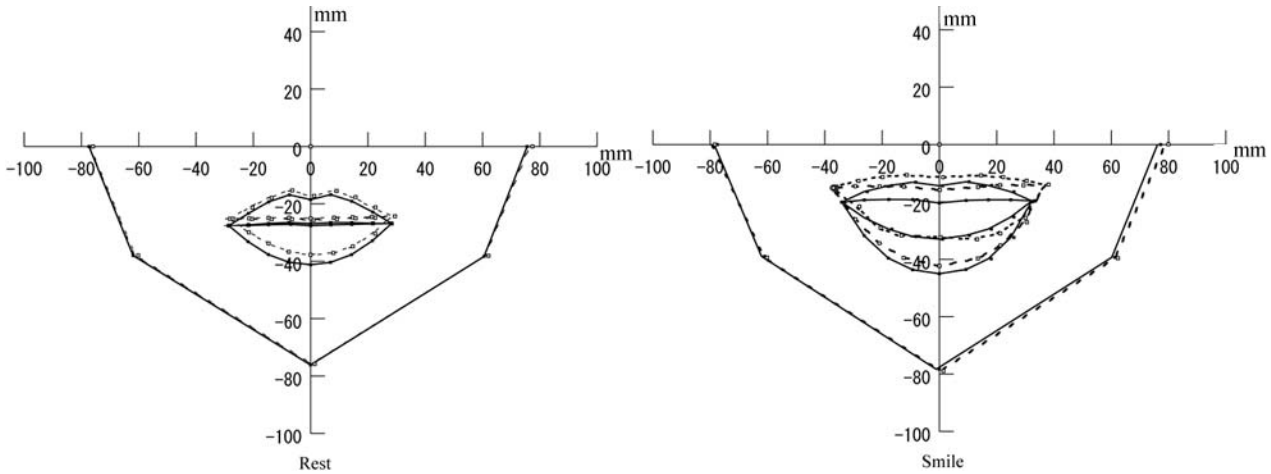


**Figure 3.** Graphics of mean value of landmarks for Class II pretreatment (black) and control (dotted).

**Table 4.** Landmark Coordinates and Measurements in the Class II Division 1 Posttreatment Group

| | | Rest | | Smile | |
|---|---|---|---|---|---|
| Point | | X Mean ± SD | Y Mean ± SD | X Mean ± SD | Y Mean ± SD |
| Outline, mm | 1 | −75.3 ± 3.5# | 0.0 ± 0.0 | −77.3 ± 3.5#* | 0.0 ± 0.0 |
| | 2 | −60.2 ± 4.8# | −38.9 ± 2.6# | −61.7 ± 4.9 | −40.2 ± 2.4# |
| | 3 | 0.9 ± 3.5 | −77.9 ± 5.8# | 0.2 ± 3.7# | −80.7 ± 5.3# |
| | 4 | 61.6 ± 4.7 | −38.8 ± 2.6 | 62.0 ± 4.3# | −40.4 ± 2.6# |
| | 5 | 76.1 ± 4.6 | 0.0 ± 0.0 | 77.2 ± 4.5 | 0.0 ± 0.0 |
| Upper lip, mm | 6 | −29.1 ± 2.6 | −26.7 ± 3.7# | −35.9 ± 4.5# | −20.0 ± 4.5*** |
| | 7 | −22.2 ± 2.0 | −23.4 ± 3.1** | −27.4 ± 3.5#* | −16.4 ± 3.8*** |
| | 8 | −14.8 ± 1.7 | −19.9 ± 2.5** | −19.0 ± 2.9#* | −14.5 ± 3.5*** |
| | 9 | −7.5 ± 1.7 | −17.5 ± 2.2** | −10.5 ± 2.7#* | −13.5 ± 3.2*** |
| | 10 | 0.0 ± 0.0 | −19.2 ± 2.5#** | 0.0 ± 0.0 | −14.7 ± 2.8*** |
| | 11 | 7.2 ± 1.8 | −17.4 ± 2.1** | 10.6 ± 3.7#** | −13.5 ± 2.9*** |
| | 12 | 14.8 ± 1.9 | −19.5 ± 2.6** | 19.0 ± 3.7##** | −14.5 ± 3.2*** |
| | 13 | 22.6 ± 2.3## | −23.0 ± 2.9* | 27.1 ± 3.9##* | −16.4 ± 3.7*** |
| | 14 | 29.3 ± 3.0# | −26.2 ± 3.6* | 35.4 ± 4.8### | −19.6 ± 4.9*** |
| | 15 | −22.2 ± 2.0 | −26.6 ± 3.3#* | −27.4 ± 3.5#* | −18.9 ± 3.9*** |
| | 16 | −14.9 ± 1.7 | −26.2 ± 2.8 | −18.9 ± 3.0#* | −18.6 ± 3.8*** |
| | 17 | −7.5 ± 1.6 | −26.5 ± 2.7* | −10.4 ± 2.8#* | −18.9 ± 3.8*** |
| | 18 | 0.0 ± 0.0 | −27.0 ± 2.8** | 0.0 ± 0.0 | −20.3 ± 3.1*** |
| | 19 | 7.2 ± 1.8* | −26.6 ± 2.5** | 10.6 ± 3.6#** | −19.1 ± 3.6*** |
| | 20 | 14.8 ± 2.0 | −26.3 ± 2.6* | 18.9 ± 3.6##** | −18.6 ± 3.8*** |
| | 21 | 22.5 ± 2.4# | −26.4 ± 3.0* | 27.1 ± 4.0##* | −18.7 ± 4.2*** |
| Lower lip, mm | 22 | −22.2 ± 2.0 | −26.7 ± 3.2# | −27.5 ± 3.4#* | −25.8 ± 3.7*** |
| | 23 | −14.9 ± 1.6 | −26.4 ± 2.9# | −19.0 ± 2.9#* | −30.4 ± 3.9** |
| | 24 | −7.6 ± 1.6 | −26.8 ± 2.8* | −10.5 ± 2.7#* | −33.4 ± 4.5** |
| | 25 | 0.0 ± 0.0 | −27.2 ± 2.8* | 0.0 ± 0.0 | −34.4 ± 4.6* |
| | 26 | 7.2 ± 1.8* | −26.9 ± 2.7* | 10.5 ± 3.6#** | −33.3 ± 4.4** |
| | 27 | 14.8 ± 2.1 | −26.5 ± 2.7* | 19.0 ± 3.5##** | −30.3 ± 4.0** |
| | 28 | 22.4 ± 2.3# | −26.5 ± 3.1* | 27.3 ± 4.1##* | −25.7 ± 3.9*** |
| | 29 | −22.2 ± 2.1 | −32.1 ± 3.7* | −27.5 ± 3.4#* | −32.5 ± 4.9*** |
| | 30 | −14.8 ± 1.7 | −37.3 ± 3.3*** | −19.1 ± 2.9#* | −40.4 ± 4.9*** |
| | 31 | −7.5 ± 1.6 | −40.0 ± 3.3** | −10.5 ± 2.8#* | −44.7 ± 4.6*** |
| | 32 | 0.0 ± 0.0 | −40.8 ± 3.3** | 0.0 ± 0.0 | −46.3 ± 4.5*** |
| | 33 | 7.2 ± 1.9 | −40.0 ± 3.6** | 10.5 ± 3.6#** | −44.8 ± 5.1*** |
| | 34 | 14.9 ± 2.0# | −37.2 ± 3.7* | 19.0 ± 3.7###** | −40.8 ± 5.2*** |
| | 35 | 22.6 ± 2.4## | −32.1 ± 4.1 | 27.2 ± 4.0##* | −33.1 ± 5.0*** |

# Indicates significant difference between Class II division 1 posttreatment group and pretreatment group.
# $P < .05$; ## $P < .01$; ### $P < .001$.
* Indicates significant difference between Class II division 1 posttreatment group and control group.
* $P < .05$; ** $P < .01$; *** $P < .001$.

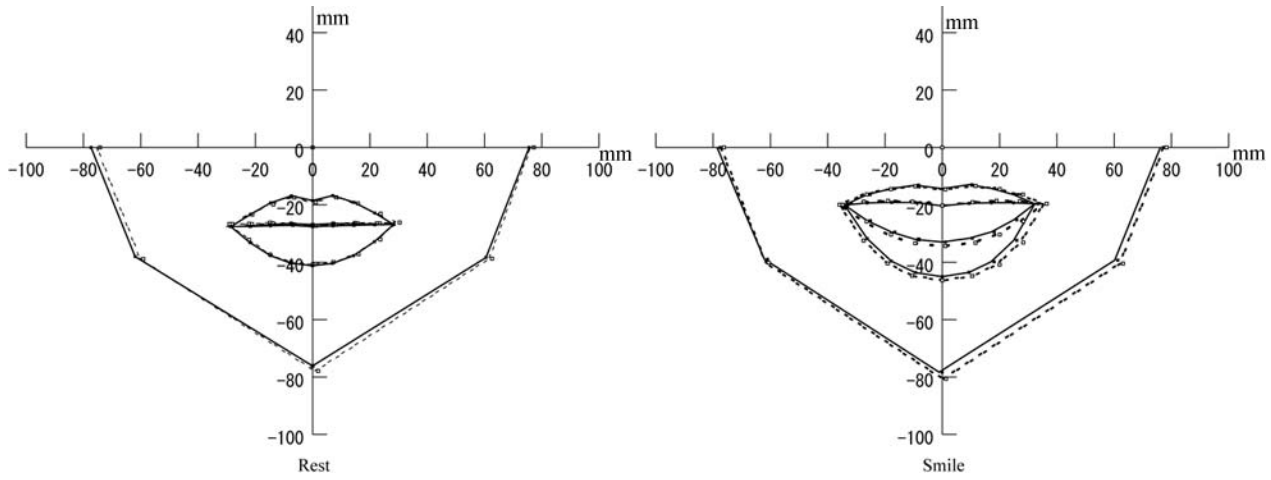


**Figure 4.** Graphics of mean value of landmarks for Class II pretreatment (black) and posttreatment (dotted).

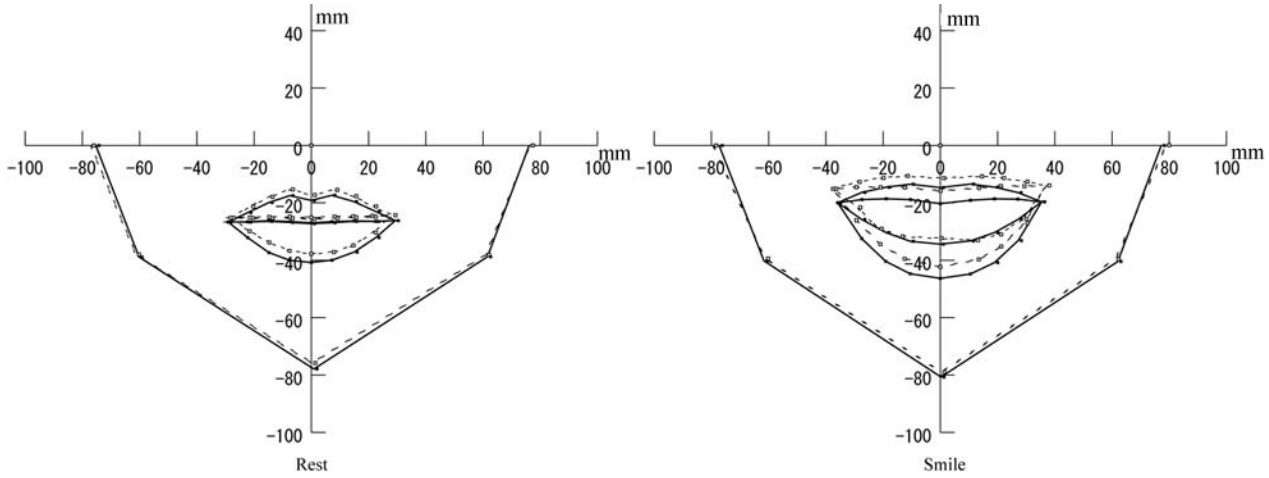


**Figure 5.** Graphics of mean value of landmarks for Class II posttreatment (black) and control (dotted).

sible that the abnormal overjet and overbite increase the lip area and lose the upper and lower lip balance. After the treatment, in the smile, the angle of the mouth corners became wide and near to the control, but both lips were still positioned downward. Cummins et al[26] showed in their study that in the posttreatment of Class II division 1 malocclusion, the mouth corners were wider than in pretreatment. Ishikawa et al[25] studied the smile in Class III malocclusion, and they reported that both lips showed a larger downward displacement. After the correction of Class II malocclusion, both lips were still loose in the smile. As a result the lip area may be larger than the control after treatment.

The overall analysis of the study indicates that there are improvements in features of the smile for the patients who have undergone treatment for Class II division 1 malocclusion. Even after treatment, the Class II division 1 subjects showed a difference from the control subjects regarding their smile; namely, the downward movement of the upper lip and the mouth corners of the Class II division I subjects was smaller than that of the control group. Perhaps immediately after treatment, the lips cannot adapt properly in the new position and need time for adaptation. Furthermore, the braces worn during orthodontic treatment for about 2 years might have been interrupting the natural movement of the lips. This study, therefore, can be used in future research regarding the soft tissue analysis after retention.

## CONCLUSIONS

- This study showed that both the upper and lower lips in the smile of the Class II division 1 pretreatment group moved to an inferior position, and the upward movement of the upper lip and mouth corners was smaller in comparison with the control group.
- These characteristics of the Class II smile were improved by the orthodontic treatment, but the differences in comparison with the control group remained immediately after treatment.

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