A Study on Smile Esthetics and Lip Morphological Changes Following Orthodontic Treatment

Md. Rafiqul Islam
Section of Orthodontics, Division of Oral Health,Growth and Development, Graduate School of Dental Science, Kyushu University

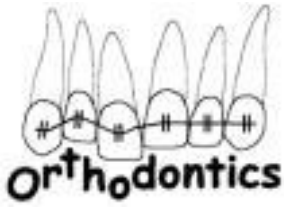
https://doi.org/10.15017/18405

出版情報：九州大学, 2009, 博士（歯学）, 課程博士
バージョン：
権利関係：

A Study on Smile Esthetics and Lip Morphological Changes Following Orthodontic Treatment

2010

Md. Rafiqul Islam BDS



Section of Orthodontics

Division of Oral Health, Growth and Development

Graduate School of Dental Science

Kyushu University, Japan.

Supervisor

Professor Ichiro Takahashi DDS, PhD.

A Study on Smile Esthetics and Lip Morphological Changes Following Orthodontic Treatment

Thesis

Submitted as a partial fulfilment of the requirements for the degree of Doctor of Philosophy (Ph.D) in Orthodontics of Dental Science

By Md. Rafiqul Islam BDS

Section of Orthodontics

Division of Oral Health, Growth and Development

Graduate School of Dental Science

Kyushu University, Japan.

2010

List of Publications and Presentations

Publications:

1. Rafiqul Islam[1], Toru Kitahara[2], Lutfun Naher[3], Atsushi Hara[4], and Akihiko Nakasima[5] Lip Morphological Changes in Orthodontic Treatment: Class II division 1 Malocclusion and Normal Occlusion at Rest and on Smiling. *Angle Orthod.* 2009;79 (2):256-264.
2. Rafiqul Islam[1], Toru Kitahara[2], Lutfun Naher[3], Atsushi Hara[4], and Shunsuke Nakata[5] Lip Morphological Changes following Orthognathic Surgery for Class III Malocclusion. *Angle Orthod.* 2010;80 (2):344-353.
3. Toru Kitahara[1], Rafiqul Islam[2], and Shunsuke Nakata[3] Evaluation of Lip Morphology at Rest and on Smiling after Mandibular Setback Surgery Orthodontic Waves (in press)
4. Toru Kitahara[1], Rafiqul Islam[2], Ichiro Takahashi[3], Yuji Shiratsuchi[4]. Evaluation of Lip Morphology at Rest and on Smiling after Mandibular Setback Surgery in Japanese Females. (submitted)

Presentations:

1. Rafiqul Islam[1], Toru Kitahara[2], Lutfun Naher[3], Atsushi Hara[4], and Shunsuke Nakata[5] Lip Morphological Changes following Orthognathic Treatment for Class III Malocclusion. *87th General Session of the IADR, Miami Florida, USA. April 1-4 2009*
2. Toru Kitahara[1], Rafiqul Islam[2], Shunsuke Nakata[3], Evaluation of Lip Morphology at Rest and on Smiling after Mandibular Setback Surgery. *41th Annual Scientific Congress of the Korean Association of Orthodontists, Seoul, Korea. November 7-8, 2008.*

Contents

Chapter 1 **Page**

Introduction……1

Chapter 2

Systems for Research…….4

2.1.Materials and Methods……..……..4

2.2.Error of Methods……7

Chapter 3

Lip Morphological Changes in Orthodontic Treatment: Class II division 1 Malocclusion and Normal Occlusion at Rest and on Smiling…….....10

3.1.Purpose 10

3.2.Materials and Methods.....10

3.3.Results.....12

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

3.3.2. Lip Morphology at Rest and on Smiling for Class II Pretreatment

3.3.3. Lip Morphology at Rest and on Smiling for Class II Posttreatment

3.4.Discussion.....20

3.5.ShortSummary.....23

Chapter 4

Lip Morphological Changes following Orthognathic Surgery for Class III Malocclusion……..24

4.1.Purpose 24

4.2. Materials and Methods.....24

4.3.Results.....25

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

4.3.2. Lip Morphology at Rest and on Smiling for Class III Pretreatment

4.3.3. Lip Morphology at Rest and on Smiling for Class III Posttreatment

4.4.Discussion.....34

4.5.Short Summary.....36

Chapter 5

5.1.General Summary.....37

5.2.Conclusion.....38

5.3.Acknowledgement.....39

5.4.References.....41

Chapter 1

Introduction

The treatment goal[1-2] of modern orthodontic and orthognathic treatment is to produce morphological and functional harmony in maxillofacial complex. Orthodontic researches had evaluated the structural harmony in craniofacial skeletons from early to middle 20th century, and many different types of the cephalometric analyses had been established based on the hard tissue morphology of the patients on the cephalometric radiographs. After the hard tissue analyses came into consensus, functional analyses such as electromyography has been introduced into the field of clinical orthodontics to evaluate the masticatory function, and functional matrices hypothesis emphasized the importance of the relationship between the shape and the function of craniofacial structures. Equilibrium of muscular function around the oral cavity was also focused on the prognostic stability of orthodontic treatment and equilibrium theory was incorporated into the orthodontic treatment planning. At the same time, many orthodontists have focused on the changes of soft tissue profile[3] before and after orthodontic treatment. Facial esthetics[4-5] is one of the most important issues to be solved by the orthodontic treatment because the patients' chief complaints are mostly the enhancement of facial esthetics rather than the improvement of masticatory functions. Relationships between the amount of the retraction of anterior teeth and alteration in lip position was surveyed. Differences in soft tissue profile with or without premolar extraction[7] was also evaluated to show the lip changes after orthodontic treatment in relation to facial harmony and perioral functions. Thus, orthodontists have considered it is important to harmonize facial profile and physiological function of maxillofacial

complex, and they believed that the well-balanced maxillofacial structures would produce best functional outcomes after orthodontic treatment.

On the other hand, accompanied with the development and maturation of the procedure for orthognathic treatment, importance of facial attractiveness was correlated with the improvement of social activity of patients. Facial esthetic harmony was firstly evaluated, as described above, as a balance of vertical and antero-posterior relationship among the tip of the nose, upper lip, lower lip and chin in the lateral cephalometric analysis by using parameters, such as E-line, Sub-nasale vertical line, and Holdaway angle. Those parameters were used to establish the customized treatment goal for orthodontic and orthognathic treatment. While most of those parameters were utilized on the lateral cephalometric analysis at resting or enforced lip closing positions, those concepts lacked to estimate the frontal appearance of the face and dynamic relationship between tooth and lips during they are functioning. Consequently, in addition to static evaluation of the frontal balance of the face, smile attractiveness was considered to be critical parameter to evaluate the orthodontic outcomes. Smile arc and tooth exposure on smile are the common parameter to evaluate the dynamic function of the lips. It was demonstrated that the attractiveness of smile is enhanced when smile arc of lower lip coincides with the tip lines of upper anterior teeth, and the anterior tooth exposure is about 75 to 100% while smiling. In the previous studies, the improvement of structural facial esthetics and social activity is related[8-11] to the enhancement of attractiveness of smile. Thus, psychosocial factors such as smile attractiveness have been emphasized to be involved into orthodontic treatment planning and assessment of treatment outcomes.

In the present study, Angle Class II division 1 malocclusion and skeletal Class III severe jaw deformity were selected as the research subjects for smile improvement after

orthodontic and/or orthognathic treatment. Since these two types of malocclusion are the most common types of malocclusion in Japanese population, typical results were expected to be obtained. To test the hypothesis that the alignment of anterior teeth and occlusal improvement by orthodontic and/or orthognathic treatment for Class II division 1 cases or severe skeletal Class III patients lead improvement of smile after the treatment.

Chapter 2

Systems of the Research

2.1 *Materials and Methods*

The frontal photographs were taken without facial make-up in a normal seated posture with the head fixed by ear rods, with a distance of 1.5 m between the camera lens and the subject. The subject's head was positioned so that the F-H (Frankfort Horizontal) plane was parallel to the floor and the mid sagittal plane of the head was aligned with the center of the camera lens. The 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. All the photographs were taken with the same camera (Nikon), lens (Nikon-P Auto 1:2.5 f = 105mm) and film (Dyna, for color slides, Kodak).

The frontal photographs of the patients 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 the patients were photographed in a posed smile, the perioral soft tissues and mandibular posture were unstrained. On smiling, the teeth were closed lightly. The frontal photographs were printed out on A4 size and tracings were made using tracing paper and 35 facial landmarks were placed on it

The subnasal (Sn) point was fixed 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. Thereafter, two vertical lines were drawn through the right and left superior vermilion point (9, 11). From the superior vermilion point to the corners of the mouth, in both the right (6) and left (14) sides, were divided into three equal parts (Figure 1).

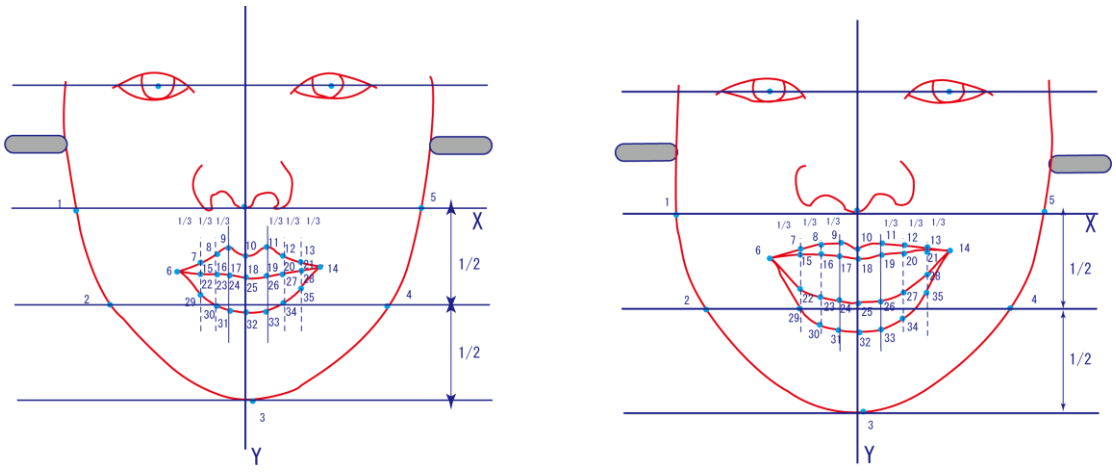


Figure 1. Facial landmarks. (1) Zygion (right). (3) Soft tissue pogonion. (5) Zygion (left). (6) Commissure (right). (9) Christa philtri (right).(10) Vermillion superior. (11) Christa philtri (left). (14) Commissure (left). (32) Vermillion inferiore. 6_14, 15_21 Upper Lip 22_28, 29_35 LowerLip.

Every landmark was digitized into x- and y-coordinate values, and a statistical analysis was performed using these values. The landmarks numbered 6~14, 15~21 indicated the upper lip area, and 22~28, 29~35 indicated the lower lip area.

Table1. *Summary of the subjects*

		Control group (N=28)	Class II group (N=20)	Class III group (N=30)
		Mean ± SD	Mean ± SD	Mean ± SD
Age of the patients	Yrs.	25.0 ± 3.0	22.2 ± 5.6	23.8 ± 4.7
Treatment period	Yrs.	-	2.3 ± 0.5	2.7 ± 0.8
Tooth extracted	Number	-	Ext = 17 Non-Ext = 3	Ext = 25 Non-Ext = 5
Opreration	Number	-	-	SSRO=17 IVRO=13

We examined the differences in the facial width by measuring the distance between the center of the right and left eyeballs of the patients and control groups. There were no significant differences in the facial size between the two groups.

Table2. *Analysis of facial width between the patient and the control group.*

Point	Class II patient group	Control group	
mm	Mean ± SD	Mean ± SD	Student`s *t* -test
Po-Or	73.6 ± 4.08	73.78 ± 3.18	NS

mm	Class III patient group	Control group	
	Mean ± SD	Mean ± SD	
Po-Or	74.55 ± 2.99	73.78 ± 3.18	NS

* P<0.05; **P<0.01;***P<0.001. NS= Not Significant
Po-Or indicates the average distance between the two eye balls.

The pre-treatment rest and smile conditions were compared with the post treatment using paired *t*-tests using the Microsoft Excel software program (Microsoft Corporation, Redmond, WA 98052). In addition, two sample *t*-tests were used to test for differences between the patient group and the control group. Differences with a *p* value of <.05 were considered to be statistically significant.

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.

2.2 *Error of the method*

The intra-examiner error was evaluated by measuring the same facial photograph 30 times by the same tracer and by calculating the standard error of the *x* and *y* coordinate values for all 35 landmarks to estimate the accuracy of the method. Consequently, the mean of the error in the *x* and *y* coordinate values, expressed by the coefficient of variation, was 0.05 and 0.01 respectively (Table 3).

Table3. *Analysis of intra-examiner error*

	X			Y				X			Y		
Landmarks	Mean	SD	Standard Error	Mean	SD	Standard Error	Landmarks	Mean	SD	Standard Error	Mean	SD	Standard Error
S	-	-	-	-	-	-	17	-5.1	0.27	0.05	-9.1	0.17	0.03
N	-	-	-	33.4	0.19	0.04	18	-	-	-	-9.4	0.17	0.03
Or	20.2	0.22	0.04	33.4	0.15	0.03	19	5.0	0.25	0.05	-9.4	0.18	0.03
Po	-19.4	0.19	0.03	33.4	0.15	0.03	20	10.0	0.24	0.04	-10.1	0.22	0.04
1	-42.9	0.17	0.03	0.0	0.00	0.00	21	14.9	0.26	0.05	-10.7	0.16	0.03
2	-35.2	0.19	0.04	-23.5	0.29	0.05	22	-15.1	0.26	0.05	-14.4	0.28	0.05
3	0.3	0.33	0.06	-47.5	0.20	0.04	23	-10.2	0.22	0.04	-18.7	0.19	0.04
4	38.7	0.22	0.04	-23.2	0.17	0.03	24	-5.2	0.19	0.03	-20.3	0.16	0.03
5	45.2	0.19	0.04	-	-	-	25	-	-	-	-20.7	0.18	0.03
6	-19.0	0.22	0.04	-9.8	0.16	0.03	26	5.0	0.20	0.04	-20.7	0.23	0.04
7	-15.3	0.17	0.03	-7.9	0.21	0.04	27	9.9	0.19	0.03	-19.6	0.25	0.05
8	-10.3	0.17	0.03	-7.0	0.21	0.04	28	14.6	0.21	0.04	-16.4	0.15	0.03
9	-5.3	0.20	0.04	-6.4	0.13	0.02	29	-15.1	0.17	0.03	-18.9	0.22	0.04
10	-	-	-	-7.2	0.20	0.04	30	-10.3	0.17	0.03	-23.8	0.21	0.04
11	4.8	0.14	0.02	-6.8	0.22	0.04	31	-5.0	0.27	0.05	-26.1	0.19	0.04
12	9.9	0.14	0.03	-7.4	0.23	0.04	32	-	-	-	-26.9	0.19	0.03
13	14.9	0.25	0.05	-9.0	0.18	0.03	33	5.0	0.24	0.04	-26.6	0.21	0.04
14	19.0	0.24	0.04	-10.9	0.17	0.03	34	9.8	0.23	0.04	-24.7	0.17	0.03
15	-15.1	0.24	0.04	-9.4	0.21	0.04	35	14.6	0.19	0.03	-20.4	0.19	0.03
16	-10.2	0.21	0.04	-9.3	0.20	0.04							

The 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 was

recorded. The error variance was calculated according to the Dahlberg formula[12] 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, the coefficients of reliability values were high, thus indicating the sufficient accuracy of the measurements (Table 3).

Table 4. *Error of the method 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<0.05

Chapter 3

Lip Morphological Changes in Orthodontic Treatment: Class II Division 1 Malocclusion and Normal Occlusion at Rest and on Smiling.

3.1 *Purpose*

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 for Class II division 1 malocclusion.

3.2 *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 over jet of 7.4 mm and over bite of 3.8 mm. Seventeen subjects were treated with extraction of the premolars and three subjects were treated without extraction.

Table1: *Summary of the Class II patient and the Control group*

		Control group (N=28)	Class II group (N=20)
		Mean ± SD	Mean ± SD
Age of the patients	Yrs.	25.0 ± 3.0	22.2 ± 5.6
Treatment period	Yrs.	-	2.3 ± 0.5
Tooth extracted	Number	-	Ext = 17 Non-Ext = 3

All patients came to the University Hospital, Orthodontic Clinic from 1996 to 2003. The control group consisted of 28 adult women volunteers (age range 20-30 years; mean, 25 years) with Angle Class I normal occlusion, with both the overbite and over

jet of 1.5 mm. All of the 28 subjects in the volunteer group were healthy and free from any craniofacial anomalies.

The frontal photographs were taken without facial make-up in a normal seated posture with the head fixed by ear rods, with a distance of 1.5 m between the camera lens and the subject. The subject's head was positioned so that the F-H (Frankfort Horizontal) plane was parallel to the floor and the mid sagittal plane of the head was aligned with the center of the camera lens. The 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.

The frontal photographs of the Class II patients 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 posed smile, the teeth were slightly closed. The frontal photographs were printed out on A4 size and tracings were made using tracing paper and 35 facial landmarks were placed on tracing paper.

3.3 *Results*

3.3.1 *Lip morphology at rest and on smiling for normal occlusion in the Control*

Table 2 shows the control group upper lip area to be smaller than the lower lip area in the rest, while the upper lip area decreased and the lower lip area increased in the smile condition. The upper and lower lips ratio (U/L ratio) was 0.76 at rest and 0.43 when smiling.

Table2. *Area Measurements*

		Control			Pretreatment Cl. II				Posttreatment Cl. II			
Rest		Mean	±	SD	Mean	±	SD		Mean	±	SD	
Upper lip	(mm2)	325.86	±	58.93	348.09	±	64.30		322.89	±	70.28	
Lower lip	(mm2)	432.52	±	66.40	487.38	±	123.27	*	502.34	±	68.60	***
U/L lip ratio		0.76	±	0.12	0.82	±	0.59		0.65	±	0.15	**
Smile												
Upper lip	(mm2)	217.52	±	71.64	277.97	±	83.19	**	263.88	±	85.18	*
Lower lip	(mm2)	513.07	±	93.84	553.60	±	102.75		595.33	±	89.78	**
U/L lip ratio		0.43	±	0.14	0.51	±	0.17	*	0.45	±	0.15	

* Indicated significant difference in Class II division 1 group from Control group.

Table 3 shows the landmark coordinates and Figure 2 displays the lip morphology at rest and when 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.

Table 3. *Landmark coordinates and measurements in the Control group.*

		Rest						Smile					
mm		X			Y			X			Y		
Point		Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD
Outline	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	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	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

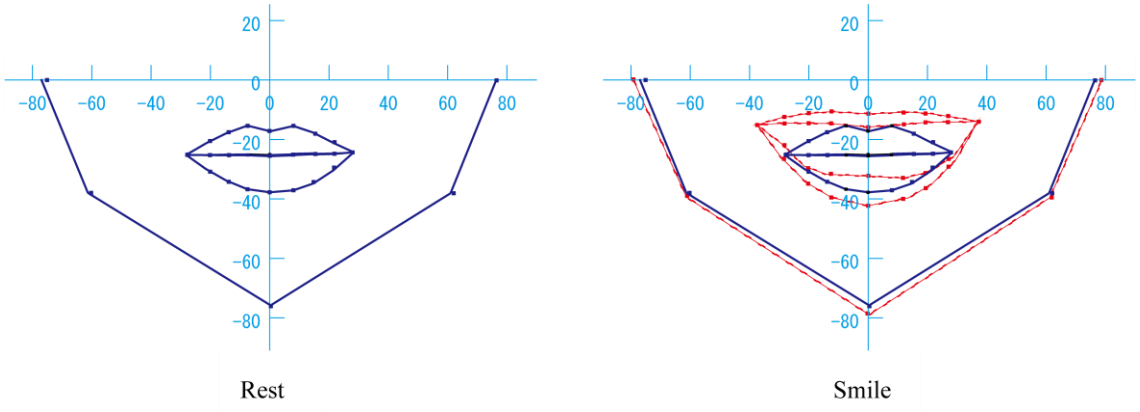


Figure 2. *Graphics of mean value of landmarks for the Control group rest (blue) and smile (red).*

3.3.2 *Lip morphology at rest and on smiling for Class II pre-treatment*

Table 2 shows that, in the Class II pre-treatment 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 lips ratios were 0.82 at rest and 0.51 on smiling, where the lower lip was significantly larger than the control.

Table 4. *Landmark coordinates and measurements in Class II division 1 pretreatment group*

		Rest							Smile						
mm		X			Y				X			Y			
Point		Mean	±	SD	Mean	±	SD		Mean	±	SD	Mean	±	SD	
Outline	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	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	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 in Class II division 1 pretreatment group from Control group.

* P<0.05; **P<0.01;***P<0.001.

Table 4 and Figure 3 show significant differences in the landmark coordinates between the Class II pre-treatment and the control groups in the rest condition, where both lips 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 pre-treatment group were positioned significantly inferior than 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.

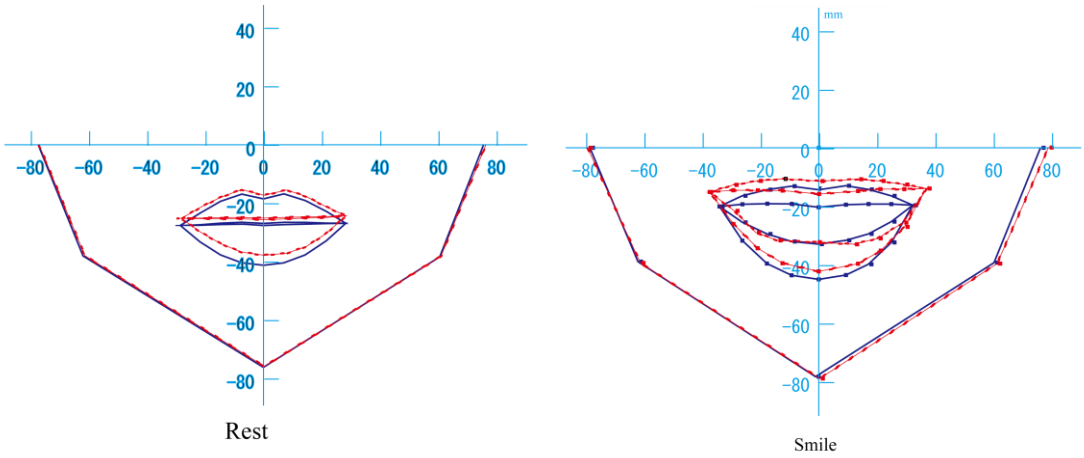


Figure 3. *Graphics of mean value of landmarks for the Class II pretreatment (blue) and Control (red).*

3.3.3 *Lip morphology at rest and the smile of Class II post treatment*

Table 2 shows, in the Class II post-treatment 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 lips ratios were 0.65 at rest

and 0.45 on smiling. The lip ratio of the Class II in smile was the same as that in the control group. This indicated the improvement of the upper and lower lips balance by the orthodontic treatment.

Table 5 and Figure 4 show that there was a slight difference between the pre- and post-treatment 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 post-treatment smile than in the pre-treatment smile.

Table 5. *Landmark coordinates and measurements in Class II division 1 posttreatment group.*

		Rest								Smile							
mm		X				Y				X				Y			
Point		Mean	±	SD		Mean	±	SD		Mean	±	SD		Mean	±	SD	
Outline	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	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	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 in Class II division 1 post-treatment group from pre-treatment group.

# P<0.05; ##P<0.01;###P<0.001.

* Indicates significant difference in Class II division 1 post-treatment group from Control group.

* P<0.05; **P<0.01;***P<0.001.

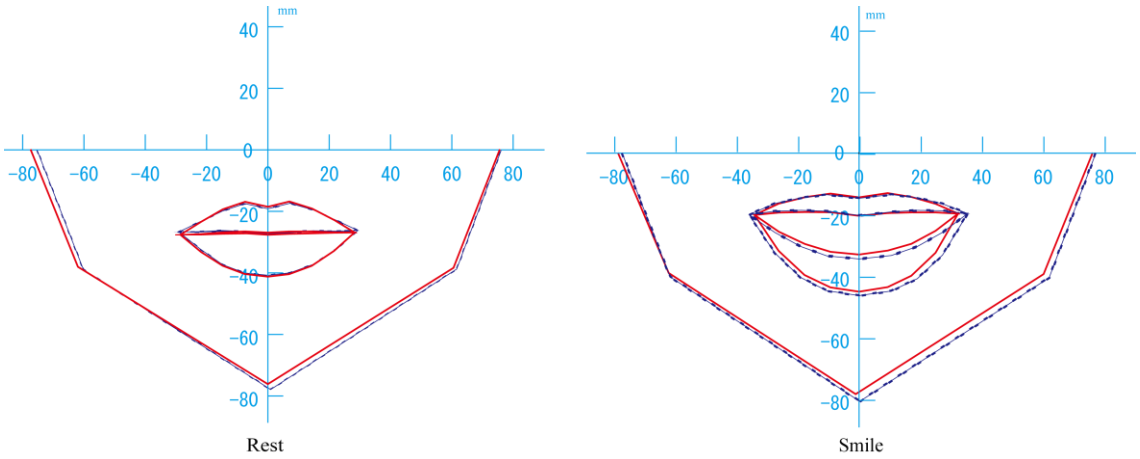


Figure 4. *Graphics of mean value of landmarks for the Class II pretreatment (blue) and posttreatment (red)*

Table 5 and Figure 5 show the differences between the post-treatment of the Class II and control groups in the rest condition. In the Class II group, the lips moved to an 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 pre-treatment lip position. In the smile condition, post-treatment observations showed that both lips of the Class II group were positioned significantly inferior to those of the control group ($P<.001$).

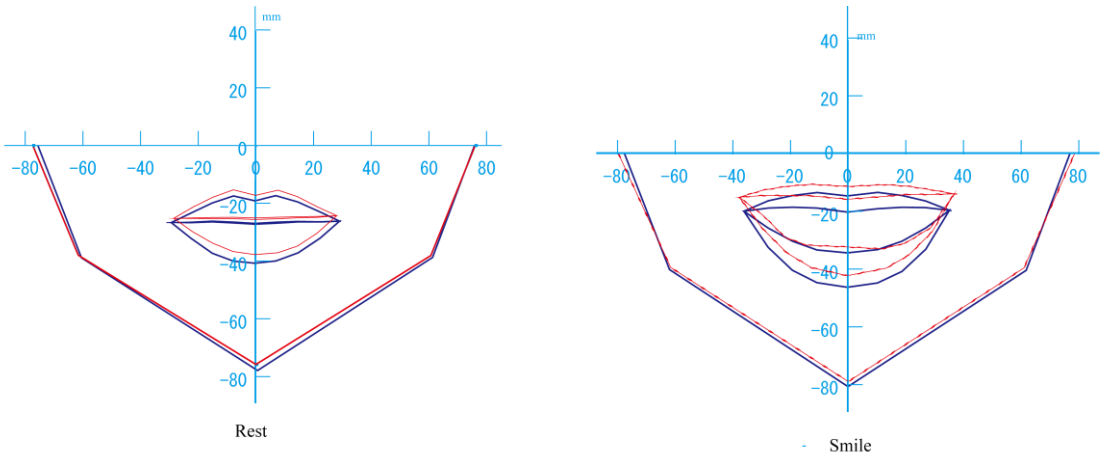


Figure 5. *Graphics of mean value of landmarks for the Class II posttreatment (blue) and the Control (red)*

Less significant differences between the Class II post-treatment and the control group were observed in the horizontal (*** P<0.001 no land marks showed, ** P<0.01 showed only 8 land marks, * P<0.05 showed only 17 land marks out of 35 land marks) direction than in the vertical (*** P<0.001 showed 25 land marks, ** P<0.01 showed only 4 land marks, * P<0.05 showed only 1 land marks out of 35 land marks), 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, horizontally after the treatment.

3.4 *Discussion*

Generally, patients believe that they will become more attractive, better liked, and more successful in their social[13] and occupational life after orthodontic treatment, and the facial esthetics is one of the important social concerns in current society. Eighty percent of patients seek orthodontic treatment for esthetic reasons[14]**.** Facial

attractiveness influences mating success, kinship opportunities, personality evaluations, performance and employment prospects[15]. Therefore, orthodontic treatment has gained momentum in modern society and orthodontic treatment will therefore 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[2] 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[16-38] regarding soft tissues morphology and behavior analysis was done by a lateral cephalometric or video graphic 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[19] 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[20-22]. Mackley[23] 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 malocclusion.

The advantage of this facial photograph based study is that the procedure is simple, economical and easy to increase the number of samples. In addition, these photographs are usually available in the orthodontic office and they are rated as more attractive than the profile views[24] Some reports[25-26] 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[27] reported that significant differences were found between the coordinates obtained in the smile while saying cheese and the natural smile. Another limitation is the difficulty in collecting a smiling photograph, as before orthodontic treatment, the patients have an unusual alignment and occlusion. In addition, they might feel shy about smiling.

In Class II division 1 pre-treatment 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 possible that the abnormal overjet and overbite increase the lip area and lose the upper and lower lip balance. After the treatment, the angle of the mouth corners in the smile became wide and near to the control, but both lips are still positioned downward. Cummins et al[28] showed in their study that in the post-treatment of Class II division 1 malocclusion, the mouth corners were wider than in pre-treatment. Ishikawa *et al*.[27] studied smile in Class III malocclusion; they also reported that both lips showed a larger displacement to downward. 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 respectable improvements in the post-treatment smile than in the pre-treatment smile in the Class-II division 1 malocclusion. Even after treatment, the Class II division 1 group showed a difference from the control group regarding their smile, namely the downward movement of the

upper lip and the mouth corners were smaller than those of the control group. It could be considered that 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 can therefore be used in future research regarding the soft tissue analysis after retention.

3.5 *Short Summary*

- The soft tissue morphology shows a relative improvement after orthodontic treatment, but the differences in comparison to the control group remained immediately after treatment.

Chapter 4

Lip Morphological Changes following Orthognathic Surgery for Class III Malocclusion

4.1. *Purpose*

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 orthognathic-orthodontic treatment for Class III jaw deformity. To test the hypothesis that the smile after orthognathic surgery for Class III malocclusion is improved, frontal facial photographs at smile and rest where compared before and after treatment and with controls.

4.2. *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. The surgical treatments were performed with either sagittal split ramus osteotomy (SSRO, 17 patients) or intraoral vertical ramus osteotomy (IVRO, 13 patients) without genioplasty surgery, twenty-five subjects were treated with tooth extraction, and five subjects were treated without extraction.

Table 1: *Summary of the Class II patient and the Control group.*

		Control group (N=28)	Class III group (N=30)
		Mean ± SD	Mean ± SD
Age of the patient	Yrs.	25.0 ± 3.0	23.8 ± 4.7
Treatment period	Yrs.	-	2.7 ± 0.8
Tooth extracted	Number	-	Ext = 25 Non-Ext = 5
Opreration	Number	-	SSRO=17 IVRO=13

All of the patients were treated at the Kyushu University Hospital, Orthodontic Clinic from 2001 to 2007. The control group is the same as the chapter 3 and 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.

The photographic procedure was described previously in the chapter 3. 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 mid sagittal plane of the head was aligned with the center of the camera lens.

4.3. *Results*

4.3.1. *Lip Morphology at Rest and on Smiling for the Normal Occlusion in the Controls*

Table 2 shows the control group upper lip area to be smaller than the lower lip area at rest, while the upper lip area decreased and the lower lip area increased when smiling. The upper and lower lip ratio (U/L ratio) was 0.80 at rest and 0.40 on smiling.

Table 2. *Area measurements*

		Control		Pretreatment Class III			Posttreatment Class III			
Rest		Mean	± SD	Mean	± SD		Mean	± SD		
Upper lip	mm2	325.9	± 58.9	353.5	± 67.3	*	362.3	± 69.4	*	
Lower lip	mm2	432.5	± 66.4	471.0	± 76.3	*	498.2	± 61.9	***	
U/L lip ratio		0.8	± 0.1	0.8	± 0.1		0.7	± 0.1		
Smile										
Upper lip	mm2	217.5	± 71.6	314.1	± 64.8	***	303.6	± 63.7	***	
Lower lip	mm2	513.1	± 93.8	550.4	± 72.4	*	583.4	± 61.6	***	
U/L lip ratio		0.4	± 0.1	0.6	± 0.1	***	0.5	± 0.1	**	

* Indicated significant difference in Class III group from Control group.* P<0.05; **P<0.01;***P<0.001.

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.

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	-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

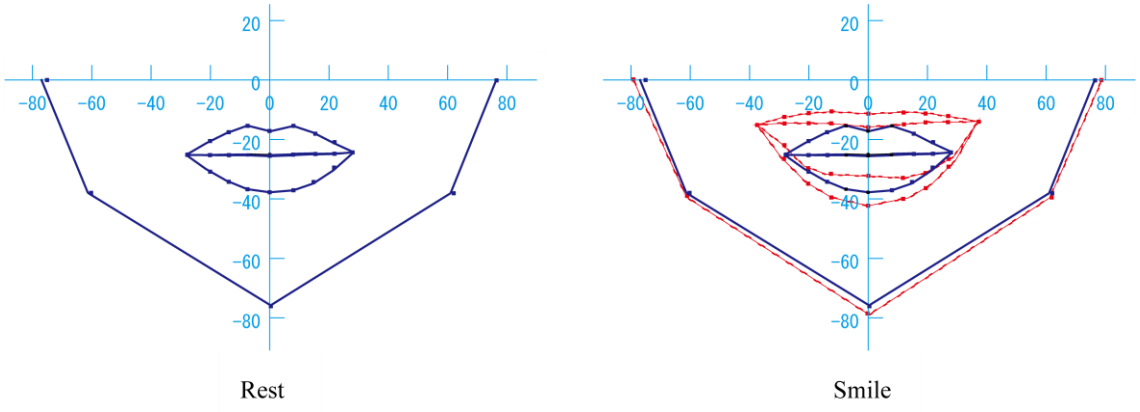


Figure 2. *Graphics of mean value of landmarks for the Control group rest (blue) and smile (red).*

4.3.2. *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 the control group at rest and while smiling. The lip ratio (U/L ratio) was 0.80 at rest and 0.60 on smiling.

Table 4. *Landmark coordinates and measurements in the Class III pretreatment group*

		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	***

* Indicates significant difference in the Class III pretreatment group from the Control group.

* P<0.05; **P<0.01;***P<0.001.

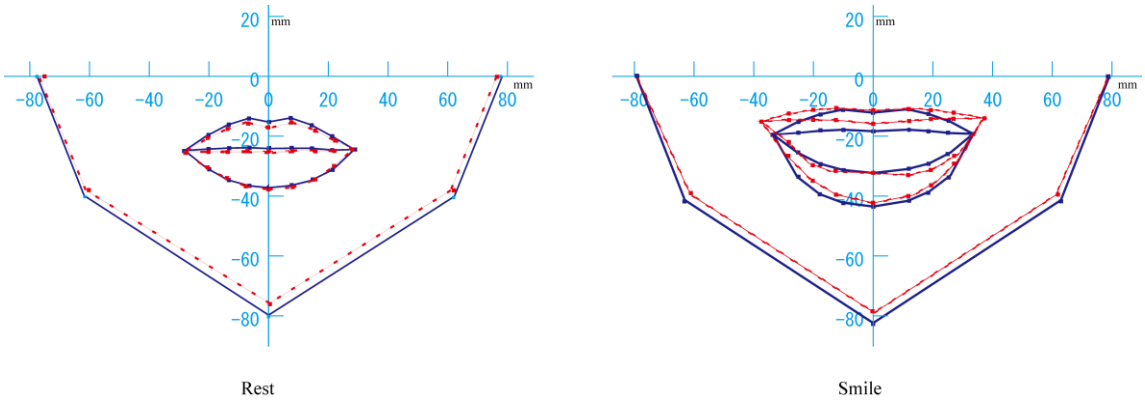


Figure 3. *Graphics of mean value of landmarks for the Class III pretreatment (blue) and the Control (red).*

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

4.3.3. *Lip Morphology at Rest and on Smiling for the Class III Posttreatment*

Table 2 shows that, in the post treatment group, both lips area in the rest and smiling positions were larger than those of the control group. But the lower lip at rest and both upper and lower lip during smiling were significantly larger. The lip ratio (U/L ratio) was 0.70 at rest and 0.50 on smiling. The lip ratio of the class III posttreatment group in smiling was the same as that of the control group. This indicated an improvement of the upper and lower lip balance by the orthognathic treatment.

Table 5. *Landmark coordinates and measurements in Class III posttreatment group*

		Rest									Smile								
		X				Y					X				Y				
Point		ClassIII Mean	±	Control Mean		ClassIII Mean	±	Control Mean			ClassIII Mean	±	Control Mean		ClassIII Mean	±	Control Mean		
Outline, mm	1	-76.9	±	-77.1		0.2	±	0.0		**	-78.9	±	-79.4		0.1	±	0.0		
	2	-61.3	±	-61.3		-38.7	±	-38.0	##		-62.8	±	-61.3		-40.4	±	-39.4	#	
	3	0.0	±	0.3	*	-77.7	±	-75.8	##		0.0	±	0.3		-80.7	±	-79.0	#	
	4	61.4	±	61.0		-38.9	±	-38.1	##		63.4	±	61.2	*	-40.5	±	-39.6	#	
	5	76.9	±	76.4	##	-0.1	±	0.0			79.5	±	78.9		0.1	±	0.0		
Upper lip, mm	6	-29.3	±	-28.2	## *	-24.8	±	-25.2			-36.4	±	-37.5	###	-16.6	±	-15.1	###	
	7	-21.7	±	-21.4	#	-20.5	±	-21.3			-27.2	±	-29.3	### **	-13.8	±	-12.7	##	
	8	-14.3	±	-14.7		-17.0	±	-17.9	#		-19.0	±	-20.9	# *	-11.9	±	-11.3	#	
	9	-7.1	±	-7.5		-14.9	±	-15.3	##		-10.7	±	-12.4	*	-10.8	±	-10.6		
	10	0.0	±	0.0		-16.0	±	-17.3	#	*	0.0	±	0.0		-11.8	±	-11.4		
	11	7.4	±	8.0		-14.7	±	-15.5	##		12.9	±	13.5	##	-10.6	±	-10.8		
	12	14.5	±	14.6		-16.8	±	-17.7	#		20.6	±	21.2	###	-11.8	±	-11.3	#	
	13	21.9	±	21.6		-20.6	±	-21.2			28.3	±	29.4	###	-13.8	±	-12.6	#	
	14	29.3	±	28.3	#	-24.2	±	-24.3			36.3	±	37.0	###	-16.0	±	-14.0	###	*
	15	-21.7	±	-21.5	#	-24.7	±	-25.1			-27.2	±	-29.3	## **	-16.7	±	-14.5	##	**
	16	-14.4	±	-14.7		-24.6	±	-24.9			-19.0	±	-20.9	# *	-16.7	±	-14.6	#	**
	17	-7.0	±	-7.5		-24.7	±	-24.9	#		-10.7	±	-12.4	*	-16.7	±	-14.7	#	**
	18	0.0	±	0.0		-24.9	±	-25.1	#		0.0	±	0.0		-17.5	±	-15.8	#	**
	19	7.3	±	8.1	*	-24.7	±	-24.8			12.9	±	13.5	#	-16.8	±	-14.8	#	**
	20	14.5	±	14.7		-24.6	±	-24.7			20.6	±	21.2	###	-16.7	±	-14.1	##	***
	21	22.0	±	21.4		-24.7	±	-24.6			28.2	±	29.4	###	-16.8	±	-14.2	###	**
Lower lip, mm	22	-21.7	±	-21.5	#	-24.8	±	-25.3			-27.1	±	-29.2	**	-24.1	±	-21.8		*
	23	-14.4	±	-14.7		-24.8	±	-25.3			-19.0	±	-20.9	# *	-28.8	±	-27.1		*
	24	-7.0	±	-7.6		-24.8	±	-25.3	#		-10.7	±	-12.5	*	-31.3	±	-30.3		
	25	0.0	±	0.0		-25.0	±	-25.6	#		0.0	±	0.0		-32.4	±	-32.0		
	26	7.3	±	8.1	***	-24.8	±	-25.3	#		13.0	±	13.4	##	-30.7	±	-30.2		
	27	14.5	±	14.6		-24.8	±	-25.1			20.6	±	21.2	###	-28.4	±	-27.2		
	28	22.0	±	21.5		-24.8	±	-24.9			28.3	±	29.3	###	-23.9	±	-21.7	#	*
	29	-21.7	±	-21.6	#	-31.2	±	-29.9			-27.2	±	-29.3	### **	-31.8	±	-26.1	#	***
	30	-14.4	±	-14.7	#	-35.4	±	-33.8		*	-19.0	±	-21.0	# **	-38.3	±	-34.4		***
	31	-7.2	±	-7.6		-37.5	±	-36.7	#		-10.6	±	-12.5	*	-42.0	±	-39.5		*
	32	0.0	±	0.0		-38.2	±	-37.8	#		0.0	±	0.0		-43.8	±	-42.3		
	33	7.3	±	7.9		-37.5	±	-37.1	#		13.0	±	13.5	##	-41.0	±	-39.7		
	34	14.4	±	14.7		-35.5	±	-34.8			20.6	±	21.3	###	-37.4	±	-35.2		*
	35	22.1	±	21.5		-31.2	±	-30.4			28.3	±	29.4	###	-30.8	±	-27.1	#	***

# Indicates significant difference in the Class III posttreatment group from pretreatment group. # P<0.05; ##P<0.01;###P<0.001.

* Indicates significant difference in the Class III posttreatment group from the Control group. * P<0.05; **P<0.01;***P<0.001.

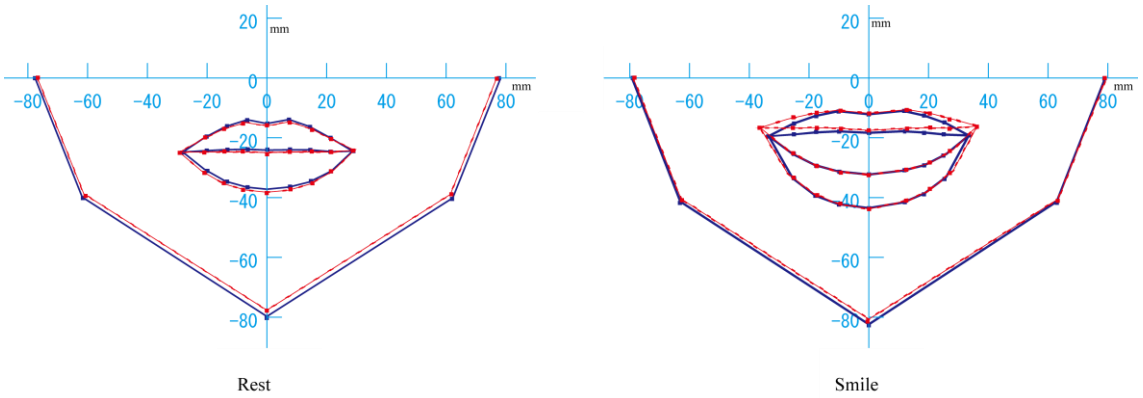


Figure 4. *Graphics of mean value of landmarks for the Class III pretreatment (blue) & posttreatment (red).*

Table 5 and Figure 4 illustrate only a slight difference between the pretreatment and posttreatment at rest condition. The facial outline were positioned significantly superior to those in the pretreatment (P<.001). When smiling, the mouth corners (P<.001), 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 the mandible became shorter after orthognathic treatment.

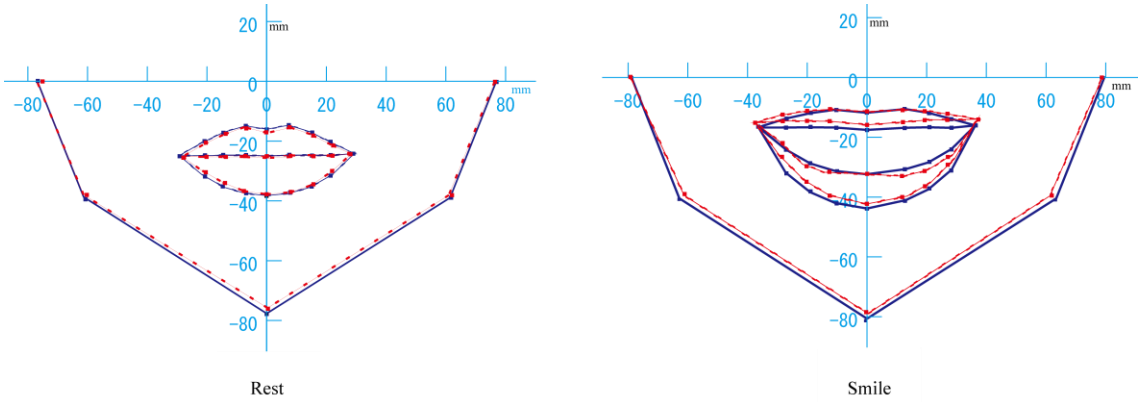


Figure 5. *Graphics of mean value of landmarks for the Class III posttreatment (black) and the Control group (dotted).*

Table 5 and Figure 5 show the difference between the posttreatment and the control groups. At rest, there was no significant difference both horizontally and 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.

Fewer significant differences between the Class III posttreatment and the control group were observed in the horizontal (***** P<0.001 no land marks showed,** ** P<0.01 showed only 5 land marks, * P<0.05 showed only 8 land marks out of 35 land marks) direction than in the vertical (***** P<0.001 showed 4 land marks,** ** P<0.01 showed only 6 land marks, * P<0.05 showed only 6 land marks out of 35 land marks) 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.

4.4. *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 esthetic smiles, who were also judged to be more attractive than the same people with modified lower level esthetic smiles. Since the mouth is the center of communication in the face, the aesthetic 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 aesthetic dentistry.

Many studies have reported[29-32] 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.[51] In addition, a lateral cephalograph is not suitable for evaluation of frontal view of the face. Furthermore, a lateral cephalograph is costly and radiation is also required. On the other hand, the standard frontal photograph technique is easy and repeatable, cost-effective and simple.

Regarding standardized photography of the facial profile, Claman et al[33] 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 parallel 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 1.5m.

Holberg et al[34] reported a large 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 lips area after orthodontic treatment, and it is essential for achieving successful orthodontic treatment goal. In general, posterior repositioning of the mandible by SSRO yields a 90% ~100% 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.[35-36] This study quantitatively evaluated the morphological changes in the lips and to determine 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 the control in the smile. It may be due 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.[37] After the treatment, in the smile, the angle of the mouth corners became wide and close to that in the controls. 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 in their study that in the posttreatment of Class II division 1 malocclusion, the mouth corners were wider than in pretreatment. 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 similar to the result in the previous study for Class II malocclusions.[33]

The overall analysis of the study indicates the achievement of improvements 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 control subjects regarding their smile. 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.

4.5. *Short Summary*

- The soft tissue morphology of the patients with dento-skeletal Class III malocclusion shows a significant improvement following orthognathic surgery.

Chapter 5

5.1. *General Summary*

In the both study (Class II and Class III Malocclusions) indicates the improvements in the features of the smile after orthodontic treatment.

Even after treatment, both class II and class III subjects showed a difference from the control subjects regarding their smile. 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 2-3 or more years might have been interrupting the natural movement of the lips.

This study can therefore be used in future research regarding the soft tissue analysis after retention.

This method of analysis represents a new, dynamic approach to assessing the soft tissue changes associated with orthodontic treatment. As most of the accidental errors smaller than 1 mm and the errors did not exceed 0.59 mm. In addition, the coefficients of reliability values were high, thus indicating the sufficient accuracy of the measurements.

5.2. *Conclusions*

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

- In the smile 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 were smaller in comparison to the control group.
- The soft tissue morphology shows a significant improvement following orthognathic surgery for Class III malocclusion.

5.3. *Acknowledgement*

I express my commendation extolment with feelings of gratitude to **Allah** Subhanata-ala for the successful completion of this thesis work. I would like to express my deepest gratitude and appreciation to **Professor Ichiro Takahashi,** Department of Orthodontics, Division of Oral Health, Growth & Development, Faculty of Dental Science, Kyushu University for his magnanimity and generosity. Without his guidance and persistent help this dissertation would not have been possible. I also express my deepest love and gratitude to **Emeritus Professor Akihiko Nakashima,** Department of Orthodontics, Faculty of Dental Science, Kyushu University, who had the attitude and the substance of a genius: he continually and convincingly conveyed a spirit of adventure in regard to research and my scholarship to continue my study and giving me the opportunity to conduct research in the Orthodontics. I would like to extend my most sincere gratitude and regard with wonder and pleasure to **Assistant Professor Toru Kitahara** for his kindness, guidance, support and valuable suggestions and fruitful discussions about my research project and for instructing me in all aspects about this research with unlimited patience. I am also expressing my thanks and gratefulness to **Professor Seiji Nakamura,** and **Emeritus Professor Masamichi Ohishi,** Section of Oral and Maxillofacial Oncology, Division of Maxillofacial Diagnostic and Surgery, Faculty of Dentistry, Kyushu University for his financial support and encouragement. I also greatly appreciate the help of **Associate Professor Shunsuke Nakata.** I had like to applaud **Assistant Professor Hideki Ioi** for his cordial support and advice. In addition, I express my sincere thanks and gratefulness to **Dr Eiji Mitate** Section of Oral and Maxillofacial Oncology, Division of Maxillofacial Diagnostic and Surgery, Faculty of

Dentistry, Kyushu University for his inexpressible and cordial help through out the life in Japan. I also appreciate the members of Orthodontics department specially Dr. Atsushi Hara, Dr. Noboyoshi Imamura and the international and national students of Kyushu University, who made my life full of joy during my study. I would like to express my special eulogy and intense gratefulness to my great parents **Md. Jonab Ali and Mrs. Amina Begum**, who sacrificed many things to bring into being a dentist and to set aloft in the society. I also express my love wishes to my sisters and brother for their encouragement and support for my study. I would like to express my sincere gratefulness to my father in law **Mr. Moqbul Ahmed** for his help and spiritual encouragement for my higher study. I obliged to **Watanuki International Scholarship Foundation** for their great financial support to reach the goal of my life.

Finally I would like to extend my abstruse and deep seated gratitude to my wife **Dr. Lutfun Naher** and loving son **Nahian Ibrahim**, for taking care and support me during completion of this study.

5.4. *References*

1.Subtelny JD. The soft tissue profile, growth and treatment changes. *Angle Orthod.* 1961; 31:105-122.

2.Wylie WL. The Mandibular Incisor- Its Role in Facial Esthetics. *Angle Orthod.* 1955; 25:32-41.

3.Hulsey CM. An esthetic evaluation of lip-teeth relationships present in smile. *Am J Orthod.* 1970; 57:132-144.

4.Shaw WC, Rees G, Dawe M, Chatles CR. The influence of dentofacial appearance on the social attractiveness of young adults. *Am J Orthod.* 1985; 87:21-26.

5.Marglis MJ. Esthetics considerations in orthodontic treatment of adults. *Dent Clin N Am.* 1997; 41: 29-48.

6.Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. *J Clin Orthod.* 2002; 36:221-236.

7.Moseling KP, Woods MG. Lip curve changes in females with premolar extraction or nonextraction treatment. *Angle Orthod.* 2004; 74:51-62.

8.Sabri R. The eight components of a balanced smile. J Clin Orthod. 2005;39(3):155-67

9.Ackerman JL, Proffit WR, Sarver DM. The emerging soft tissue paradigm in orthodontic diagnosis and treatment planning. Clin Orthod Res. 1999;2:49-52.

10. Ackerman MB, Ackerman JL. Smile analysis and design in the digital era. J Clin Orthod. 2002;36:221-236.

11. Hulsey CM. An esthetic evaluation of lip-teeth relationships present in the smile. Am J Orthod. 1970;57:132-144.

12. Houston WJ. The analysis of errors in orthodontic measurements. Am J Orthod.

1983;83:382-390.

13. Shaw WC, Gabe MJ, Jones BM. The expectation of orthodontic patients in South Wales and st. Louis, Missouri. *Brit J Orthod.* 1979;6:203-205.

14. Albino JE, Cunat JJ, Fox RN, Lewis EA, Slakter MJ, Tedesco LA. Variables discriminating individuals who seek orthodontic treatment. *J Dent Res.* 1981; 60:1661-1667.

15. Bull R, Rumsey N. The social psychology of facial appearance. New York, NY: Springer Verlag; 1998: 9-79.

16. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: part 1. Evaluation of the concept and dynamic records for smile capture. *Am J Orthod Dentofacial Orthop.* 2003; 124: 4-12.

17. Sarver DM, Ackerman MB. Dynamic smile visualization and quantification: part 2. Smile analysis and treatment strategies. *Am J Orthod Dentofacial Orthop.* 2003; 124:116-127.

18. Miyakawa T, Morinushi T, Yamasaki Y. Reproducibility of a method for analysis of morphological changes in perioral soft tissue in children using video cameras. *J Oral Rehabil*. 2006; 33:202-208.

19. Holberg C, Maier C, Steinhauser S, Rudzki-Janson I. Inter-individual Variability of the Facial Morphology During Conscious Smile. J Orofac Orthop 2006;4:234-243

20. Reidel, R. A.: Esthetics and its relation to orthodontic therapy, *Angle Orthod.* 1950 ; 20 : 168-178.

21. Spyropoulos MN, Halazonetis D J. Significance of the soft tissue profile on facial esthetics, *Am J Orthod Dentofacial Orthop.* 2001; 119:464-471.

22. De Smit A, Dermaut L. Soft tissue profile preference. *Amer J Orthod.* 1984;86: 67-73

23. Mackley RJ. An evaluation of smiles before and after orthodontic treatment. Angle Orthod. 1993; 63:183–190

24. Kerr W J S, O`Donnel J M. Panel perception of facial attractiveness. *Brit J Orthod.* 1990; 17:299-304.

25. Johnston DJ, Millett DT, Ayoub AF, Bock M. Are facial expressions reproducible? *Cleft Palate Craniofac J.* 2003;40:291-296.

26. Zachrisson BU. Esthetic factors involved in anterior tooth display and the smile: vertical dimension. *J Clin Orthod.* 1998;32:432-445

27. Ishikawa T, Saito Y, Muraoka S, Kitahara T, Ioi H, Nakasima A. Three-dimensional analysis of smile movement using high speed cameras for the subjects with normal occlusions and jaw deformities. *Orthodontic Waves*-Jpn Ed 2007; 66:92-105.

28. Cummins DM, Bihara SE, Jakobsen JR. A computer assisted photogrammetric analysis of soft tissue changes after orthodontic treatment. Part II: Results. *Am J Orthod Dentofacial Orthop.* 1995; 108:38-47.

29. Suckiel JM, Kohn MW. Soft-tissue changes related to the surgical management of mandibular prognathism. Am J Orthod. 1978;73:676-680.

30. Kajikawa Y. Changes in soft tissue profile after surgical correction of skeletal class III malocclusion. J Oral Surg. 1979;37:167-174.

31. Enacar A, Taner T, Toroglu S. Analysis of soft tissue profile changes associated with mandibular setback and double-jaw surgeries. Int J Adult Orthod Orthognath Surg. 1999;14:27-35.

32. Soncul M, Bamber MA,Evaluation of Facial Soft Tissue Changes With Optical Surface Scan After Surgical Correction of Class III Deformities. J Oral Maxillofac Surg. 2004;62:1331-1340.

33. Claman L, Patton D, Rashid R. Standardized portrait photography for dental patients. Am J Orthod Dentofacial Orthop. 1990;98:197-205.

34. Holberg C, Maier C, Steinhauser S, Rudzki-Janson I. Inter-individual variability of the facial morphology during conscious smiling. J Orofac Orthop. 2006;67:234-243.

35. Islam R, Kitahara T, Naher L, Hara A, Nakasima A. Lip Morphological Changes in Orthodontic Treatment: Class II division 1 Malocclusion and Normal Occlusion at Rest and on Smiling. Angle Orthod. 2009;79:256-264.

36. Hershey HG, Smith LH. Soft-tissue profile change associated with surgical correction of the prognathic mandible. Am J Orthod. 1974;65:483-502.

37. Okudaira M, Ono T, Kawamoto T, Moriyama K. Three-dimensional analysis of lower lip movement during articulation in subjects with mandibular prognathism. Orthod Waves. 2008;67:93-103.