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Abstract

The purpose of this study was to examine the changes in lip pressure before and after orthognathic surgery for skeletal Class III patients.

The subject groups were 32 female and 31 male patients diagnosed with mandibular prognathism and/or maxillary retrognathism who underwent orthognathic surgery. Control groups consisted of 20 women and 20 men with normal occlusion without dento-alveolar deformity. Maximum and minimum lip closing force were measured with Lip De Cum® for the control groups and subject groups preoperatively and at 6 months post-operative. The difference between pre and postoperative values of the groups were examined statistically.

The maximum lip closing force in men was significantly larger than that in women in both the preoperative Class III group ($p=0.0330$) and control group ($p=0.0097$). Preoperative Class III group was significantly smaller than the control group in the maximum lip closing force in both men ($p<0.0001$) and women ($p<0.0001$). Postoperative maximum lip closing force was significantly larger than the preoperative value in both men ($p=0.0037$) and women ($p=0.0273$) in the Class III group.

This study suggested that the maximum lip closing force increases after orthognathic surgery in Class III patients.

Introduction

In the lip and cheek area, many muscles converge or are intermingled with each other. Their functional harmony and balance is very important in the growth and development of the dento-alveolar morphology and craniofacial region. The influence of the forces exerted by the perioral musculature on the position of the teeth has been the object of several scientific studies.[10,16,17]

In some patients with maxillary protrusion or severe Class II Division 1 malocclusion, lip incompetency and muscle imbalance are observed.[5,14,15] Posen[15] found that the subjects with bimaxillary protrusion had low lip strength, compared with Class I and Class II Division 2 patients, using a device for measuring the strength of the lips. Ruan et al.[20] reported that patients aged 4 to 6 years with Class III malocclusion had lower perioral forces and this muscle hypofunction might be secondary to the spatial relation of the jaws.

On the other hand, orthognathic surgery induces not only morphological but also functional improvements. Surgical orthodontic correction of skeletal class III physiology reportedly has favorable effects on the function of the mandible, such as an increased range of maximum motion in the anterior, posterior, and lateral excursions[11]. Several studies have examined the opening and closing movements[1,3] and the chewing rhythm and path[24,25]. However, there was no report regarding the lip closing force in adult patients with jaw deformity who should undergo orthognathic surgery.

The purpose of this study was to examine the changes in lip pressure before and after orthognathic surgery for patients with Class III malocclusion.

Patients and Methods

Patients

The subjects consisted of 31 men (average age, 25.5±7.7 years) and 32 women (average age, 32.9±12.5 years) with Class III malocclusion. All cases were diagnosed as skeletal class III including mandibular prognathism and/or maxillary retrognathism on the basis of a lateral cephalogram analysis and the patients underwent orthognathic surgery. Control groups consisted of 20 women (average age, 29.5±4.9 years) and 20 men (average age, 29.5±3.9 years) with normal occlusion without dento-alveolar deformity.

Cephalogram assessment

The cephalograms were entered into a computer and analyzed using appropriate computer software (Cephalometric Ato Z, Yasunaga Labo Com, Fukui, Japan). Measurement landmarks were SNA, SNB, ANB, U1 to FH plane, Gonial angle, Ramus inclination (FH), Occlusal plane (FH), Interincisal angle, Po-N Perpent.(distance between Pog and Nasion parallel to FH plane), Mandibular length (Co-Gn), Incisor overjet, Incisor over bite, and Convexity.

These measurements were used to examine which variants significantly correlated to maximum lip closing force by stepwise regression analysis.

One skilled observer performed all the digitization so that errors in the

cephalometric method were small and acceptable for the purposes of this study. Error analysis by digitization and remeasurement of 10 randomly selected cases generated an average error of less than 0.4 mm for the linear measurements and 0.5 degree for the angular measurements.

Measurement of lip closing force

Maximum and minimum lip closing forces were measured with Lip De Cum LDC-110R® (Cosmos instruments Co.LTD, Tokyo, Japan) for the control groups and subjects groups preoperatively and at 6 months post-operative. This device consists of a sensor with a lip adaptor and digital display.[12]

The Lip Closure Strength (force) Indicator (Lip De Cum®) was set up with a Lip holder (Ducklings®) mounted to the sensor, and the subject was instructed to bite the holder between the upper and lower lips. Then, Lip Closure Strength (force) of the subject was measured while the subject was sitting upright (with the FH plane parallel to the floor plane) and was instructed to close the upper and lower lips with utmost strength but never allowing the upper and lower teeth to touch. This device contains 4 strain gauges at the sensor and converts the measurement value into load value (N). During measurement for 30 seconds, the shape of the wave is shown on the display of a personal computer connected to the Lip De Cum®. In the wave, the largest value and the smallest vale were defined as the maximum and minimum values, respectively.

Statistical analysis

Data were statistically analyzed with Stat View 4.5 (ABACUS Concepts, Inc., Berkeley, CA, USA) and Dr. SPSSII (SPSS Japan Inc., Tokyo, Japan). Differences between the groups were analyzed by non-paired comparison using Scheffe's F test. Differences between the pre-and postoperative values were analyzed by paired t-test. Stepwise regression analysis was carried out to examine the morphological factors affecting the maximum lip closing force. Differences were considered significant at $P < 0.05$.

Results

Twelve of 31 men with mandibular prognathism underwent Le Fort I osteotomy with bilateral sagittal split ramus osteotomy (SSRO), 16 underwent SSRO alone, 2 underwent Le Fort I osteotomy alone and 1 underwent Le Fort I osteotomy with bilateral intra-oral vertical ramus osteotomy (IVRO). On the other hand, 10 of 32 women with mandibular prognathism underwent Le Fort I osteotomy with bilateral SSRO, 19 underwent SSRO, 2 underwent maxillary anterior segmental osteotomy with bilateral SSRO, and 1 underwent unilateral SSRO and IVRO. The mean setback amount by SSRO with and without Le Fort I osteotomy was 6.4 ± 3.5 mm on the right side and 5.6 ± 3.8 mm on the left side in men, and 5.8 ± 3.5 mm on the right side and 6.1 ± 3.6 mm on the left side in women. There were no significant differences in setback amount between men and women.

When the post-operative recording at 6 months was performed, the occlusion was normal and stable in all patients.

The maximum lip closing force in men was significantly larger than that in women in both the preoperative Class III group ($p=0.0330$) and control group ($p=0.0097$). Preoperative Class III group was significantly smaller than the control group regarding maximum lip closing force in both men ($p<0.0001$) and women ($p<0.0001$). Postoperative maximum lip closing force was significantly larger than the preoperative value in both men ($p=0.0037$) and women ($p=0.0273$) in the Class III group.

However, in the minimum lip closing force, there were no significant differences between men and women in both the preoperative Class III group and control group. Preoperative Class III group was significantly smaller than the control group regarding minimum lip closing force in both men ($p<0.0001$) and women ($p<0.0001$). Postoperative maximum lip closing force was significantly larger than the preoperative value in both men ($p=0.0004$) and women ($p=0.0021$) in the Class III group. However, postoperative maximum lip closing force in the Class III patients was still smaller than that in the control group in both men ($p<0.0001$) and women ($p<0.0001$). In the minimum lip closing force, similar results were shown in both men ($p<0.0001$) and women ($p<0.0001$).

Statistical comparison between surgical procedures (SSRO group versus SSRO with Le Fort I osteotomy group) did not show any significant differences. Furthermore, there were no significant differences among the other procedures for lip closing force.

With regard to the results of stepwise regression analysis, the maximum lip closing

force could be determined by an equation using only the morphological parameter as follows: (Maximum lip closing force) = 10.535+0.125×(Po-N perpent.) (n=63, R=0.413, adjusted R^2 =0.157, RMS Residual=2.555, F=12.541; P=0.0008).

Discussion

Orthognathic surgery can alter not only morphological aspects, but also functional aspects. Many studies have been published regarding occlusal force after orthognathic surgery.[6,13,23] However, there was no knowledge on how weak lip closing force was in skeletal class III patients in comparison with normal subjects and it was unclear whether orthognathic surgery could improve the lip closing force. In the lip and cheek area, in particular, many muscles converge or are intermingled with each other. Their functional harmony and balance is very important in the growth and development of the craniofacial region.

Oral competence is maintained by the orbicularic muscle.[2,4] The orbicularis oris is a concentric muscle around the mouth, and its action and muscle composition are analogous to the orbicularis oculi located around the eye.[21] Elevation and protrusion of the central aspects of the lower lip are caused by the paired mentalis muscles.[26] They are often overactive during lip closing in patients with lip incompetence,[18] who must voluntarily close their lips, causing the chin prominence to be heavily dimpled during use of these muscles.

When the maximum lip closing force was measured and examined, it was necessary to recognize the difference between the genders. More specifically, a higher lip

pressure was measured in men than in women. Kato et al.[8] and Posen[14] also demonstrated the same variation in the force with gender. The same trend was found by Ruan et al.[19] who measured muscle pressure exerted on the primary normal occlusion and concluded that the primary dentition is in a state of dynamic equilibrium. In this study, similar results were found in both the patients and control.

Proffit[1] described the primary and secondary force factors related to tooth position, and he concluded that pressure of the tongue and lips is one of the primary factors, but other factors are also related to equilibrium. Thüer and Ingervall[9] recorded, with a dynamometer, the lip pressure of 84 patients at rest and during chewing and swallowing of crisp bread. They found that a Class II division 2 malocclusion was not provoked by a strong upper lip but that the incisor position was responsible for the low lip pressure in such patients. In contrast, the study of the maximum lip pressure during maximum voluntary contraction showed that lip pressure was lowest in children with a Class II division 2 malocclusion.

Posen[14] stated that great lip strength, measured with the pommeter (perioral muscle meter) during maximum voluntary contraction, can be an indication of high lip tonus and thus substantial outer forces are acting on the anterior teeth. The study showed that Class II division 2 subjects had high lip strength, while bimaxillary protrusion subjects had low lip strength, and the pressure in Class II division 1 subjects was lower than in subjects with Class I occlusion. Lambrechts et al.[9] found that the maximum lip pressure in the Class II division 1 was lower than that in Class I, but there were no significant differences in the other comparisons (Class I, Class II division 1, Class II division 2 and Class III).

Ruan et al.[7] showed that pediatric patients (4-6 years old) with Class III malocclusion generated lower perioral muscle forces. This may cause less bone apposition in this area, which aggravates the clinical features of Class III malocclusion. They postulated that their results reflected muscle hypofunction secondary to the spatial relationship of the jaw in Class III subjects, namely, retroposition of the maxilla.

However, there was no report regarding the lip closing force in adult patients with jaw deformity who should undergo orthognathic surgery. In this study, Class III patients had significantly lower maximum lip closing force than those in the control group. This finding was similar to that of the previous study of Ruan et al.[20] This suggested that the maximum lip closing force of Class III patients is weaker in both adults and children.

Jung et al.[7] found that the values of lip closing forces were related to the variables of the upper incisor angulation, and that in Class II were related to the vertical skeletal pattern, with Y-meter (measurement device of the vertical closing force of the upper lip). On the other hand, the distance between Pog and Nasion parallel to the FH plane was related to the maximum lip closing force in Class III patients in this study. These findings suggested that the region reflected by lip closing force was different in each skeletal and occlusal pattern.

Postoperative maximum lip closing force was significantly larger than the preoperative value in Class III patients in this study, although postoperative minimum lip closing force did not change. Regarding surgical procedure, there was no significant difference between SSRO and SSRO with Le Fort I osteotomy. This suggested that

change in the maximum lip closing force was not related to the surgical procedure, and the skeletal and occlusal changes per se could increase the maximum lip closing force. However, postoperative maximum lip closing force in the Class III patients was still smaller than that in the control group. Postoperative training of lip closing may play an important role in the maintenance of skeletal and occlusal stability.

In conclusion, this study showed that postoperative maximum lip closing force increased more than the preoperative value after orthognathic surgery in Class III patients, although the postoperative value was significantly smaller than that of the control group.

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Legend

Fig. 1 A) Lip Closure Strength (force) Indicator (Lip De Cum®) with a Lip holder (Ducklings®), B) The subject puts the lip holder between the upper and lower lips.

Fig.2 The recorded wave of the lip closing force for 30 seconds.

Table. 1 The results of the lip closing force. SD, indicates standard deviation.

A

B

Fig. 1

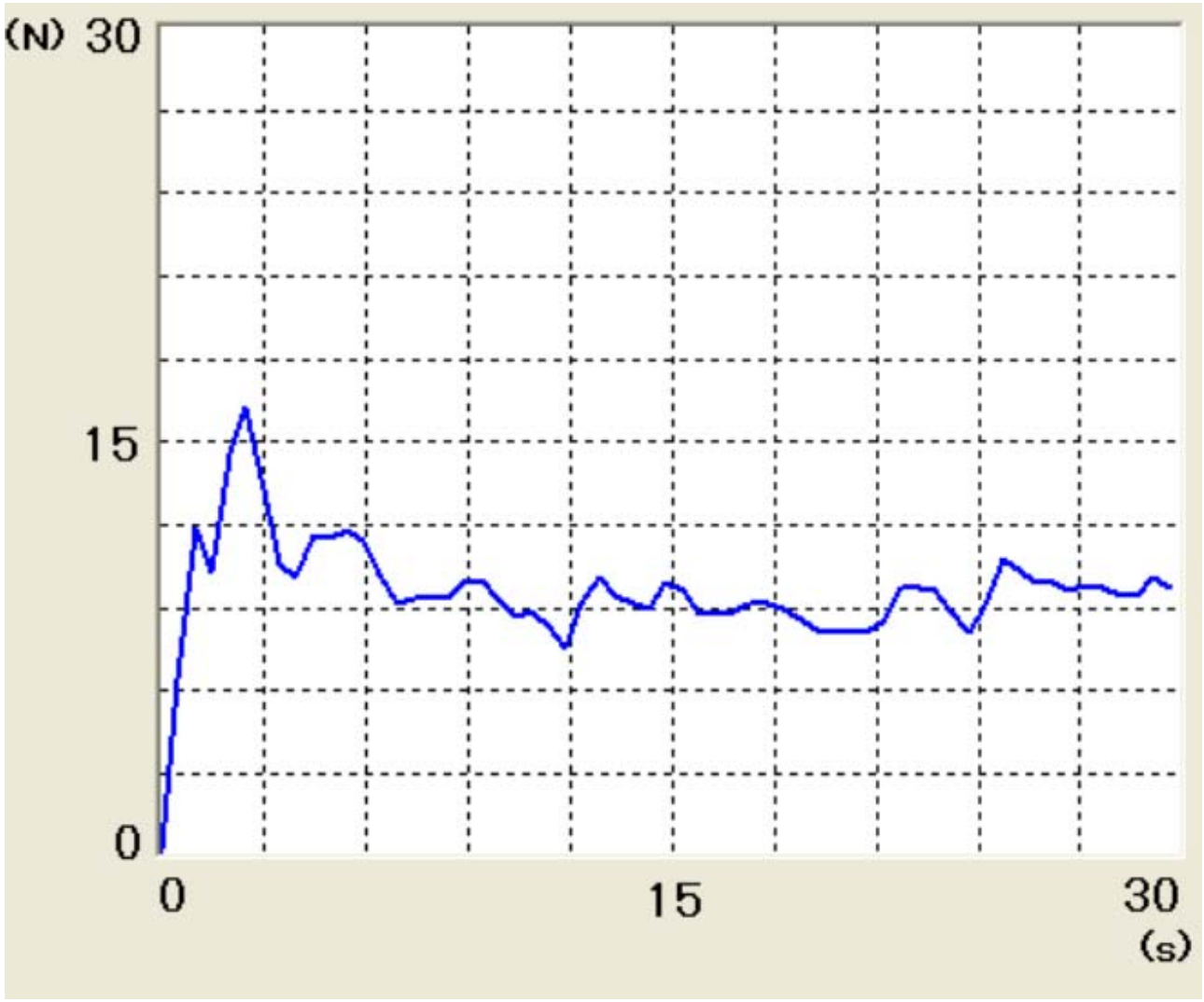

Fig. 2

		Pre-operative		Post-operative	
		Maximum (N)	Minimum (N)	Maximum (N)	Minimum (N)
Class III Men	Mean	9.4	3.4	10.4	4.2
	SD	2.1	1.4	2.7	1.3
Class III Women	Mean	7.8	2.9	8.6	3.8
	SD	2.7	1.4	2.6	1.9
Control Men	Mean	15.0	6.8		
	SD	1.8	0.9		
Control Women	Mean	12.7	6.2		
	SD	1.1	1.0		

Table. 1