

Lip Competence in Class III Patients Undergoing Orthognathic Surgery: An Electromyographic Study

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Purpose: The aim of this study was to compare the presurgical and postsurgical electromyographic (EMG) activities of the lips in patients with skeletal Class III treated with combined orthognathic surgery and contrast these data with those obtained from a control group with skeletal Class I.

Patients and Methods: Ten patients with skeletal Class III underwent the registration of EMG activity before an orthognathic surgical procedure and 4 months after surgery. The results were compared with a control group of 11 healthy patients with skeletal Class I and clinical and EMG lip competence. EMG activity was recorded from the upper orbicularis oris and mentalis muscles during swallowing, lips in contact (LC), and lips apart (LA) using bipolar surface electrodes. The competence condition was assessed by determining the difference in the EMG activity of the mentalis muscle (LC-LA ≤ 0 for lip competence).

Results: Patients with skeletal Class III showed greater EMG activity than the control group before and after surgery. Patients with skeletal Class III showed a significantly greater difference in LC-LA than the control group before surgery for the 2 muscles ($P < .05$). No significant difference was found between the skeletal Class III group after surgery and the control group for the mentalis muscle ($P > .05$).

Conclusions: Four months after treatment with orthognathic surgery, patients with skeletal Class III and an initial muscle activity pattern of lip incompetence different from the control group ($P < .05$) showed EMG values compatible with lip competence. These values were similar to the control group.

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The primary goals of orthognathic surgery are skeletal and occlusal stability, restoration of dental function, and harmonious proportions of facial soft tissues.¹⁻⁴ Numerous publications have attested to the positive impact of the technique on occlusion and facial esthetics. However, few studies have addressed the altered functional aspects in some patients.^{4,5} Orthognathic surgery involves modifications in the muscle groups responsible for the dynamics and physiology of the lips, thus compromising their role and competence.^{6,7}

Clinical lip competence is defined as passive lip contact in the mandibular rest position, without dis-

tinguishable visual muscle activity. Individuals with labial incompetence present stress, particularly in lower lip activity, and atypical movements of the tongue to keep the lips in contact.⁸⁻¹¹ Contraction of the orofacial muscles in the subdermal plane cannot be assessed by visual observation. Therefore, electromyographic (EMG) techniques are used.⁸

According to Yamaguchi et al⁸ and Tomiyama et al,¹⁰ the EMG definition of lip competence is the difference in EMG mentalis muscle activity between the lips in contact (LC; exhibiting no gap) and the lips apart (LA; exhibiting a gap). This definition

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classifies as “lip competent” those individuals with negative or close to 0 difference (LC-LA \leq 0) and “lip incompetent” those with a positive difference (LC-LA $>$ 0).^{8,10} Furthermore, this definition indicates that lip-competent patients have greater lip mentalis activity with LA than with LC, because the latter is the usual position. Conversely, patients with lip incompetence usually have separated lips, showing increased activity by forced closure.

Three-dimensional studies have described improved lip esthetics after treatment with orthognathic surgery by reporting the parameters of a control group.¹ Clinical studies have shown that a significant change in lip function occurs in patients undergoing orthognathic surgery. The results for these individuals have indicated similarities to the control patients, such as improved lip competence and lip occlusion without muscle tension.^{12,13} These results are obtained through the visual observation of the patients and without objective measurements or quantification.

The question then arises as to what sort of changes patients with dentoskeletal dysmorphism and altered labial muscle function might develop after orthognathic surgery.

The purpose of this study was to measure the EMG activity of perioral muscles in patients with skeletal Class III and compare these results with a Class I control group. These results would determine if there is indeed a distinct labial muscle function in the presence of this dentoskeletal dysmorphism. In addition, the results would determine if perioral muscle activity is altered after correcting the dysmorphism by orthognathic surgery.

Patients and Methods

PATIENTS

Two groups of patients participated in this prospective clinical study, which was approved by the review board of the Faculty of Dentistry, University of Chile. The first group consisted of 10 patients (6 women and 4 men). The average age was 23.3 ± 7.987 years. All patients had Class III dentoskeletal dysmorphism as diagnosed by clinical examination, cephalometric study, and cast mounting, indicating a need for orthognathic surgery. This study used the structural and architectural analysis of Delaire et al¹⁴ and the Wits appraisal.¹⁵ Sagittal split osteotomy, Le Fort I, and genioplasty were performed in all patients. This group was referred to having “skeletal Class III” independent of whether they were no longer diagnosed as such after surgery. Thirty-one patients were contacted initially, and all were scheduled for orthognathic surgery in different hospitals in Santiago, Chile

from September 2006 through November 2007; only 10 patients completed the required recordings for this study.

The control group consisted of 11 healthy individuals (7 men and 4 women). These subjects' mean age was 21.82 ± 1.94 years. All patients in this group were classified as skeletal Class I and exhibited clinical and EMG lip competence. The study was communicated to all patients, and all signed an informed consent to participate voluntarily in the study.

METHODS

Each subject's body mass index (BMI) was measured. Age, gender, and BMI were used to verify their possible influence on the muscle activity recorded.

EMG activity was recorded from the upper orbicularis oris and mentalis muscles before and after (4 mo) orthognathic surgery was performed (Le Fort I maxillary osteotomy and sagittal mandibular osteotomy). Surface electrodes with bipolar technology were used (Biotrode No-Gel Electrodes, Bio-Research Associates, Inc, Milwaukee, WI). Electrodes were placed along the fibers of the upper lip orbicularis muscle, immediately above the lip vermilion in the midline and mentalis muscle, and beneath the mentolabial groove^{5,8,9,11,14} (Fig 1).

Captured EMG activity was amplified (model 7P5B, Grass Instrument Co, Quincy, MA). The output of this signal was filtered (low-pass filter, 2 kHz; high-pass filter, 2 Hz) and subsequently corrected. To obtain the EMG signal envelope, a low-pass filter was used with a time constant of 0.1 second. The signal was recorded on a polygraph (Nihon Kohden, RJG 4022, Kogyo Co, Ltd, Tokyo, Japan) that was calibrated before each recording. EMG activity was monitored continuously by a dual-channel oscilloscope (502, Tektronix, Inc, Portland, OR).

The recordings were performed with the subjects in a standing position with the head in a natural position, the eyes open and looking straight ahead, and with 4 inches separating the feet. There were 6 EMG activity recordings of the orbicularis and mentalis muscles in each of the following conditions: 1) normal saliva swallowing; 2) rest or basal activity with LC; and 3) rest or basal activity with LA.

To record muscle activity, the patients were asked to swallow 6 times, with an interval of 1 minute without swallowing between each measurement to reach the mandibular rest position. Then, the patients were asked to swallow and then not swallow until further instructions, producing 3 EMG measurements during this period. They were asked to swallow again and 3 new measurements were recorded. In patients whose lips were not in contact during the measurement, the series was

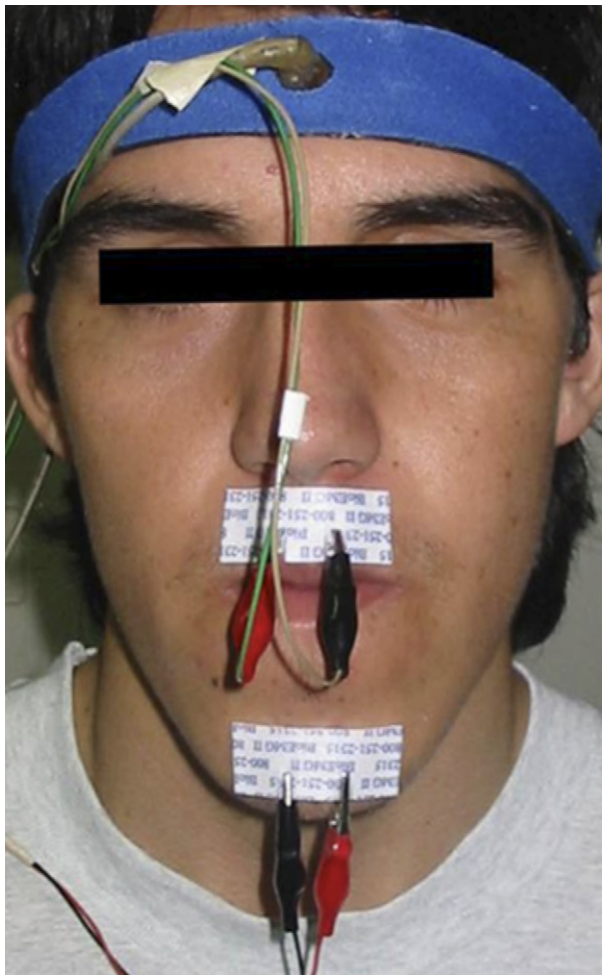


FIGURE 1. Surface electrode placement.

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repeated while trying to keep a soft lip contact between each swallow. Otherwise, if the patients had a labial occlusion, then they were asked to keep their lips apart between each swallow.

A postoperative control was performed 4 months after orthognathic surgery because several studies have suggested patients recover most normal functions within this period.^{2,4,15,16}

DATA ANALYSIS

Analysis of the generalized estimating equation was performed, where the dependent variable was the total EMG activity of the upper orbicularis oris and mentalis muscles. The variables were gender, age, and BMI. Because of the data distribution, nonparametric statistics were used. The Wilcoxon signed rank test was used to compare the EMG activity recorded in the Class III group before and after surgery for each muscle and each condition. The Mann-Whitney test was used to compare the EMG activity recorded in the Class III and control groups. Statistical significance was set at $P < .05$. The data were analyzed using SYSTAT 9.0 (Systat Software, Inc. Chicago, IL).

Results

The mean EMG activity values for each group and each condition studied are listed in Table 1.

The mean value and standard deviation of the EMG activity of the upper orbicularis oris and mentalis muscles were calculated for each condition, study, and individual. According to the generalized estimating equation, variables such as gender, age, and BMI showed no significant effect on the EMG activity for any group.

Before surgery, the Class III group showed significantly greater EMG activity than the control group with LC for both muscles ($P < .01$; Table 2). After surgery, the Class III group had greater EMG activity than the control group with LC in the 2 muscles ($P < .01$) and LA in the mentalis muscle alone ($P < .05$; Table 3).

The authors determined that the Class III group showed no significant differences in the EMG activity average before versus after surgery for any muscle in any condition ($P > .05$; Table 4).

The difference in EMG activity between LC and LA was used to assess lip competence. These values were significantly higher in the group with skeletal Class III before surgery than in the control group for both muscles ($P < .05$; Table 5). A comparison of the LC-LA difference between the Class III group after surgery

Table 1. UPPER ORBICULARIS ORIS AND MENTALIS MEAN ELECTROMYOGRAPHIC ACTIVITY VALUES FOR PATIENTS WITH SKELETAL CLASS III BEFORE AND AFTER SURGERY AND CONTROL SUBJECTS IN EACH CONDITION STUDIED

Condition	Mean UO Activity			Mean MM Activity		
	Before Surgery	After Surgery	Control	Before Surgery	After Surgery	Control
Swallowing	33.17 ± 24.1	34.58 ± 38.8	21.67 ± 18.4	75.83 ± 68.4	68.00 ± 57.4	37.73 ± 26.9
Lips in contact	5.64 ± 2.9	8.59 ± 9.3	2.97 ± 1.1	20.97 ± 20.6	25.45 ± 22.2	4.64 ± 2.1
Lips apart	4.90 ± 3.7	6.21 ± 4.3	3.66 ± 1.6	18.95 ± 17.9	26.18 ± 22.5	8.03 ± 4.7

Abbreviations: MM, mentalis muscle; UO, upper orbicularis oris muscle.

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Table 2. UPPER ORBICULARIS ORIS AND MENTALIS ELECTROMYOGRAPHIC ACTIVITY FOR PATIENTS WITH SKELETAL CLASS III BEFORE SURGERY AND CONTROL SUBJECTS

Condition	Mean UO Activity			Mean MM Activity		
	Before Surgery	Control	<i>P</i> Value*	Before Surgery	Control	<i>P</i> Value*
Swallowing	33.17 ± 24.1	21.67 ± 18.4	.216‡	75.83 ± 68.4	37.73 ± 26.9	.217‡
Lips in contact	5.64 ± 2.9	2.97 ± 1.1	.007†	20.97 ± 20.6	4.64 ± 2.1	.005†
Lips apart	4.90 ± 3.7	3.66 ± 1.6	.573‡	18.95 ± 17.9	8.03 ± 4.7	.205‡

Abbreviations: MM, mentalis muscle; UO, upper orbicularis oris muscle.

*Mann-Whitney test.

†*P* < .01.

‡No statistical significance.

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and the control group for each muscle resulted in a significantly higher value for the particular orbicularis muscle in the Class III group (*P* = .049). No significant difference for the mentalis muscle was found after surgery (*P* > .05; Table 6), which differed from the individual condition results.

Discussion

Large increases in standard deviations were found, especially in the swallowing condition, for both muscles in the 2 groups and in all conditions for the mentalis muscle in the Class III group. This standard deviation was expected because swallowing requires muscular activity, unlike the other 2 conditions examined in this study, which can differ from one normal subject to another. For the mentalis muscle values, the control group data showed a normal distribution; in contrast, the Class III group showed large increases in the standard deviations, probably because of the patients' structural abnormality.

In the resting condition with LC, patients with skeletal Class III before surgery showed significantly greater activity than the control group (*P* < .01). These results were similar to those found in previous

studies for other muscles, in which subjects with Class III showed a greater EMG activity than subjects with Class I for the masseter and temporal muscles during a postural position.¹⁹⁻²¹ No similar study was found to compare the results for the upper orbicularis oris and mentalis muscles. Probably the greatest EMG activity was found because of the skeletal imbalance, conditioning abnormal muscle activity, and labial incompetence.⁸⁻¹⁰ As previously observed, patients with labial incompetence required muscular effort to achieve lip closure.^{8,11,22}

Contrary to initial expectations, EMG activity values were not significantly different before and after orthognathic surgery, perhaps because of an insufficient period after surgery. Some patients reported varying degrees of paresthesia and impaired proprioception, especially in the chin area. These symptoms resulted in excessive muscular effort and high EMG values.

The values reported refer to the net values of each muscle activity for a given condition only. More important than the increase or decrease in EMG activity is what happens to muscle function. Based on these values, it was not clear whether the muscle function of patients with skeletal Class III after surgery was similar to the control group. Thus,

Table 3. UPPER ORBICULARIS ORIS AND MENTALIS ELECTROMYOGRAPHIC ACTIVITY FOR PATIENTS WITH SKELETAL CLASS III AFTER SURGERY AND CONTROL SUBJECTS

Condition	Mean UO Activity			Mean MM Activity		
	After Surgery	Control	<i>P</i> Value*	After Surgery	Control	<i>P</i> Value*
Swallowing	34.58 ± 38.8	21.67 ± 18.4	.547§	68.00 ± 57.4	37.73 ± 26.9	.245§
Lips in contact	8.59 ± 9.3	2.97 ± 1.1	.002†	25.45 ± 22.2	4.64 ± 2.1	.002†
Lips apart	6.21 ± 4.3	3.66 ± 1.6	.139§	26.18 ± 22.5	8.03 ± 4.7	.024‡

Abbreviations: MM, mentalis muscle; UO, upper orbicularis oris muscle.

*Mann-Whitney test.

†*P* < .01.

‡*P* < .05.

§No statistical significance.

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Table 4. UPPER ORBICULARIS ORIS AND MENTALIS ELECTROMYOGRAPHIC ACTIVITY FOR PATIENTS WITH SKELETAL CLASS III BEFORE SURGERY AND AFTER SURGERY

Condition	Mean UO Activity			Mean MM Activity		
	Before Surgery	After Surgery	P Value*	Before Surgery	After Surgery	P Value*
Swallowing	33.17 ± 24.1	34.58 ± 38.8	.878 [†]	75.83 ± 68.4	68.00 ± 57.4	.185 [†]
Lips in contact	5.64 ± 2.9	8.59 ± 9.3	.169 [†]	20.97 ± 20.6	25.45 ± 22.2	.878 [†]
Lips apart	4.90 ± 3.7	6.21 ± 4.3	.333 [†]	18.95 ± 17.9	26.18 ± 22.5	.241 [†]

Abbreviations: MM, mentalis muscle; UO, upper orbicularis oris muscle.

*Wilcoxon signed rank test.

†No statistical significance.

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EMG lip competence was assessed as defined in the literature reviewed, according to which LC value smaller than the LA value indicates lip competence with negative or near 0 values and labial incompetence with positive values.^{8,10} EMG mentalis muscle activity has been shown to be significantly greater than upper orbicularis activity, which is considered more indicative of the lip seal than other muscles in the area.^{8,10,16,22} Thus, the authors emphasize the results obtained from the mentalis muscle because they provides an objective criterion for lip competence evaluation.^{8,15,22}

The LC-LA values for the Class III group before surgery were positive, whereas those for the control group were negative; this difference was statistically significant ($P < .05$). This confirmed that patients with skeletal Class III had an altered function compatible with labial incompetence. In contrast, patients with skeletal Class III after surgery showed negative LC-LA values for the mentalis muscle, as did the control group, with no statistical differences, compatible with lip competence.

This result is of considerable interest because independent of whether there was significant variation in the net EMG activity of each muscle in the different conditions for patients with skeletal Class

III before and after orthognathic surgery, mentalis muscle function, which is fundamental in labial competence and activity, changed from values associated with labial incompetence, which were significantly different from the control group, to values similar to the control group, consistent with lip competence. These results support the clinical observations published by other investigators who described an improvement in lip competence after orthognathic surgery.¹² No similar study was found to compare these results.

Thus, one might conclude that in the early stages after surgery, positive changes in muscle function are observed. It is expected that in a later stage, after fully overcoming temporary surgical complications, including changes in sensation and proprioception, the EMG values for patients with skeletal Class III treated with orthognathic surgery would become similar to those obtained from a skeletal Class I group with lip competence.

One limitation of this study is the small group of patients with skeletal Class III. Nevertheless, the number of patients is comparable to the number found in similar studies.^{1,17,18,23} The second EMG measurement was performed 4 months after surgery based on

Table 5. DIFFERENCE IN ELECTROMYOGRAPHIC ACTIVITY BETWEEN LIPS IN CONTACT AND LIPS APART FOR PATIENTS WITH SKELETAL CLASS III BEFORE SURGERY AND CONTROL SUBJECTS

Muscle	Difference Before Surgery	Difference From Controls	P Value*
UO	0.73 ± 2.3	-0.69 ± 1.0	.049 [†]
MM	2.02 ± 10.5	-3.38 ± 3.1	.014 [†]

Abbreviations: MM, mentalis muscle; UO, upper orbicularis oris muscle.

*Mann-Whitney test.

† $P < .05$.

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Table 6. DIFFERENCE IN ELECTROMYOGRAPHIC ACTIVITY BETWEEN LIPS IN CONTACT AND LIPS APART FOR PATIENTS WITH SKELETAL CLASS III AFTER SURGERY AND CONTROL SUBJECTS

Muscle	Difference After Surgery	Difference From Controls	P Value*
UO	2.38 ± 6.7	-0.69 ± 1.0	.049 [†]
MM	-0.73 ± 11.4	-3.38 ± 3.1	.573 [‡]

Abbreviations: MM, mentalis muscle; UO, upper orbicularis oris muscle.

*Mann-Whitney test.

† $P < .05$.

‡No statistical significance.

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the parameters studied in the literature, with the expectation that after this period almost all the temporary consequences of the procedure would resolve.^{2,4,17,18} However, the presence of nonresolved proprioceptive alterations that could influence the results were as found; these alterations probably will resolve favorably after a longer period.

The skeletal Class III group presented an EMG pattern compatible with lip incompetence before orthognathic surgery. Four months after orthognathic surgery, the Class III group presented an EMG pattern compatible with lip competence, similar to the control Class I group. Patients with skeletal Class III showed no significant variations in the net EMG activity of the orbicularis oris and mentalis muscles after undergoing combined orthognathic surgery.

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