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## **Assessment of changes in muscle activity using electromyography in patients undergoing orthognathic surgery**

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**Abstract**--The aim of the present clinical trial study is to evaluate the effect of double jaw orthognathic surgery (OGS) on electromyographic activity of the masseter, anterior temporal, digastric, and sternocleidomastoid muscles in skeletal Class III patients. This prospective study included 10 patients who underwent Lefort 1 osteotomy of the maxilla and genioplasty of the mandible to correct skeletal dental class III malocclusion and presurgical and postsurgical EMG data were analyzed and compared. The participants underwent bilateral surface electromyography activity evaluation with a focus on the masseter, anterior temporalis, digastric and sternocleidomastoid muscles. Recordings were made each during 3 jaw positions: clench, resting and swallowing positions. The pre-surgical EMG data were compared with the post-surgical EMG data taken after 1 month to evaluate any changes in muscle activity. A significant increase in the average EMG activity after an orthognathic corrective surgery was observed. There were no significant postoperative changes in the EMG

potentials of the anterior temporalis and masseter bilateral balance in the pre-op and post-op clench positions. Significant muscle posturing was observed in the post-op resting position with bilateral masseter, sternocleidomastoid, and right temporalis values >2mV with mandible and rest. Within the limitations of the present study, Orthognathic surgery improves the muscular activity of patients who present skeletal dental class III malocclusion with patients who benefit more from orthognathic surgery displaying the lowest presurgical EMG activity.

**Keywords**---orthognathic surgery, electromyography, muscle activity, muscle changes, clench position, resting position, swallow position.

## Introduction

Orthodontic-orthognathic surgery (OGS) is the primary treatment option for skeletal Class III patients with facial asymmetry. The goal of the treatment is not only to improve facial aesthetics and functional occlusion but also to achieve recovery of the stomatognathic system. Facial asymmetry is known to affect the function and structure of the stomatognathic system, and it causes imbalances in bite forces, electromyography (EMG) activity levels, muscular thicknesses, chewing patterns, and condylar paths [1–4]. Orthognathic surgery, in combination with orthodontic treatment, corrects the dentofacial deformity and improves occlusal contacts, masticatory efficiency, bite force, and EMG activity. A number of studies reported the increased bite force and occlusal contact area after orthognathic surgery [5–7]. Although OGS corrects the skeletal frame, it is unclear whether adaptation of muscles or jaw movements occurs directly as a result of the surgery. The muscles are detached and spontaneously reattached during surgery, causing reversible atrophy of the muscles, and they recover with a morphological adaptation that includes changes in the muscle length or direction [8].

Orthognathic surgery helps patients with skeletal dental class III malocclusions increase their muscle activity. EMG measures can be used to objectively assess this improvement. Patients with the lowest presurgical EMG activity appear to benefit the most from orthognathic surgery. Surface electromyography (sEMG) is a non-invasive technique for determining the level of myoelectric activity. The anterior temporalis and superficial masseter muscles are the most typical locations for sEMG recording of the masticatory muscles due to their accessibility. EMG is routinely observed during clenching and chewing at maximal or submaximal bite force. The amount of sEMG represents how active the muscles are. Previously our team has rich experience in working on various research projects across multiple disciplines [9–23]. Now the growing trend in this area motivated us to pursue this project. Based on this inspiration we aimed to evaluate the effects of double jaw orthognathic surgery (OGS) on electromyographic activity of the masseter, anterior temporal, digastric and sternocleidomastoid muscles in skeletal Class III patients.

## Materials and Methods

### Study setup

This randomized prospective controlled clinical study was conducted among patients reporting to the outpatient dental department of the oral surgery clinic during the period between June 2020- March 2021. The study population included 10 adult patients who underwent Lefort 1 osteotomy of maxilla and genioplasty of the mandible to correct skeletal dental class III malocclusion and presurgical and postsurgical EMG data were analyzed and compared.

#### Inclusion Criteria

- Patients between 18 years - 50 years of age
- Both genders
- Skeletal Class III malocclusion requiring double jaw surgery
- Stable occlusion after OGS
- 1st molars present in each quadrant
- No history of previous TMD treatment
- Absence of craniofacial anomalies and cleft lip and palate
- Absence of facial trauma, condylar fracture, and jaw bone defect
- No history of psychological or neurological disorder
- Absence of pain in masticatory muscles and bilateral temporomandibular joints

#### Exclusion criteria

Patients with hemifacial microsomia, cleft lip and/or palate, or disease of the temporomandibular joint were excluded from the study.

#### Procedure:

The participants underwent bilateral surface electromyography (sEMG) activity evaluation at (Occlusal Calibration Centre - OCC) with a focus on the masseter, anterior temporalis, digastric and sternocleidomastoid muscles. The records were taken in a calm and quiet room in which the subjects sat in a comfortable chair while maintaining an erect head posture. Prior to the placement of the electrodes, the skin was cleaned until oil was removed. Pre-gelled disposable electrodes were applied to the muscle belly, which was detected by palpation when the patient clenched. All muscle electrodes and a reference electrode were then connected to an EMG amplifier. Recordings were made each during 3 jaw positions: clench, resting, and swallowing positions. For resting tonus (relaxation), the patients relaxed again and opened their mouths slightly, after which the recording was stopped. For clench tonus, patients were asked to bite as hard as possible without relaxing for 2s. For swallow tonus, patients were asked to swallow following which recording was made for 5s. The pre-surgical EMG data were compared with the post-surgical EMG data taken after 1 month to evaluate any changes in muscle activity.

### **Patient preparation**

The patient was made to sit in a relaxed upright position and the skin was cleaned with surgical spirit. Electrodes were placed in the motor centers of the masseter, anterior temporalis, digastric and sternocleidomastoid muscles.

### **Anatomical landmarks**

The active motor center for masseter and anterior temporalis was located 50mm anterior to the tragus of the ear(A), 20mm inferior to point A(B), and 20 mm below the angle of the mandible. Point (C) was designated as being 25 mm superior to point A. The active motor center of temporalis was again designated 25 mm superiorly at a 45-degree angle towards the outside canthus of eyepoint (D).

### **Study parameters**

The following data were extracted for the purpose of the study:

- Age of the patient
- Gender of the patient
- Preoperative clench reading
- Postoperative clench reading

The subjects were divided into four age groups- Group 1: 11-20 years, Group 2: 21-30 years, Group 3: 31-40 years, Group 4: 41-50 years.

### **Data collection**

The data relating to the study parameters were obtained from among patients who reported to the Outpatient Department from June 2020- to March 2021. Approval for the study was obtained from the Institutional Ethical Committee. **Institutional Ethical Committee(SDC/SIHEC/2020/DIASDATA/0619-0320)**. All assessments were done by a single examiner and the findings were reviewed and recorded by two investigators. Written informed consent was obtained from all the patients.

### **Statistical analysis**

The data were tabulated and analyzed using IBM SPSS version 23.0 software. Non- parametric data were analyzed using descriptive statistics measuring frequency and percentage.

### **Results**

A total of 10 patients participated in this study, with an overall 100% participation.

- Age Distribution:  
The youngest and oldest patients were aged 18 and 40 years, respectively. The distribution of study subjects based on age revealed that most patients belonged to 31-40 years of age group (67.50%).
- Gender distribution:  
The distribution of study subjects based on gender, over a ten-month period, revealed that among patients 6 women (60%) and 4 men (40%) participated in this study.

### **Electromyography analysis**

- Clench Position:
  - Pre-op clench:
    - Anterior temporalis bilateral balance was fair at 76%, middle masseter bilateral balance was good at 98%. Right anterior temporalis and masseter synergy were poor at 47% with temporalis lower.
  - Post-op clench:
    - Anterior temporalis bilateral balance was good at 80%, middle masseter bilateral balance was good at 90%. Left anterior temporalis and masseter synergy were good at 95% with the masseter lower.
- Resting position:
  - Pre-op Resting:
    - Bilateral Digastric, right sternocleidomastoid values were greater than 2mcv with mandible at rest, indicating significant muscle posturing.
  - Post-op Resting:
    - Bilateral masseter, bilateral sternocleidomastoid, and right temporalis values were greater than 2 mcv with mandible at rest, indicating significant muscle posturing.
- Swallow position
  - Pre-op Swallow:
    - The intensity of digastric was greater than the intensity of temporalis in some patients indicating the patient may have had a tongue thrust.
  - Post-op Swallow:
    - The intensity of digastric was lesser than the intensity of temporalis post-surgery, indicating the patient may not have the tongue thrust.

### **Discussion**

Orthognathic treatment requires a variety of adjustments, including three-dimensional changes of the jawbones and the surrounding soft tissue [24]. With respect to jaw movement, three-dimensional movement of the distal segment would inevitably lead to unpredictable movements of the condyles. Therefore, it is difficult to anticipate the exact changes in jaw movement patterns after OGS [25]. Previous studies have reported that surgical correction in skeletal Class III patients improved the balance of masticatory muscles on both sides and changed the temporalis-dominant pattern to the masseter-dominant pattern [26,27].

EMG can be used for diagnosis to discover muscular diseases such as myotonias by comparing muscle activity in healthy people. EMG can also be used to

investigate the negative consequences of TMJ problems on muscle activity. [28] Several studies have evaluated the changes in muscle activity and jaw movement after OGS. According to a study performed by Celakil et al [24,29], the results showed a dramatic decrease in muscle activity following double jaw OGS in the first month, and the masticatory muscle performance was also found to be significantly reduced following surgical intervention.

These findings are aligned with those reported by Ko et al [24,29], who found a statistically significant decrease in anterior temporalis and masseter muscle biting activity. However, studies by Trawitzki et al [30,31] found an increase in the EMG activity of masticatory muscles after surgical corrections in Class III patients. These results were in accordance with our study. After surgical treatment of skeletal class III malocclusions and improvement in functional deficits associated with this dentofacial deformity, EMG can be employed as an important technique to indicate increased muscle activity and improvement in functional deficits. The surgical treatment improves occlusion, resulting in greater eccentric tooth contacts and muscular mean power frequency, all of which translate to better muscle activity.

According to a study performed by Ko et al [24,29], the resting tonus of the anterior temporalis and masseter muscles was not affected by OGS. The improvement of EMG mastication after OGS was shown by biomechanical advantage or occlusal stability [32,33]. Normalizing the skeletal pattern after OGS did not achieve similar improvements on the sEMG image. The results were similar to those performed by Iwase et al, Youssef et al, Sforza et al, and Di Palma et al [32,34,35]. Our institution is passionate about high-quality evidence-based research and has excelled in various fields [13,36–45].

### **Limitations**

Future long-term follow-up studies are needed to determine whether OGS in skeletal Class III patients can improve masticatory performance and muscle activity. Furthermore, patient compliance for controls and long-term evaluation of these patients is a necessity to confirm the reported changes.

### **Future scope**

Although the literature provides a number of studies on the application of sEMG in orthodontics, there are limited studies related to assessing the muscle activity by surface electromyography in patients undergoing orthognathic surgery.

### **Conclusion**

Orthognathic surgery improves the muscular activity of patients who present skeletal dental class III malocclusions. This improvement can be objectively assessed with EMG measurements. Patients who benefit more from orthognathic surgery seem to be those displaying the lowest presurgical EMG activity. Modifications in surgical design and overcorrection should be considered in patients with greater masticatory muscle activity before OGS.

## Consent

As per international standards or university standards, participants' written informed consent has been obtained and preserved by the author(s).

## Ethical approval

Ethical approval was obtained from the institution's ethical committee. Approval for the study was obtained from the Institutional Ethical Committee. Institutional Ethical Committee (SDC/SIHEC/2020/DIASDATA/0619-0320)

## Competing interests disclaimer

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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