IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 14, Issue 4 Ver.VI (Apr. 2015), PP 44-48
www.iosrjournals.org

Evaluation of Masseter Electric Activity following Bilateral Sagital Split Osteotomy in Patients with Mandibular Retrognathism

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Abstract: *Bilateral sagittal split osteotomy (BSSO) in order or advance mandible is a common surgery for patients with mandibular retrognathism. While various complications could result after this surgery, the aim of the present study was to evaluate the effect of BSSO surgery on electric activity and function of masseter muscle. 36 patients in need of mandibular advancement with BSSO technique participated in the present study. At three time points including prior the surgery, 3months, and 6 months after electromyography (EMG) of the masseter was recorded. The results indicated that the electric function of the muscle decreased significantly after 3 months (P-value < 0.05); however, no significant difference was observed between baseline and 6 month follow up EMG values (P-value > 0.05). According to the results of the present study, orthognathic surgery of retrognathic mandible lead to transient alterations of masseter muscle activity which would be resolved after 6 months.*

Keywords: *Electromyography, Lip Paresthesia, Mandibular Retrognathism, Masseter Muscle, Sagital Split Osteotomy.*

I. Introduction

The knowledge regarding management of maxillofacial abnormalities has been improved drastically during the recent decades. Among various surgical interventions, osteotomy techniques regarding mandible bone have been improved more than other techniques. Anterior Subapical Osteotomy was the first technique which introduced mandibular osteotomy which was further improved to intraoral vertical ramus osteotomy by Laterman and Caldwell [1, 2].

The sagittal split ramus osteotomy (SSRO) was first introduced by Obwegeser and Trauner which became the favorable technique in skeletal corrections involving mandible bone [2]. In comparison to other surgical techniques for mandible, SSRO requires less intermaxillary fixation (IMF) period and higher postoperative satisfaction for patients [2].

The favorable surgical approach for patients with mandibular retrognathism is bilateral sagittal splint osteotomy (BSSO). However, diminished masticatory force, lip paresthesia, dysfunctions in tempromandibular joint, and limitation in jaw opening are among the complications of BSSO surgery [3-10]. Hence the aim of the present study was to evaluate the effect of BSSO on the function of masseter muscle in patients with mandibular retrognathism.

II. Materials and Methods

The present study performed at Oral and Maxillofacial Clinic of Mashhad Dental School. The study protocol was approved by ethical committee of Mashhad University of Medical Sciences. All the patients provided signed informed consent.

2.1 Patients Population:

36 patients with mandibular retrognathism in need of surgical management with BSSO technique (Epker modification) between March 2010 and July 2011 participated in this study. All participants had started their orthodontics treatment. In case of temperomandibular joint disorder (TMD), history of trauma to the maxillofacial area, taking medications affecting neuromuscular or sensory system, history of neuromuscular diseases, or former orthognatic surgery patients was excluded from the study. In addition, unexpected situation - fracture of pieces during the osteotomy, obtaining incorrect occlusion after surgery, post surgical infection - also led to exclusion of patient.

2.2 Surgery Technique:

Three weeks before the surgery, lateral cephalogram was obtained at Oral and Maxillofacial Radiology department in Natural Head Position. Three months after another cephalogram was obtained at the same position and by the same radiologist. In addition, prior the surgery prediction tracing was performed and model casts were mounted on semi adjustable articulator in order to review the final occlusion.

The surgery was performed under general anesthesia by a maxillofacial surgeon using the BSSO method (Obwegeser modification). After osteotomy and repositioning of jaw, the pieces were fixed by three bicortical titanium screws (length: 11 mm; diameter: 2 mm). The packed bandage was used for three days after the surgery. Patient was instructed to remain on liquid diet during the first postoperative week. Maxillomandibular fixation (MMF) was performed for one week.

2.3 Masseter Electromyography:

In order to observe the changes in masseter function, electromyography (EMG) activity was recorded bilaterally using a needle electromyograph (Toennies, Germany) which performed by a neurologist at Neurology Department of Ghaem hospital (Mashhad, Iran).

The electrodes were placed on the bulk of each masseter muscle (most prominent part). The bulk of the muscle was found during clenching. The patient was instructed to seat upright in order to have the Frankfort line parallel to the floor. In addition, the ground electrode was placed on the forearm of left hand. In the relax situation of masseter, EMG must recorded a straight line indicating no noise. Then the patient was instructed to clench with maximum power and maintain it for 10 seconds. During this period the muscular activity was recorded every 2 second. The recording was repeated after 1 minute and in case of more than 10% variation in two records, the process had to be repeated.

The EMG of masseter in maximum contraction was recorded as Raw EMG Signal. The analog signals changed into digital ones by the software in the device. The following variables were measured: root of mean EMG signal value was calculated as root mean square (RMS); the average of each RMS as average rectification value (ARV) for each second; the integral of EMG cross time was also calculated and set as integrated EMG (IEMG) of first, fifth and tenth seconds.

It should be noted that the EMG of masseter muscle was recorded at three time points; one week prior the surgery (baseline), 3 months, and 6 months after surgery.

2.4 Statistical Analysis:

Data were reported descriptively and also analyzed using t-test and repeated measures with the confidence interval of 95% in SPSS version 11.0 software.

III. Results

33 patients including 21 females and 12 males completed the study with the mean age of 22.51 ± 3.91. Two patients were excluded from the study due to complications during the surgery and the other patient did not participate in the follow up sessions regularly.

The mean amounts of RMS and ARV at different time points is presented in Table 1. Based on repeated measures analysis, the average amount of ARV and RMS significantly decreased during the10 seconds in all of the three measurement sessions (P-value < 0.001) (Fig 1 and 2). Based on t-test, the total amount of RMS and ARV was significantly lower after 3 months when compared with baseline or 6 months measurement (P-value < 0.001). However, no significant differences was observed between the total value of RMS and ARV at baseline and 6 months after surgery (P-value = 0.683 and 0.419, respectively).

The mean value of IEMG is presented in Table 2. According to the repeated measure test, all of the IEMGs were significantly changed during the measurement period (P-value < 0.001) (Fig 3). Although the mean IEMG was significantly reduced in 3 months follow up in comparison to baseline (P-value < 0.001), no significant difference was observed between 6 months and baseline values (P-value > 0.05).

IV. Discussion

Based on the results of present study the electric activity of masseter muscle was changed after the BSSO surgery in patients with mandibular retrognathism. While the EMG of masseter was reduced significantly after 3 months, at the 6 months follow up the electrical activity of the muscle was back to its baseline value as no significant difference was observed.

Similar to the results of the current study, in the study reported by Ueki et al [11], the maximum masticatory forces reached the baseline amounts after 3-6 months of bilateral sagital split osteotomy. They observed no significant differences between various surgical techniques considering the effect on masticatory forces [11]. In addition, Ingervall et al [12] demonstrated that muscular function of masseter muscle reduced significantly after the surgery and increased to the baseline value after 8 months. In another study, Raustia and

Oikarinen [13] found that contraction function of the masseter muscle diminished significantly after 6 weeks of sagital split osteotomy surgery; however, after 1 year the muscular activity was similar to the baseline values [13].

Considering the muscular measurements, a reduction pattern was observed in muscular contraction force during the 10 seconds of isometric contraction. This indicates the normal pattern of fatigue was present in all of the time points. Eshghpour et al [14] also found similar pattern in patients with mandibular prognathism in need of setback surgery.

Song et al [15] implemented an animal study on rabbit model; they performed mandibular osteotomy and investigated the changes in the masseter muscle. They found muscular atrophy along with muscular mass attenuation after the surgery. Song et al reported that the atrophy was the result of adaptation of sarcomer's, muscle fibers' atrophy, and alterations in muscular fibers' type rather than changes in connective tissue [16]. In clinical studies, decrease in muscle balk and replacement with fatty tissue has been reported in vertical ramus osteotomy following mandibular setback [17].

Generally, two factors that affect the biting forces are muscular contraction and the Length of actuator arm [18]. While protraction of the mandible bone would decrease the mechanical advantage, the adaptation of muscle fibers may compensate the reduction in biting force [19]. While the electric activity of masseter did not reach its baseline values after 6 months, it has been reported that 2 years is the required time to observe the complete improvement in biting force of muscle [20].

The other factor contributing to the changes in masticatory forces is orthodontic treatment prior the surgery which reduces the biting forces [21]. In the present study, all of the patients had previous orthodontic treatment.

In addition, the other factor affecting the activity of masticatory muscles is the period of maxillomandibular fixation (MMF). While a long period of MMF would result in the fibers degeneration, it could also attenuate the healing rate [22, 5]. In the present study the MMF was performed for one week. However, Raustia and Oikarinen performed 16 days MMF after BSSO which could explain the lower healing rate in their patients in comparison to the current study [13].

The device used to record the electric activity of muscle is also a variable. While the former transducers had relatively bigger diameter, in later studies the diameter has been reduced. Throckmorton et al [19] used a transducer with 15 mm of diameter; however, in the present study needle transducer was used. It should be noted that the accuracy of measurements increases by reducing the diameter of the transducer. In addition, needle transducers are more accurate than other shapes including pad-transducers [23, 24].

The experience of surgeon affects the outcome of the surgery; Kobayashi et al [25] reported that surgeon experience affected the frequency of sensory alterations following BSSO surgery. In order to eliminate this variable, all the surgeries were performed by a single experienced surgeon in the present study.

Sample size was of limitations of present study. In addition, monitoring patients for longer periods is recommended as it would enable us to provide a wider point of view regarding the post-surgical complications.

V. Conclusion

Considering the results of the present study, mandibular protrusion surgery leads to temporary and transient alterations in the masticatory function of masseter muscule. However, the electric activity of muscle reached the baseline value after 6 months. Hence the mandibular protrusion surgery using BSSO technique is a reasonable and also safe technique to manage patients with mandibular prognathism.

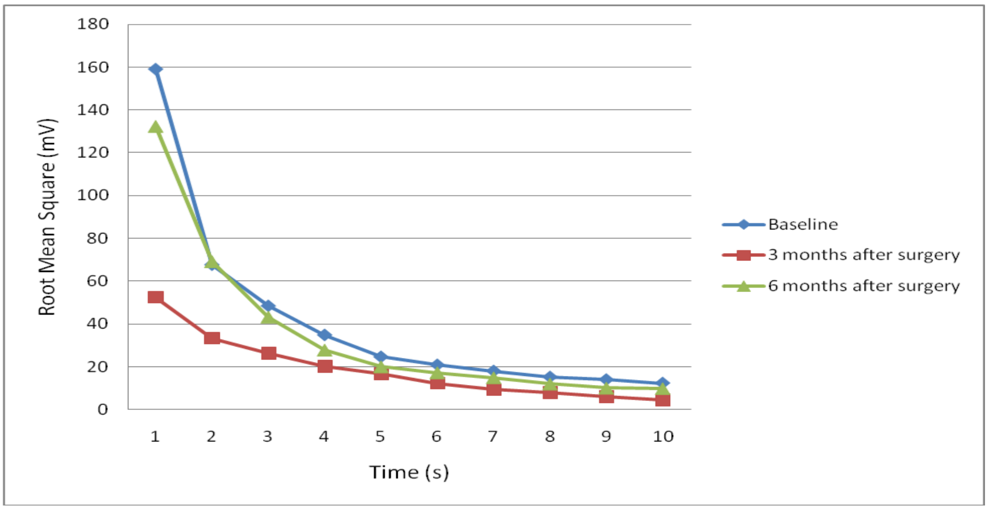
VI. Figures and Tables (11 Bold)

Table 1: Mean values of root mean square (RMS) and average rectification value (ARV) in different time points

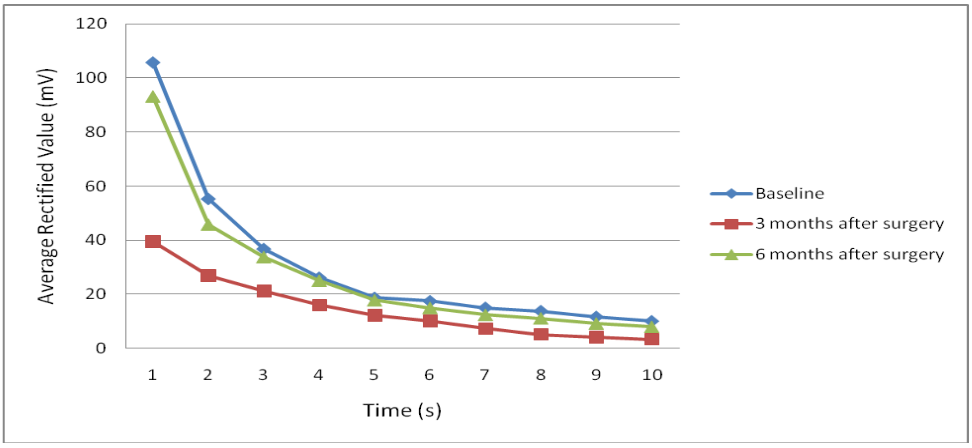
Time	Before Surgery		3 months after surgery		6 months after surgery	
	RMS*	ARV*	RMS	ARV	RMS	ARV
1 s	159.12 ±45.20	105.78± 33.98	52.45± 6.66	39.45 ± 7.17	132.33 ± 37.07	93.22 ± 30.02
2 s	67.60 ±17.22	55.28 ± 16.92	33.29 ± 4.89	26.88 ± 12.02	69.18 ± 15.05	45.82 ± 22.17
3 s	48.39 ± 15.59	36.78 ± 13.72	26.28 ± 8.18	21.09 ± 5.68	43.27 ± 8.49	33.76 ± 10.14
4 s	34.76 ± 10.92	26.15 ± 12.11	20.12 ± 5.12	15.99 ± 4.42	27.88 ± 7.33	25.05 ± 9.78
5 s	24.56 ± 6.23	18.72 ± 7.77	16.62 ± 7.82	12.17 ± 5.19	20.06 ± 8.18	17.79 ± 7.66
6 s	20.81 ± 7.48	17.46 ± 6.47	12.29 ± 5.22	10.08 ± 4.28	17.27 ± 5.29	14.92 ± 5.92
7 s	17.92 ± 5.21	15.02 ± 5.44	9.33 ± 4.17	7.27 ± 2.92	14.92 ± 5.78	12.39 ± 4.12
8 s	15.14 ± 4.92	13.81 ± 4.15	7.88 ± 3.53	5.14 ± 1.79	11.99 ± 4.12	11.08 ± 3.67
9 s	13.92 ± 3.36	11.66 ± 2.28	6.08 ± 2.07	4.14 ± 1.44	10.08 ± 3.67	9.18 ± 3.22
10 s	12.29 ± 3.77	10.06 ± 3.90	4.49 ± 1.18	3.35 ± 0.68	9.85 ± 3.01	7.93 ± 2.76
Total	49.55 ± 15.48	32.75 ± 11.48	25.05 ± 10.65	14.69 ± 8.015	45.89 ± 8.22	28.94 ± 9.52

Table 2: the integrated EMG (IEMG) at different time points

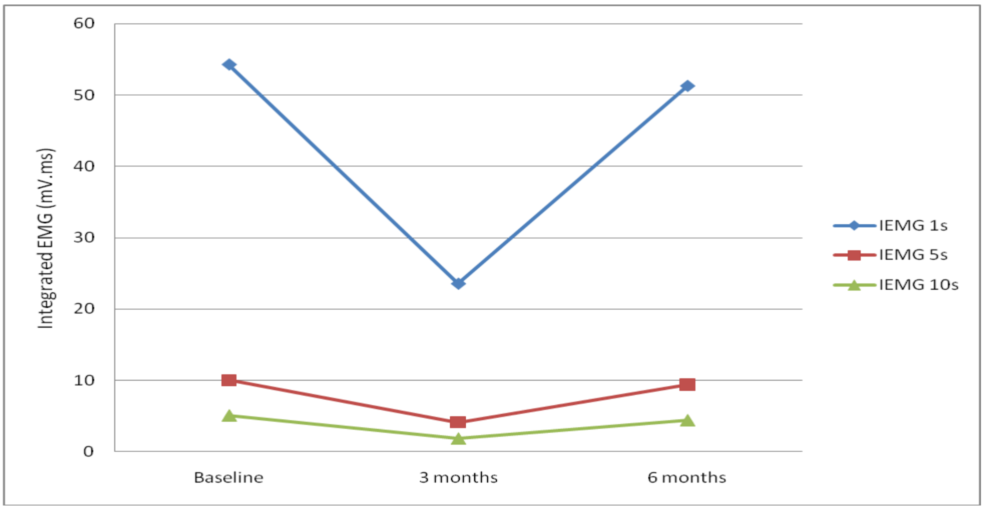
Time	Before Surgery	3 months after	6 months after
1 s	54.29 ± 16.22	23.56 ± 9.82	51.29 ± 15.12
5 s	10.02 ± 3.15	4.12 ± 2.31	9.42 ± 2.31
10 s	5.05 ± 1.42	1.85 ± 0.77	4.39 ± 2.02



Graph 1: Changes in root mean square (RMS) at three measurements



Graph 2: Changes in average rectified value (ARV) at three measurements



Graph 2: Changes in average rectified value (ARV) at three measurements

Acknowledgements

Authors would thank Oral and Maxillofacial Surgery Clinic staff and also Dental Research Centre of Mashhad Dental Faculty according to their cooperation. In addition, we would thank Dr. Amir Hossein Nejat for his assistance with statistical analysis and study design..

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