Complications of Bilateral Sagittal Split Osteotomy in Patients with Mandibular Prognathism

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Abstract

Introduction: Bilateral sagittal split osteotomy (BSSO) of mandible is vastly used in treatment of mandibular deficiencies and discrepancies. Since this method could affect esthetic as well as function, evaluating these effects from various aspects is crucial. This study assessed the effects of this technique on the function of masseter muscle, jaw movements, and sensory changes along with failures in screws used for fixation. **Methods:** 48 patients with mandibular prognathism participated. Electromyography (EMG) of the masseter muscle; limits of jaw movements including maximum opening (MIO), protrusive (PM), lateral movements (LLE and LRE); presences of sensory changes and two point discrimination test; and number of removed screws were recorded at the baseline, 3 months, and 6 months after surgery. **Results:** EMG activity of masseter decreased significantly 3 months after the surgery. However, after 6 months the masseter activity revealed no statistically significant difference with baseline activity. There was a significant decrease in MIO and PM after 3 months. The 6 month measurement of MIO and PM was also lower than baseline. However, no difference was observed between LRE and LLE in both follow up sessions. Among 46 patients, 27 patients developed lip paresthesia 3 months after surgery. After 6 month, lip paresthesia remained in 11 patients. Among 276 screws used for fixation 3 screws removed due to exposure to oral cavity and 2 due to patient discomfort. **Conclusion:** As BSSO in patients with mandibular prognathism revealed temporary functional and sensory changes, it is a safe and appropriate method in orthognathic surgery.

Key words: Lip paresthesia, mandibular prognathism, muscular function, sagittal split osteotomy.

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Introduction

Along with great increase in our knowledge over maxillofacial abnormalities and their surgical treatment during the recent decades, mandibular osteotomy techniques have improved more than other surgical techniques (1,2).

Mandibular osteotomy was first introduced as anterior subapical osteotomy. It improved when Laterman and Caldwell proposed the Intraoral Vertical Ramus Osteotomy (IVRO). However, it was Obwegeser and Trauner who first developed sagittal splitting ramus osteotomy (SSRO). The primary goal of SSRO was correction of mandibular skeletal malocclusions (2). SSRO has less inter-maxillary fixation (IMF) period and improved patient comfort are advantages of this technique.

The current surgical technique for treatment of mandibular prognathism is bilateral sagittal splint osteotomy (BSSO). Following BSSO, some complications has been reported including loss of masticatory force, muscular and temporomandibular joint dysfunctions, lip paresthesia, limitation in jaw opening, infection, patient discomfort due to screws, and screw loosening (3-12).

The aim of the current prospective study was to perform a thorough investigation on complications following BSSO surgery in patients with mandibular prognathism without maxillary involvement in an Iranian population.

Materials and Methods

Patients Population

A number of 48 patients with mandibular prognathism, who were referred to oral and maxillofacial surgery clinic of Mashhad Dental Faculty between September 2008 and February 2010, participated in this study. Informed consent was signed and Ethical Board of Mashhad Medical University approved the project. Twenty nine females and 19 males who were in need of mandibular retraction surgery (Setback) with BSSO technique (Epker modification) entered this study.

Using drugs affecting neuromuscular system, history of neuromuscular diseases, prior trauma to the maxillofacial area, history of prior orthognathic surgery, systemic disorders, consumption of drugs affecting sensory system, mandibular asymmetry, open bite, and presence of signs or symptoms of temporomandibular joint disorders led to exclusion of patient from study. In addition, patients who had more than 7 mm set back also excluded from study.

All subjects had been performed initial orthodontic therapy. It should be stated that patients who faced any unexpected problems such as fracture of pieces during the osteotomy, post surgical infection and not having correct occlusion after the surgery were also excluded from study.

Cephalometric Evaluation and Prediction Tracing

Lateral cephalography was obtained in Department of Oral Radiology of Mashhad Faculty of Dentistry, three weeks before and three months after the surgery. All cephalographs were taken in natural head position by the same radiologist.

Prediction tracing was performed for all the patients before the surgery. Then, model surgery was mounted on semi adjustable articulator and final occlusion was reviewed.

Surgical Procedure

The surgery was performed bilaterally by a maxillofacial surgeon with BSSO method. Each side was fixed with three bicortical titanium screws (11 mm in length and 2 mm in diameter). The packed bandage was used after the surgery for 72 hours and the patients were on liquid diet during the first week after the surgery. Following surgery, due to the internal rigid fixation there were no need for further inter-maxillary fixation and only elastic therapy was performed.

Electromyography

The electromyography activity of masseter was recorded bilaterally (left and right) with a needle electromyography (Toennies, Germany) by a neurologist in a room with fix temperature of 25°C, Department of Neurology at Ghaem hospital (Mashhad, Iran). The electrodes were placed on the most prominent part of masseter muscle (bulk of the muscle) which was located during clenching. Subjects sat upright on a chair with their Frankfort line parallel to floor. Ground electrode was placed on the left hand forearm and one electrode was placed on each side. Subjects were asked to make their masseter muscle relaxed so that the EMG could record a straight line without any noise. Then it recorded the maximum muscular activity in clenching position which should last for 10 seconds. Muscular activity recorded for 2 times with 1 minute interruption for relaxation. If the difference between 2 records were varied more than 10%, the experiment would be repeated.

EMG was assessed one week before the surgery (baseline), 3 months, and 6 months after surgery as follow up measures. The electromyographic activity of masseter in maximum contraction (clenching) was recorded in Raw EMG Signal during 10 seconds of contraction. Analog records were converted into digital by the software in electromyographic device system. The root of mean value of EMG signals was calculated as root mean square (RMS); root of each square calculated and the average of each second calculated as average rectification value (ARV) for each second; to calculate the integral of EMG the sum of EMG cross time calculated and set as integrated EMG (IEMG) of first, fifth and tenth seconds.

Jaw Opening

Maximum inter-incisal opening (MIO), left and right lateral movement (LLE and RLE, respectively), and protrusive movement (PM) were recorded at the baseline, 3 months, and 6 months after surgery. All measurements performed with a calibrated caliper.

Lip Paresthesia

To evaluate the paresthesia of lip after surgery, two point discrimination-test (TPD) was performed on both sides of lip. This test was conducted with a compass which had two sharp tips. The minimum distance between two tips in which patient could discriminate two tips was recorded at baseline, 3 months, and 6 months after surgery. During the test, patient was seated in a calm room with his/her eyes completely shot. The presence of paresthesia and the triggers were also recorded.

Screw Removal

Soft tissue dehiscence and exposure, infection, screw loosening, and patient discomfort were of reasons, leading to remove screws. Number of removed screws along with its removal time and indication recorded.

Statistical Analysis

Data were reported descriptively and analyzed using t-test, nonparametric tests of Friedman and Wilcoxon Signed Ranks with the confidence interval of 95% in SPSS version 11.0 software.

Results

A total number of 46 patients including 29 females and 17 males completed the study. The age of patients varied between 17 and 27 years old with the mean of 20.6 ± 2.89. One patient was excluded from the study due to complications during surgery and the other did not attend to follow up sessions. It should be mentioned that no complication like infection or hematoma observed during the study period.

The mean amounts of RMS, ARV, and IEMG has been listed in Table 1. The average amount of ARV and RMS significantly decreased during 10 seconds in all three sessions of measurement (P=0.001) (Figs. 1 and 2). According to Wilcoxon test, the mean amounts of RMS and ARV at the 3 months measurement was significantly lower than baseline values (P=0.01, P=0.015, respectively) and 6 months after surgery values (P= 0.01 for both). However, there were no significant differences between baseline and 6 months after surgery mean amounts of RMS and ARV (P=0.77, P=0.67, respectively) (Fig. 3).

Table 1. Mean values of RMS and ARV in various times along with Integrated EMG values

Time	Before Surgery		3 months after surgery		6 months after surgery	
	RMS*	ARV*	RMS	ARV	RMS	ARV
1 s	157.95 ±45.20	104.53± 32.06	56.90± 4.60	44.83 ± 0.21	120.53 ± 37.71	95.64 ±31.13
2 s	62.56 ±18.99	48.83 ± 15.00	27.89 ± 3.09	21.73 ±0.15	61.36 ± 7.42	48.80 ± 3.95
3 s	46.64 ± 16.62	37.15 ± 13.10	21.76 ± 9.92	16.20 ± 7.80	42.83 ± 3.34	34.03 ± 0.42
4 s	33.58 ± 11.02	26.21 ± 8.30	15.08 ± 6.93	11.71 ± 5.45	28.62 ± 9.36	25.04 ± 7.14
5 s	25.02 ± 7.43	19.70 ± 5.80	10.20 ± 4.97	8.35 ± 3.83	23.31 ± 6.46	18.29 ± 5.09
6 s	21.85 ± 6.50	16.49 ± 5.47	9.41 ± 4.27	7.28 ± 3.51	18.36 ± 4.48	15.15 ± 4.03
7 s	18.24 ± 6.13	14.27 ± 4.31	7.05 ± 3.41	5.83 ± 2.65	15.69 ± 4.36	12.31 ± 2.87
8 s	15.32 ± 4.46	12.21 ± 2.86	6.18 ± 2.67	4.59 ± 2.16	12.98 ± 3.04	10.18 ± 2.39
9 s	14.42 ± 4.74	10.87 ± 3.91	5.03 ± 2.36	4.12 ± 1.63	12.02 ± 2.78	9.02 ± 2.40
10 s	13.31 ± 4.33	10.38 ± 3.51	4.92 ± 2.15	4.00 ± 1.33	10.79 ± 2.80	8.53 ± 2.03
Total	51.45 ± 16.09	30.56 ± 9.62	22.38 ± 9.86	12.82 ± 6.02	48.01 ± 4.41	28.01 ± 7.97

IEMG*

Time	Before Surgery	3 months after	6 months after
1 s	52.36 ± 15.87	22.43 ± 9.82	48.36 ± 15.32
5 s	9.95 ± 3.12	4.31 ± 2.04	9.85 ± 2.52
10 s	4.98 ± 1.48	1.85 ± 0.77	4.09 ± 1.18

* RMS is root mean square, ARV is average rectification value, and integrated IEMG is integral of electromyography

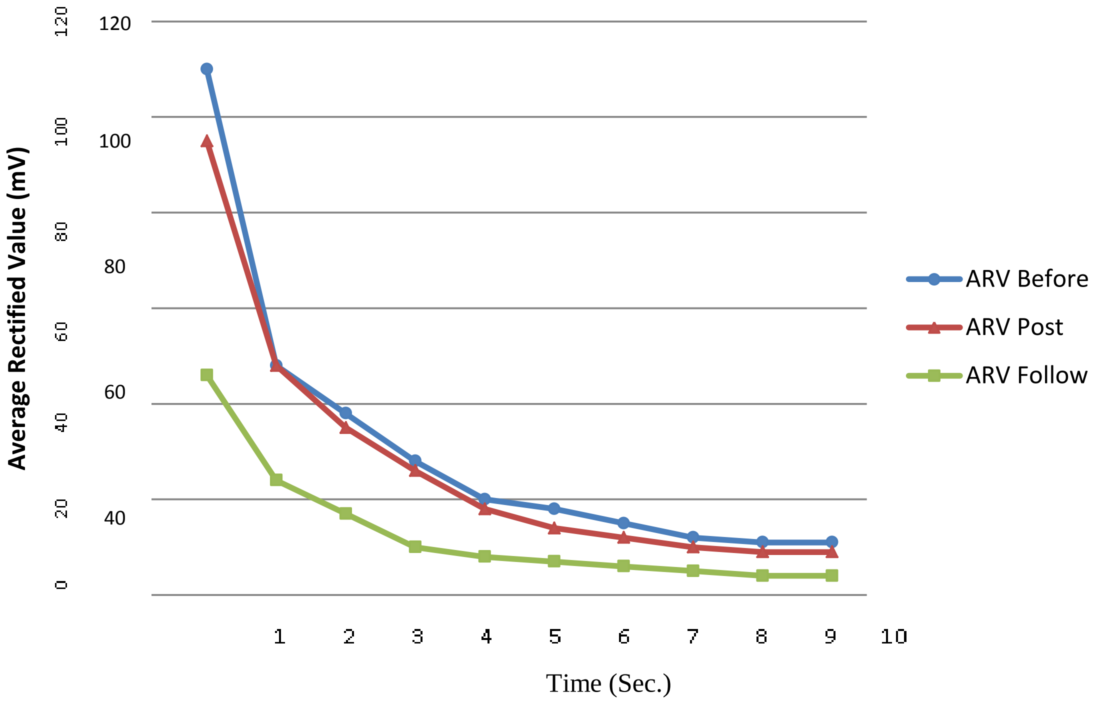

Figure 1. Changes of RMS index during ten seconds pre-surgery, 3 months, and 6 months after surgery

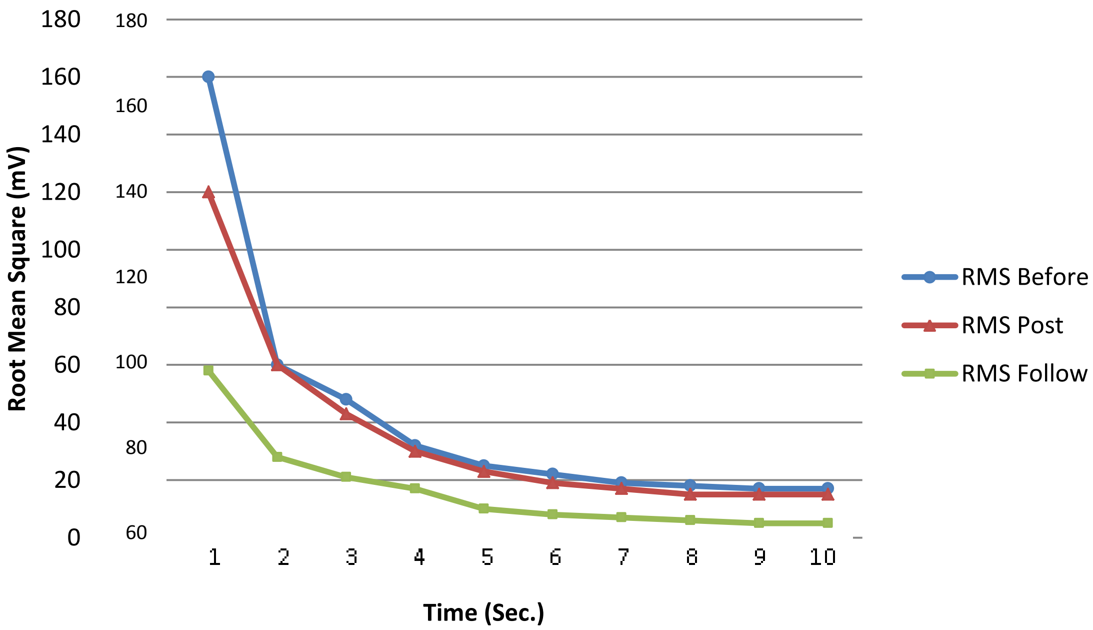

Figure 2. Changes of ARV index during ten seconds pre-surgery, 3 months, and 6 months after surgery

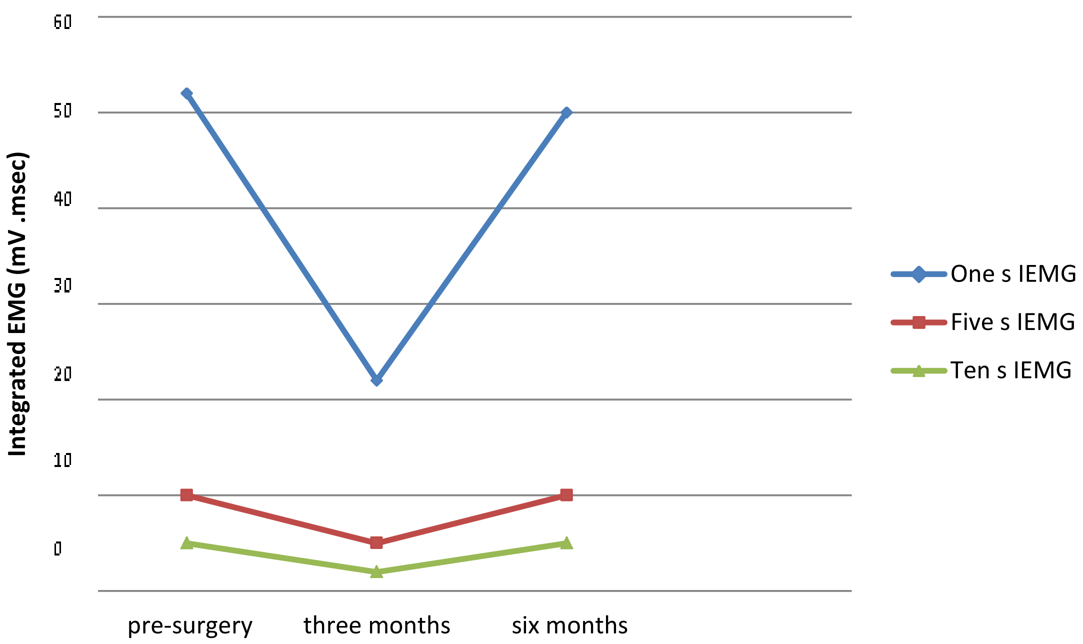

Figure 3. Changes of masseter activity level (IEMG) in three different times of before, after and follow sessions

The mean amount of jaw opening indicators along with standard deviation is presented in graph 4. At the baseline, 3 months, and 6 months after surgery 3, 36, and 11 patients had MIO less than 40 mm, respectively. There was a significant decrease in MIO and PM when comparing baseline and 3 months measure (P=0.022 and 0.008, respectively). The 6 month measure of MIO and PM was also significantly lower than baseline (P=0.044 and 0.036, respectively). However, no statistically difference was observed between LRE and LLE in both follow up sessions (P>0.05).

The mean amount of jaw opening indicators along with standard deviation is presented in Fig. 4. At the baseline, 3 months, and 6 months after surgery 3, 36, and 11 patients had MIO less than 40 mm, respectively. There was a significant decrease in MIO and PM when comparing baseline and 3 months measure (P=0.022 and 0.008, respectively). The 6 month measure of MIO and PM was also significantly lower than baseline (P=0.044 and 0.036, respectively). However, no statistically difference was observed between LRE and LLE in both follow up sessions (P>0.05).

Among 46 patients (92 sides), 27 patients (56.25%) in 45 sites (48.91%) developed lip paresthesia 3 month after surgery. After 6 month, lip paresthesia remained in 11 patients (23.91%) in 15 sites (16.30%). Mean of 92 measurements regarding TPD test are presented in table 2. There were no statistically difference between right and left lip in baseline, 3 month, and 6 month (P=0.987, 0.776, and 0.612, respectively). The difference between TPD test in baseline and 3 month was significant (P=0.026); however, no significant difference observed between baseline and 6 month (P=0.219). The trigger of annoyance in paresthesia was mainly in touch and feed/mastication (Table 3). After 6 months, all of the patients revealed complete or partial healing of lip paresthesia except in one patient which revealed continuous and severe discomfort in the left side of her lip.

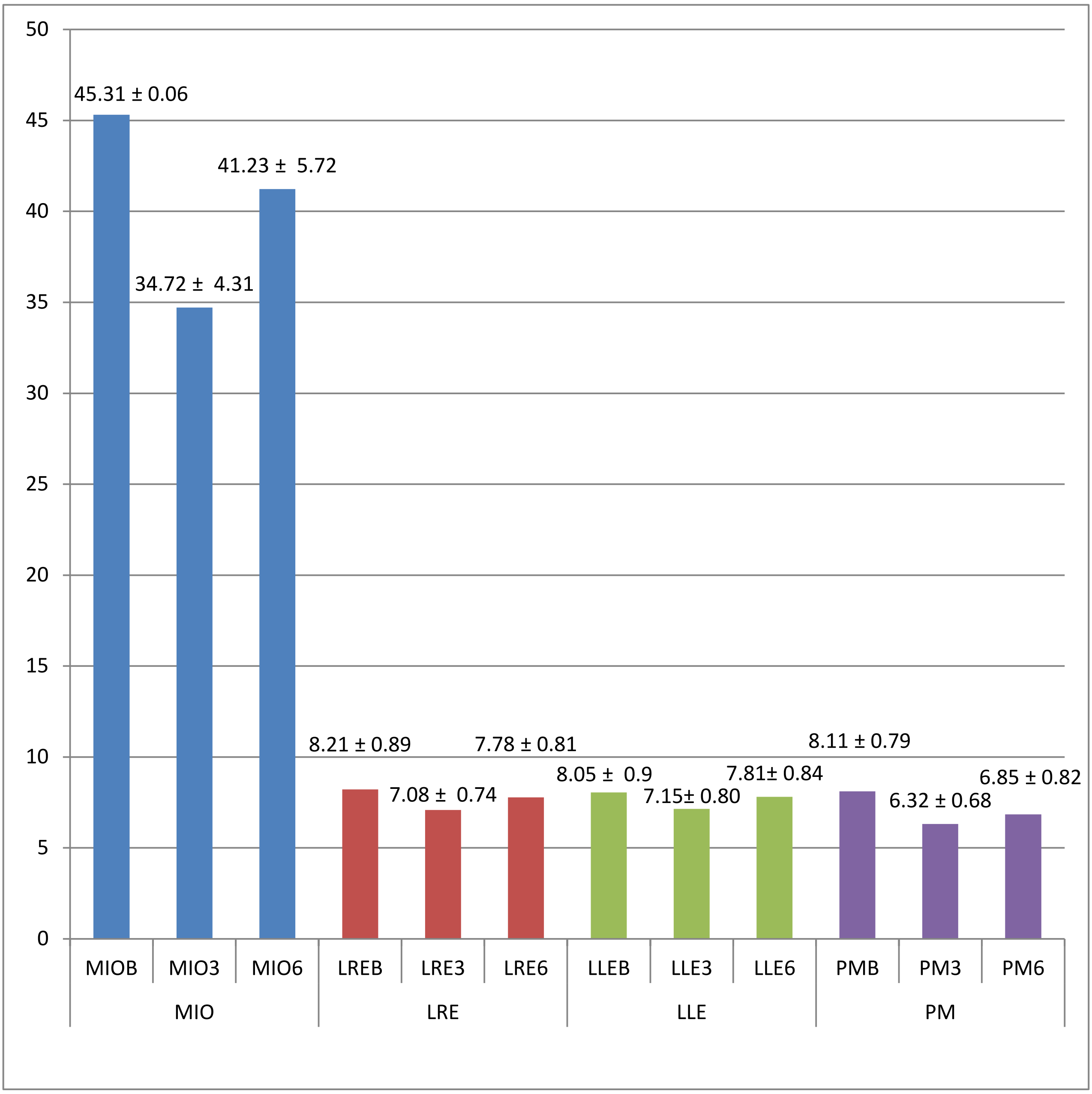

Figure 4. Mean amount of MIO, LRE, LLE, and PM in baseline, 3months, and 6 months after surgery

Table 2. Mean of two point discrimination test in both sides of lip in various times

TPD test*	Mean ± SD	
	Right side	Left side
Baseline	3.67 ±2.81	3.65± 2.69
3 month	6.78 ±3.13	6.32± 3.42
6 month	4.85 ±2.34	5.14± 2.31

* TPD test is two point discrimination-test

Table 3. Distribution of paresthesia triggers among patients

Trigger	N sites in 3 month (%)	N sites in 6 month (%)
None (continuous discomfort)	0 (0)	1 (1.09)
In touch	20 (21.74)	7 (7.61)
In Speech	7 (7.61)	1 (1.09)
In Feed/Mastication	18 (19.56)	6 (6.52)
No paresthesia	47 (51.09)	77 (83.69)

Total of 276 screws used for fixation of surgical sites. During study period, in the third month, none of the screws removed. However, after 6 months of surgery, 3 screws (1.08%) removed due to exposure to oral cavity. In addition, 2 screws (0.72%) removed due to patient discomfort. None of the screws loosened or became infectious.

Discussion

The results of this study revealed that electrical activity level of masseter in patients with mandibular prognathism initially had significant decrease by using the SSRO method following mandibular retraction surgery (Setback). However, the muscular activity was similar to baseline measures six months after the surgery and the masseter obtained its initial contraction ability. The reductive pattern of muscular activity in 3 different measurement times showed that the masseter muscle gradually began to feel fatigue during the isometric contraction.

Ueki et al. reported that the maximum masticatory forces returned to the baseline values after 3-6 months of sagittal split osteotomy with and without Le fort I osteotomy. They also found no significant differences within various surgical techniques according to masticatory forces (13). Raustia and Oikarinen (14) demonstrated that the masseter muscular activity decreased significantly 6 weeks after mandibular sagittal split osteotomy. One year after surgery, the muscular activity reached the same amounts of baseline. Ingervall et al. (15) also observed the normal muscular function of masseter after 8 months following a significant decline after surgical correction of mandibular prognathism. The results of mentioned studies are in accordance with current study with a trend of down falling in muscular activity followed by an uprising. Although muscular activity after 3 months was significantly lower than baseline, it reached the baseline values after 6 months.

In 1997, Song and Park (16) demonstrated that mandibular osteotomy in rabbits resulted in masseter atrophy and muscle mass reduction. They concluded that muscular atrophy was not due to connective tissue changes; rather, it occurred because of the muscle fibers atrophy, adaptation of sarcomer's function, and the change in muscular fibers' type. In human studies, smaller muscle with fatty replacement of muscle following vertical ramus osteotomy for correction of mandibular prognathism has been observed (17).

Two major factors are effective in biting force: muscular activity and Length of actuator arm (6). Retraction of mandible leads to improvement of mechanical advantage (18). Since a two-year follow-up has been mentioned as needed time for observing this effect following retraction surgery (19), the current study did not demonstrate higher values of biting force after 6 months in comparison to baseline.

One of the factors contributing in masticatory muscular activity and maximum biting force is the time of maxilla-mandibular fixation (MMF). Long period of MMF results in muscular fibers degeneration as well as muscular activity decrease (21). MMF is also a potential factor affecting healing period. It has been recommended to reduce MMF period for improvement both healing rate of masticatory muscles and biting forces (3). Raustia and Oikarinen (14) performed MMF for sixteen days and this could be probable factor of lower healing rate in their study in comparison to the current study in which MMF was not done.

In addition to MMF, pre-surgical orthodontic treatment has been demonstrated to reduce biting forces of patients (22). It should be stated that in the current study the measurements were performed after surgery and the orthodontic treatment effect did not investigate.

The device used for the measurement should also take into account. In this study, needle transducer was used to measure electromyography of masseter. Throckmorton et al. used a transducer with 15 mm of diameter in 1996 (19). However, in later studies the transducer has become smaller to increase the accuracy of measurements (23,24). It should be stated that needle transducer have more accuracy than pad-transducers which could enhance the reliability of results.

Mouth opening less than 40 mm is considered as limitation in jaw opening and is abnormal (25). In the current study, number of the patients with limitation in moth opening and reduced MIO were increased 3 months after surgery. However, after 6 months, limitation in jaw opening decreased and 59.45% of patients with limitation had MIO more than 40 mm. In addition, a significant decrease in PM was evidenced. The results of our study are in accordance with studies performed by Storum and Bell (25) and Bell (26) as they observed significant hypomobility in mandible following osteotomy. They considered pre-existing or surgically-induced TMJ dysfunction and muscular hypotrophy as possible explanation for this limitation (25). Possiet (27) also found 10.9% reduction in MIO after surgery which is similar to our results in 6 month follow up (8.9% reduction in MIO in comparison to baseline).

We did not find significant changes in LLE and RLE after surgery. Kopp found a good consistency between maximum mouth opening or protrusive movement and clinical signs. Kopp (28) also reported poor consistency with lateral movements. The results of Kopp (28) are in accordance with the results of our study.

TMJ edema, hemarthrosis, muscular inappropriate tension, muscle paralysis due to general anesthesia, wrong surgical technique, mismatch between proximal and distal segments, and inappropriate fixation would lead to changes in condylar position and translocation of proximal segments following osteotomy; two phenomena which could lead to muscular dysfunction and limitation in jaw movements (26,29).

In some reports, incidence of neurosensory disturbance of inferior alveolar nerve was between 9% and 85% (30). Hua et al. (31) and Schultze-Mosgau et al. (32) reported higher incidence of nerve disturbance after sagittal split osteotomy surgery when compared with the current study. However, Al-Bishri et al. (30) found that 40% of the patients undergoing setback surgery revealed sensory disturbance. Becelli et al. (33) reported that the highest healing rate in inferior alveolar nerve damages occur during 6 months after surgery while Schultze-Mosgau et al. (32) reported this period is 6 to 12 months post-surgery. We also observed an improvement after 6 month in comparison to 3 month. Regarding this improvement, the reason of lower incidence of sensory disturbances in Al-Bishri et al. could be explained according to the fact that all of their study population had performed surgery more than 1 year prior to study and lower incidence is due to the type of Al-Bishri et al. (30) study.

Kobayashi et al. (34) revealed that surgeon experience also affect the incidence of sensory changes following sagittal split osteotomy. In the current study, all the surgeries were performed by an experienced surgeon and this risk factor was eliminated.

Titanium screws are biologically compatible and there exists a policy to maintain them in the surgery site after healing completion. However, infection, patient discomfort, soft tissue dehiscence, sensitivity, or screw exposure are of reasons to remove this screws (35). In contrast, among researchers there exists another trend to remove screws after the healing is completed. They assume screws as implants without any function and may lead to foreign body reaction (36,37).

Weingart et al. (38) found that increased titanium level in regional lymph nodes after insertion of titanium screws in maxillofacial region. However, they did not find any foreign body or toxic reaction. Tomazic-Jezic et al. (39) revealed that titanium particle can impair the healing of bone tissue when monocytes and macrophages activated following facing particles.

The policy in Mashhad University of Medical Sciences is to maintain screws unless any complication occur or in demand of patients. We removed 1.08% of screws due to complication (exposure). In addition, 0.72% of the screws removed due to patient demand and discomfort. We did not observe any infection, screw loosening, temperature sensitivity, or wound dehiscence which leads to screw removal during study period.

We did not include patients who had their mandible set backed more than 7 mm as this amount of setback is unstable and the relapse could play as a confounding factor. One of the limitations of this study was number of the patients as with higher number of patients the results could be more precise. Moreover, checking patients in longer periods could cover the complications of this surgery broader. In addition investigation of complications following other types of orthognathic surgeries is recommended.

Conclusion

Mandibular setback surgery leads to temporary changes in masticatory muscles' activity, limitation in jaw opening, lip paresthesia. However, changes were resolved greatly after 6 months. In some cases, fixation screws may also need to be removed. Mandibular set back with BSSO technique is a safe and reasonable technique with temporary and reversible sensory, muscular, and functional changes.

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