

Changes in the Bilateral Balance of Masticatory Muscle Activity after Surgical Correction of Mandibular Lateral Shift: Report of 2 Cases

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Abstract

Objective: This case report is designed to present changes in the bilateral balance of masticatory muscle activity during daytime after surgical correction of mandibular lateral shift.

Study design: Using a portable EMG recording system, masseter and anterior temporal muscle activities were recorded in two patients with lateral deviation of the mandible for three hours at pretreatment, 6 months and 12 months after surgery.

Results: In case 1, the Asymmetry Ideex of masseter muscle activity during mealtime and during daytime was 0.3 at T0, 0.4 at T1 and 0.1 at T2, and -0.6 at T0, 0 at T1 and 0.2 at T2, respectively. With respect to anterior temporal muscle activity, the AIs were -0.1 and -0.4 at T0, -0.2 and -0.5 at T1, and 0.1 and -0.1 at T2 during mealtime and daytime.

In case 2, the AI of masseter muscle activity during mealtime and during daytime was 0.3 at T0, 0.2 at T1 and 0.3 at T2, and -0.3 at T0, -0.6 at T1 and -0.1 at T2, respectively. With respect to anterior temporal muscle activity, the AIs were 0 and 0 at T0, 0 and 0.3 at T1, and 0.1 and 0.3 at T2 during mealtime and daytime.

Conclusion: The different differing results were shown in two similar cases, although despite the surgical correction of mandibular lateral shift producing produces considerable improvement of the bilateral balance in muscle activity during mealtime and daytime.

Introduction

It is widely accepted that masticatory muscle function is closely correlated with craniofacial morphology [1-4]. However, little information is available for the association between masticatory muscle function and lateral deviation of the mandible [5,6]. Moreover, very few Electromyographic (EMG) studies have been carried out regarding the bilateral balance of masticatory muscle activities in patients with asymmetric face and its relation to the lateral deviation of the mandible [7-9]. Colangelo et al. found a positive correlation between the decrease in masseter and anterior temporal muscle activities and lateral shift of the mandible [7]. Ishii recorded the right and left masseter, anterior temporal and anterior belly of digastric muscles activities during clenching and chewing. He also found close relationships between imbalance of stomatognathic function and craniofacial asymmetry [8].

However, in these studies, masticatory muscle activity was measured only for a limited short period in the laboratory. During Maximum Voluntary Clenching (MVC), masticatory muscles contract strongly but momentarily. On the other hand, the masticatory muscles work continuously to stabilize the position of the mandible, although the activity may be weak. In addition to muscle activity during mastication, such low-level muscle activity induced widely throughout the daytime is of great importance to elucidate establish muscular equilibrium. Especially, for orthodontists, patients with lateral deviation of the mandible provide a great concern because of the bilateral balance of masticatory muscle activity. It is thus necessary to know how the balance is changed during daytime in usual daily life after surgical correction of mandibular lateral deviation.

This case report is designed to present changes in the bilateral balance of masticatory muscle activity during daytime for three hours after surgical correction of mandibular lateral shift.

Examination of EMG

EMG recording procedure: This study was approved by the Hiroshima University Hospital IRB and all participants signed an informed consent agreement.

Digital EMG recording device (Muscle Tester ME3000P, Mega Electronics Ltd., Kupio, Finland) and bi-polar silver/silver-chloride electrodes (Blue sensor, type-N-00-S, Medicotest A/S, Olstykke, Denmark) were used to record the EMG from the bilateral masseter and anterior temporal muscles. Before placing the electrodes, skin was scrubbed by an alcohol-soaked gauze pad to reduce the impedance between skin and electrodes. To locate the electrodes at proper position, one line was drawn from the inferior border of ear tragus to the angle of mouth. The masseter muscle width was measured by palpation and an ink spot was marked at the middle of width on the line. Electrodes were placed on both sides of the line around the temporal fossa in parallel to the principal direction of masseter muscle fibers. The anterior temporal muscle was also palpated at the antero-superior border and one electrode was placed 5 mm posterior to this point and the other

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Received May 28, 2012; Accepted July 15, 2012; Published July 18, 2012

Citation: Ueda H, Kato M, Horihata A, Tanne K (2012) Changes in the Bilateral Balance of Masticatory Muscle Activity after Surgical Correction of Mandibular Lateral Shift: Report of 2 Cases. Orthop Muscul Syst 1:117. doi:10.4172/2161-0533.1000117

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one at the temporal fossa in parallel to the direction of muscle fibers. An inter-electrode distance of 30 mm was maintained for both muscles (Figure 1). EMG data were recorded with a sampling frequency of 1 KHz. The mean of rectified EMG data for every 0.02-second was stored into the recording device.

Quantitative EMG analysis: Three EMG recordings were taken during MVC (repeat the performance 5 times with an interval of 10 seconds) and mealtime for the analysis: T0 initial masticatory muscle activity, T1 6 months after surgery and T2 12 months after surgery. After recording, the data were transmitted to a personal computer (Aptiva E 58, IBM, New York, USA) and the integrated EMG values ($\mu\text{V}\times\text{sec}$) were calculated for various performances. In order to investigate the bilateral balance of masticatory muscle activity, an Asymmetry Index (AI) was used. AI is calculated as a ratio of the subtraction of the left value from the right one to their sum, as shown in the following equation [10].

$$\text{Asymmetry index (AI)} = \frac{\text{R-L}}{\text{R+L}}$$

R=Right side value

L=Left side value

Case 1

The patient was a Japanese male aged 18 years 11 months who presented lateral deviation of the mandible. His chief complaint was difficulty in chewing. Cross bite and edge to edge occlusion were observed in the anterior to posterior regions on the left side. Overjet and overbite were -1.5 and +0.5 mm, respectively (Figure 2). The mandibular dental midline is shifted by 3 mm relative to the maxillary one. No signs or symptoms of temporomandibular joint disorder were found.

Cephalometric analysis of the patient showed a skeletal Class III relationship ($\text{ANB} = -4.5^\circ$) with lingual inclination of the upper and lower incisors. The maxillary dental midline was almost coincident with facial one. Menton is deviated to the left by 6 mm in relation to the facial midline (Figure 3).

Presurgical orthodontic treatment was initiated with standard edgewise appliances (0.018-inch \times 0.025-inch) at the age of 19 years and 2 month. The mandible was setback bilaterally (Right: 8.5 mm, Left: 3.5 mm) by Sagittal Splitting Ramus Osteotomy (SSRO) when the patient was 20 years and 0 months old. Figure 4 shows intraoral



Figure 1: An overall view of portable EMG recording system.



Figure 2: Case 1: Pretreatment intraoral photographs at T0.



Figure 3: Case 1: Pretreatment frontal cephalogram at T0.



Figure 4: Case 1: Intraoral photographs during orthodontic treatment after surgery at T1.

photographs during postsurgical orthodontic treatment 6 months after surgery (T1). Orthodontic treatment was completed at the age of 20 years and 6 months. The patient had a Class I molar relationship on both sides with 3.5 mm of over jet and 2.0 mm of overbite at T2 (Figure 5). The ANB angle increased to +0.3 degrees. Figure 6 shows a posttreatment cephalogram. The mandibular midline was coincident to the facial one.

Case 2

The patient was a 27 years and 1 month old Japanese female. She presented asymmetric face with cross bite in the anterior to posterior regions on the left side and complained of facial appearance. The upper first molar on the left had been extracted due to severe dental caries. The patient had Class III malocclusion with -0.5 mm of overjet and 0 mm of overbite (Figure 7). No clicking, locking, or crepitus were detected in the temporomandibular joint. Cephalometric analysis of the patient showed a skeletal Class III relationship ($\text{ANB} = -1.5^\circ$). Menton and the upper dental midline shifted to the left by 6 mm and 1 mm relative to the facial midline, respectively (Figure 8).

Presurgical orthodontic treatment was initiated with conventional edgewise appliances at the age of 27 years and 4 month. The second molar on the left side was moved mesially to the original first molar position. The mandible was setback bilaterally (Right: 9.0 mm, Left: 4.0 mm) by SSRO when the patient was 28 years and 10 months old. Figure 9 shows intraoral photographs during postsurgical orthodontic

treatment 6 months after surgery (T1). Orthodontic treatment was completed at the age of 29 years and 9 months. An acceptable occlusion was obtained, and overjet and overbite were improved to +3.5 and +2.0 mm, respectively (Figure 10). The ANB angle increased to +2.5 degrees, and facial asymmetry was improved substantially, although mandibular midline was still deviated 2 mm to the left (Figure 11).

Results

Case 1

Duration of measurement at different treatment time points is shown in Table 1. The AI of the masseter muscle activity during



Figure 5: Case 1: Posttreatment intraoral photographs at T2.



Figure 6: Case 1: Posttreatment frontal cephalogram at T2.



Figure 7: Case 2: Pretreatment intraoral photographs at T0.



Figure 8: Case 2: Pretreatment frontal cephalogram at T0.



Figure 9: Case 2: Intraoral photographs during orthodontic treatment after surgery at T1.



Figure 10: Case 2: Posttreatment intraoral photographs at T2.



Figure 11: Case 2: Posttreatment frontal cephalogram at T2.

		T0	T1	T2
Case 1	mealtime	12.1	12.9	13.0
	daytime	129.9	116.8	136.0
Case 2	mealtime	13.4	14.0	12.0
	daytime	120.4	142.0	149.0

Table 1: Duration of measurement (min).

mealtime and daytime was 0.3 at T0, 0.4 at T1, and 0.1 at T2 and -0.6 at T0, 0 at T1, and 0.2 at T2, respectively (Table 2). With respect to anterior temporal muscle activity, the AIs were -0.1 and -0.4 at T0, -0.2 and -0.5 at T1, and 0.1 and -0.1 at T2 during mealtime and daytime (Table 3).

Case 2

Duration of measurement at different treatment time points is shown in Table 1. The AI of the masseter muscle activity during mealtime and daytime was 0.3 at T0, 0.2 at T1, and 0.3 at T2 and -0.3 at T0, -0.6 at T1, and -0.1 at T2, respectively (Table 4). With respect to anterior temporal muscle activity, the AIs were 0 and 0 at T0, 0 and 0.3 at T1, and 0.1 and 0.3 at T2 during mealtime and daytime (Table 5).

Discussion

Orthognathic surgery not only changes facial profile and occlusion but also affects the craniofacial skeleton and masticatory muscles. Although diagnosis and treatment planning for orthognathic surgery is usually determined by dento-skeletal correction rather than improvement of masticatory muscle activity, the morphological changes can bring about favorable changes in masticatory function [11-17]. Ingervall et al. examined masseter and temporal muscle activity during MVC, chewing and swallowing of peanuts and swallowing of water after surgical correction of mandibular prognathism. They found an increase in EMG activity to approach the control levels. However, very few EMG studies have been carried out regarding the bilateral balance of masticatory muscle activities in patients with lateral deviation of the mandible [7-9]. Moreover, most of previous studies were executed with particular type of performance like MVC and/or chewing gum only for a short while in the laboratory. High-level muscle activity like that during MVC does not often occur in usual daily life. Thus, it would appear a reasonable assumption that low-level but widely induced masticatory muscle activity during daytime rather plays a more important role in craniofacial morphogenesis. Recently, development of portable EMG recording system has provided us with a great opportunity to record data for considerably longer period during usual daily life [18-20].

In the present study, AIs of masseter muscle activity during mealtime were 0.3 and 0.3, although those during daytime were -0.6 and -0.3 in cases 1 and 2, respectively. As the preferred biting side seemed to be opposite between mealtime and daytime for about three hours, it is of great importance to estimate muscle activity during daytime. The difference is explained, in part, by the fact the both patients had cross/edge to edge bite on the left side so that it might be harder to induce muscle activity during food chewing. However, for masseter muscle activity during daytime, premature contact or occlusal interference on the left side could exhibit excessive muscle function resulted resulting in imbalance of muscle activity. Several previous reports demonstrated that influence of asymmetrical occlusal interferences with an overlay to

make a premature contact artificially on jaw and neck muscle activities was found [21-23]. According to Naeije et al., it would be reasonably assumed that the subjects tend to bite more asymmetrically at the low contraction levels than higher levels for masseter and temporal muscles [24]. Most of the AIs in masseter muscle activity were approaching getting close to 0 at 12 months after surgery. That means that the balance of the right and left muscle activities is improved during mealtime and daytime due to significant increase in the number of total occlusal contact after orthodontic treatment [25].

With respect to anterior temporal muscle activity, the highest AIs at T1 were found during daytime in cases 1 and 2. Actually, orthodontic treatment was continued at T1 after surgery to get achieve desirable interdigitation between upper and lower dentitions. Thus, it might be speculated that the balance of temporal muscle remained unstable at 6 months after surgery, although AIs during mealtime were low. A strand found that masticatory muscle function in prognathic patients were not improved 6 months after surgery. After surgery, it may be anticipated adaptive changes in the structures of the stomatognathic system such as, temporomandibular joint structures, periodontal adjustment and changes in the myosin expression of the jaw muscles [26]. Especially, the periodontal mechanoreceptors may influence the muscle reflex during orthodontic treatment after surgery [27]. Moreover, at 12 months after surgery the patient in case 1 showed an improvement of AI during mealtime and daytime. On the contrary in contrast, AI during daytime was not changed from T1 to T2 in case 2. The reason for the difference in changes between masseter and temporal muscle activities might be explained that two muscles exert different role in the stomatognathic function. Masseter muscle works mainly during biting or chewing according to occlusal contact [28,29]. On the other hand, temporal muscle works to stabilize the mandibular position [30]. Thus, temporal muscle might be more reactive after setback of the mandible than masseter muscle, particularly in daytime.

Conclusion

The different differing results were shown in two similar cases; although despite the surgical correction of mandibular lateral shift producing produces considerable improvement of the bilateral balance in muscle activity during mealtime and daytime. All events expected after surgery are physiological adaptive processes and may influence jaw muscles balance. A further investigation focusing on long-term careful monitoring will be needed to confirm the masticatory muscle equilibrium in patients with lateral deviation of the mandible before and after surgical orthodontic treatment.

Conflict of Interest

The authors declare no conflict of interest.

References

1. Ringqvist M (1973) Isometric bite force and its relation to dimensions of the facial skeleton. *Acta Odontol Scand* 31: 35-42.
2. Ingervall B, Thilander B (1974) Relationship between facial morphology and activity of the masticatory muscles. *J Oral Rehabil* 1: 131-147.
3. Miralles R, Havia R, Contreras L, Carvajal R, Bull R, et al. (1991) Patterns of electromyographic activity in subjects with different skeletal facial types. *Angle Orthod* 61: 277-284.
4. Fogle LL, Glaros AG (1995) Contributions of facial morphology, age, and gender to EMG activity under biting and resting conditions: a canonical correlation analysis. *J Dent Res* 74: 1496-1500.
5. Goto TK, Yamada T, Yoshiura K (2008) Occlusal pressure, contact area, force and the correlation with the morphology of the jaw-closing muscles in patients with skeletal mandibular asymmetry. *J Oral Rehabil* 35: 594-603.

	T0	T1	T2
mealtime	0.3	0.4	0.1
daytime	- 0.6	0	0.2

Table 2: Case1: The AI of masseter muscle activity.

	T0	T1	T2
mealtime	- 0.1	- 0.2	0.1
daytime	- 0.4	- 0.5	- 0.1

Table 3: Case 1: The AI of anterior temporal muscle activity.

	T0	T1	T2
mealtime	0.3	0.2	0.3
daytime	- 0.3	- 0.6	- 0.1

Table 4: Case 2: The AI of masseter muscle activity.

	T0	T1	T2
mealtime	0	0	0.1
daytime	0	0.3	0.3

Table 5: Case 2: The AI of anterior temporal muscle activity.

6. Castelo PM, Gavião MB, Pereira LJ, Bonjardim LR (2010) Evaluation of changes in muscle thickness, bite force and facial asymmetry during early treatment of functional posterior crossbite. *J Clin Pediatr Dent* 34: 369-374.
7. Colangelo GG, Festa F, Giovannelli S (1987) Clinical importance of electromyographic analysis in lateral deviation of the mandible. *Mondo Ortod* 12: 79-86.
8. Ishii H (1990) A study on the relationships between imbalance of stomatognathic function and asymmetry of craniofacial morphology, and the center of gravity of the upright posture. *Osaka Daigaku Shigaku Zasshi* 35: 517-556.
9. Dong Y, Wang XM, Wang MQ, Widmalm SE (2008) Asymmetric muscle function in patients with developmental mandibular asymmetry. *J Oral Rehabil* 35: 27-36.
10. Visser A, McCarroll RS, Naeije M (1992) Masticatory muscle activity in different jaw relations during submaximal clenching efforts. *J Dent Res* 71: 372-379.
11. Astrand P (1974) Chewing efficiency before and after surgical correction of developmental deformities of the jaws. *Swed Tandlak Tidskr* J 67: 135-145.
12. Proffit WR, Turvey TA, Fields HW, Phillips C (1989) The effect of orthognathic surgery on occlusal force. *J Oral Maxillofac Surg* 47: 457-463.
13. Ellis E 3rd. Throckmorton GS, Sinn DP (1996) Bite forces before and after surgical correction of mandibular prognathism. *J Oral Maxillofac Surg* 54: 176-181.
14. Throckmorton GS, Buschang PH, Ellis E 3rd (1996) Improvement of maximum occlusal forces after orthognathic surgery. *J Oral Maxillofac Surg* 54: 1080-1086.
15. Kim YG, Oh SH (1997) Effect of mandibular setback surgery on occlusal force. *J Oral Maxillofac Surg* 55: 121-126.
16. Ingervall B, Ridell A, Thilander B (1979) Changes in activity of the temporal, masseter and lip muscles after surgical correction of mandibular prognathism. *Int J Oral Surg* 8: 290-300.
17. Boyd SB, Gonyea WJ, Legan HL, Bell WH (1989) Masseter muscle adaptation following surgical correction of vertical maxillary excess. *J Oral Maxillofac Surg* 47: 953-962.
18. Miyamoto K, Yamada K, Ishizuka Y, Morimoto N, Tanne K (1996) Masseter muscle activity during the whole day in young adults. *Am J Orthod Dentofacial Orthop* 110: 394-398.
19. Ueda HM, Ishizuka Y, Miyamoto K, Morimoto N, Tanne K (1998) Relationship between masticatory muscle activity and vertical craniofacial morphology. *Angle Orthod* 68: 233-238.
20. Ueda HM, Miyamoto K, Saifuddin M, Ishizuka Y, Tanne K (2000) Masticatory muscle activity in children and adults with different facial types. *Am J Orthod Dentofacial Orthop* 118: 63-68.
21. Funakoshi M, Fujita N, Takehara S (1976) Relations between occlusal interference and jaw muscle activities in response to change in head position. *J Dent Res* 55: 684-690.
22. Ferrario VF, Sforza C, Serrao G (1999) The influence of crossbite on the coordinated electromyographic activity of the human masticatory muscles during mastication. *J Oral Rehabil* 26: 575-581.
23. Ferrario VF, Sforza C, Dellavia C, Tartaglia GM (2003) Evidence of an influence of asymmetrical occlusal interferences on the activity of the sternocleidomastoid muscle. *J Oral Rehabil* 30: 34-40.
24. Naeije M, McCarroll RS, Weijis WA (1989) Electromyographic activity of the human masticatory muscles during submaximal clenching in the inter-cuspal position. *J Oral Rehabil* 16: 63-70.
25. Haydar B, Ciger S, Saatci P (1992) Occlusal contact changes after the active phase of orthodontic treatment. *Am J Orthod Dentofacial Orthop* 102: 22 -28.
26. Gedrange T, Luck O, Hesske G, Büttner C, Seibel P, et al. (2001) Differential expression of myosin heavy -chain mRNA in muscles of mastication during functional advancement of the mandible in pigs. *Arch Oral Biol* 46: 215-220.
27. Nakanishi H, Seki Y, Kohno T, Muramoto T, Toda K, et al. (2004) Changes in response properties of periodontal mechanoreceptors after experimental orthodontic tooth movement in rats. *Angle Orthod* 74: 93-99.
28. Bakke M (1993) Mandibular elevator muscles. Physiology, action and effect of dental occlusion. *Scand J Dent Res* 101: 314-331.
29. Blanksma NG, van Eijden TM (1995) Electromyographic heterogeneity in the human temporalis and masseter muscles during static biting, open/close excursions, and chewing. *J Dent Res* 74: 1318-1327.
30. Latif A (1957) An electromyographic study of the temporalis muscle in normal persons during selected positions and movements of the mandible. *Am J Orthod* 43: 577-591.