Original

Evaluation of Masticatory Muscles Function in Different Malocclusion Cases Using Surface Electromyography

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Abstract: A malocclusion is a misalignment or incorrect relation between the teeth of the two dental arches when they approach each other as the jaws close. It has been suggested that masticatory function varies in relation to different malocclusion. Thereby, masticatory muscle can be affected with different malocclusion as masticatory process is related with this. The aim of this study was to evaluate the function of masticatory muscles (masseter and temporalis muscles) in patient with different malocclusion by surface electromyography (sEMG). On masticatory muscle, twenty eight patients (13 male and 15 female) were assessed by using sEMG and the results compared between gender and different malocclusions. Male and female group in left masseter muscle during chewing and right temporalis muscle during clenching. No significant difference ($p > 0.05$) for class I, II and III malocclusion, except right temporalis muscle showed significant difference ($p = 0.010$) on clenching. In conclusion, the function of the masticatory muscles were varies between male and female and different malocclusion of class I, II and III.

Key words: Malocclusions, Masticatory muscles, Electromyography

Introduction

The malocclusions are very common in modern generation which caused by misalignment or incorrect relation between the teeth of two dental arches when they approach each other as the jaws close¹⁻²⁾. According to Edward Angle's classification of malocclusion, it can be 3 types: Class I, II and III. Angle's classification was based on the mesio-distal relation of the teeth, dental arches and the jaws³⁾. The classification be determined by on where the buccal groove of the mandibular first molar contacts the mesiobuccal cusp of the maxillary first molar: on the cusp (Class I, neutroclusion, or normal occlusion); distal to the cusp by at least the width of a premolar (Class II, distocclusion); or mesial to the cusp (Class III, mesiocclusion)³⁾.

Angle's class I malocclusion present with normal inter-arch molar relation. Patients with class I malocclusion exhibits normal skeletal relation with normal muscle function³⁾. Class II malocclusion is characterized when the disto-buccal cusp of the upper first permanent molar occludes in the buccal groove of the

lower first permanent molar. Class II malocclusions are most frequent problem faced in orthodontic practice⁴⁾. Angle has sub-classified class II malocclusions into two divisions: class II division I and class II division 2. Class II division 1 malocclusion patient exhibits hyperactive buccinators and mentalis muscle function with altered tongue position³⁾. Class II division 2 patients exhibit normal perioral muscle activity⁵⁾. Class III malocclusion characterized by a class III molar relation with the mesio-buccal cusp of the maxillary first permanent molar occluding in the interdental space between the mandibular 1st and 2nd molars³⁾. It can be true class III and Pseudo class III. Class III malocclusion appears with altered muscle function⁵⁾.

Mastication procedure involves chewing, swallowing and digestion of food where the occlusal surface of post-canine teeth is involved for crushing of solid foods. In this process, masticatory movements are associated with the masseter, temporalis, medial and lateral pterygoid muscles, together with the submental muscles, i.e. the digastric, mylohyoid and geniohyoid muscles⁶⁾. Neuromuscular disorder negatively influence oral functions and orofacial morphology and these diseased muscles causes changing of malocclusions such as anterior and posterior open bites or cross

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bite etc.⁷⁻⁸⁾.

Electromyography is the recording of the electrical activity of muscle tissue, or its representation as a visual display or audible signal, using electrodes attached to the skin or inserted into the muscle⁹⁾. Surface electromyography is mainly performed by an instrument called electromyography and that produce a record called an electromyogram¹⁰⁾. sEMG used to assess muscle function by recording muscle activity from the surface above muscle on the skin using a pair of electrodes. Because EMG recording shows the potential difference between two separate electrodes. Surface electromyography permits the non-invasive investigation of the bioelectrical phenomena of muscular contraction¹¹⁾. sEMG adequately allows the examination of some important muscles involved in chewing, swallowing and posture of the head (typically masseter, temporalis anterior and posterior, digastric anterior, sternocleidomastoid)¹²⁾. Usually, the masseter and the temporalis are synergists and function concurrently. Whereas the temporalis provides a basis for mandibular balance and postural control, the masseter is responsible for grinding and chewing¹³⁾. Malocclusion can negatively affect the masticatory process (like chewing, clenching) where masticatory muscle also get affected. It has been suggested that masticatory function varies in relation to different malocclusion (class I, II and III)¹²⁾.

The aim of the present study was to assess the function of masticatory muscles (the masseter and temporalis muscles) in patients with different gender and malocclusion (class I, II, III) by surface electromyography (sEMG).

Materials and Methods

In this study, all participants provide their verbal and written informed consent. This study was approved by the Ethical Committee of the Hospital Universiti Sains Malaysia (HUSM). Letter from Human Research Ethics Committee (HREC) has assigned a study protocol code USM/ JEPeM/1405200.

Subjects and Sample Selection

The subjects of this study consisted of a total of 28 subjects (13 male and 15 female), age group was 18 to 25 years of age. Subject group were refer to patients of School of Dental Science, Hospital University Sains Malaysia (HUSM).

Inclusion criteria

1. The patients with different malocclusion (Class I, II and III).
2. Age between 18 to 26 years.
3. Patients with all sound erupted permanent teeth (except considering 3rd molars).

Exclusion criteria

1. Patients with congenital / craniofacial deformities.
2. Unhealthy patients (patients with TMJ dysfunction, parafunctional habit etc).

3. Patients having pathology within the maxilla or mandible.

Clinical examination

Intraoral examination was done to detect different malocclusion according to Angle's classification of malocclusion³⁾.

Electromyography

After the clinical examination, surface electromyography (sEMG) of the masseter and temporalis muscles was done using an electromyography device (ProComp Infiniti Encoder SA7500, Montreal, Quebec, Canada). There were total 3 surface leads, 2 electrodes were recording electrode and another one was reference electrode for each side to record muscle activity for the masseter and temporalis muscle respectively. For temporalis muscle a line were drawn from upper Earline to canthus of the eye and the electrode were placed above this line by palpating muscle contraction position. In case of masseter muscle, after palpating angle of mandible, the electrode was placed over muscle (antero-superior to the angle of the mandible). The patients were given clear instructions before the sEMG recording started. The instructions were:

- To keep the head and body still as movement of the head and neck region or the body might affect the sEMG results.
- Do not move the tongue as it would result in stimulation to the muscles thus affecting the results.
- A chewing gum was given, but chewing were only started on signal provided.
- The surface leads were placed at different areas respectively: started with left masseter, then right masseter, followed by left temporal region and ended with right temporal region.
- The sEMG recording was started with the left masseter after surface lead placement with the patients' masticatory muscles-being at rest for 10 seconds, followed by 10 seconds of chewing on the left side, then 10 seconds of rest and after that 10 seconds of continuous clenching, ending with another 10 seconds of rest.
- Next, the surface leads were placed on the right masseter region for sEMG recording with the same instructions.
- For the left and right temporalis muscle, patients were instructed to rest for 10 seconds, followed by continuous clenching for 10 seconds and ending with another 10 seconds of rest.

Statistical analysis

The data were verified and analyzed statistically using IBM SPSS Statistics Version 22.0 (Armonk, NY: IBM Corp.) with confidence level set at 5% ($P < 0.05$) to test for significance. Mean amplitude of the muscles (masseter and temporalis) between male and female patients were analyzed by t test. Mean amplitude of the muscles (masseter and temporalis) in patients with class I, II and III during basal stage (resting), post chew resting stage, post

Figure 1. Mean amplitude of the right masseter between male and female patient

Figure 2. Mean amplitude of the left masseter between male and female patient

Figure 3. Mean amplitude of the right temporalis between male and female patient

Figure 4. Mean amplitude of the left temporalis between male and female patient

Figure 5. Mean amplitude of the right masseter muscle activity among class I, II and III malocclusion groups

Figure 6. Mean amplitude of the left masseter muscle activity among class I, II and III malocclusion groups

clenching basal stage (resting), left chewing stage, right chewing stage and during clenching stage was analyzed by One-Way ANOVA.

Result

Gender disparities

In right masseter muscle, mean value was higher in female group than the male (Fig. 1). But only post basal mean value showed higher in male (57.42mV) than female (70.09mV). Here, right masseter muscle showed no significant difference ($p>0.05$) for male and female groups. Left masseter muscle showed

significantly different ($p=0.041$) for male and female group during chewing (Fig. 2). Here mean value of male patient was 155.67mV and for female patient was 85.42mV. Right temporalis muscle also showed significantly different ($p=0.024$) during clenching (Fig. 3). Where the mean value was 198.69mV for male patient and 301.27mV for female patient. Left temporalis muscle showed no significant difference for male and female group during basal stage (resting), post basal (resting after clenching) and clenching (Fig. 4).

Malocclusion disparities

Figure 7. Mean amplitude of the right temporalis muscle activity among class I, II and III malocclusion groups

Figure 8. Mean amplitude of the left temporalis muscle activity among class I, II and III malocclusion groups

Table 1. Comparison of present study with different study

Year	Author	Muscle	Action	Malocclusion	Result
1980	Pancherz and Anethus ¹⁷⁾	Masseter and temporalis	Chewing and Clenching	Class II division 1 and normal occlusion	Masseter muscle during chewing less EMG activity in boys with class II division 1.
1986	Ahlgren ²³⁾	Temporalis	Clenching	Normal occlusion	No significant difference.
1988	Miralles <i>et. al</i> ¹⁸⁾	Masseter and temporalis	Maximal voluntary clenching (MVC)	Class II division 1	No significant difference.
2012	Piancino <i>et.al</i> ²⁴⁾	Masseter and temporalis	Chewing	Class I malocclusion with open bite and normal occlusion	Significantly different.
2013	KO <i>et. al</i> ¹⁹⁾	Masseter and temporalis	Maximal voluntary clench	Class III (before and after treatment)	No significant difference.
2016	Piancino <i>et.al</i> ²⁰⁾	Masseter	Chewing	Unilateral posterior cross bite and normal occlusion	Significantly different.
2016	Present study	Masseter and temporalis	Chewing and clenching	Class I,II and III malocclusion	Significantly different.

Using ANOVA (Bonferroni) right and left masseter muscle showed no significant difference for basal, post basal, chewing and clenching in class I, II and III malocclusion respectively (Fig 5 & 6). Only right temporalis muscle showed significant difference ($p=0.010$) on clench (Fig 7). Where mean value was 330.74mV in class I malocclusion, 201.88mV in Class II and 191.11mV in class III malocclusion. Left temporalis muscle showed no significant difference for basal, post basal and clenching in class I, II and III malocclusion respectively (Fig 8).

Discussion

Different malocclusion (class I, II and III) can alter muscle activity which can act as a predisposing factor for more severe malocclusion. This study have been evaluated the functional ability of masticatory muscle in different malocclusion by using surface electromyography (sEMG). Patient with different malocclusion may show different efficacy of masticatory muscle. Masticatory

muscle with neuromuscular disorder can act as an aggravating factor for malocclusion. For different malocclusion patient may adapt faulty masticatory position which may cause interference to orthodontic treatment.

Present study compared the muscle activity of masseter and temporalis in male and female group during basal or rest, post basal, chewing and clench. In current study left masseter muscle was more active during chewing in male patient than female. On the other hand right temporalis muscle was more active in female patient during clenching. Craniofacial structure for male and female varies in diameter and length. Masticatory muscle activity has been determined to be associated with craniofacial morphology¹⁴⁾. Therefore, muscular arrangement can act as a factor for this active EMG response in male and female group. Masseter and temporalis are important masticatory muscle as they act by elevation, proclination and retraction of mandible. Thus the chewing and clenching force can be affected by misaligned teeth¹²⁾.

The relationship between EMG and craniofacial morphology, were identified high EMG activity of the masseter muscle in children with normal occlusion¹⁴⁾. It has been reported that the onset of temporal muscle activity was involved in the positioning of the mandible during masticatory movement in patients with normal occlusion and that the temporal muscle was activated earlier than the masseter muscle¹⁵⁾(Table 1).

Moyer¹⁶⁾ using surface electrode and unipolar recording, where result found that balanced activity in all three parts of the temporalis muscle (anterior, middle, and posterior) at rest and during habitual clenching in normal occlusion. In Angle Class II, Division 1 there were uneven EMG activity with a strong dominance of the posterior regions. In present study, right temporalis muscle showed more activity during clenching in male patient than female.

Pancherz *et al.*¹⁷⁾ conducted a study to evaluate the effect of continuous bite jumping in masticatory muscles in ten growing boys with Class II, Division I malocclusion cases treated with the Herbst appliance. They analyzed EMG from the temporal and masseter muscles during maximal biting in intercuspal position and during chewing of peanuts. They found that the EMG activity from the temporal and masseter muscles was reduced in Class II, Division 1 malocclusions when compared to normal occlusions. But a significant increase in EMG activity was found, especially for the masseter muscles during maximal biting. In this study, right temporalis muscle of different malocclusion group showed more response for class I malocclusion during clenching than class II and class III. Right and left masseter muscle showed no significant difference during chewing and clenching in class I, II and III malocclusion.

According to a study by Miralles *et al.*¹⁸⁾ that aims to evaluate EMG activities of masseter and anterior temporalis muscle during maximal voluntary clenching in class II division 1 patient and the result showed no significant difference. In present study also suggested class II malocclusion patient showed no significant difference during clenching in masseter and temporalis muscle. Ko *et al.*¹⁹⁾ Class III patient before orthognathic surgery showed more EMG response then after surgery. In current study, Class I patient showed high EMG activity than class II and class III. The effects of therapy on masseter activity and chewing kinematic in patients having unilateral posterior cross bite was undergone for a study introduced by Piancino *et al.*²⁰⁾ in 2016 . They analyzed on the mandibular motion and the muscular activity during chewing soft and hard boli were consecutively recorded, before and after correction with function producing bite. There were significant reduction of masseter muscles activity with reverse chewing patterns. In current study masseter activity had been increased during normal chewing activity for male patient. Multi-channel EMG recordings are indicated to compare activation patterns between several muscles or muscle regions and it can

provide data for individual muscle activity at the same time²¹⁾. Hence, recording of chewing activity in several muscle in same time, may avoid electrical error with more accurate data²¹⁾. sEMG result provides electrical activity in muscles and numerous factors like rate of muscle stimulation, size and morphology of motor units, electrical properties of the tissues can alter electrical signal of EMG²²⁾.

There are various method of EMG recording. Mainly it depends on muscle function or expression while recording. However, the present study reveals the masticatory muscle function using sEMG. This study has not focused on the methods of EMG and had not compared with the EMG methods with other reports. Therefore, it can be a topics of interest in future research and need to pay more attention on this. As, EMG is a clinical approach and requires careful handling for accurate recording. In consequence it will be beneficial for clinicians during EMG recording.

In conclusion, this study showed right temporalis muscle activities were significantly high in male group and different malocclusion group. Right masseter muscle activities showed no significant difference in gender and different malocclusion groups. Left masseter muscle showed increased chewing activities in male group than female group. Patient with class I malocclusion group found higher EMG activity than class II and class III malocclusion group.

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Conflict of Interest

The authors have declared that no conflict of interest.

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