Masseter Muscle Activity in Dolichofacial Patients with Temporomandibular Joint Disorders: An Electromyographic Study

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Abstract

This study aimed to analyze the influence of temporomandibular joint disorder (TMD) on surface electromyography activity in the masseter muscles.

Dolichofacial patients (n = 22) aged 15 to 35 years were examined: 11 with TMD and 11 control subjects without TMD. A standardized surface electromyography recording was performed on the masticatory muscle during 5 s of maximum voluntary contraction on cotton rolls.

The root mean square value of each muscle was calculated and analyzed for differences using an unpaired Student's t-test. Spearman's correlation coefficients (r) were calculated for the determination of correlations between TMD and root mean square values.

Surface electromyography revealed significant differences in the right and left masseter during maximum voluntary contraction. Both sides of the masseter muscles also showed a negative correlation with TMD. During maximum voluntary contraction, TMD patients had relatively lower elevator muscle activity.

Electromyographic activities in the masseter muscles were lower in dolichofacial patients with TMD than non-TMD. Surface electromyography of masticatory muscles may assist the clinical assessment of TMD patients.

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Introduction

Temporomandibular joint disorders (TMD) are musculoskeletal and neuromuscular conditions affecting temporomandibular joints (TMJ), masticatory muscles, and all associated tissues, according to the American Association of Dental Research. Signs and symptoms related to TMD may vary and include TMJ sounds, orofacial pain, and a restricted range of motion.[1] Epidemiology studies report that TMD signs and symptoms may occur in 25% of the population, escpecially in adults[2], yet the etiology remains unclear due to the range of factors affecting the development of TMD.[1]

Patients with a vertical facial growth pattern (dolichofacial) may possess a higher risk for the development of TMD.[3–6] Researchers have highlighted an association between vertical growth pattern and internal derangement of TMJ.[3–5] Furthermore, dolichofacial patients produce a higher TMJ load than brachyfacial patients.[6] Girardot (2001) has concluded that hyperdivergent patients exhibit more significant condylar displacement than hypodivergent patients.[4]

Over the years, surface electromyography (sEMG) has been widely used as a noninvasive method to record and evaluate myoelectric signals generated during muscle contraction. In dentistry, sEMG is beneficial for monitoring the activity and understanding the function of masticatory muscles.[7]

Due to the diverse nature of TMD, a better comprehension of TMD has been sought through electromyography studies. Associations have been made among masticatory muscle activities, TMD,[8–10] and facial types.[11–13] However, these studies have been conducted separately; a thorough understanding of TMD conditions is essential for orthodontists to determine proper treatment plan measures.

Therefore, this study aimed to evaluate

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the EMG activities of masseter muscles in dolichofacial patients with TMD before orthodontic treatment.

Materials and methods

The Ethical Committee of Faculty of Dentistry (28/*Ethical Approval*/FKGUI/III/2019) and Faculty of Medicine (LB.02/2.21/1459/2019) Universitas Indonesia approved this research. Informed consent was obtained from all participants.

New patients (n = 22) from the Orthodontic Clinic, Faculty of Dentistry, Universitas Indonesia were selected as participants. The consecutive sampling method was used, and patients were divided evenly into two groups: the TMD group, consisting of patients who showed at least one TMD sign or symptom, and the control group, consisting of patients who did not show any TMD signs or symptoms.

The inclusion criteria were dolichofacial patients aged between 15 and 35 years of a normal body mass index (BMI). Patients with any of the following conditions were excluded: a history of orthodontic treatment or orthognathic surgery, missing more than two permanent teeth, neurological disorder, history of facial trauma, facial asymmetry, or bad habits such as bruxism or unilateral chewing.

Surface Electromyography Examination

During all examinations, the subject sat while maintaining the natural head position. The skin surface was carefully prepared to ensure excellent contact between the skin and all sensors. Electrodes were placed according to the recommendations of sEMG for noninvasive assessment of muscles (SENIAM); the muscle belly position was determined by visual assessment and palpation, and the common ground electrode was attached to the subject's forehead (Fig. 1). The raw signal displayed on the real-time screen was used to standardize the most symmetrical and greatest muscle activities during maximum voluntary contraction (MVC).

EMG activity was recorded using the same approach as the previous study conducted by Szyzka-Sommerfeld et al.[14] The subject was instructed to clench as hard as possible for 5 s with two, 10-mm-thick cotton rolls on the mandibular second premolars or first molars. This procedure was repeated twice to ascertain stability. Between each section, rest was permitted to avoid any effects of fatigue. The raw EMG signal was later calculated as the root mean square (RMS) value in Microsoft Excel (Microsoft, Inc., Redmond, WA, USA) under blinded conditions.[7]

Statistical Analysis

To evaluate the reliability of this study, 10% of the subjects were randomly selected and analyzed with intraclass coefficient correlation (ICC) using SPSS v22.0 (SPSS, Inc., Chicago, IL, USA). sEMG examinations were evaluated with an inter-reliability test between the author and an experienced neurologist as the gold standard. Afterward, intra-reliability tests were performed to measure the consistency of the author between examinations. Shapiro–Wilk tests were conducted to confirm the normality of the data ($p > 0.05$). Unpaired t-tests were used to compare masseter activity on both sides of the jaw and to detect any asymmetry. Student's t-tests were also used to compare EMG values between TMD and non-TMD groups. Spearman's correlation coefficient determined possible associations between masseter muscle activity and TMD. The level of significance was set at $p < 0.05$ for all statistical analyses.

Results

The subject distribution for gender, age, BMI, and facial index are shown in Table 1. The 22 participants consisted of 5 males and 17 females. The mean age of the subjects was 25–26 years old; the average BMI was 22.1–22.6 kg/m^2 and was similar for both TMD and non-TMD groups.

	Non-TMD (mean ± SD)	TMD (mean ± SD)
Gender:		
Male (N)	2	3
Female (N)	9	8
Age (years)	26.73 ± 0.86	25.27 ± 2.47
BMI	22.66 ± 0.92	22.12 ± 1.27
Facial Index (%)	91 ± 0.38	93.55 ± 1.03

Abbreviation: TMD, temporomandibular joint disorder

Table 1. Distribution of subjects according to TMD, gender, age, BMI, and facial index.

Table 2 exhibits the ICC for the EMG values of each muscle group. Intra-observer and inter-observer excellent consistency and agreement were demonstrated with an ICC 0.85–0.99.

	Intraclass correlation coefficient	*Interclass correlation coefficient*
Left masseter	0.99	0.99
Right masseter	0.97	0.98

*Values: excellent agreement > 0.8

Table 2. Intraclass correlation coefficient of the masticatory muscles measured.

Masseter muscles	P-value
Non-TMD	0.508
TMD	0.705

Table 3. Comparison of the masticatory muscle activity between left and right sides.
*Significant difference ($p < 0.05$).
Abbreviation: TMD, temporomandibular joint disorder.

Masticatory muscles	Mean ± SD		P-value
	Non-TMD (μV)	TMD (μV)	
Left masseter	135.92 ± 58.91	80.32 ± 37.19	0.015*
Right masseter	119.14 ± 57.78	74.34 ± 35.94	0.044*

Table 4 Comparison of the masseter activity between TMD and non-TMD groups.
*Significant difference ($p < 0.05$).
Abbreviation: TMD, temporomandibular joint disorder.

Unpaired t-tests revealed symmetrical sEMG activity in all the masticatory muscles ($p < 0.05$) (Table 3). Table 4 shows the RMS values of all muscle activities for both TMD and non-TMD groups. EMG values were significantly different between both sides of the masseter ($p= 0.015 - 0.044$). EMG values of masseter for TMD groups were lower than that for the non-TMD groups. EMG values of the masseter muscle had significant associations with TMD ($p = 0.019 – 0.050$). Moreover, Spearman's coefficient correlation showed a negative correlation between all masticatory muscle activities and TMD ($r = −0.3$ to $−0.7$).

Discussion

Meticulous and standardized procedures are essential to obviate various biological and technical biases from affecting the sEMG records.[7] Tartaglia et al.[9] and Ferrario et al.[14] reported that the normalization of muscle potentials during maximum voluntary contraction on cotton rolls has the highest repeatability and the smallest inter-variability.[10,15] Here, we confirmed that sEMG normalization is necessary to measure the actual influence of TMD on muscular features and to ensure inter-individual comparisons.[7,16]

With regard to masticatory function in dolichofacial patients, previous studies confirmed that these patients generate a lower level of bite force and muscular activity during MVC.[11,17] The higher gonial angle features in dolichofacial patients bring a mechanical disadvantage to their stomatognathic system by pushing the position of load application backward, thus increasing the loading moment arm.[12,13] Gupta et al.[11] and Grunheid et al.[12] have also reported that the masticatory muscles of dolichofacial patients have a thinner and smaller cross-sectional area, thus producing lower masticatory muscle activity.[12,13]

	TMD	
	r	p-value
Left masseter	−0.494	0.019*
Right masseter	−0.423	0.050*

Table 5 Association of the masseter activity with TMD.
Abbreviation: TMD, temporomandibular joint disorder.

The results in this study showed a significant association between TMD and EMG values of the masseter muscles (Table 5). Moreover, this study revealed a negative correlation between TMD and EMG values during MVC, indicating that masticatory muscle activities were lower in dolichofacial subjects with TMD. This finding aligns with other studies in TMD patients of all facial types that the masticatory muscles of TMD patients generate reduced electric potential and maximum bite force.[8,10,18] Consequently, their jaw elevator muscles work less efficiently and are prone to fatigue than those of non-TMD patients.[19,20] These findings corroborate the validity of the integration pain adaptation model theory, which postulates that TMD and orofacial pain induces adaptations by altering masticatory muscle activities to protect the stomatognathic system against further injury.[21]

This study has also revealed that a well-controlled sEMG could provide additional diagnostic value in TMD diagnoses. For example, patients with lower sEMG activity during MVC may be discerned with TMD. Ferrario et al.[22] have also reported a correlation between masticatory muscles and TMD signs or symptoms, implying potential sEMG efficiency in differentiating each category according to the research diagnostic criteria for temporomandibular disorders. Nonetheless, TMD

is a multifactorial disorder that has a range of symptom variations; thus, sEMG acts as an adjunct to clinical evaluations in TMD patients.[1,23] Based on the clinical point of view of an orthodontist, understanding the muscular environment is fundamental to achieving stability and stomatognathic balance. Reduced muscle activity is expected from dolichofacial patients than patients of other facial types, and the reduction should be even more pronounced in patients with TMD. Orthodontic biomechanics should be planned carefully with consideration for a less efficient masticatory function in dolichofacial patients to avoid any functional disturbances.[24]

Nonetheless, the results of this study must be interpreted with caution, as it contains a number of limitations. Although the sample size fulfilled minimal sample calculations, it is relatively small, considering the multifactorial determinants of muscular function. In addition, some variables, such as severity of TMD and malocclusion, were not considered in this study. Therefore, further study is necessary to substantiate these results.

Conclusions

In conclusion, this study demonstrated reduced masseter muscle activity in dolichofacial patients with TMD during MVC. We found significantly lower electromyographic activity from both masseter muscles in dolichofacial patients with TMD. These findings underscore the benefits of a well-controlled sEMG as a TMD diagnostic tool before orthodontic treatment.

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Declaration of Interest

The authors report no conflict of interest.

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