The Electrical Activity of Masseter and Anterior Temporal Muscles in Patients with Unilateral Cleft Lip and Palate

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Abstract: This study aimed to determine the electrical activity of masseter and anterior temporal muscles in patients with unilateral cleft lip and palate (CLP) and compare it with healthy volunteers. The study involved 20 female patients (mean age 20 ± 4 years) with unilateral cleft lip and palate who had undergone lip and palate surgery in childhood and finished the first-phase orthodontic therapy with level and align teeth. Twenty age- and sex-matched volunteers with no cleft lip and palate were involved as controls. Electromyographic (EMG) signals of masseter and anterior temporal muscles were recorded at rest position, during swallowing and during maximum bite force (MBF). EMG signals at different test conditions were compared between the cleft and noncleft sides of CLP patients and between CLP patients and healthy individuals. The EMG potentials of masseter (rest, swallowing, MBF) and temporal (rest, MBF) muscles were significantly higher in the cleft than the noncleft side of CLP patients (P value <0.001). Generally, patients with unilateral cleft lip and palate experienced a significant increase in the electrical activity of the masseter and temporal muscles in both sides compared to the control group ($P<0.05$). In conclusion, patients with unilateral cleft lip and palate exhibit overall greater masticatory muscle activity compared to healthy individuals. The asymmetric masticatory function in subjects with unilateral cleft lip and palate may be associated with severe consequences such as asymmetric facial growth, implying the importance of early diagnosis and orthodontic treatment to achieve a favorable environment for balanced facial growth in CLP affected patients.

Key Words: Cleft lip, cleft palate, electrical activity, electromyography, masseter muscle, masticatory muscles, temporal muscle

Cleft lip with or without cleft palate is one of the most common craniofacial congenital anomalies.[1,2] This deformity encompasses a variety of phenotypes and adversely affects the facial morphology and dentofacial aesthetics.[3,4] The disease severity varies from complete bilateral cleft lip and palate (CLP) at one end of the spectrum to a minimal cleft lip at the other end[5] and its prevalence differs between genders.[6,7] The incidence of CLP has been reported to range from 1 in 300 to 1 in 2500 live births.[8] In Iran, the overall incidence of CLP is 1.9 per 1000 live births.[9] The deformity may appear in non-syndromic or syndromic forms. Although the pathogenesis of non-syndromic CLP is largely unknown,[10] it is believed that this congenital malformation is the result of interactions between multiple genes and environment.[10–13]

Craniofacial anomalies are among the factors that affect masticatory function and interfere with working and at rest muscle functions. The top list of these anomalies is CLP as it interferes with adaptations needed for normal mastication since birth.[14] Patients with cleft lip and/or cleft palate generally experience numerous muscular disorders and imbalances as represented in their swallowing, speech, eating, drinking, and chewing functions.

Most studies in patients with CLP have assessed the growth pattern of facial bones[15–18] and there are a few studies regarding the effect of cleft lip and palate on the muscle function. Electromyography (EMG) studies regarding different maxillofacial muscles have been generally performed in patients having temporomandibular disorders[19,20] or some types of malocclusion,[21–24] but there are a few studies regarding masticatory muscle activity in patients with cleft lip and palate. Masticatory muscles have a great role in elevating the mandible during eating, different facial expressions, saliva swallowing, and precise movements during speech. The outcomes of some previous studies demonstrated that patients with CLP have deficiencies in masticatory function that may be due to the presence of a malocclusion such as anterior or posterior cross bite.[25–27]

There is little information regarding the muscular activity in the cleft versus non-cleft side of patients with unilateral CLP. Comparison of masticatory muscle activity in the cleft versus noncleft side of unilateral CLP patients indicates whether the presence of cleft affects the symmetry of masticatory function in the same subject. Theoretically, the presence of a cleft can cause disruption in the formation or development of masticatory muscles at the cleft side or the masticatory muscles in the cleft area may be more influenced by the greater severity of malocclusion (due to abnormal tooth position, missing teeth, and abnormal growth pattern) at that side.

The present clinical case-control study aimed to assess the function of the masseter and anterior temporal muscles by means of electromyography (EMG) in both sides of patients with unilateral cleft lip and palate and compare it with healthy volunteers.

METHODS

Participants

Twenty patients with unilateral cleft lip and palate who had undergone lip and palate surgery in childhood were included as the case group in this study. All the patients were females and aged between 15 and 30 years (mean age 20 ± 4 years). From the 20 included cases, 11 had CLP on the right side and 9 had CLP on the left side. All the CLP patients were under fixed orthodontic therapy at the Department of Orthodontics of Mashhad Dental School, Mashhad University of Medical Sciences, Mashhad, Iran and had completed the first phase of orthodontic therapy with level and align teeth. The exclusion criteria consisted of subjects who showed bilateral CLP or had CLP in association with a syndrome, as well as patients who were being prepared for orthognathic surgery. Furthermore, the individuals with any muscle disorder, temporomandibular dysfunction or neuromuscular disease were removed from the sample. The control group of the study consisted of 20 healthy; age- and sex-matched volunteers with no cleft lip and palate (mean age 24 ± 2 years). They had a nearly normal occlusion

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with no history of orthodontic treatment. The exclusion criteria for the control group involved subjects who showed any symptoms of temporomandibular dysfunction or general disorders affecting the muscles or neuromuscular function. All the participants or their parents were provided with written consent document after complete explanation of the examination procedures. The research protocol was reviewed and approved by the Ethics Committee of Mashhad University of Medical Sciences with assigned number of IR.mums.sd.REC.1394.178.

Electromyographic Examination

Surface EMG signals of masseter and anterior temporal muscles were recorded using a Nihon Kohden Neuropack S1 MEB-9400K Measuring System (EMG/EP; Nihon Kohden Corporation, Tokyo, Japan). Each patient was asked to sit upright on a comfortable chair without head support and assume a natural head position by looking straight ahead, so that the Frankfurt plan of the patient was parallel to the ground. Surface electric activity of the muscles was detected by 4 disposable, self-adhesive, silver/silver chloride (Ag/AgCl) bipolar electrodes (Noraxon Dual Electrodes, Noraxon USA Inc., Scottsdale, AZ) with a fixed inter-electrode distance of 20 mm. The electrodes were positioned on the masseter and anterior portion of temporal muscles according to a standard method described previously.[21,25] For the anterior temporal muscle, the electrodes were connected vertically along the anterior margin of the muscle; and for the masseter muscle, the electrodes were placed parallel to the muscular fibers with the upper pole of the electrode located at the intersection between the tragus-labial commissure and the exocanthion-gonion lines. A reference electrode was attached to the forehead or cheek. Before the placement of the electrodes, the surface was cleaned with 70% ethyl alcohol and dried with disposable cotton wool in order to reduce the impedance of the skin. The electrodes were then rubbed with an electrolyte gel and fixed. EMG recordings were performed on both the right and the left sides of CLP patients with equal distance to the midsagittal plane. The electrical activity of the temporal and masseter muscles was recorded during 3 different conditions as follows:

1. Rest-activity of the masticatory muscles, in which the patient was asked to sit in the clinical rest position with slightly touching teeth and lip.
2. Saliva ingestion
3. Maximum bite force (MBF), in which the patient was requested to exert maximal bite force for 5 seconds with the teeth in intercuspal position.

A rest period of at least 5 minutes was allowed between the recordings of muscle activities to avoid any effects of fatigue. Each of these 3 activities was repeated 10 times and the mean peak value was calculated to represent the muscular activity. Finally, the EMG signals at different test conditions were compared between the cleft and noncleft sides of CLP patients and between CLP patients and healthy individuals.

Statistical Analysis

The activity of temporal muscle at swallowing was 0 and thus this variable was excluded from the analysis. The normality of the data was assessed by the Kolmogorov–Smirnov test, and the results showed that only EMG signals of anterior temporal muscle at MBF had a normal distribution in both sides of CLP patients and healthy controls. Furthermore, the activity of masseter muscle at MBF showed a normal distribution in intact side of CLP patients and healthy controls. Therefore, any significant difference in EMG results was detected by Mann–Whitney *U* or Wilcoxon tests (for non-parametric data) and independent samples t-test or paired samples t-test (for parametric data). The statistical analysis was performed by SPSS, version 16.0 for Windows (SPSS, Chicago, IL), and *P* values less than 0.05 were considered statistically significant.

RESULTS

Table 1, http://links.lww.com/SCS/A500 presents the mean (for parametric variables) or median (for nonparametric variables) electrical activity of the temporal and masseter muscles at different tests in the cleft and noncleft sides of CLP patients. The results of Wilcoxon test demonstrated that the EMG signals of masseter muscle at rest, swallowing and MBF and the EMG activity of temporal muscle at rest was significantly higher in the cleft side compared to the noncleft side ($P < 0.05$; Table 1, http://links.lww.com/SCS/A500). Furthermore, the result of paired sample *t* test revealed a significantly higher temporal muscle activity at MBF in the cleft side than the noncleft side of CLP patients ($P < 0.001$; Table 1, http://links.lww.com/SCS/A500).

Table 2, http://links.lww.com/SCS/A500 presents the mean (for parametric variables) or median (for nonparametric variables) electrical activity of the masticatory muscles at different tests in the cleft side of CLP patients and healthy controls. According to the statistical analyses, patients with unilateral cleft lip and palate exhibited a significant increase in the electrical activity of masseter (at rest, swallowing, and MBF) and temporal (at rest and MBF) muscles at the cleft side compared to healthy individuals ($P < 0.05$; Table 2, http://links.lww.com/SCS/A500).

Table 3, http://links.lww.com/SCS/A500 compares the mean (for parametric variables) or median (for nonparametric variables) electrical activity of the masticatory muscles at different tests in the noncleft side of CLP patients and healthy controls. There was no significant difference in the activity of the masseter muscle at swallowing in either examined group ($P = 0.56$; Table 3, http://links.lww.com/SCS/A500). The results of Mann–Whitney *U* test exhibited that the rest-activity of the masseter and temporal muscles was significantly higher in the noncleft side of CLP patients as compared to the normal controls ($P < 0.001$; Table 3, http://links.lww.com/SCS/A500). In addition, intergroup differences in the EMG activity of masseter and temporal muscles at MBF were significantly different between the noncleft side of CLP patients and healthy controls ($P = 0.001$ and $P < 0.001$, respectively; Table 3, http://links.lww.com/SCS/A500).

DISCUSSION

The present study compared EMG findings of temporal and masseter muscles in the cleft and noncleft sides of patients with unilateral cleft lip and palate and healthy volunteers. The analysis of the electrical activity of the masticatory muscles was contemplated at mandibular rest position, during saliva swallowing, and at maximum bite force (MBF). The study involved subjects who had been finished the leveling and aligning phase of orthodontic therapy to provide more homogeneity in the sample. Surface electromyography was used in this study as it is a noninvasive, objective, repeatable, and accurate method to determine the activity of muscles and is well tolerated by the patients.[22] The study involved subjects who were older than 15 years age to ensure attaining maximum muscle strength of adolescence.

The findings of this study demonstrated that patients with unilateral cleft lip and palate experience overall greater muscle activity in the rest position, saliva ingestion and maximum bite force compared to healthy volunteers. The cleft side of CLP patients showed significantly higher electrical activity than the control group at all evaluated parameters. The difference in electrical activity between the noncleft side of CLP patients and healthy individuals was not as much as the cleft side, but the EMG potentials of the masseter and anterior

temporal muscles were still significantly greater at rest and MBF in the noncleft side of CLP patients compared to the control group. The higher muscle activity in patients with cleft lip and palate may be related to the presence of malocclusion especially the anterior and/or posterior cross bite, which has been shown to have a great effect on masticatory muscle function.[21,23,25–27] It is believed that in an attempt to make adaptation with the hyperactivity of temporal and masseter muscles many structural changes may occur in CLP patients in long term including tooth movements, muscular reactions, temporomandibular joint remodeling, or other pathologic changes in the stomatognathic system.[23,26,28]

The outcomes of this study revealed that all variables including the activity of masseter muscle at rest, masseter muscle at swallowing, masseter muscle at MBF, temporal muscle at rest, and temporal muscle at MBF significantly differed between the cleft and noncleft sides of CLP patients, so that the cleft side showed greater muscle activity than the noncleft side. This may be related to the possible deficiency in the formation or development of muscular system at the cleft side or to the more severe dental and skeletal deformities in the cleft area, which influence masticatory muscle function. Bilateral symmetry is extremely important in the masticatory organ. It is clear that the imbalance in muscle function can disturb the harmony of the masticatory system and lead to detrimental effects on stomatognathic system such as asymmetric facial growth, TMJ disorders or unilateral pain in CLP patients. If the muscle imbalance in unilateral CLP patients results from more severe malocclusion in the cleft area, it is expected that orthodontic treatment leads to symmetric masticatory function by providing a good occlusion and harmonized relationship between the dental arches and thus creating a suitable environment for symmetric facial growth.

The outcomes of this study are in line with the results of Li et al[29] who showed that patients with unilateral cleft lip and palate (UCLP) and anterior cross bite showed inharmonious activity of the masticatory muscles during mandibular movement and a higher asymmetry index of the masseter and temporal muscles, compared to noncleft controls. Recently, da Costa et al[30] analyzed the masticatory muscle function during different tasks (rest, isometry, mastication) in 6 to 12 years patients with complete unilateral cleft lip and palate and found that as a consequence of malocclusion, children with CLP have longer muscle activation and increased time during the chewing cycle, which may result in difficult chewing. Other studies also reported altered masticatory muscle function in cleft subjects compared to healthy individuals.[25,31] Szyska-Sommerfeld et al[26] found that patients with clefts had a significant increase in EMG potentials of temporal muscle at rest compared to healthy controls. In contrast to the findings of this study, they observed no significant differences in the rest-activity of the masseter muscle, and also in the maximum voluntary contraction (MVC) of the masseter and temporal muscles between cleft and noncleft children.[26] The difference between the results of this study and those of Szyska-Sommerfeld et al[26] may be related to the different age range of the participants, as their study involved children at the mixed dentition stage who may have different muscular strength than the adolescents and adults participated in this study.

Regarding swallowing function, the outcomes of this study showed that EMG activity of the masseter muscle was higher in the cleft side of CLP patients compared to the noncleft side or the control group. Since the temporal muscle has minor role in swallowing, the activity of this muscle was zero in all groups. Studies that assessed the swallowing function of cleft subjects mainly assessed the EMG potentials of orbicularis oris muscle.[32,33] Carvajal et al[33] demonstrated higher electrical activity of orbicularis oris muscle during swallowing of saliva in children with cleft lip and palate compared to noncleft children, which may cause a counteracting effect on the growing maxilla.

Our study assessed the activity of temporal and masseter muscles in 3 situations including at rest, during swallowing and during maximum bite force in adolescents and adults with unilateral CLP. The overall outcomes showed that CLP patients express greater muscle activity than healthy volunteers and show asymmetric masticatory function between the cleft and noncleft sides. These results may contribute to find a way to further help CLP patients gain normal masticatory function. However, our investigation involved a small sample size and this may be considered as a limitation of this study. Further studies with larger sample size are warranted to compare muscular function in unilateral versus bilateral CLP patients with different malocclusions and evaluate the effect of orthodontic/orthognathic treatment on muscular activity of these patients.

CONCLUSION

1. Patients with unilateral cleft lip and palate experienced overall greater masticatory muscle activity in the rest position, saliva ingestion, and maximum bite force compared to healthy volunteers.
2. In subjects with unilateral cleft lip and palate, the EMG potentials of the masseter and anterior temporal muscles were significantly greater in the cleft side compared to the noncleft side. This asymmetric masticatory function may be associated with severe consequences such as asymmetric facial growth, implying the importance of early diagnosis and orthodontic treatment to achieve a favorable environment for balanced growth and development in CLP patients.

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