

Effect of the Mandibular Orthopedic Repositioning Appliance on Trunk and Upper Limb Muscle Activation during Maximum Isometric Contraction

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Abstract. [Purpose] The purpose of this study was to measure the muscle activities of the trunk muscles and upper limb muscles during maximum isometric contraction when temporomandibular joint alignment was achieved with a mandibular orthopedic repositioning appliance in order to provide basic data on the effects of mandibular orthopedic repositioning appliance on the entire body. [Subjects] The present study was conducted with healthy Korean adults in their 20s (males=10, females=10). [Methods] An 8 channel surface electromyography system was used to measure the muscle activities of the upper limb muscles and neck muscles of the subjects during maximum isometric contraction with and without use of a mandibular orthopedic repositioning appliance. [Results] The maximum isometric contractions of the trunk and upper limb muscles when mandibular orthopedic repositioning appliance were used were compared with those when no mandibular orthopedic repositioning appliance was used. The results showed that the sternocleidomastoid muscle, cervical and lumbar erector spinae, upper trapezius, biceps, triceps, rectus abdominis and internal oblique and external oblique muscles all showed significant increases in maximum isometric contractions with a mandibular orthopedic repositioning appliance. [Conclusion] The use of a mandibular orthopedic repositioning appliance is considered to be a method for normal adults to improve the stability of the entire body with the improvement of the stability of the TMJ. The proximal improvement in stability improves of the proximal thereby improving not only muscle strength with increased muscle activation but also stability during exercises.

Key words: Electromyography, Maximum isometric contraction, MORA

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INTRODUCTION

The temporomandibular joint (TMJ) is a joint present above the spine. From a Kinematic standpoint, the alignment of the TMJ directly affects the stability and alignment of the spine, and the TMJ is the only bilateral joint among all joints in the human body¹⁾. When the position of the lower jaw is misplaced, it is generally pushed toward the rear of the head. In this case, due to the homeostasis of the human body that tends to maintain balance in any event, the center of gravity of the head leans toward the rear of the head to make the entire head lean backward. When the position of the TMJ is changed, the axis of the center of gravity of the head is changed, leading to misalignment of

the entire spine. The position of the TMJ is closely related with masticatory functions, and this factor is important for control of the entire body's postures such as the functions of the cerebellum, vestibular functions, oculomotor functions, and proprioceptive senses²⁾.

Mouth guards are used in a wide range of sport activities in order to increase the stability of the TMJ, the importance of which has been emphasized, to protect the TMJ from external resistance, and to protect teeth and periodontal tissues. They are also used in patients with any stomatognathic disability that may affect exercise habits or postures or any abnormality in occlusion in order to induce normal occlusion.

Thanks to the development of science, these mouth guards have been developed into many shapes fit for their purposes depending of their manufacturing methods and materials. Mouth guards can be largely divided into three types based on their manufacturing methods. Stock-type mouth guards (STM) are ready-made mouth guard that cannot be adjusted, and boil-and bite-type mouth guards (BTM) are those that are to be molded by the user. Finally,

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custom-made mouth guards (CTM) are those made from models after obtaining impressions of the teeth of the athletes who will use them. With regard to materials, those made of soft materials have been developed for the prevention of sport injuries, and those made of hard materials have been developed for oral functions and alignment³. All oral appliances including mouth guards developed with a wide range of methods and materials are called mandibular orthopedic repositioning appliances (MORAs).

MORAs are known to affect the relief of neck stress and postures, improve respiratory functions⁴, and improve body balance⁴. Thus, MORAs affect the entire body by causing changes in the stomatognathic system. However, since studies of the relationship between muscle activation and a MORA that directly affects body balance are insufficient, basic data on the effects of a MORA on the entire body are insufficient. Therefore, the purpose of this study was to measure the muscle activities of the trunk muscles and upper limb muscles during maximum isometric contraction when TMJ alignment was achieved with a MORA in order to provide basic data on the effects of a MORA on the entire body.

SUBJECTS AND METHODS

The present study was conducted with healthy adults in their 20s (males=10, females=10) who had not been diagnosed with any medical conditions within the last six months. All the subjects voluntarily participated in this study and signed an agreement for this experiment that stated that they were able to reject participation anytime if they wanted. An 8 ch surface electromyography (Myo-System DTS, Noraxon U.S.A. Inc., Scottsdale, CA, USA) system was used to measure the muscle activities of the upper limb muscles and neck muscles of the subjects during maximum isometric contraction when a MORA was used and when no MORA was used. The MyoResearch XP master edition 1.06 program was used to store and process electromyographic signals with a sampling rate of 1,000 Hz, a 20–500 Hz band-pass filter, a 60 Hz notch filter, and IWC-DTS electrodes (9113A-DTS). The sites for electrodes were shaved with a razor, and the horny substance was removed with sandpaper. The electrodes were attached after cleaning the sites with an alcohol swab to ensure collection of accurate electromyogram data. Disposable, bipolar Ag–AgCl EMG surface electrodes were applied with a 3 cm center-to-center spacing over the lumbar and cervical erector spinae, upper trapezius, biceps, triceps, rectus abdominis, internal abdominal obliques, external abdominal obliques, and sternocleidomastoid muscle. The maximum isometric contraction of each muscle was achieved in the manual muscle testing position⁵. Regardless of whether a MORA was used or not, all the measurements were conducted when the TMJ was closed at the maximum force.

The root mean square data of each muscle was measured for five seconds in maximal voluntary isometric contraction. The level of muscle activation during maximum isometric contraction was expressed as %MVIC by calculating the relative muscle contraction of the 100% average muscle

contraction in the middle one second of a 3-second measurement, i.e., by ignoring the first and last second of the measurement.

The MORA used in the experiment was made of hard-type splint 020 (Easy-Vac Gasket, 3A MEDES, Goyang, South Korea), and Ortho-Jet (fast curing orthodontic acrylic resin, Lang Dental, Wheeling, IL, USA) was used to set the occlusion of the hard-type MORA.

To obtain elaborate maxillary and mandibular casts of the study subjects, the subjects' impressions were obtained using alginate impression materials and plaster casts were made.

When mandibular centric bites were obtained, each subject was instructed to bite down on cotton rolls on both sides of his/her oral cavity and maintain the state for approximately five minutes to eliminate the effects of teeth on the muscles and stabilize the muscles. To eliminate the effects of gravity on the mandibular bites, mandibular centric bites were obtained in upright positions.

The maxillary cast was attached to a semi-adjustable articulator using a facebow, and the mandibular cast was attached to the semi-adjustable articulator using the obtained mandibular centric waxbite.

A random point was marked on the attached gingiva between the right canine tooth and the first premolar of the attached maxillary and mandibular casts on the working model, the distance between the maxillary and mandibular casts was measured based on the marked point, and the incisal guide pins of the articulator were lifted so that each of them was lifted by 3 mm from their position.

The prepared primary MORA was mounted on the maxillary working cast, the occlusal vertical dimension was increased by 3 mm at the centric occlusion, and the maxillary overbite-type primary MORA was attached to the maxillary front teeth and set at the lifted occlusal vertical dimension by covering it with paraffin wax. Then, the MORA was adjusted using a self-curing resin so that all teeth would evenly come into contact with the centric occlusion, canine guidance would be given during lateral movements to the left and right, and the front teeth group would be evenly guided anteriorly during anterior movements. Although the deep fossae formed by the occlusal tables of antagonist teeth are generally not included in MORAs that are widely used to treat TMJ disorders, 1 mm deep fossae were artificially formed so that all cusp tips of antagonist teeth would come into contact with the MORA evenly and no locational change would occur.

The fabricated MORAs were placed into the oral cavities of the study subjects and adjusted so that all teeth would evenly come into contact with them so that the centric relation and centric occlusion would match and the mutually protected occlusion would be precise. The occlusions were adjusted so that anterior movements would be guided by the front teeth group and lateral movement would be guided by the canines. Then, the set occlusal vertical dimension was rechecked, and the experimental MORAs was completed.

Collected data were statistically processed using the SPSS 20 for Windows statistical program. The subjects' general characteristics were checked through percentage

Table 1. Comparison of upper limb and trunk muscle activation during maximum isometric contraction between each condition (Unit: %MVIC)

Muscle	Without a MORA	With a MORA
SCM*	111.6 ± 6.0	125.4 ± 15.6
C-ES*	115.0 ± 8.2	138.1 ± 18.0
UT*	114.5 ± 7.7	123.7 ± 9.2
Biceps*	114.7 ± 5.1	125.2 ± 7.6
Triceps*	111.2 ± 4.9	120.9 ± 8.6
RA*	116.0 ± 6.3	128.8 ± 6.7
IAO*	116.3 ± 4.2	128.1 ± 5.0
EAO*	117.7 ± 5.1	128.1 ± 6.0
L-ES*	118.7 ± 4.7	130.8 ± 6.2

Mean ± SD, $p < 0.05$

SCM, sternocleidomastoid muscle; C-ES, cervical erector spinae; IAO, internal abdominal oblique; EAO, external abdominal oblique; L-ES, lumbar erector spinae; RA, rectus abdominis

and frequency analyses, and the differences in the muscle activities of individual muscles between using MORA and not-using MORA, were analyzed using independent t-tests. The statistical significance level was set to $\alpha = 0.05$. This study was approved by the Institutional Review Board.

RESULTS

The maximum isometric contractions of the trunk and upper limb muscles when a MORA was used were compared with those when no MORA was used. The results showed that the sternocleidomastoid muscle, cervical and lumbar erector spinae, upper trapezius, biceps, triceps, rectus abdominis, and internal oblique and external oblique muscles all showed significant increases in maximum isometric contractions when using a MORA (Table 1) ($p < 0.05$).

DISCUSSION

Human postures are determined and maintained by the coordinated movements of muscles, proprioceptive senses, the sense of equilibrium, and the positions and functions of joints⁶). Among joint positions, the position of the TMJ, which is characterized as a bilateral joint, can control the position of the head, which is the heaviest part of the body, and thus it affects the stability and functions of the entire body²).

Therefore, the present study was performed to examine the effects of the use of a MORA that can provide positional changes and stability to the lower joint, which in turn moves the TMJ, on the body.

The maximum isometric contractile power of the trunk and upper limb muscles when a MORA was used was compared with that when no MORA was used, and the results showed significant increases in power in all the muscles measured. Given these results, it seems like the increase in stability of the TMJ resulting from use of a MORA af-

ected the stability and balance of the entire body so that the maximal isometric contraction of the trunk and upper limb muscles increased⁷). Muscle activation is closely related to the stability of the spine and the entire body⁸), and proper body alignment increases the muscle activation of distal part of the body^{9, 10}). According to the results of a study conducted by Bates and Atkinson¹¹), a MORA affects the TMJ and moves it into its normal position. Therefore, MORAs can be widely used in treating craniomandibular disorders, and treatment with them can improve motor abilities, muscle strength, endurance, and concentration^{12, 13}). The results of these studies indicate that use of a MORA is one method of increasing muscle activation in the entire body in stable positions.

Therefore, the use of a MORA is considered to be a method for normal adults to improve the stability of the entire body through improvement of the stability of the TMJ; that is, the proximal improvement in stability improves not only muscle strength with increased muscle activation but also stability during exercises.

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