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ORIGINAL ARTICLE

Effects of increasing the jaw opening on the maximum bite force and electromyographic activities of jaw muscles

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Abstract *Background/purpose:* Increased occlusal jaw opening may lead to some changes in the bite force and electromyographic (EMG) activities of the jaw muscles. This *in situ* study was conducted to determine the immediate influence of three different occlusal vertical dimensions on the maximum bite force and EMG activities of the masseter and anterior temporalis muscles.
Materials and methods: Five healthy subjects participated in the study. Two maxillary occlusal splints of 2 and 4 mm thickness were fabricated, and their use created, respectively, 8 and 10 mm of intermolar distances in the first molar region with a strain-gauge-mounted metal arch. EMG activities of the muscles and the maximum bite force were simultaneously recorded using an EMG device and two miniature strain-gauge transducers. Recordings were made in the first molar region without a splint, but with two splints to produce 6, 8, and 10 mm of intermolar distances.
Results: EMG activities of both muscles decreased with increased jaw opening; however, the differences were not statistically significant. The highest maximum bite force was found at a 6-mm intermolar distance, which significantly differed from those at 8- and 10-mm intermolar distances ($P < 0.05$). The most efficient bite force was exerted with 6 mm of intermolar distance. The least EMG activity of both muscles was found with 10 mm of intermolar distance.
Conclusion: An increase in the vertical thickness of the splint to 10 mm may provide an immediate effect of reducing masseter and anterior temporalis muscle hyperactivity.

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Introduction

Occlusal jaw opening may be altered by certain clinical procedures such as occlusal splint therapy,[1] orthodontic treatment,[2] and restorative rehabilitation of a patient.[2,3] This may lead to some changes in the orofacial structures, including the length of the main jaw elevator muscle fibers and the position of the mandibular condyles in the fossa articularis.[2] Changing the length of the main elevator muscle fibers will affect the bite force applied.[4,5] When a muscle fiber is stretched beyond its resting length, more force is generated up to a point; further stretching results in reduced force generation.[6] It was stated that the maximum bite force increases as the jaw is opened, reaches a maximum level at 14—20 mm of interincisal distance, and then decreases as the jaw is further opened.[4,7]

Several authors also demonstrated a decrease in the electromyographic (EMG) activities of the masseter and temporal muscles with different increases in jaw opening.[4,5,8,9] Decreased EMG activity of the jaw muscles with an increased jaw opening is one of the hypotheses that explains the clinical efficiency of occlusal splints for treating masticatory muscle hyperactivity generally seen in patients with temporomandibular (TMD) disorders and bruxism.[1,10,11] It was suggested that adjusting the thickness of splints to or near the vertical dimension that produced the least EMG activity may be effective in reducing masseteric muscle hyperactivity and related symptoms.[1] It is assumed that insertion of an occlusal splint increases the jaw opening, helps relax muscles,[12,13] and redistributes intraoral forces more evenly throughout the masticatory system.[14] However, there is no agreement on the optimal thickness of the splints used. Although some clinicians proposed that occlusal splints be employed in different thicknesses ranging from 1[15] to 12—15 mm,[16,17] Manns et al[15] stated that the use of an average of 8.1-mm splint thickness appeared to be most efficient in achieving a rapid improvement in symptoms.

The aim of this *in situ* study was primarily to determine the immediate influences of an increased occlusal vertical dimension on the maximum bite force and EMG activities of the left and right masseter and anterior temporalis muscles. A second aim was to compare the effects of three occlusal jaw opening distances on EMG activities of the two muscle groups.

Materials and methods

Five healthy subjects (two females and three males) volunteered to participate in this study. The experimental protocol was approved by the Ethics Committee of Gazi University (process no. 20/2009). All subjects received a written explanation of the study, and informed consent was obtained from each person before the start of the study. The ages of the subjects ranged from 18 to 32 years. No participants reported any systemic disease; they had no symptoms of TMD joint dysfunction or periodontal diseases, and all had an Angle Class 1 molar relationship on both sides with full permanent dentition (not including the third molars). Subjects who had vital first molars without mesio-occluso-distal restorations were included in the study.

Fabrication of maxillary splints

Two maxillary occlusal splints with flat surfaces were fabricated in a conventional manner using a clear autopolymerizing acrylic resin (Akribel, Belmar, Izmır, Turkey). Occlusal splints were constructed to cover all the occlusal surfaces and one-third of the buccal and labial surfaces of the maxillary teeth. The thicknesses of the splints were determined to be 2 and 4 mm. After adjustment, they created 8- and 10-mm intermolar distances, respectively, in the first molar region with a strain-gauge-mounted metal arch.

Bite-force measurement

Maximum bite forces were measured from each side of the dental arch using two miniature strain-gauge transducers with stainless-steel cases (Fig. 1) (Model VLPB, Load Cell Central, Monroeton, PA, USA). Two transducers were placed bilaterally on a flat metal arch, and the button of the strain-gauge transducer was in contact with the flat metal arch (Fig. 2). The transducers were fixed with plaster (Betasan, Kocaeli, Turkey) to the metal arch (Fig. 3). The metal arch and transducers were further covered with a disposable latex finger coating to avoid contamination during measurements (Figs. 4—6). Each transducer had a height of 4 mm and a diameter of 12 mm; in these applications, transducers reached a height of 6 mm.

The bite force was detected as a two-channel signal from each side with a biosignal acquisition device designed by Kardiosis (Tepa, Kardiosis, Ankara, Turkey). The force signals were monitored online and then measured on a PC screen, using a specific software program developed by the same company. The transducers were calibrated by loading them with known force values.

EMG recording

EMG data were recorded with a BioEMG II (BioPAK version 2.03, BioResearch, Milwaukee, WI, USA) EMG amplifier connected to a PC running Windows™ (Microsoft, Redmond,

Figure 1 Strain-gauge transducer.