CONCLUSION

Knowing that articulating paper may not be accurate,\(^8\) photocclusion should be considered for diagnosis and treatment of occlusal disharmonies. Combined with articulating paper, it might indicate the precise area in which a deflective contact occurs. It might also be advisable to use the photocclusion method as a follow-up to occlusal adjustment in all patients.

We wish to thank Professor M. Arcan of Tel-Aviv University for his advice and Mr. Ed Warner, Director of Biomedical Communications, Faculty of Medicine, Technion-Israel Institute of Technology, for the illustration.

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Influence of vertical dimension on masseter muscle electromyographic activity in patients with mandibular dysfunction

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Several investigators have demonstrated a decrease in electromyographic (EMG) activity of the masseter and temporal muscles when the mandible is depressed beyond the postural position.\(^7\) Others have observed that the vertical dimension of occlusion can be increased several millimeters with occlusal splints without evidence of EMG disturbances.\(^7\)\(^9\)

We studied the relation between basal tonic EMG (BT-EMG) activity and variations of vertical dimension in patients with normal function of the masticatory system and in patients with mandibular dysfunction.\(^10\)\(^11\) Through static and dynamic variations of the vertical dimension of occlusion, the exact site where minimum BT-EMG activity of the masseter muscle occurred was determined (mean 10 mm of interocclusal distance in normal function and 8.45 mm in myofascial pain-dysfunction syndrome). Rugh and Drago\(^12\) also observed a specific vertical dimension of occlusion of least BT-EMG activity for the patients studied that ranged from 4.5 to 12.6 mm (mean, 8.6 mm).

The purpose of the present study was to analyze the influence of increments in the vertical dimension on BT-EMG activity of the masseter muscle by means of occlusal splints adjusted at different heights in patients with mandibular dysfunction.

MATERIAL AND METHODS

The study was carried out on 60 patients, 51 women and nine men, ranging from 13 to 52 years of age (mean age, 27.3 years). They were selected according to the following criteria: spontaneous fascial pain in the preauricular area, severe painful tenderness to palpation of the elevator jaw muscles, mandibular deviation or
Fig. 1. Occlusal splints in patients of A, group No. 1; B, group No. 2; and C, group No. 3

Fig. 2. BT-EMG activity of masseter muscle registered in postural mandibular position (series A) throughout control sessions and for each treatment group.

Fig. 3. BT-EMG activity of masseter muscle registered with splint (series B) worn throughout control sessions and for each treatment group.

restricted opening, clicking or popping sounds of the TMJ, and grinding or clenching of the teeth. Patients who had previously used an occlusal splint, showed radiographic changes in the TMJs, or used removable prostheses were not included.

A maxillary occlusal splint was used. It was made with heat-polymerized acrylic resin and had a flat occlusal surface with stable contact and freedom in centric occlusion, with uniform anterior and canine guidance. Disclusion of the posterior teeth was obtained in the different contact positions and functional jaw movements. The use of the splint was restricted to 3 hours diurnally and all night for 3 weeks to avoid extrusion of the posterior teeth.

The vertical dimension of minimum BT-EMG activity or "neuromuscular resting vertical dimension" was determined for each patient according to a technique in which we used a device specifically designed for that purpose. EMG recordings were performed by placing bipolar surface electrodes (Grass 5s, Grass Instrument Co., Quincy, Mass.) on the masseter muscle of the most affected side in the same place each session. EMG activity was filtered (80 Hz to 100 kHz), amplified 1000 times, and then amplified again 10 to 50 times, integrated (time constant 1800 msec), and finally registered on a polygraph (Nihon Khoden Rjg-4022, Nikon Kohden Kogyo Co. Ltd., Tokyo, Japan). The recordings of the masseter muscle were used because they showed a more circumscribed EMG activity decrease when compared with the temporal muscle.

The patients were randomly divided into three groups according to the vertical dimension to which the occlusal
Table I. Analysis of variance for BT-EMG activity recorded in postural mandibular position (series A)

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groups</td>
<td>59</td>
<td>940.25</td>
<td></td>
<td>f = 2.88 (0.05 &lt; p &lt; .10)</td>
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<tr>
<td>Error</td>
<td>2</td>
<td>14.16</td>
<td></td>
<td></td>
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<tr>
<td>Within subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>300</td>
<td>43.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time x groups</td>
<td>1</td>
<td>7.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error 2</td>
<td>2</td>
<td>2.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>359</td>
<td>1,887.86</td>
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</tr>
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</table>

Table II. Analysis of variance for BT-EMG activity recorded with splint (series B)

<table>
<thead>
<tr>
<th>Source of variance</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>f (p &lt; 0.001)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
<td></td>
<td>1,297.59</td>
<td></td>
<td></td>
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<tr>
<td>Groups</td>
<td>2</td>
<td>430.42</td>
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<td>f = 14.15</td>
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<td>Error 1</td>
<td>57</td>
<td>15.21</td>
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<td></td>
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<tr>
<td>Within subjects</td>
<td></td>
<td>1,269.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>5</td>
<td>91.99</td>
<td></td>
<td>f = 39.70</td>
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<tr>
<td>Time x groups</td>
<td>10</td>
<td>14.89</td>
<td></td>
<td>f = 6.43</td>
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<tr>
<td>Error 2</td>
<td>285</td>
<td>2.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>359</td>
<td>2,566.88</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The splint was adjusted (Fig. 1). Group No. 1 included 20 patients with the splint adjusted to 1 mm from occlusal vertical dimension. There were two men and 18 women in the group, whose mean age was 26 years with a range of 13 to 52 years. Group No. 2 included 20 patients with splints adjusted to a vertical dimension that corresponded to half the difference between occlusal vertical dimension and the vertical dimension of least BT-EMG activity of the masseter muscle. There were four men and 16 women in group No. 2, whose mean age was 28 years with a range of 15 to 52 years. The mean vertical dimension was 4.25 mm. Group No. 3 included 20 patients with splints adjusted to a vertical dimension of least BT-EMG activity of the masseter muscle. There were three men and 17 women in group No. 3, whose mean age was 28 years with a range of 15 to 53 years. The mean vertical dimension was 8.25 mm.

BT-EMG activity of the masseter muscle was evaluated initially and during control sessions (24 hours, 72 hours, first week, second week, and third week) under two experimental conditions: A, recordings in the postural mandibular position; and B, recordings with the splint inserted and with slight tooth contact. Three recordings of BT-EMG activity were performed in each series for a total of 60 recordings each in series A and in series B, in each control session, and for group treatment.

ANALYSIS OF DATA

Recordings of BT-EMG activity obtained in each control session lasted approximately 20 seconds; there-
registered in the postural mandibular position was considered to be the initial value. In this figure a reduction of EMG activity when the splint was worn (from 24 hours to the third week of treatment) for group Nos. 2 and 3 can be observed compared with group No. 1. Note also the faster masseter muscle EMG reduction at 24 hours for group Nos. 2 and 3 and the gradual decrease to the last session (third week). Group No. 1 shows only a slight, fluctuating decrease throughout the control session.

Table II shows the ANOVA for series B. There was a significant overall group effect ($f = 14.15, p < .001$) and also group × time interaction ($f = 39.70, p < .001$). There were significant differences between group Nos. 1 and 2 as well as between group Nos. 1 and 3 (Tukey test).

DISCUSSION

Several hypotheses have been offered to explain the clinical efficacy of occlusal splints in the treatment of masticatory muscle hyperactivity. One hypothesis maintains that success is due to the muscular relaxation produced by a decrease of EMG activity of the jaw muscles.17,20

In this study the occlusal splint design was kept constant, with changes introduced exclusively in its vertical height. It is therefore tempting to conclude that the significant reduction of BT-EMG activity of the masseter muscle at the end of treatment was due to the vertical dimension increment factor. The vertical height of the splints of group Nos. 2 and 3, which were adjusted at or near the vertical dimension of least EMG activity, may be effective in short-term efforts to reduce masseteric muscle hyperactivity.

These results are similar to those obtained by Carlsson et al.8 and Clark et al.21 It should be mentioned that the Carlsson study used asymptomatic subjects. Our results are in disagreement with the "clinical criterion" that an increase in vertical dimension of occlusion beyond the postural one would trigger muscular hyperactivity.

BT-EMG activity reduction observed throughout control sessions with splints in place, which exceeded the interocclusal distance in comparison with those obtained initially in the postural mandibular position, can be explained as follows. To maintain the vertical jaw postural position, a certain amount of muscular tonic activity is necessary. This means a certain number of muscle fibers are active and finally a certain number of sarcomere cross-bridges are involved.

In group Nos. 2 and 3 patients, the vertical height of the splints lengthened the masseter muscle near its optimum physiologic elongation, where the highest number of sarcomere cross-bridges between thin and thick myofilaments of its muscle fibers are available.

The gradual decrease of EMG activity observed in the postural mandibular position (series A) throughout the control sessions, especially that of group Nos. 2 and 3 compared with group No. 1, can be explained by the effect of EMG activity reduction induced by the vertical height factor of the splints already mentioned. On the other hand, the apparent muscular relaxation is also due to a lower integrated EMG activity of the masseter muscle developed during maximum clenching with a splint worn in group Nos. 2 and 3 as demonstrated in a previous study.23

SUMMARY

Occlusal splints were adjusted to different vertical heights and used to single out the influence of vertical dimension of occlusion in increments on BT-EMG activity of the masseter muscle in patients with mandibular dysfunction.

The vertical dimension of least EMG activity was determined for each of 60 patients, who were randomly divided into three groups according to the vertical dimension at which the occlusal splint was adjusted: group No. 1, 1 mm from occlusal vertical dimension; group No. 2, mean vertical dimension, 4.25 mm; group No. 3, mean vertical dimension, 8.25 mm. Results showed a significant reduction of masseter BT-EMG activity (series A and B) at the end of the 3-week treatment period for patients in group Nos. 2 and 3 in comparison with group No. 1. Furthermore, the short-term use of occlusal splints with a vertical height that exceeded the so-called physiologic interocclusal distance did not result in an increase in masseter BT-EMG activity.

This study suggests that an increase of vertical dimension of occlusion to or near the vertical dimension of least EMG activity by means of occlusal splints can be an effective way to obtain a reduction in masseteric muscle activity.

We would like to thank Dr. Fernando Lolas for reading and commenting on this article.

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Reproduction of waxed functional occlusal patterns in fired ceramics

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Salto and Montevideo, Uruguay

The typical ceramic materials used in dentistry cannot be cast. Therefore, it is difficult to successfully transfer the occlusal morphology from wax to porcelain. Procedures have been reported to create functional occlusion in ceramics.1,4 Among them are the use of silicone indesce®7 and the “every other tooth” technique.5,6 All these methods are expensive and time consuming. Most require several additional bakes to form the final anatomy. They must be performed by highly skilled ceramists with excellent knowledge of occlusion.

This article presents a simplified technique to reproduce a functional occlusion in ceramics as formed previously by the drop-wax technique. It can be used for single, multiple, or full arch restorations. It incorporates the standard steps for gnathologic reconstruction and makes it possible to reproduce individualized occlusal morphology in ceramic material.

All the steps in this method are controlled by four