Changes in Occlusal Contact Area during Oral Appliance Therapy Assessed on Study Models

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ABSTRACT

Objective: To test the hypothesis that long-term use of an oral appliance (OA) does not cause changes in the occlusal contact area (OCA).

Materials and Methods: Baseline and follow-up treatment study models were obtained for 45 patients with obstructive sleep apnea who had been using an OA for 4 or more days/week for more than 5 years. Study models in centric occlusion, with an inserted pressure-sensitive sheet, were loaded in compression. An image scanner was used to evaluate OCA.

Results: A significant change in total OCA was identified in 39 patients (86.7%): a decrease in 26 (66.7%) and an increase in 13 (33.3%) patients. Regional changes >5% were observed in >90% of patients in each of the three regions. In the molar and premolar regions, 24 (53.3%) and 27 (60.0%) of the patients showed an OCA decrease, while only 16 (35.6%) and 15 (33.3%) showed an increase. Conversely, for the anterior region, more increases (24 patients–53.3%) than decreases were identified.

Conclusion: The hypothesis is rejected. Long-term OA therapy resulted in dramatic changes of occlusion, suggesting that monitoring of occlusal changes is required.

KEY WORDS: Occlusal contact area; Oral appliance; Obstructive sleep apnea

INTRODUCTION

Obstructive sleep apnea (OSA), the periodic reduction/cessation of breathing due to narrowing of the upper airway during sleep, is a common condition that has major consequences for public health and an associated morbidity and mortality. Oral appliances (OAs), aiming to enlarge the upper airway by repositioning the mandible forward, have been established as a lifelong treatment. Hence, knowledge of side effects and their likely prevalence is important in helping to optimize patient selection and to monitor treatment effects.

Recent studies of long-term OA users have shown that the treatment may be accompanied by initial jaw discomfort and/or difficulty chewing in the morning and possible dentofacial changes, such as reductions in overbite and overjet and a mesial shift of mandibular molars. For some patients, a decrease in occlusal contact area (OCA) around the molar and premolar regions has also been reported. Almeida et al estimated OCA by counting the number of contact points before and after 5 years of OA therapy using articulating paper on patients’ models. However, this widely used conventional method for detecting occlusal contact points is best suited for qualitative analysis and may be highly influenced by interpretation. For a proper occlusal relationship analysis, both qualitative and quantitative assessments are necessary. A quantitative measurement of OCA after long-term use of OAs has not yet been performed. Dental Prescale (Fuji Film Co, Tokyo, Japan) can measure OCA quantitatively (in mm²) by computer analysis of information obtained from a pressure-sensitive sheet (PSS).

The aim of this study was to test the hypothesis that...
long-term use of OAs causes significant changes in OCA by measuring and comparing OCA after long-term OA usage on dental study models with a PSS under constant load conditions.

MATERIALS AND METHODS

Forty-five patients (characteristics are summarized in Table 1) were enrolled in this study. Sleep disorder physicians, otolaryngologists, or family physicians referred the patients for OA therapy with a diagnosis of snoring and/or OSA. Patients with fewer than 10 teeth on either jaw were excluded; so were patients who had a change in the number of teeth or in any crown shape due to dental treatment. The ethics committee of the university approved the secondary use of data. Baseline and treatment follow-up study models in centric occlusion were obtained.

All subjects had used an OA on a consistent basis for 4 or more days per week for more than 5 years. At the time of the study, all patients were using Klearway (Space Maintainers Laboratories Canada Ltd; Vancouver, BC, Canada; Figure 1), an OA constructed of a thermoplastic acrylic resin that provides full occlusal coverage of the teeth20,21 and permits lateral and vertical jaw movements during sleep. The palatal screw enables 44 advancements of the mandible in 0.25-mm increments. The initial mandibular advancement was set at two-thirds of maximum mandibular advancement and then progressively increased 2.0 mm/month until the most effective and comfortable position was reached. Uncomfortable pressure points on the teeth and gums were relieved. The jaw was advanced until the symptoms were resolved, the snoring was significantly reduced, and/or the patient could not tolerate any further advancement.

An occlusal diagnostic system, Dental Prescale Occluzer, (Fuji Film Co, Tokyo, Japan) was used to evaluate OCA, as described previously.15–19 Dental Prescale is a 98-μm thick horseshoe-shaped sheet wrapped with poly(ethylene terephthalate) film. The microcapsules in the sheet break and release a color-forming material at various occlusal pressures,16 thus detecting OCs. An image scanner (FPD-703, Fuji Film Co, Tokyo, Japan) was used to determine OCA and estimate occlusal loads. The OCA was quantified with an occlusion pressure graph, based on the degree of coloring. The sheet is unaffected by temperature changes.
Table 2. Changes in the Total Occlusal Contact Area (OCA)

<table>
<thead>
<tr>
<th>Change</th>
<th>No. of Patients</th>
<th>Increase or Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤5% (no change)</td>
<td>6 out of 45 (13.3%)</td>
<td>(P = 0.34)</td>
</tr>
<tr>
<td>&gt;5%</td>
<td>39 out of 45 (86.7%)</td>
<td>13 out of 39 (33.3%) (P = 0.001)</td>
</tr>
<tr>
<td>≥20%</td>
<td>20 out of 45 (44.4%)</td>
<td>6 out of 20 (P = 0.001)</td>
</tr>
</tbody>
</table>

Table 3 summarizes the identified regional OCA changes in all but 2 of the 20 patients (90.0%) in the group with at least 20% (highlighted in Table 4). In this group, the influence of molar changes was predominant in 12 patients (60.0%). In only 2 of 20 patients (10.0%) were changes in the anterior region responsible for the change in total OCA. Ten of 20 patients (50.0%) showed molar and premolar OCA changes in the same direction, and in 9 the changes were associated with the direction of the change in total OCA.
Table 4. Total and Regional Occlusal Contact Area (OCA) Measurements Where Total OCA Change was ≥20%

<table>
<thead>
<tr>
<th>Case nr.</th>
<th>Total change (%)</th>
<th>OCA in mm² and Increase or Decrease</th>
</tr>
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<tr>
<td></td>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>22</td>
<td>31</td>
<td>6.55</td>
</tr>
<tr>
<td>12</td>
<td>38</td>
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<td>33</td>
<td>61</td>
<td>12.01</td>
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<tr>
<td>41</td>
<td>48</td>
<td>8.38</td>
</tr>
<tr>
<td>21</td>
<td>57</td>
<td>9.55</td>
</tr>
<tr>
<td>10</td>
<td>57</td>
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<td>7</td>
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<td>30</td>
<td>7.03</td>
</tr>
<tr>
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<td>20</td>
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</tr>
<tr>
<td>11</td>
<td>20</td>
<td>3.26</td>
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<tr>
<td>31</td>
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<td>3.86</td>
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<td>40</td>
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<td>24</td>
<td>69</td>
<td>6.43</td>
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<td>35</td>
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<td>5.2</td>
</tr>
<tr>
<td>34</td>
<td>70</td>
<td>7.65</td>
</tr>
</tbody>
</table>

Changes in the molar and premolars area that are in the same direction and delineated by rectangles.
Changes in the regional OCA that were responsible for the change in the total OCA are highlighted.

The results of the baseline and follow-up OCA measurements for each tooth are presented in Figure 4 as a box plot. A significant decrease in OCA was found in both right and left first molars, and an increase was observed in the second molars. The left second premolar showed a significant decrease in OCA whereas the one on the right side did not. The anterior teeth showed a tendency for an increase in OCA, and the left canine showed a significant change.

**DISCUSSION**

As far as the authors are aware, there is only one other study on the quantitative changes in OCA due to OA therapy. Otsuka et al., using the same occlusal diagnostic system, found a significant decrease in total OCA after the jaw had been advanced by an OA. However, they had a relatively small sample size (n = 12) and short-term (6 months) OA use. The present study is the first quantitative assessment of the effect of long-term OA use on OCA. The results showed that 86.7% of patients underwent a significant change (>5%; P < .001) in total OCA; 44.4% of them showed changes ≥20%. The majority of total OCA changes were a decrease (66.7%; Table 2). Regional changes >5% and ≥20% were observed in more than 90% and 80% of the patients, respectively.

Qualitative changes in OCA after OA therapy have been assessed in only a few published studies., Pantin et al. reported that 14% of patients showed occlusal changes, based on their assessment of OCs using shimstock passed through the occlusion, with the patient biting in centric occlusion. Almeida et al. using articulating paper on 70 OSA patient models, showed that OCA increased in 14.3% of patients, did...
not change in 24.3%, and decreased in 61.4%. The reported 61.4% decrease in OCA is similar to the result obtained in this study. The other proportions, however, are different, probably because of differences in methodology.

In the ≥20% change group, regional changes in the molar region paralleled those in total OCA, with the exception of two patients. This suggests that changes in total OCA were caused, in general, by changes in the molar/premolar region. There was no apparent correlation between the direction of change in the molar and premolar region; half of the patients showed a change in the same direction while the other half showed changes in opposing direction.

The most likely explanation for the changes in OCA in the molar/premolar regions is that the distal cusp of the second molar had tipped mesially because of long-term OA use and led to some cuspal interference (which may be revealed by heavy contacts) and induced an open-bite tendency around the premolars and first molars. Almeida et al\(^9\) found that premolars were most commonly in an edge-to-edge or open-bite relationship after OA therapy. The increase in anterior OCA might be caused by the lingual tipping of upper incisors and the labial movement of lower incisors, as described in previous studies.\(^{11,12,26,27}\) Canines may be unique among the anterior teeth because they are located at the corner of the dental arch and are thought to be sensitive to lateral and/or anteroposterior jaw positions.\(^{28}\) Slight variations in bite could considerably influence the OCA in the canine area, and a lateral open-bite may be attributed to canine contacts.

Our data also showed some considerable difference between the right and left sides, especially in the change in OCA on second premolars and canines. It was found that malpositioned second premolars of the left dentition (e.g., rotational tooth, cross-bite, edge-to-edge bite) before treatment were, in most cases, associated with large right/left differences. Some large right/left-differences were presented with a Class II canine relationship on the left side. Consequently, in the follow-up study models, a larger contact was observed between teeth 23 and 33–34 than on the other side, as the mandibular dentition drifted forward.

Articulating paper under extraoral conditions was also used to evaluate OCs.\(^{29–31}\) Articulating paper is preferred primarily for detecting OCs because of low cost and ease of application.\(^{29}\) However, it should only be used for qualitative analysis to establish the location and number of contacts. Moreover, detecting OCs according to the darkness of the marks is quite subjective. Carossa et al\(^{29}\) using an articulator-mounted cast and recording strips, concluded that the assessment of OCs was significantly influenced by paper thickness, operator experience, bite force, and time. Saracoglu et al\(^{30}\) used acrylic resin casts mounted in an articulator and a universal testing machine to compare occlusal indicator reliability with an in vivo measurement. They recommended that the recording materials be used carefully in the mouth and that teeth be dry during occlusal analysis. The system used in this study, the computerized scanning of exposed PSSs, enables an objective, accurate evaluation of occlusal relationships and quantitative evaluation of OCA, with more reliability and reproducibility.

This study determined OCA before and after OA
therapy using mounted casts in an articulator. A significant advantage of study model analysis is that the presence of patients is not required and the measurement can be done outside the clinic. Although useful data can be obtained from models, there are also limitations. It is considered that possible problems of inaccuracy in the transfer of maxillo-mandibular relationships from the mouth to an articulator were negligible because a single operator performed all the mountings.

With respect to the load, it is known that bite force influences the number of tooth contacts, prompting an evaluation of near contacts. The mean bite force in patients with OSA after OA therapy had been shown to be around 400 N, the load selected for this study. Therefore, it is considered that most of the relevant OCs were identified and recorded. Moreover, 400 N did not damage the models, which was an important consideration. The current approach enabled the identification and quantification of changes in OCA recorded on study models.

Finally, one must address the question of whether the changes in OCA warrant advising OSA patients to stop wearing OAs. This side effect in a potentially life threatening disease appears to be relatively minor. Current clinical practice involves identifying such changes and educating patients about potential benefits/side effects before considering any change in therapy.

CONCLUSIONS

- The results support the hypothesis that long-term OA therapy results in a dramatic change in OCA. A significant decrease in OCA was identified in most of the patients. To confirm these findings, OCA measured on patients after long-term OA use should be undertaken.
- Long-term careful monitoring of the change in occlusion due to OAs is recommended.

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REFERENCES


