Effects of tongue movements on lingual sulcus depth while border molding in mandibular complete dentures

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ABSTRACT

Background: In general, people speak and swallow frequently in their daily lives rather than making exaggerated tongue movements.

Aim: The aim was to compare the effect of tongue movements on lingual sulcus depth, during the border molding process of impression making of mandibular complete dentures.

Settings and Design: In total, 32 double master impressions were made. One of these pairs was obtained by allowing the patient to swallow and the other by enabling the tongue to make excessive movements.

Materials and Methods: Measurements were taken from different regions of the lingual sulcus by determining the length of the parallel lines drawn from fixed points marked on the residual ridge crest to the deepest point of the alveolingual sulcus. These measurements were performed using a RMI three-dimensional measurement system.

Statistical Analysis Used: Data were compared using the paired t-test (alpha = 0.05).

Results and Conclusion: The high value found in casts with border molding, while swallowing was statistically significant in vertical and horizontal directions of the anterior lingual sulcus region (<0.001), vertical direction of the middle lingual sulcus region (MLSR) (<0.05) and horizontal direction of the retromylohyoid and MLSR (<0.05). According to the paired t-test, the mean differences between the 32 casts were statistically significant (<0.001). Within the limitations of this study, the swallowing in the vertical and horizontal directions provided higher values compared to the excessive movement of the tongue.

Key words: Border molding, lingual sulcus, mandibular complete dentures, swallowing, tongue

There are some literatures available on the effects of the tongue, muscles and other adjacent tissues on the retention and stability of the mandibular complete dentures. Many impression making procedures were defined in association with difficult complete lower dentures. The dentist must know all the oral and facial anatomy that is associated with impression making and also why and when these structures function and how they relate to various parts of the impression.

The construction of well-arranged mandibular complete denture is commonly more difficult than that of the maxillary one. The mandibular denture is more likely to be displaced during tongue and muscle movement than that of the maxillary one. The contour of the mandibular denture should be in a state where there is minimal interference with the denture related to soft tissues during functional movements. Furthermore, mechanical and anatomic factors and neuromuscular control also have some effects on retention and stability of the complete dentures.

The primary aim of the final impressions is to record accurately all available tissues of the denture foundation area. Without recording the functional width and depth of the lingual sulcus, a stable and retentive denture cannot be constructed. It is not appropriate to extend the denture border at random. The denture border should be appropriately extended in areas where possible and the border should be limited otherwise. This study is related with the evaluation of lingual sulcus depth, which constitutes regions of the tongue movement during the act of swallowing and excessive movements of the tongue.
The aim of this study was to compare the lingual sulcus depth obtained, while the patient swallows with the one obtained with excessive tongue movements.

MATERIALS AND METHODS

A total of 32 voluntary edentulous patients who had successful swallowing functions were included in the study. While selecting the patients, care was taken to include only those individuals with minimal residual ridge resorption and having no undercut area in the retromylohyoid region (RR). Thirty two double impressions were made from the participants. One of these pairs was obtained by asking the patient to do Group 1 movement while border molding [Table 1].

For the border molding of the second trays, the patient was asked to do Group 2 functions. The measurements of the obtained casts were made on four different parts of the alveolingual sulcus, at the point of the anterior lingual sulcus region (ALSR), middle lingual sulcus region (MLSR), RR and lingual frenulum (LF) region. The measurements were performed by using RMI three-dimensional measuring instrument (SAM Präzisionstechnik 80637 München taxistrasse 41, Germany) [Figure 1]. The series of the measurements were taken on the right and left sides and vertical and horizontal parts (Y- and X-axis) of residual ridge of the cast, as schematically represented in Figure 2.

Preliminary impressions were made by using perforated standard stainless steel tray (Jescoform, Aesculap AG and Co. KG Am Aesculap-Platz D-78532 Tuttlingen, Germany) with irreversible hydrocolloids (Alginoplast, Heraeus Kulzer GmbH Grü ner Weg 11, D-63450 Hanau, Germany) and poured with plaster of paris (BMT, PK 121 Sivas, Turkey). The obtained diagnostic casts were examined on the point of bone and tissue undercuts and border lines of denture. Existing undercuts were blocked out. Anticipated border extensions of the denture were carefully outlined with a pencil. Then a secondary line was drawn, which was 2 mm shorter and parallel to the previous outline. The cast was painted with thin foil substitute and left to dry. The custom tray was built by using autopolymerizing resin tray material (Trayresin Dentsply/Austenal, Trubyte Division, 570 W. College Avenue, York, PA 17405) and adjusted by grinding up to the secondary line in order to create a space for the impression compound. For each patient, two custom trays were prepared. The handles of the custom tray were designed in such a way as not to obstruct the closure of the mouth.

The borders of the custom trays were checked for stability, retention and muscle interferences and adjusted for each patient at chairside.[13] For carrying out border molding in one step, an adequate amount of soft green stick modeling plastic impression compound (Kerr Italia SpA, Salerno, Italy) was softened over a flame. It was also applied to the whole lingual border of the custom tray and was provided with equal thickness with finger. Following this procedure, in order to ensure a homogenous softness, the custom tray was dipped into a water bath, which contained hot water of 55°C. The patient was instructed to do Group 1 movements when the custom tray was seated in the mouth. The second group of impressions was made by asking the patient to do Group 2 movements with the tongue using the other prepared custom tray. Zinc-oxide eugenol impression material (SS White impression paste, SS White group, unit 9, Madleaze Estate, Bristol Road, Gloucester, GL1 5SG, England) was loaded into the custom tray; and the final impressions were made, while repeating each groups tongue movements. Definitive casts were obtained after boxing the
master impressions. A key substructure was prepared to ease the assembly of the definitive casts to the measurement tool [Figure 3].

In order to provide standardization for the measurements, of each cast guide points had previously been marked on the residual ridge of both pair casts, corresponding to the same points. Parallel lines were then drawn from these points to the lingual sulcus. There were 13 lines drawn on either side: Of these lines, four were in the RR, four in the ALSR, four in the MLSR and one in the LF [Figure 4]. The distance between the determined points and the lingual sulcus was measured with the RMI digital three-dimensional measurement appliance on X and Y axis. Four measurements were made for the previously determined regions, and the average of each region was recorded as one data for vertical (Y) and one for horizontal (X). For the LF, a single vertical measurement was carried out. This study was a prospective study and was continued for 3 months.

**Ethics**

This study was approved by the Respective Ethics Committee of authors’ affiliation and provides the number of the protocol approval (2013/1 - Ethics Committee of Faculty of Dentistry, Atatürk University).

**Statistical analysis**

Data were analyzed using a statistical package program, SPSS version 10.0 (SPSS Inc., Chicago, IL, USA). Paired t-test was conducted to statistically determine the differences between the mean values of each of the four regions and to compare the data obtained with Group 1 to those with Group 2 tongue movements (alpha = 0.05).

**RESULTS**

The averages of the sums obtained from the measurements on the right and left sides for each RR, MLSR and ALSR were evaluated as a single measurement. The means and standard deviations values for each group are given in Table 2. Data were compared using the paired t-test [Table 3].

According to the paired t-test, the border moldings obtained by Group 1 tongue movements yielded higher results than the ones made by Group 2 movements in the vertical direction of the RR. The results for RR were high, but statistically insignificant. The border moldings obtained for the RR by Group 1 gave significantly higher values than those made with Group 2 movements in the horizontal direction (<0.001). In the MLSR, the depths obtained with Group 1 were higher both horizontally (<0.001) and vertically (<0.05) than those done with Group 2 movements. On the other hand, in the ALSR, the measurements of the lingual sulcus depths obtained with Group 1 on the casts were horizontally and vertically higher than those done with Group 2 movements (<0.001). High values were also obtained in the LF during measurements in Group 1 than

<table>
<thead>
<tr>
<th>Pair</th>
<th>Measurement region and tongue movement group</th>
<th>Mean (SD)</th>
<th>n</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LF Group 1</td>
<td>6.5791 (2.1046)</td>
<td>32</td>
<td>0.3720</td>
</tr>
<tr>
<td></td>
<td>LF Group 2</td>
<td>5.4866 (1.9752)</td>
<td>32</td>
<td>0.3492</td>
</tr>
<tr>
<td>2</td>
<td>RR Group 1 vertical</td>
<td>16.3370 (2.7597)</td>
<td>32</td>
<td>0.4879</td>
</tr>
<tr>
<td></td>
<td>RR Group 2 vertical</td>
<td>15.8648 (3.1149)</td>
<td>32</td>
<td>0.5506</td>
</tr>
<tr>
<td>3</td>
<td>MLSR Group 1 vertical</td>
<td>10.6775 (2.2815)</td>
<td>32</td>
<td>0.4033</td>
</tr>
<tr>
<td></td>
<td>MLSR Group 2 vertical</td>
<td>9.9823 (2.4472)</td>
<td>32</td>
<td>0.4326</td>
</tr>
<tr>
<td>4</td>
<td>ALSR Group 1 vertical</td>
<td>8.6194 (2.1149)</td>
<td>32</td>
<td>0.3739</td>
</tr>
<tr>
<td></td>
<td>ALSR Group 2 vertical</td>
<td>7.3753 (2.0406)</td>
<td>32</td>
<td>0.3607</td>
</tr>
<tr>
<td>5</td>
<td>RR Group 1 horizontal</td>
<td>7.6814 (1.3304)</td>
<td>32</td>
<td>0.2352</td>
</tr>
<tr>
<td></td>
<td>RR Group 2 horizontal</td>
<td>6.8155 (1.2292)</td>
<td>32</td>
<td>0.2173</td>
</tr>
<tr>
<td>6</td>
<td>MLSR Group 1 horizontal</td>
<td>6.8972 (1.2758)</td>
<td>32</td>
<td>0.2255</td>
</tr>
<tr>
<td></td>
<td>MLSR Group 2 horizontal</td>
<td>6.4041 (1.2063)</td>
<td>32</td>
<td>0.2132</td>
</tr>
<tr>
<td>7</td>
<td>ALSR Group 1 horizontal</td>
<td>4.1805 (1.0840)</td>
<td>32</td>
<td>0.1916</td>
</tr>
<tr>
<td></td>
<td>ALSR Group 2 horizontal</td>
<td>3.8619 (1.0699)</td>
<td>32</td>
<td>0.1891</td>
</tr>
</tbody>
</table>

**Figure 3:** The key substructure prepared so that the casts could be attached to the measurement tool readily and in a standard fashion

**Figure 4:** The lines drawn to determine the distance between the preestablished points on the residual ridge and lingual sulcus. Pink: Anterior lingual sulcus region blue: Middle lingual sulcus region, orange: Retromylohyoid region

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those with Group 2 movements (<0.001). The paired t-test showed that the mean differences between the 32 casts were statistically significant (<0.001). The measurements of the master cast obtained with Group 1 were higher than those done with Group 2 movements. The mean differences were as follows: In the vertical direction, 0.5 mm higher in RR, 0.7 mm higher in MLSR, 1.25 mm higher in ALSR and 1.1 mm higher in LF region, and in the horizontal direction, 0.9 mm higher in RR, 0.5 mm higher in MLSR and 0.3 mm higher in ALSR [Figures 5 and 6].

**DISCUSSION**

In the selection of patients in this study, care was taken to include cases without severe bone resorption. This enabled an accurate determination of the denture border on the cast. Furthermore; patients, who have excessive bone and tissue undercuts, especially at RR, were not included in this study due to the fact that the RMI digital measurement tool was incapable of making sufficient and effective measurements in this area. Care was also taken to ensure that patients whose impressions were made had no swallowing problems. In order for patients to fulfill the required instructions properly such as physiological and extreme tongue movements, they were instructed to do exercises to confirm standardization between the impressions before making final impressions.

One of the drawbacks of this study may be related with the selection of the participants. The patient material in this study was limited to those individuals with minimal residual ridge resorption. On the other hand, severely resorbed cases are also likely to be encountered in clinical practice. This study can further be supported by researches that focus on clinical follow-ups of dentures designed using different tongue movements.

The only standardization in terms of patient selection was done with regard to swallowing and only those individuals were included who were able to swallow successfully with the impression tray placed in the mouth. However, these functions may exhibit individual differences. Even though, a relatively high number of patients were included to overcome these variables, it is practically impossible to make a definite standardization in terms of these functions. Nevertheless, the patients were instructed to practice these functions as much as they can until it was ensured that they would accomplish them without experiencing any difficulty.

Most of the literature describes a functional impression procedure for the severely atrophic mandible. Defranco and Sallustio[10] described a procedure that will provide the patient with a denture that functions with maximum support and stability. Borders are developed with the utmost extension and can be considered a physiologic overextension. Swallowing is a functional movement that provides physiologic overextension. As demonstrated in this article, a long and favorable amount of residual ridge was obtained with swallowing, especially in the LF and ALSR as addressed in this study.

**Table 3: Results of the paired t-test**

<table>
<thead>
<tr>
<th>Measurement region and tongue movement group</th>
<th>Paired differences</th>
<th>t</th>
<th>P (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF Group 1</td>
<td>1.0925 (.9127)*</td>
<td>6.771</td>
<td>0.000</td>
</tr>
<tr>
<td>LF Group 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR Group 1</td>
<td>0.4722 (1.3531)*</td>
<td>1.974</td>
<td>0.057</td>
</tr>
<tr>
<td>RR Group 2 vertical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MLSR Group 1</td>
<td>0.6952 (1.2512)*</td>
<td>3.143</td>
<td>0.004</td>
</tr>
<tr>
<td>MLSR Group 2 vertical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALSR Group 1</td>
<td>1.2441 (1.0843)*</td>
<td>6.490</td>
<td>0.000</td>
</tr>
<tr>
<td>ALSR Group 2 vertical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR Group 1</td>
<td>0.8759 (0.8381)*</td>
<td>5.912</td>
<td>0.000</td>
</tr>
<tr>
<td>RR Group 2 horizontal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MLSR Group 1</td>
<td>0.4931 (0.4830)*</td>
<td>5.775</td>
<td>0.000</td>
</tr>
<tr>
<td>MLSR Group 2 horizontal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALSR Group 1</td>
<td>0.3186 (0.4606)*</td>
<td>3.913</td>
<td>0.000</td>
</tr>
<tr>
<td>ALSR Group 2 horizontal</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*P<0.001, †P<0.05. LF=Lingual frenulum, RR=Retromylohyoid region, MLSR=Middle lingual sulcus region, ALSR=Anterior lingual sulcus region, SD=Standard deviation
Tongue movement effects on lingual sulcus depth

Denizoğlu, et al.

The use of undercut areas for retention has disadvantages. The insertion and removal procedures damage the mucosa resulting in tissue atrophy. The excessive retention also allows the patient to function in masticatory acts such as biting apples and corn on the cob or chewing sticky foods. These acts are potentially damaging to the supporting tissues. Anteroposterior extensions in the anterior lingual sulcus in selected situations have been used successfully.[20] In this study, when the patient was instructed to swallow, the widest border was obtained, especially in the anterior lingual area and LF. Clinically speaking; this may be advantageous in increasing the retentive quality of the mandibular denture.

As for the anatomic formation, known as retromylohyoid curtain, which defines the limits of the distal extension of the denture, Neil described this important area and noted that the denture could have three possible lengths, depending on the tonicity, activity and anatomic attachments of the adjacent structures.[14] In swallowing, the hyoid is described as tracing a path first upward, then forward, then returning to the starting position. Studies on hyoid motion indicate that it is an important component of the swallowing mechanism, with a role in the control of tongue movement.[21] This motion of the hyoid is provided by the contraction of geniohyoid and anterior digastric muscles. This constitutes part of the intra-oral phase of the swallowing process during which the oral cavity gets narrower.[22] This narrowing is especially pronounced in the RR which is in relation with especially the mandibular denture. For minimizing denture impingements in this area, transferring this movement to the master cast while final impression making may be beneficial. In this study, the horizontal difference found between the two groups shows that the influence of intra-oral narrowing due to swallowing on the RR may diminish during impression making. Since the shape of the retromylohyoid area may vary according to the patient, this process should be completed taking individual differences into consideration.

The middle lingual vestibule is the largest area and is influenced mainly by the mylohyoid muscle and somewhat by the sublingual glands. The mylohyoid muscles’ principal function occurs during the act of swallowing; however, at the maximum contraction, the fibers are still in a downward and forward direction so that a denture can be extended below the muscle attachment along the mylohyoid ridge.[14] Sublingual glands lie on the mylohyoid muscle.

There is a wrong convention about the middle mylohyoid vestibule that the movement of the mylohyoid muscle being contracted elevates the sublingual glands and restricts the lingual vestibule in an ostensible way. This convention has influenced the dentist to the extent of believing that lingual flanges should have minimal extensions. It can be demonstrated in most cases that unstable mandibular dentures have borders, which are too short and too thin and that peripheral seal is not present.[14]

In this study, horizontal extensions were found to be wider in the impressions made with swallowing. Edge thicknesses can be obtained more appropriately in mandibular complete dentures made in this way.

As described by Bocage and Lehrhaupt,[2] the extension of a mandibular denture, resting upon the prominence of the sublingual gland and protruding toward the root of the tongue and consisting of a lower surface, an upper surface and an internal edge, is subjected to stresses from the adjacent muscles. The horizontal extension of the lingual flange that is defined as the lower surface is affected by any rising movement on the floor of the mouth, such as when opens the mouth, swallowing or rising or protruding the tongue. The border of the horizontal extension is functionally affected when the patient thrusts his/her tongue laterally into the cheek and forward. This determines the border dimension of the horizontal extension of the lingual flange. In other words, the suggested sublingual horizontal extension is placed in a biologically acceptable fashion by increasing the area of the denture, which enhances retention and stability. However, the mandibular denture will not be lifted up even if the sublingual gland is raised; this is due to the maxillary and mandibular teeth being in contact while swallowing. The mucosa position of the floor of the mouth may be recorded as higher through impression making by moving the tongue excessively. However, the lingual flange extension decreases, and a space is created between the denture border and the mucosa of the floor of the mouth whilst the mylohyoid muscle is at rest, leading to impairment of the peripheral seal.[19] As reported in this study, the impressions should be made with swallowing so that the acceptable horizontal lingual flange design of denture can be obtained.

This in vivo study shows that allowing patients to make excessive movements with their tongues during the impression making of the mandibular complete denture may lead to short lingual flange. If the aim is to have a long lingual flange in complete mandibular dentures with poor retention, it is advisable to allow patients to swallow during the border molding process so that their lingual sulcus grows deeper.

CONCLUSION

This study intended to evaluate the lingual sulcus depths of the pair casts obtained with swallowing and excessive movements of the tongue. Within the limitations of this study, it can be concluded that lingual sulcus depth, which is very important in the mandibular complete dentures where retention problems are commonly seen, is vertically and horizontally higher in the casts obtained with swallowing than those with excessive movements.
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REFERENCES