In Vitro Effect of Vent Size and Spacer Thickness on Pressure Produced during Maxillary Edentulous Impression Making by Different Impression Materials


1 Resident, Department of Prosthodontics, School of Dentistry, Yazd University of Medical Sciences, Yazd, Iran
2 Associate Professor, Department of Prosthodontics, School of Dentistry, Yazd University of Medical Sciences, Yazd, Iran
3 Prosthodontist, Private Office, Tehran, Iran
4 Dentist, Private Office, Kerman, Iran

Abstract

**Background and Aim:** Inappropriate transfer of pressure during final impression making in fabrication of complete denture can result in ridge resorption. This study aimed to assess the effect of vent size and spacer thickness on pressure produced during maxillary edentulous impression making by different impression materials in vitro.

**Materials and Methods:** This experimental study was carried out using a maxillary edentulous model, two types of impression materials (regular body addition silicone and zinc oxide eugenol) and two types of trays with spacer thicknesses of 0 and 1.5 mm and each thickness with four vent sizes of 0, 0.5, 1 and 2 mm. Totally eight types of trays for each impression material (80 samples) were used. Impressions were made and transferred pressure in the first molar area of edentulous ridge and mid-palatal raphe was measured (g/mm²) by two load cells. Data were analyzed using two-way ANOVA, post hoc Tukey’s test and t-test.

**Results:** As the vent size or thickness of spacer increased, the mean pressure on maxillary edentulous ridge decreased from 59.0±2.22 to 36.8±2.50 and 98.5±5.85 to 42.8±2.11 g/mm² in ridge area and 35.0±1.66 to 19.4±1.74 and 52.1±3.80 to 22.3±1.25 g/mm² in mid-palatal raphe for regular body addition silicone and zinc oxide eugenol, respectively. Comparison between groups indicated that there were significant differences in the magnitude of pressure in use of the two materials and areas with different vent sizes and thicknesses of spacer (P< 0.001).

**Conclusion:** Impression pressure changes significantly by change in tray design or impression material. For making impressions of an edentulous maxilla, using a tray with a 1.0 mm or larger venthole or 1.5 mm spacer thickness is recommended.

**Key Words:** Dental Impression Materials, Dental Impression Technique, Dentures, Maxilla

Introduction

Alveolar ridge mucosa in edentulous patients has variable thickness and mobility in different areas, and may be stimulated during impression making [1]. One concern in dental rehabilitation of edentulous patients is recording of mucosal tissue with an impression technique causing minimal tissue distortion and an impression material with...
optimal flow to obtain favorable retention and stability of denture. Consistency of impression material affects the pressure applied to the mucosal tissue beneath denture base [2]. Differences in properties of impression materials enable the use of different methods to obtain the best results. Selection of impression material by clinician must be based on oral status, function of tissue and operator’s skills [3]. Muco static impression techniques record tissues with minimal distortion while muco compressive impression techniques record tissues in function. Minimal pressure technique applies slight pressure and ranks between the two afore-mentioned techniques. To decrease tissue distortion, new techniques such as selective pressure impression technique have been suggested to adjust the applied pressure based on the shape and anatomy of the underlying tissue. In this technique, pressure is selectively applied to the residual ridge based on the mobility of the supporting, stress bearing tissues [4-11]. This technique is highly accepted by clinicians and patients [12]. Due to morphological differences between the hard and soft tissues, pressures applied on oral mucosa must be controlled. Cortical bone can receive functional loads while the residual alveolar ridge is susceptible to resorption and cannot tolerate such loads. Similarly, keratinized, firm masticatory mucosa can resist functional and normal loads while non-keratinized alveolar mucosa and submucosa with slight thickness cannot tolerate such loads. Areas such as incisive papilla and mid-palatal raphe have low stress bearing ability and loads applied to them must be minimal to minimize trauma. Adequate distribution of functional loads in these areas prevents subsequent problems in mucosa beneath the denture base (such as pain and inflammation) and consequent bone loss [3,13].

Several designs of custom trays have been suggested to control for the pressure applied to residual ridge in final impression making based on changing the relief space and vent hole size. Komiyama et al. [3] suggested an escape hole measuring 1mm or spacer with a thickness equal to that of baseplate wax to relieve pressure [3]. Marsi et al. [13] assessed changes in special tray in application of different loads by use of different impression materials and showed that the effect of tray design was less important than the type of impression material. Reddy et al. [14] measured the pressure applied on the maxillary alveolar ridge by different impression materials and tray designs and reported that use of a tray with spacer was effective for decreasing this pressure but no significant difference was noted in use of different impression materials. Al-Ahmad et al. [15] measured the pressure applied to different areas during impression making of edentulous mandible using an analog simulator. Nishigawa et al. [16] recorded visual observations of flow and speed of escape of elastomeric impression materials when seating special trays and their association with escape hole size and relief space width. Chopra et al. [17] measured the pressure applied during impression making using minimal pressure and selective pressure techniques and stated that changing the tray design was an important factor to change the pressure produced during impression making [17].

Considering the significance of loads applied to the mucosa in edentulous maxilla during impression making and controversial results reported in use of different sizes of vent and spacer thicknesses as well as use of different impression materials [13-15], this study aimed to evaluate the effect of vent size and spacer thickness on pressure applied to edentulous maxillary mucosa during impression making with regular body addition silicon impression material and zinc oxide eugenol in.

Materials and Methods
In this in vitro, experimental study, regular body addition silicon impression material (President; Coltene, Altstatten, Germany), zinc oxide eugenol impression material (Duralite; Golchait, Tehran, Iran) and an edentulous model of the maxilla (Nissan Dental, Beijing, China) were used. Two load cells [2X PX40 PC board-mountable pressure transducers sensors (AEG, Hamburg, Germany) with cord conventional balance and board and elastic pad board screen] were placed beneath an aluminum plate and edentulous mold was placed on this plate. Pressure produced during impression making was measured by two bars with 1mm cross-section placed at the mid-palatal raphe and right first molar site of the edentulous ridge of the
model, which were attached to the sensors. Two trays were fabricated with different spacer thicknesses of no spacer (0mm thickness) and wax sheet with 1.5 mm thickness. Four sizes of vent holes were created at the mid-palatal raphe and incisive-papilla areas: no hole (0mm) and holes with 0.5, 1 and 2mm diameters. Eighty trays in eight groups of 10 were fabricated of each impression material (a total of 160 trays) as follows:

Group 1. Tray without vent and spacer
Group 2. Tray without spacer but with a vent with 0.5mm diameter
Group 3. Tray without spacer but with a vent with 1mm diameter
Group 4. Tray without spacer but with a vent with 2mm diameter
Group 5. Tray with a spacer with 1.5mm thickness without a vent
Group 6. Tray with a spacer with 1.5mm thickness and a vent with 0.5mm diameter
Group 7. Tray with a spacer with 1.5mm thickness and a vent with 1mm diameter
Group 8. Tray with a spacer with 1.5mm thickness and a vent with 2mm diameter

All trays were fabricated using prefabricated sheets of light-polymerized resin (Light Cure Custom Tray Material; Megatray, NY, USA) with 3mm thickness on edentulous maxillary model and three handles were incorporated in the rays for load application at the site of molars and canine-canine distance. Edentulous maxillary model and resin were placed in light curing unit for three minutes according to the manufacturer. Then, the tray was removed from the cast. In spacer group, wax was removed and trays were placed again in light curing unit and cured. Impressions were then made according to the manufacturer’s instructions. A small square-shaped aluminum sheet measuring 5x5 cm was placed over the tray handles (it was very light so its weight was disregarded). A 0.5kg [4] weight was glued to the aluminum sheet and in each impression making, it was placed in the same location over the handles (Figures 1-3). The data obtained from the load cells were displayed on a monitor and the values were recorded in g/mm².

Data were analyzed using two-way ANOVA and Tukey’s post hoc test. The effect of type of impression material, site of load application and spacer on produced pressure was analyzed using t-test.

Figure 1. Edentulous maxillary model, tray and sensors placed in point R (molar site in right side of the edentulous maxilla) and point P (mid-palatal raphe area)

Figure 2. Mountable pressure transducer

Results
Tables 1 and 2 show the mean pressure applied on mucosa of the edentulous maxillary ridge in the first molar site and mid-palatal raphe during impression making with President and Duralite in use of different spacer thicknesses and vent sizes. Two-way ANOVA showed that this difference was
Table 1. Mean pressure (g/mm²) produced at the first molar site during impression making with President and Duralite in use of different spacer thicknesses and vent sizes (n=40)

<table>
<thead>
<tr>
<th>Spacer thickness</th>
<th>Vent diameter</th>
<th>Pressure (g/mm²)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>President</td>
<td>Duralite</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>59.0 ± 2.22</td>
<td>98.5 ± 5.85</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>58.9 ± 0.46</td>
<td>82.8 ± 3.84</td>
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<tr>
<td></td>
<td>1</td>
<td>45.4 ± 1.74</td>
<td>62.7 ± 3.08</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>38.8 ± 1.75</td>
<td>51.6 ± 4.46</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>56.1 ± 2.35</td>
<td>70.2 ± 2.01</td>
</tr>
<tr>
<td>1.5</td>
<td>0.5</td>
<td>54.8 ± 1.54</td>
<td>65.2 ± 3.54</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>43.8 ± 2.76</td>
<td>50.2 ± 2.44</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>36.8 ± 2.50</td>
<td>42.8 ± 2.11</td>
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</tbody>
</table>

Table 2. Mean pressure (g/mm²) produced at the mid-palate during impression making with President and Duralite in use of different spacer thicknesses and vent sizes (n=40)

<table>
<thead>
<tr>
<th>Spacer thickness</th>
<th>Vent diameter</th>
<th>Pressure (g/mm²)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>President</td>
<td>Duralite</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>35.0 ± 1.66</td>
<td>52.1 ± 3.80</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>33.7 ± 3.39</td>
<td>50.6 ± 2.70</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>25.1 ± 3.37</td>
<td>37.3 ± 3.47</td>
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<tr>
<td></td>
<td>2</td>
<td>21.3 ± 3.96</td>
<td>26.4 ± 2.38</td>
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<tr>
<td></td>
<td>0</td>
<td>25.3 ± 0.99</td>
<td>45.2 ± 2.53</td>
</tr>
<tr>
<td>1.5</td>
<td>0.5</td>
<td>24.9 ± 1.62</td>
<td>40.7 ± 2.12</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>23.3 ± 2.40</td>
<td>29.8 ± 1.92</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>19.4 ± 1.74</td>
<td>22.3 ± 1.25</td>
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statistically significant (P<0.001) and by an increase in vent size and spacer thickness, the pressure produced at the interface of edentulous model and impression material decreased at both sites (first molar and mid-palate). Since the interaction effect was significant, post-hoc t-test was applied, which showed significant differences between and within groups. T-test for assessment of the effect of type of impression material on produced pressure showed a significant difference in produced pressure between the use of President and Duralite impression materials (P<0.01), and President impression material applied less pressure to the surface of edentulous model. The mean pressure produced at the ridge and mid-palate in use of different vent sizes and spacer thicknesses with President and Duralite is shown in Diagram 1 and 2. T-test showed that the difference in pressure applied to ridge and mid-palate was significant (P<0.01), and the pressure applied to the first molar site was higher than that applied to the mid-palatal raphe during impression making. In assessment of the effect of spacer thickness, t-test showed that in absence of spacer, pressure was significantly different from that in presence of spacer (P<0.001). In other words, irrespective of presence of vent (constant variable), by increasing the spacer thickness from 0 to 1.5mm, the mean pressure produced at the interface of impression material and model decreased in use of both impression materials. Diagram 3 indicates the effect of spacer and site of load application on pressure produced during impression making.

Diagram 1. Mean pressure (g/mm²) produced at the first molar site during impression making with President and Duralite in use of different spacer thicknesses and vent sizes

Diagram 2. Mean pressure (g/mm²) produced at the mid-palate during impression making with President and Duralite in use of different spacer thicknesses and vent sizes
Discussion
Adequate retention and support of complete denture, optimal esthetics and preservation of alveolar ridge can only be achieved by comprehensive knowledge about the anatomy and histology of oral tissues as well as impression techniques and materials to precisely record the tissues with minimal distortion [18]. Studies have emphasized on the significance of type and consistency of impression materials and tray design and their effect on loads transferred to the edentulous mucosa during impression making [2,14,17]. The significance of vent in impression tray for leak out of material and reliving pressure on the mucosa has been documented [3,16]. Spacer also provides a space for impression material and prevents excessive pressure on the supporting tissue [14,19]. Our study showed that following placement of tray containing impression material on the model, pressure gradually increased until reached its peak and then decreased to reach a plateau. On the other hand, our study showed that as the diameter of vent and thickness of spacer increased, pressure applied to tissues decreased and a significant difference was noted in this regard between trays with and without vent and spacer. On the other hand, maximum pressure is applied to tissues when no spacer or vent has been incorporated in the tray. Reduction in pressure had a direct relationship with increasing the size of vent and diameter of spacer.
Reddy et al. [14] measured the pressure applied to the residual maxillary alveolar ridge during impression making of five edentulous ridges by zinc oxide eugenol and light-body poly vinyl siloxane with two different tray designs (with and without spacer) in the clinical setting. They reported that use of spacer with modeling wax thickness was effective for pressure reduction during impression making and stated that the pressure applied to the palate was significantly higher than that applied to the edentulous ridge crest; this indicated the need for creation of vent hole in these areas. Our study had a larger sample size and evaluated the effect of different spacer thicknesses as well as vent sizes on pressure applied to the edentulous maxilla during impression making and showed that pressure applied to the mid-palatal raphe was less than that applied to the ridge due to incorporation of vent in this area.
Chopra et al. [17] measured the pressure applied to edentulous analog using zinc oxide eugenol and light-body addition silicon in minimal pressure and selective pressure techniques and found the same results as ours; although we compared regular body addition silicon and zinc oxide eugenol.
Komiyama et al. [3] used miniature pressure sensor to assess the effect of vent size and spacer.
thickness on pressure produced during impression making with silicon impression material. In our study, the effect of type of impression material was also evaluated in addition to the above-mentioned factors and their measurement system was simulated [3]. Al Ahmad et al. [15] measured the pressure applied to the edentulous mandible by four different impression materials and use of four types of trays (no relief space with and without holes and relief space with and without holes) using Setac universal testing machine and showed that pressure in use of poly vinyl siloxane with regular consistency was significantly higher than that in use of its light consistency and stated that presence of holes and relief space was significantly effective in reducing pressure in use of regular body impression material. Our study further assessed the effect of vent size and spacer thickness on pressure applied to mucosa in impression making with regular-body silicon material. Nishigawa et al. [16] witnessed the flow of elastomeric impression materials when seating a tray and reported that escape hole and relief space affected the speed and direction of flow of impression materials. They only visually inspected these parameters and did not quantify the pressure applied to mucosal surface. Hyde et al. showed that dentures fabricated with silicon impression material are preferred by patients because they are more comfortable, have higher chewing efficacy, higher stability and less need for adjustment after delivery [2]. In contrast, Marsi et al. [13] reported that changes created in special trays had no effect on pressure produced during impression making and believed that the impression material had the greatest effect on this issue. Last but not least, it should be noted that this study had an in vitro design and although we did our best to optimally simulate edentulous maxilla for impression making, clinical studies are required on the maxilla of patients with different mucosal thicknesses and by use of different impression materials to obtain more reliable results.

Conclusion

President impression material applies less and more uniform pressure to tissues compared to Duralite in impression making. Impression material and tray design significantly affect the pressure applied to tissue during impression making, and the pressure applied to tissue was less in use of regular-body addition silicon compared to zinc oxide eugenol in our study. As the vent size and thickness of spacer increased, pressure applied to tissue at different sites decreased. To make an impression of an edentulous maxilla, a tray with a vent 1mm or larger in diameter and a spacer with 1.5mm thickness is recommended.

References