Evaluation of the rigidity of dentures made of injection-molded materials

Juro WADACHI, Masayuki SATO and Yoshimasa IGARASHI

Removable Partial Prosthodontics, Masticatory Function Rehabilitation, Division of Oral Health Sciences, Graduate School, Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo-ku, Tokyo, Japan
Corresponding author, Juro WADACHI; E-mail: juropro1@tmd.ac.jp

Dentures made of 2 different types of injection-molded thermoplastic resins (polyamide resin and polyester resin) and a denture made of conventional heat-polymerized resin were used to create an experimental model of a mandibular molar region with a two-tooth gap. In the experimental model, a force of 100 N was applied onto the mesial fossa of the first molars of the dentures, and comparisons were performed by measuring the pressure applied under the denture base and the subsidence rate of the denture. The polyamide resin denture showed the highest subsidence, exerted the highest pressure on the underlying mucosa, and showed significant differences with the other types of dentures. The findings showed that polyamide resins have the lowest degree of elasticity, and that when resins with such low elasticities are used in the denture base, they should preferably be reinforced with metals.

Keywords: Denture, Thermoplastic resins, Non-metal clasp dentures

INTRODUCTION

In recent years, injection-molded thermoplastic resins such as polycarbonate, polyamide, and polyester have been used as denture-base materials1-2). These materials have high toughness and low elasticity, and have found applications as non-metal clasp dentures, which are mainly characterized by the non-use of metal clasps3-5). Nevertheless, these materials are controversial because of various issues such as their adhesion to heat-curing resins (which are conventional base materials) and their resistance to abrasion6-11). With regard to the effect on the mucosa underlying the denture base made of polyamide resin, the difference in the force transmitted onto the denture base by the existence of a metal rest was reported, and the application of a metal rest with the non-metal clasp denture was recommended12).

Therefore, simulation models of intermediate missing teeth were created using dentures made of thermoplastic resin and conventional dentures made of polymethyl methacrylate resin. The movements of the models, as well as the load applied onto the denture base, were measured and compared between the models. The aim of this study is to examine whether dentures made of injection-molded resin have sufficient stiffness in comparison with conventional dentures.

MATERIALS AND METHODS

Materials

As shown in Table 1, two types of injection-molded thermoplastic resins [the polyamide resin (Valplast; VAL) and the polyester resin (EstheShot; PET)] were used for the manufacture of dentures in this study. In addition, dentures made of polymethyl methacrylate resin (Physio Resin; PMMA) were used as controls.

Fabrications of dentures

The dentures used in the experiments consisted of missing tooth models (E16-516; Nisshin, Kyoto, Japan); that is, with a missing left mandibular second premolar and first molar (Fig. 1). A load sensor was placed on the slope on the buccolingual side of the alveolar ridge, under a silicon membrane corresponding to the mucosa directly under the first molar. An impression was taken under this condition, and a denture was manufactured.

The design of the denture used in the experiment is shown in Fig. 2. The dentures used in this study were designed in such a way that at the site of the missing middle teeth, a metal rest was set to the tooth adjacent to the deletion; however, inside the denture base, the pedicles of the metal rest were not connected to each other. The Co-Cr alloy (Wironit®, Bego, Bremen, Germany) was used for making the metal rest. Table 2 shows heating temperature, heating time, injection pressure and the temperature of the flask. Five dentures made with each of the materials were manufactured and used for the measurements.

Method

To apply a load on the denture, the occlusal force was estimated using a universal testing machine (Autograph, Shimadzu Corporation, Kyoto, Japan); the experimental denture was set to a fixed position that allowed for the load to be applied on the mesial fossa of the first molar, and a pressure of 100 N was applied at a crosshead speed of 0.5 mm/min. The amounts of displacement upon the application of pressure and the output from the load sensor were recorded. The distance covered by the head (amount of movement of the head) from the time when...
Table 1 Materials used in this study

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Type</th>
<th>Color</th>
<th>Lot</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valplast®</td>
<td>VAL</td>
<td>Polyamide</td>
<td>Original Pink</td>
<td>70933</td>
</tr>
<tr>
<td>EstheShot</td>
<td>PET</td>
<td>Polyester</td>
<td>Live Pink</td>
<td>IJA</td>
</tr>
<tr>
<td>Physio Resin</td>
<td>PMMA</td>
<td>PMMA</td>
<td>Live Pink</td>
<td>IG</td>
</tr>
</tbody>
</table>

Fig. 1 Experimental model.
A load sensor was placed on the slope on the buccolingual side of the alveolar ridge.

Table 2 Molding conditions for thermoplastic resins

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Heat temperature (ºC)</th>
<th>Heat time (min)</th>
<th>Pressure (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAL</td>
<td>205</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>PET</td>
<td>240</td>
<td>20</td>
<td>1</td>
</tr>
</tbody>
</table>

pressure on the load sensor started to increase until the load reached 100 N was recorded as the amount of displacement resulting from the application of pressure. The output value from the load sensor was calculated by considering the value calculated from the control PMMA denture as 100%. Statistical analysis was done using Tukey’s multiple comparison test. SPSS 11.5 J (SPSS Japan, Inc., Tokyo, Japan) was used for the statistical analyses.

RESULTS

The amount of displacement was maximal with the polyamide resin and minimal with the control; significant differences were found between the control and polyamide resin, as well as between the polyester and polyamide resin (Fig. 3). The force transmitted under the denture base was minimal with the control and maximal with the polyamide resin, which has the lowest elasticity (Fig. 4). Significant differences were found between the control and polyamide resin, as well as between the polyester and polyamide resin. The results for the amount of displacement, as well as those pertaining to the pressure applied on the mucosa under the denture base, showed no significant difference between the control and polyester resin.

DISCUSSION

Several reports have shown measurement results from studies examining the amount of pressure applied on the mucous membrane under the denture base[13-15]; however, no report has shown specifically how much pressure is appropriate. In addition, the physical properties required of denture base materials are defined by the ISO standard[16], but the rationale is poorly evidenced[17-19]. Therefore, evaluations were conducted by using conventional dentures made of PMMA as the control and by comparing the pressure applied by these
dentures on the underlying mucosa with that resulting from dentures made of injection-molded resin. The dentures used in this study were designed in such a way that at the site of the missing middle teeth, a metal rest was set to the tooth adjacent to the deletion; however, inside the denture base, the pedicles of the metal rest were not connected to each other. In other words, the metal used as a material in the rest did not reinforce the denture base material, and the mesiodistal rest served as a supporting point while the load point applied the load while being bent at 3 points. As a result, although the morphological differences between the denture bases may provide some reinforcing effect, it is reasonable to think that differences in the amount of displacement of the load point, as well as differences in terms of pressure under the denture base, resulted in apparent differences in the degree of elasticity between the denture base materials. Typical values of elastic properties of resins used in this study are shown in Table 3.

Table 3 Elastic properties of thermoplastic denture base resins

<table>
<thead>
<tr>
<th></th>
<th>Modulus of elasticity (MPa)</th>
<th>Flexural strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAL</td>
<td>1.0×10^3</td>
<td>50</td>
</tr>
<tr>
<td>PET</td>
<td>2.1×10^3</td>
<td>77</td>
</tr>
<tr>
<td>PMMA</td>
<td>3.0×10^3</td>
<td>90</td>
</tr>
</tbody>
</table>

Fig. 3  The amount of displacement (*p<0.05).

Fig. 4  The force transmitted under the denture base (*p<0.05).

CONCLUSIONS

This study has shown that with the injection-molded resin used in this experiment, the denture was deformed when the denture base material had low elasticity and a heavy load was applied to the mucosa under the denture base. Therefore, when a material with a low degree of elasticity is used as a denture base, reinforcement using metal frames is needed to prevent deformations due to occlusal force.

REFERENCES