Retention Force of Complete Palate Coverage and Palate-less Dentures in vitro

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The purpose of this study was to investigate the retention force of complete palate coverage and palate-less dentures made with three polymerization systems (DS system, SR-Ivocap system, microwave polymerization system) in vitro. The retention force between each denture and a polyurethane model by intervening artificial saliva was measured using a tensile tester. In addition, discrepancies between the denture base and the stone cast were measured at several points. The retention force of complete palate coverage and palate-less dentures made with the 3 polymerization systems shows that the DS system had a greater retention force than the SR-Ivocap system and the microwave system. Moreover, the retention force of palate-less dentures was greater than that of complete dentures only in the case of the DS system. The interaction of the polymerization system and the denture type also had a statistically significant effect on the retention force. Dentures made with the DS system had smaller discrepancies compared with dentures processed with the other systems. The retention force correlated very closely with discrepancies at the denture border and the residual ridge.

Key words: Retention force, Complete palate coverage denture, Palate-less denture

INTRODUCTION

When designing a maxillary denture, complete palatal coverage has been generally extended to near the vibration line. However, this denture design is not always advantageous to denture wearers when these dentures induce gag reflexes and interfere with the perception of heat and taste. The influence of saliva viscosity, palatal form, denture design and texture of the fitting surface has been demonstrated1-4. Shannon et al.5 reported that usual coverage of palatal tissues by a maxillary complete denture exerts a significant depressant affect on parotid salivary flow as elicited with candy drops. It was also reported that a reduction in the palatal coverage positively influenced a patient’s sense of taste and an occasional gagging tendency disappeared6-8. Consequently, chewing ability, taste perception, swallowing and phonetics are significant factors that contribute to the quality of life for denture wearers. Moreover, adequate retention of maxillary dentures is important clinically.

Oral candidiasis frequently occurs in individuals with dry mouth syndrome (xerostomia) and in denture wearers9. It was also reported that a denture wearer’s susceptibility to oropharyngeal candidiasis may be due to enhanced adherence of Candida species to acrylic, reduced saliva flow under the surfaces of denture fittings, improperly fitted dentures, or poor oral hygiene10-13. Moreover, Epstein et al.14 reported that the complications of xerostomia arise due to the effect of oral secretions on microbial coloniza- tion of the oral cavity, reduction in denture retention, mucosal dehydration and atrophy, reduced clearance rates of substances from the mouth, and reduction lubrication of oral tissues. Thus the palate-less dentures will be more advantageous than conventional complete palate coverage dentures in clinical use.

The purpose of this study was to investigate the retention force of complete palate coverage and palate-less dentures made with three polymerization systems in vitro.

MATERIALS AND METHODS

Trial denture fabrication

Sixty edentulous maxillary stone casts were prepared by pouring mixtures of dental stone (Plaston L, GC Corp., Tokyo, Japan) into a negative rubber mold (H3-402U, Nissin Dental Products Inc., Kyoto, Japan). By following conventional dental procedures, plastic artificial teeth (Endure HS S30, Shofu Corp., Kyoto, Japan) were set in wax (Paraffin wax, GC Corp., Tokyo, Japan) on the stone cast to make the maxillary trial complete palate coverage and palate-less dentures. The area of palatal reduction for the palate-less denture was 7.0 cm² (Fig.1). A silicone impression material (TSE 3455T, Toshiba Silicone Corp., Tokyo, Japan) was used to make two negative molds of each trial denture15.

The original trial denture and the cast were removed from the silicone molds. A new set of artificial teeth and a new cast were placed in each mold. The cast and mold were held together while molten wax was poured through a hole in the mold. After
the wax hardened, the mold was removed leaving a new trial denture on the cast. Thirty nearly identi-
cal complete palate coverage and palate-less trial den-
tures were made in this manner. The trial dentures
were randomly divided into 3 groups (DS system,
SR-Ivocap system, and microwave system) of 10 com-
plete palate coverage and palate-less dentures. Each
group was processed by 1 of the 3 systems and each
system used its own unique formulation of acrylic
resin. The DS system and the microwave polymeri-
ization method are our original polymerization sys-
tems\textsuperscript{16-18}.

\textit{Denture fabrication}

\textbf{DS system}\textsuperscript{18}

The 20 trial dentures fabricated by this system
(Okamoto Dental Corp., Shiga, Japan) were made
into resin dentures by following the manufacturer's
directions. The system has the following five prop-
erties at the same time: (1) a reduced amount of free
water in the stone cast and gypsum mold; (2) the
resin dough (P/L=28 g/10 g) (DS resin, Okamoto
Dental Corp., Shiga, Japan) must be injected and
held under a pressure of about 3.5 MPa until the po-
lymerization is complete; (3) uses the minimum tem-
perature necessary to completely polymerize the
monomer; (4) initiate polymerization evenly and uni-
formly from the surface of the cast upward so the
resin in the sprue is the last to harden; and (5) im-
mediately initiate polymerization after the resin
dough is injected into the mold space.

\textit{SR-Ivocap system}\textsuperscript{19-21}

The 20 trial dentures made by this system were made
into resin dentures by following the manufacturer's
introductions precisely. A capsule that contained the
recommended Ivocap resin (Ivoclar North America,
Inc., Amherst, N.Y., USA) was used and the ratio
was 20 g of powder to 30 ml of liquid.

\textit{Microwave polymerization system}\textsuperscript{22-24}

Twenty trial dentures were invested in a fiber-
reinforced polyester (FRP) flask (GC, Corp., Tokyo,
Japan). Next, conventional dental laboratory pro-
cedures were followed to invest, boil-out, coat the stone
with irreversible hydrocolloid separating material,
and pack the resin. The mixture of microwaveable
resin (MC resin, GC Corp., Tokyo, Japan) was pro-
portioned at 2.5 polymer: 1 monomer by weight
(P/L=25 g/10 g). After the resin was packed, the
flask was placed on its base on the revolving table in a
microwave oven (RE-22, Sharp Corp., Osaka,
Japan) and irradiated for 1.5 min at 500 W. The
flask was then placed on its top and irradiated for
another 1.5 min. The flask was then allowed to cool
to room temperature before recovering the cast and
denture.

\textit{Retention force measurement}

Fig. 2 shows a photograph (A) and schematic dia-

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**Fig. 1** Schematic diagram of a palate-less denture. Length of palatal border of complete (L1; broken line) and palate-less (L2; solid line) den-
tures.

**Fig. 2** Photograph (A) and schematic diagram (B) of measuring
retention force.
gram (B) of the measuring retention force. The retention force between the denture and a polyurethane model (402U, Nissin Dental Products Inc., Kyoto, Japan) by intervening with 1 ml of artificial saliva (Salivaht, Teijin Pharma Ltd., Tokyo, Japan) was measured using a tensile tester (AGS-500D, Shimazu, Kyoto, Japan) after applying a compressive load of 5 N for 1 min. Shore hardness for the polyurethane was 50. The experiments were carried out at 1, 2, 5 and 10 mm/min tensile speeds using artificial saliva of $3.89 \times 10^{-5}$ and $5.23 \times 10^{-5} \text{m}^2/\text{sec}$ viscosity from the vertical and 45° directions to the occlusal plane as shown in Fig. 2. The dentures were immersed in water at 37°C for 30 days until measurement. Statistical analyses of the retention force were accomplished by a two-way analysis of variance (ANOVA) and post hoc tests.

**Discrepancy measurement**

Each of the 30 polymerized complete palate coverage dentures was kept on its respective cast and sectioned parallel to its posterior border through the center of the mesiodistal width of the second molars (Fig. 3) after immersion in water at 37°C for 30 days. The machine used for the sectioning was a low-speed cutter (U-32, Luxo Corp., Tokyo, Japan). The discrepancy between the denture base and the stone cast was measured with a reading microscope (Measurerscope, Nikon Corp., Tokyo, Japan). The points measured were at the right and left denture borders, the crest of the residual ridge on the right and left, and the midline of the palate (Fig. 3).

**RESULTS**

Increasing the tensile speed and viscosity of artificial saliva caused an increase in the retention force (Fig. 4). Subsequent experiments were carried out at a 5 mm/min tensile speed using artificial saliva of $5.23 \times 10^{-5} \text{m}^2/\text{sec}$ viscosity.

The retention force of the complete palate coverage and palate-less dentures made with the 3 polymerization systems reveal that the DS system had a higher retention force than either the SR-Ivocap system or microwave system when loaded in the 90° and 45° directions (Table 1). Statistically significant differences were detected among the 3 systems when loaded in each direction (p<0.0001). The means of the retention force of the two types of dentures did not differ remarkably (p=0.4926). The interaction of the polymerization method and the denture type (complete palate coverage or palate-less) influenced the retention force when loaded in each direction (p<0.0001).

Discrepancies between the stone casts and denture bases made with the 3 polymerization systems, measured at the denture borders, residual ridges, and midline, show that the DS system had smaller discrepancies than either the SR-Ivocap system or microwave system (Fig. 5). The mean of the discrepancies for the DS system was 0.101 mm at the borders, 0.069 mm at the residual ridges, and 0.094 mm at the midline. Mean discrepancies at the borders, residual ridges, and midline for the Ivocap system were 0.219 mm, 0.251 mm, and 0.434 mm respectively; and were 0.240 mm, 0.241 mm, and 0.195 mm, respectively, for the microwave system. Statistically significant differences were detected among the 3 systems at each measurement location (p<0.0001).

The retention forces of the complete palate coverage dentures were inversely proportional to the discrepancies at the denture border (r=0.997) and residual ridge (r=0.992) (Fig. 6).

**DISCUSSION**

The retention force of the complete palate coverage

| Loading direction | Group                  | Mean (N)  
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<tr>
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<tbody>
<tr>
<td></td>
<td>DS system</td>
<td></td>
</tr>
<tr>
<td>90° direction</td>
<td>Complete denture</td>
<td>2.82±0.13</td>
</tr>
<tr>
<td></td>
<td>Palate-less denture</td>
<td>3.13±0.12</td>
</tr>
<tr>
<td></td>
<td>Ivocap system</td>
<td></td>
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<tr>
<td>45° direction</td>
<td>Complete denture</td>
<td>1.23±0.20</td>
</tr>
<tr>
<td></td>
<td>Palate-less denture</td>
<td>1.10±0.18</td>
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<td></td>
<td>Microwave system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complete denture</td>
<td>1.12±0.18</td>
</tr>
<tr>
<td></td>
<td>Palate-less denture</td>
<td>0.95±0.15</td>
</tr>
<tr>
<td></td>
<td>DS system</td>
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<tr>
<td>90° direction</td>
<td>Complete denture</td>
<td>2.72±0.12</td>
</tr>
<tr>
<td>45° direction</td>
<td>Palate-less denture</td>
<td>3.01±0.13</td>
</tr>
<tr>
<td></td>
<td>Ivocap system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complete denture</td>
<td>1.19±0.18</td>
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<tr>
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<td>Palate-less denture</td>
<td>1.01±0.16</td>
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<td></td>
<td>Complete denture</td>
<td>1.01±0.16</td>
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<td></td>
<td>Palate-less denture</td>
<td>0.90±0.14</td>
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and palate-less dentures made with the 3 polymerization systems showed that the DS system had a retention force of about three times greater than that of the two other systems (Table 1). In addition, the dentures fabricated with the DS system exhibited smaller discrepancies to the casts at all measurement locations than those made with the other systems (Fig. 5). These results demonstrate that the retention force of the dentures is dependent on the polymerization method. This is attributed to the differences in the mechanism of polymerization inherent in the three systems. Almost all of the conventional polymerization processes, including the SR-Lvocap and microwave system, are accomplished by heating the flask after the resin dough is packed or injected into the mold space. Therefore, polymerization is locally initiated in the resin dough at different times because the temperature of the mold and the resin dough is elevated by thermal conduction. Additionally, since a denture has a complicated shape with thin and thick sections, the conventional methods cannot always produce dentures that precisely fit the mucosal surface of the cast. On the other hand, the resin dough is injected into the mold space that is heated to 2 temperatures in the case of the DS system. Therefore, polymerization uniformly begins from the mucosal surface of the dried stone cast which is at the higher temperature of 98°C. Moreover, the polymerization shrinkage is largely compensated for by the resin dough being fed from the sprue that is the last to harden, so the DS system can always produce more precise dentures.

The retention force is inversely proportional to discrepancies at the denture border and residual ridge (Fig. 6). Discrepancies at the denture border correlate very closely with the retention force \( r=0.997 \). These data reveal that a sufficient retention force results from a superior denture border seal. Colón et al. reported that the form of the palate has a direct influence on the retention of complete palate coverage dentures and will aid in the selection of the type of posterior palatal seal needed. From our experimental results, however, it may be inferred that the seal not only at the posterior palatal area but also the denture border significantly contributes to the retention of the dentures.

The retention force of palate-less dentures was greater than that of complete dentures only in the case of the DS system (Table 1). Since the seal
around the border of the denture fabricated with the DS system is already obtained, an increase in the length of the palatal border from L1 to L2 shown in Fig. 1 will increase the retention force. Moreover, as the palate reduces, discrepancies between the stone casts and denture bases at midline tend to decrease as compared with complete palate coverage dentures. This will also result in an increase in the retention force of the palate-less dentures fabricated with the DS system. Fleysstrand et al.\(^7\) reported that the ability to withstand tilting loads was insignificantly altered by a reduction in the palatal coverage during experimental dislodgement tests. Furthermore, Akeel et al.\(^9\) reported that palate-less dentures could be as effective as dentures with complete palatal coverage. When wearing a denture, it is necessary that a uniformly strong sealing is completely obtained in order to obtain a higher retention force. The DS system is an effective method to make palate-less dentures with a high retention force. Thus we conclude that the DS system will clinically provide an effective method of constructing palate-less dentures.

REFERENCES


