ORIGINAL ARTICLES

Comparative Adaptation Accuracy of Heat Cured and Injection Molded Resin Denture Base Materials

Amani Ramadan Ali Moussa, Dalia Yehia Ibrahim Zaki, Hisham Samir El Gabry, Tamer Mahmoud Ahmed

1Department of Prosthodontic Research, Division of Oral and Dental Research, National Research Center, Giza, Egypt.
2Department of Restorative and Dental Materials Research, National Research Center, Giza, Egypt.
3Department Dental Anthropology, Institute of African Research and Studies, Cairo University, Egypt.

ABSTRACT

Background: Polymethyl methacrylate (PMMA) resin has been the most commonly used material for denture bases, despite its popularity, PMMA resin is far from ideal. Polymerization shrinkage and release of thermal stresses are the major disadvantages exhibited by the material. In an attempt to overcome dimensional in accuracies of PMMA resin, new thermoplastic resins and alternative processing techniques have been developed. Purpose: The purpose of this study was to evaluate and compare the adaption accuracy of two commercial heat cured resins and an injection molded resin. Materials and Methods: a total of 21 accurate denture bases with the same dimension were fabricated, 14 denture bases were made using conventional compression molding technique (Acrostone, WHW plastic, England and Vertex regular, Zeist, Netherlands), and 7 dentures were processed using injection molding technique (Crystal, Bredent, Germany). The adaptation accuracy was examined using universal measuring microscope. The gap between the resin base and stone cast was measured at canine region and posterior palatal area at five points at 5 points, corresponding to the right and left residual ridge crests, the midline, and the right and left marginal limits of the flanges. Results: The least total gap score measured was for Bre-Crystal followed by Vertex-regular while the highest gap score was for Acrostone group. However, there was no statistically significant difference between the Vertex-regular and Acrostone groups. Conclusion: injection moulded PMMA resin showed superior dimensional accuracy compared to conventional pressure packed PMMA resin.

Key words: Gap measurement, Heat cured resin, Injection molded resin.

Introduction

Polymethyl methacrylate (PMMA) resin has been the most commonly used material for denture bases since 1937 (Memon, 2001 and Yunus et al., 2005). Several studies have reported the desirable properties of PMMA resin, such as biocompatibility, excellent esthetics, insolubility in oral fluids, simple processing technique, and reasonable cost (Anusavive, 1991; Craig, 2002 and Pires-de-Souza et al., 2009).

Despite its popularity, PMMA resin is far from ideal (Darbar et al., 1992 and Dhiman et al., 2009). Polymerization shrinkage and release of thermal stresses are the major disadvantages exhibited by the material (Anusavice, 2003). Such changes are unavoidable during processing of the resin (Chung-Jae Lee, 2010). The accurate fit of denture base is a principle criterion in the physical mechanisms of complete denture retention (Anthony & Peyton, 1962 and Darvell & Clark, 2000). Nevertheless, the combination of polymerization shrinkage and distortion due to thermal stresses affects the adaptation accuracy of denture base to underlying tissue and creating a microgap (Garfunke, 1983; Baemmert et al., 1990 and Jackson et al., 1993).

For a long time, PMMA resin was polymerized using compression molding technique by heating the molded resin in temperature controlled water bath (Takamata & Setcos, 1989 and Phoenix, 2004). In an attempt to overcome dimensional in accuracies of PMMA resin new thermoplastic resins (Memon, 2001 and Parvizi et al., 2004) and alternative processing techniques have been developed (Takamata & Setcos, 1989, Keenan et al., 2003 and Ono et al., 2004). Of these techniques is the injection molding technique; in which the polymerization shrinkage is compensated by continuously injecting resin at certain pressure through a carefully controlled procedure (Young, 2010). Several studies have revealed that injection molding techniques result in fewer dimensional inaccuracies and more accurate denture base than conventional processing techniques (Nogueira et al., 1999; Parvizi et al., 2004 and Ganzarolli et al., 2007)
The purpose of this study therefore was to evaluate and compare the adaptation accuracy of two commercial heat cured resins and injection molded resin.

Materials and Methods

Preparation of denture base samples:

Accurate denture bases with the same dimension were fabricated from twenty one master casts. These casts were made from a silicone negative replica (Dupliflex, Proctechno, Spain, batch no. 503- M1T1). Compression molding heat cured denture bases (Acrostone, WHW plastic, England Packed by Anglo Egyptian Lab and Vertex regular, Zeist, Netherlands) were polymerized according to each manufacturer instruction.

Injection molding denture bases were cured using thermopress 400 injection molding unit at temperature 260 °C and at pressure 5 bar for 26 minutes (Bre-Crystal 2nded, pink stippled, Bredent, Germany). After polymerization, the curing flasks were bench cooled to room temperature. Then, they were polished on their casts with a wet rag wheel and pumice. For injection molded bases, spruces and small flashes were removed carefully and the denture bases were also polished on their casts with a wet rag wheel and pumice.

<table>
<thead>
<tr>
<th>Denture resin</th>
<th>Processing type</th>
<th>Polymerization Procedure</th>
<th>Powder/Liquid Ratio-</th>
<th>Batch no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrostone (WHW plastic, England Packed by Anglo Egyptian Lab)</td>
<td>Heat activation fast heat</td>
<td>Pack and press curing at boiling water 100 for 20 min</td>
<td>21/6 ml</td>
<td>17236</td>
</tr>
<tr>
<td>Vertex- regular Zeist, Netherlands</td>
<td>Heat activation</td>
<td>Pack and press curing at boiling water 100 for 30 min</td>
<td>2.2g/0.95 g or 1mm</td>
<td>Pyk272p05</td>
</tr>
<tr>
<td>Bre-Crystal bredent- Germany</td>
<td>Heat activation</td>
<td>Injection-molding 260 °C for 26 min. Pressure: 5 bar</td>
<td>Single component</td>
<td>JB C240</td>
</tr>
</tbody>
</table>

All denture base-cast sets were sectioned transversely in canine region and posterior palatal area 5-mm away from the posterior end of the denture base using vertical cutting machine with diamond disk (2800/3800 revolution/min WOCO 50, JeanWirtz, GmbH & Co Kg, Germany) under water cooling.

**Fig. 1:** A. Cast-base set with transverse cut sections at: canine and posterior palatal area. B: measurement points

Measurement of adaptation accuracy:

The adaptation accuracy of the denture bases was examined using universal measuring microscope with an accuracy of 0.001mm (Universal Testing Microscope Carlzeiss(JENA) Resolution .001mm Magnification 3x). The gap between the resin base and stone cast was measured at canine region and posterior palatal area at five points, corresponding to the right and left residual ridge crests, the midline, and the right and left marginal limits of the flanges (deepest vestibule gap). The dimension (V), was determined from the mean of both vestibule gaps \( V = \frac{(V_1+V_2)}{2} \), similarly the dimension, C, was determined from the mean of both ridge crest gaps \( C = \frac{(C_1+C_2)}{2} \).

Three measurements were made at each location and the mean values were calculated. Arithmetical mean of the reference points were considered as the adaptation value for each denture base material.
Fig. 2: Gap measurement for the denture base materials under investigation (a. Acrostone, b. Vertex regular and c. Bre-Crystal).

Statistical analysis:

All statistical analyses were performed using SPSS software package (Statistical Package for Social Sciences version 16, SPSS Inc, Chicago, IL, USA). Comparisons of data were made by one-way Analysis of Variance (ANOVA) with a Tukey’s multiple comparisons test at p<0.05 level to establish significance of differences.

Results:

The Mean values and standard deviations for the maximum posterior border gap (P), crest gap (C) and vestibule gap (V) for different materials are shown in table 2, and fig (3) represents the adaptation accuracy of the three examined denture bases.

Table 2: Mean values and standard deviations for the maximum posterior border gap (P), crest gap (C) and vestibule gap (V) for different materials

<table>
<thead>
<tr>
<th>Material group</th>
<th>Section A</th>
<th>Section B</th>
<th>Total section gap</th>
<th>Total score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P</td>
<td>C</td>
<td>V</td>
<td>P</td>
</tr>
<tr>
<td>Vertex-regular</td>
<td>0.541±0.0355A</td>
<td>0.465±0.029A</td>
<td>0.177±0.0086aA</td>
<td>0.077±0.035A</td>
</tr>
<tr>
<td>Bre-Crystal</td>
<td>0.026±0.0043B</td>
<td>0.006±0.01B</td>
<td>0.0122±0.0015B</td>
<td>0.033±0.025A</td>
</tr>
<tr>
<td>Acrostone</td>
<td>0.128±0.0199°C</td>
<td>0.135±0.0436°C</td>
<td>0.375±0.0436°</td>
<td>0.174±0.136°C</td>
</tr>
<tr>
<td>F</td>
<td>1197.347</td>
<td>477.89</td>
<td>450.884</td>
<td>24.329</td>
</tr>
<tr>
<td>P</td>
<td>&lt;0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Different small letters mean statistically significant difference within group; Different capital letters mean statistically significant difference between groups at P < 0.05; **: significant difference in t-test; F: F value for Anova between groups.

The results of statistical analysis revealed significant difference between injection moulding (Bre-Crystal) and conventional heat cured technique (Vertex-regular and Acrostone) as regarding the total gap distance (P<0.05). That is the least total gap score was for Bre-Crystal followed by Vertex-regular while the highest gap score was for Acrostone group respectively. However, there was no statistically significant difference between the Vertex-regular and Acrostone (P>0.05).

For Bre-Crystal comparison of total gap between sections A and B demonstrated that there was no statistically significant difference between the two sections (P>0.05). On the other hand, the results comparison of total gap between sections A and B for Vertex-regular and Acrostone showed a statistically significant difference between the two sections for both materials (P<0.05).

Discussion:

It is widely accepted that the successful function of a complete denture is dependent upon its accuracy of fit (Greener, 1972). Dimensional inaccuracies, because of polymerization shrinkage, have been demonstrated to cause clinical instability of the resulting denture base against the denture bearing tissues (Barsoum et al., 1968). This may in turn lead to pain during function as a result of uneven loading of the denture base. Denture base adaptation depends upon a number of factors, both clinical and laboratory in nature, as well as the dimensional accuracy of the material from which it is constructed (Zissis et al., 1991).

In order to allow accurate comparison of injection moulded and conventional pressure packed acrylic denture bases, a re-useable “master” mould was produced. Similar methodology has been used previously (Huggett et al., 1992).
A number of studies have reported that dimensional changes do not occur evenly over the entire denture base (Huggett et al., 1992; Nogueira et al., 1999; Parvizi et al., 2004 and Tezvergil, 2003). Gap formation between the denture base and cast are generally attributed to polymerization shrinkage of the resin material and a tendency of cooling shrinkage toward the central area of the denture base, as well as to subsequent distortion caused by confinement of the surface topography of the alveolar ridge (Johnson & Duncanson, 1987). Therefore, different gap formation was generally observed between the central portion of the posterior border, the crest of the ridge and buccal vestibule area.

Injection moulding has been demonstrated in a number of studies to produce better denture base adaptation than the conventional denture processing technique (Parvizi et al., 2004 and Ganzarolli et al., 2007). This study investigated overall base plate adaptation accuracy denture bases produced by conventional pressure packing or injection moulding techniques.

The dimensional accuracy of the injection-molded PMMA was better than the conventional PMMA, and these results are in agreement with (Huggett et al., 1992). Comparative studies have demonstrated that modern injection molding techniques result in fewer dimensional inaccuracies than conventional processing techniques (Strohaver, 1989 and Nogueira et al., 1999). This is based on the principle that throughout the carefully controlled polymerization procedure, PMMA resin is continuously injected at pressure to compensate for polymerization shrinkage.

The gap pattern demonstrated in the current study confirmed that the dimensional changes of the commercial acrylic resins may be dependent on many factors, such as base thickness (van Straten et al., 1991), different locations of the base (Latta et al., 1990) and palatal geometry (Sykora & Sutow, 1993), which promote critical effects in the magnitude and localization of the distortion, mainly occurring in the posterior palatal region. Therefore, the distortion pattern of the base obtained in this study agrees with those of previous investigations (Anthony & Peyton, 1962; Polyzois, 1990 and Sanders, 1991) also showing the complexity of the gap formation which involves diverse and different factors.

The gap formation occurring during the complete denture procedure has been recognized by several authors (Becket et al., 1977; Sanders et al., 1991 and Puri et al., 2008) and still continues to be the major disadvantage of the process. In this study, the smaller gap values for the Bre-Crystal system packing method compared with the conventional method, independently of the other factors, indicates that the dimensional change occurred in the denture base was influenced by the resin packing method (Leonardo et al., 2004).

It is debatable whether the differences observed between conventional pressure packed and injection moulded PMMA samples would actually be clinically significant. As the denture bearing mucosa is compressible and the palatal seal is largely dependent on the prepared post dam (Lamb et al., 2005 and Kryinski & Prylinski, 2007), dimensional changes may be of little clinical relevance to the success or failure of the material as a denture base. However, a relatively higher fit of the denture base may be helpful in reducing the initial adaptation period of the denture wearer.
Conclusion:

Within limitation of this study it could be concluded that:

- Changes of the acrylic resins depend on many factors, such as different locations of the base and palatal geometry.
- The smaller gap values for the Bre-Crystal injection moulding technique compared with the conventional method, independently of the other factors, indicates that the dimensional change which occurred in the denture base was influenced by the resin packing method.
- Injection moulded PMMA resin is superior in terms of dimensional accuracy compared to conventional pressure packed PMMA resin.

References


