ORIGINAL RESEARCH

Investigation into the role of various factors during flasking and packing of heat cure acrylic resin, resulting in occlusal discrepancies in processed complete dentures.

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Abstract
Aim-The purpose of this study is to evaluate the displacement of artificial teeth in the invested mould in different orientations of the occlusal plane and evaluation and comparison of the displacement of teeth in waxed dentures after packing & processing of complete dentures.
Materials & Method - 27 mandibular edentulous cast were selected on which waxed up dentures were prepared with six metal tubes inserted. These served as reference points for measurements. Radiographs were taken for each waxed up denture during all the stages of flasking and processing. The scanned radiographs were subjected to AutoCAD programme, to evaluate the positional variation of metal tubes, signifying the shifting of the teeth during flasking and processing of the dentures. The measurements obtained were subjected to statistical analysis. The thickness of the ‘flash’ produced during packing of the three different resins was also noted & compared.
Result- There was no statistical significant deviation in the dimensional discrepancies for 0, 20 &30 degrees orientation of occlusal plane; however, dentures made with Lucitone had minimum thickness of ‘flash’ & showed least dimensional discrepancies amongst the three heat cured resins used.
Conclusion- The use of more plastic heat cure acrylic resin material exhibit least average thickness of ‘flash’, thus minimizing the occlusal discrepancies during processing of complete dentures.

Keywords: Occlusal Discrepancies, Complete Denture, Heat Cure Acrylic Resin, Processing of Complete Denture.

Introduction
From almost the time that dentistry achieved a professional status, there has been a constant search to obtain a denture base material of life like appearance and one that would not deteriorate. For nearly seventy-five years, Vulcanite (Goodyear 1855) dominated the world market and was the most satisfactory material available for fabrication of denture bases, until celluloid was introduced which was far superior to Vulcanite aesthetically. Celluloid was later discarded because of its dimensional instability. Shortly afterwards (1920) the synthetic resin industry began to produce organic materials were the building blocks for the modern acrylic resins, introduced in 1937, and are still extensively used in dentistry for fabrication of complete dentures.

Although some of the properties of acrylic denture base resins are not ideal, it is the combination of virtue rather than one single desirable property that accounts for
their popularity and universal use. Therefore almost 99.5% of complete dentures inserted, are with heat cure acrylic resin base1-3.

Acrylic resin as denture base is preferred by the operator due to ease of fabrication, adjustment, relining and repair. Along with all these benefits the heat cure acrylic resin base provides the patient relative ease of cleaning, colour stability, excellent smooth surface, and is very economical4,6-9.

The first step in processing of trial denture is flasking i.e. investing trial dentures along with the casts in special metallic container called as flasks. This is followed by the process of dewaxing i.e. eliminating the wax and thus obtaining the mould in which the acrylic resin is packed/poured.

During conversion of trial dentures into heat cure acrylic ones, from flasking till the cured dentures are retrieved from the flasks, variations do exist in guidelines for each step. Numerous workers have experimented and have put forward conflicting guidelines for each step. Although the clinical success has not varied significantly, the resulting dimensional changes attributed to polymerization shrinkage, water sorption etc., were evaluated and remedies suggested, in order to minimize these changes effectively10-12.

**Materials and Methods**

For the proposed study 27 ideal mandibular casts were obtained by pouring dental stone in the rubber molds.

Precautions were taken to use same water – powder ratio of (30 cc of water to 100 gms of powder). Mixing time of 60 seconds as well as use of vibrator till the molds were filled ensured that obtained casts were identical.

The casts on which dentures were fabricated were identified as A, B, C, … I and the integers 1, 2 and 3 representing the type of resin used for packing i.e. regular, veined and lucitone respectively.

Likewise, A1, A2, A3 ….. 11, 12, 13 dentures along with the casts (totally 27) were designated.

**Procedure**

For preparing temporary denture base autopolymerized acrylic resin was used. Care was taken to ensure the record bases had more or less the same thickness and peripheral extensions in the respective areas.

On each temporary base occlusal wax rims were prepared with modelling wax. Acrylic teeth sets of same mold were selected and subsequent teeth arrangement waxing and carving was done for each. Orthodontic metal tubes were placed in 1st premolar teeth (points – P1 & P2) and 2nd molar teeth (points – Q1 & Q2) on either side of the arch. Two such molar tubes were also placed in the centre of the casts (points – P & Q), which served as fixed reference points for subsequent measurements. Therefore in all, six tubes were placed in each specimen (figure 1 and 2). All the tubes were made parallel to each other with help of model surveyor.

- In groups A, B and C the tubes were placed at 0° to the occlusal plane.
- In groups D, E and F the tubes were placed at 20° to the occlusal plane
- In groups G, H and I the tubes were placed at 30° to the occlusal plane.

This was carried out with the help of model surveyor where the casts were oriented at 0°, 20° and 30° respectively according to the designated identification numbers.

The distance between points P – P1, P – P2, Q – Q1, Q – Q2, P1 – Q1, and P2 – Q2 were measured with the help of Vernier Callipers. The points P, Q, P1, Q1, P2, Q2 were located at the centre of the tubes by measuring the diameter of the metal tubes.
A radiograph of each cast was taken on a 10”x8” radiographic film with the x-ray machine.

(Figure 1, Test Model)

The distance between the source of x-rays and film was kept constant for each radiograph. The exposure factors were kept constant at Kvp-70, mAs-72 values.

(Figure 2, Schematic diagram showing 6 reference points)

The distance between the source of x-rays and film was kept constant for each radiograph. The exposure factors were kept constant at Kvp-70, mAs-72 values.

Flasking was carried out in the special designed, four member varsity type dental flak, where the bottom most member was made removable. After the second pour radiograph was taken of the flask. Care was taken to remove the bottom most member of the flask to facilitate the passage of x-rays. Radiographs of the flasks were again taken after packing the mold cavity with three different types of heat cure acrylic resins.

- Groups A1-I1 was packed with regular pink colour heat cure acrylic resin.
- Groups A2-I2 was packed with veined heat cure acrylic resin.
- Groups A3-I3 was packed with lucitone heat cure acrylic resin.

All the molds were subjected to 5-bar pressure in the hydraulic press as per standard. In Compression molding technique, the thickness of the flash was measured with Vernier callipers to the accuracy of 0.02 mm at the time of trial closure of the flask.

After one hour of 5-bar static hydraulic pressure the dentures were cured in thermostatically controlled water bath kept at 75°C for 1 hour followed by 100° for 1-1/2 hour.

After curing of the dentures, the flasks were allowed to cool overnight and subsequently, radiographs were taken. All the radiographs were scanned in a transparency scanner and scanned images were subjected to AutoCAD Software programme to measure the distance between the images of the reference points (P, Q, P1, P2, Q1, and Q2).

The migration of artificial teeth during flasking procedures as shown in the radiographs by shifting of metal tubes in the 1st premolar and 2nd molar region respectively forms the basic data of the study. The radiographs were scanned with the transparency scanner and were subjected to AutoCAD programme on the computer, to evaluate the positional variation of metal tubes, signifying the shifting of the teeth during flasking and processing of the dentures. (Figure 3)

For the study only, the inter 1st premolar distance (P1-P2), the inter 2nd molar distance (Q1-Q2) and the inter 2nd molar – 1st premolar distance (P2-Q2) on right side and the inter 2nd molar – 1st premolar distance
(P1-Q1) on left side, for the various stages of fabrication of the dentures were considered for statistical analysis.

(Figure 3, Measurements done between reference points using Auto-CAD programme on the computer)

Results

Statistical analysis of Standard deviations of measurements obtained from the study for 0°, 20° and 30° angulations of orientation of the occlusal plane in different regions (Q1-Q2, P1-P2, Q2-P2 and Q1-P1) for the three resins (Table 1) showed not much deviation in the measurements for the three angulations of the orientation of occlusal plane, however dentures made with Lucitone showed least movements amongst the three heat cured resins. Dentures made with regular DPI heat cured resin showed maximum movements.

Further, when the obtained standard deviations were subjected to student (t) test (independent) for statistical comparison of the dimensional changes between 0°, 20° and 30° angulations of orientation of the occlusal plane in different regions (Q1-Q2, P1-P2, Q2-P2 and Q1-P1) (Table 2), it was observed that there no statistical significant dimensional changes amongst the three types of heat-cured resins used. (p<0.01)

The average thickness of ‘flash’ for 3 different kinds of heat cure acrylic resins was noted (Table 3) amongst the three, Lucitone produced the least thickness of ‘flash’, while Regular DPI heat –cured resin produced the thickest of flash.

Discussion

The occlusal discrepancies which occur in the final cured / polymerized dentures may be attributed to one or more factors given below:

1. Investment

The teeth may be displaced by the setting expansion of second pour of the investing stone. Grant (1962) has shown tooth movements of 0.02 mm – 0.05 mm resulting from this expansion. He claimed tooth movement during investing could be minimized by applying a matrix of plaster around the teeth prior to completion of investment.

Kenneth M. Tucker and B.J. Freeman showed no statistically significant differences between various types of investment techniques.

Sigmund Perlowski stated that close adaptation of investment by the “Brush-on” method is more important than the hardness of the material used.

Kamal N. Zakhari proposed use of plaster of paris as an investment material with stone occlusal matrix as ideal combination to prevent increase in vertical dimension of processed dentures.

Ezio T. Maineri et al compared the two investing techniques and found that both the silicon rubber with gypsum covering and all gypsum techniques of investing were equally good in minimizing the tooth/teeth movement.

However, Bennie S. Dukes et al noted that artificial stone with silicon rubber investing technique was far superior in maintaining the vertical dimension than the all gypsum technique.
Table 1 Standard deviation of the measurements obtained from the study for 0°, 20° and 30° angulations of orientation of the occlusal plane in different regions (Q1-Q2, P1-P2, Q2-P2 and Q1-P1)

<table>
<thead>
<tr>
<th>STAGE</th>
<th>TYPE OF ACRYLIC</th>
<th>Q1-Q2 DEGREE OF ANGULATION</th>
<th>P1-P2 DEGREE OF ANGULATION</th>
<th>Q2-P2 DEGREE OF ANGULATION</th>
<th>Q1-P1 DEGREE OF ANGULATION</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>0°</td>
<td>20°</td>
<td>30°</td>
<td>0°</td>
</tr>
<tr>
<td>F</td>
<td>H</td>
<td>0.19</td>
<td>0.21</td>
<td>0.29</td>
<td>0.28</td>
</tr>
<tr>
<td>P</td>
<td></td>
<td>0.96</td>
<td>0.26</td>
<td>0.10</td>
<td>0.53</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>1.38</td>
<td>0.93</td>
<td>0.54</td>
<td>0.61</td>
</tr>
<tr>
<td>F</td>
<td>V</td>
<td>0.13</td>
<td>1.05</td>
<td>0.03</td>
<td>0.43</td>
</tr>
<tr>
<td>P</td>
<td></td>
<td>0.15</td>
<td>0.72</td>
<td>0.14</td>
<td>0.15</td>
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<tr>
<td>C</td>
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<td>0.17</td>
<td>0.21</td>
<td>0.45</td>
<td>0.15</td>
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<tr>
<td>F</td>
<td>L</td>
<td>0.48</td>
<td>0.13</td>
<td>1.02</td>
<td>0.29</td>
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<tr>
<td>P</td>
<td></td>
<td>0.29</td>
<td>0.78</td>
<td>1.86</td>
<td>0.45</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>0.26</td>
<td>0.60</td>
<td>2.68</td>
<td>0.03</td>
</tr>
</tbody>
</table>

(Abbreviations: F- Flasking Stage, P- Packing Stage, C- Curing Stage, H- Regular heat cure acrylic resin, V- Veined heat cure acrylic resin, L- Lucitone heat cure acrylic resin, Q1-Q2- Inter second molar distance, P1- P2 Inter first premolar distance, Q2-P2 Inter second molar- first premolar distance on right side, Q1-P1 Inter second molar- first premolar distance on left side)

Table 2- Standard deviations were subjected to student (t) test (independent) for statistical comparison of the dimensional changes between 0°, 20° and 30° angulations of orientation of the occlusal plane in different regions (Q1-Q2, P1-P2, Q2-P2 and Q1-P1) and their significance

<table>
<thead>
<tr>
<th>ACRYLIC</th>
<th>DEGREE</th>
<th>Q1-Q2</th>
<th>P1-P2</th>
<th>Q2-P2</th>
<th>Q1-P1</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>[t]</td>
<td>P-value</td>
<td>Remar</td>
<td>[t]</td>
</tr>
<tr>
<td>H</td>
<td>0°</td>
<td>0.12</td>
<td>N.S</td>
<td>0.6</td>
<td>N.S</td>
</tr>
<tr>
<td>V</td>
<td>20°</td>
<td>0.7</td>
<td>N.S</td>
<td>1.3</td>
<td>N.S</td>
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<tr>
<td>L</td>
<td>30°</td>
<td>0.59</td>
<td>N.S</td>
<td>0.2</td>
<td>N.S</td>
</tr>
<tr>
<td>H</td>
<td>0°</td>
<td>0.9</td>
<td>O.4</td>
<td>1.4</td>
<td>0.23</td>
</tr>
<tr>
<td>V</td>
<td>20°</td>
<td>0.23</td>
<td>N.S</td>
<td>1.2</td>
<td>0.26</td>
</tr>
<tr>
<td>L</td>
<td>30°</td>
<td>0.19</td>
<td>N.S</td>
<td>0.1</td>
<td>N.S</td>
</tr>
<tr>
<td>H</td>
<td>0°</td>
<td>0.6</td>
<td>O.37</td>
<td>1.1</td>
<td>0.30</td>
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<tr>
<td>V</td>
<td>20°</td>
<td>0.3</td>
<td>N.S</td>
<td>1.3</td>
<td>0.04</td>
</tr>
<tr>
<td>L</td>
<td>30°</td>
<td>0.20</td>
<td>N.S</td>
<td>0.3</td>
<td>0.76</td>
</tr>
</tbody>
</table>

(Abbreviations: F- Flasking Stage, P- Packing Stage, C- Curing Stage, H- Regular heat cure acrylic resin, V- Veined heat cure acrylic resin, L- Lucitone heat cure acrylic resin, Q1-Q2- Inter second molar distance, P1- P2 Inter first premolar distance, Q2-P2 Inter second molar- first premolar distance on right side, Q1-P1 Inter second molar- first premolar distance on left side, [t]- Calculated ‘t’ value, N.S- Not Significant, S- Significant)
(Table 3- Comparison of thickness of flash of three different kinds of heat cure acrylic resins)

<table>
<thead>
<tr>
<th>No. of Observations</th>
<th>Regular</th>
<th>Veined</th>
<th>Lucitone</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.34</td>
<td>0.22</td>
<td>0.14</td>
</tr>
<tr>
<td>2</td>
<td>0.32</td>
<td>0.20</td>
<td>0.18</td>
</tr>
<tr>
<td>3</td>
<td>0.38</td>
<td>0.24</td>
<td>0.16</td>
</tr>
<tr>
<td>4</td>
<td>0.36</td>
<td>0.26</td>
<td>0.16</td>
</tr>
<tr>
<td>5</td>
<td>0.34</td>
<td>0.22</td>
<td>0.14</td>
</tr>
<tr>
<td>6</td>
<td>0.36</td>
<td>0.24</td>
<td>0.16</td>
</tr>
<tr>
<td>7</td>
<td>0.32</td>
<td>0.26</td>
<td>0.18</td>
</tr>
<tr>
<td>8</td>
<td>0.34</td>
<td>0.22</td>
<td>0.16</td>
</tr>
<tr>
<td>9</td>
<td>0.32</td>
<td>0.24</td>
<td>0.18</td>
</tr>
<tr>
<td>Mean</td>
<td>0.342</td>
<td>0.233</td>
<td>0.162</td>
</tr>
</tbody>
</table>

2. Denture base resin

Some teeth shift more than others because acrylic resin, at the final closure of the flaks, has sufficient internal shear resistance or viscosity to allow severe stress distributions in uncured dentures. Mahler found increased vertical dimension to a minimum limit of 0.6 mm, which he attributed to the internal stress of acrylic denture.

3. Excess of acrylic resin in the mould

The increase in vertical dimension of dentures result from excess acrylic resin in the moulds at the time of packing, which comes out as “flash”, when pressure is applied to close the flask, thus preventing the flask to close completely.

Although Henry Lerner and Pfeiffer, stressed on the usefulness of the diaphragm or layer of resin on the land around entire border of the denture in minimizing individual and multiple tooth movements during polymerization process. The diaphragm acts as a cushion and a reservoir, which helps to control the location of shrinkage in the resin that occurs immediately following polymerization and during cooling period.

Woelfel and Paffenbarger found that bulky dentures show less molar-to-molar change then thin dentures. The reason being the thicker cross section was stiff enough to prevent the release of some of the strain at the time of separation of cured dentures from the cast.

4. Temperature changes (Thermal disturbances)

Occlusal discrepancies in processed dentures, Sigmound A. Perlowski attributed the heat liberated by the setting investment material, to the movement of the teeth in their wax foundations leading to occlusal discrepancies.

Grant stated that the setting expansion of gypsum investment was responsible for the shifting of the teeth in the wax foundation rather than the thermal expansion of the wax. He further stated that the tooth movement during investing could be minimized by applying a matrix of plaster around the teeth prior to completion of the investment.

It was observed that the dimensional change in the reference points during packing stage was shown by the positional variation of the metal tubes placed in the dentures. The minimum movements of 0.4546 mm, 0.1931 mm, 0.2260 mm, 0.2032 mm and maximum movements of 4.7372 mm, 3.0201 mm, 2.0117 mm, 1.48087 mm respectively in the second molar – second molar, first premolar – first premolar, right side second molar – first premolar and left side second molar – first premolar.

The orientation of occlusal plane played an important role in shifting of the teeth during the flasking procedures. Ronald V. Lam had studied the displacement of teeth that resulted from various angulations of the cast in the flask. He found that the total deviation of the teeth was in range of 0.02-0.20mm with corresponding tilts with cast of 5-40°. In this context the present study was carried out and the results revealed that, there is no statistically
significant difference in change in dimension between 0°, 20° and 30° angulations of the occlusal plane. However, all the specimens showed a minimum movement of 0.0497mm, 0.0076mm, 0.381mm while the maximum movement of 1.3973mm, 2.3266mm, 4.7372mm at 0°, 20° and 30° angulations of the occlusal plane respectively.

Numerous investigators have shown the concern about this phenomenon of shifting of teeth during flasking and processing of waxed up dentures and have given remedies to minimize the resulting occlusal discrepancies.

Robert W. Shippee\textsuperscript{11} stated that the increase in vertical dimension of occlusion could be reduced by making provision for excess resin in the mold to escape after the final closure.

Grant \textsuperscript{1} advocated the use of core matrix around the teeth to minimize the tooth movement relative to the cast. Kenneth D. Rudd \textsuperscript{12} emphasized on minimum packing pressure to be used with maximum flow time and repeated trial closures, until no flash is evident, to prevent tooth movement during processing of complete denture.

Francisco L.E. Pera \textsuperscript{13} devised special flasks with central exhaust to allow the excess acrylic resin to flow freely under pressure. He also suggested, freezing of mould before packing of the heat cure acrylic resin helps in slowing down the transformation of resin from plastic to elastic state.

Honorato \textsuperscript{14} used double processing technique for fabrication of complete denture to eliminate occlusal errors resulting from shifting of teeth during processing of acrylic dentures. Our present day knowledge is still inadequate and procedures not entirely satisfactory so far in minimizing the occlusal discrepancies during processing of the dentures are concerned.

Even with these handicaps we can still minimize the occlusal discrepancies by employing the procedure of selective grinding. Laboratory and chair side remounting procedures are mandatory. Careful manipulation of the materials can minimize the role they play in resulting occlusal discrepancies in processed complete denture.

**Conclusions**

1. Dimensional changes were evident in all the reference points at 0°, 20° and 30° angulations of the occlusal plane, however, there are no statistically significant different between them.
2. Lucitone is relatively more plastic material than veined heat cure acrylic resin.
3. Veined heat cure acrylic resin is more plastic material than regular heat cure acrylic resin.
4. The use of more plastic heat cure acrylic resin material exhibit least average thickness of flash, thus minimizing the occlusal discrepancies.

**References**


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