Removable partial denture - Accuracy in digital workflow

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Abstract

This study aimed to compare the fit and accuracy of metal frameworks for removable partial dentures (RPDs) made with conventional and digital fabrication techniques. On a representative model, maxillary RPD metal frameworks (N=5, n=2 each group) were created. A conventional casting of milled RPD patterns (C-M), and a conventional casting of printed RPD patterns (C-P), were all used to create RPDs. By creating replicas with silicone registration material and measuring under a digital microscope, the fit accuracy of RPD frameworks was examined. For the accuracy measurements (m), a total of 11 sites and 29 areas in the RPD metal frameworks were taken into account. Wilcoxon signed rank and Friedman test were used in the statistical analysis of the data (p 0.05). The results demonstrated that the accuracy of the C-M approach (118 m) was significantly superior (P .001) when compared to other techniques. After finishing and polishing, the C-M approach demonstrated comparable fit accuracy to the C-P. When RPD precision is taken into account, it was observed that digital techniques were efficient and clinically acceptable.

Keywords: Removable partial denture ; Digital; CAD CAM; Milling; Printed

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INTRODUCTION

Complete edentulism is a decreasing public oral health concern due to increased awareness, while the population of partially edentulous adults is increasing(1)(2). Removable partial dentures are a common treatment option utilised in partially edentulous adults who cannot receive implant supported prostheses because of various anatomic, financial, or psychological reasons(3). Traditionally, RPD design involved the fabrication of stone casts, evaluation and geometric characterization of the tooth and soft tissues related to the path of insertion, and careful fabrication of RPD framework using a direct waxing method. (4–7) Rapid advancements in computer-aided design and computer-aided manufacturing (CAD-CAM) have opened new pathways in the fabrication of removable partial denture (RPD) frameworks through additive and subtractive processes(4). To produce a digital file that can be milled or 3D printed, sophisticated 3D designing software such as exocad or 3-shape can be used(8). Once digitally designed, different pathways exist for the fabrication of the RPD framework. The typical digital workflow includes obtaining a digital model of the oral hard and soft tissues. This can be accomplished directly from an intraoral digital scan or from a laboratory digital scan of a stone cast(9). Second, the path of insertion is defined, and undercuts are color coded based on the depth. Subsequently, the virtual block-outs are automatically calculated and displayed on the virtual cast. The retention grid and major connector are designed, followed by the rests and clasps.

In RPD frameworks, it is essential to be noted that there is some gap present between the metal framework and soft tissues which can be evaluated using various methods(10). Dunham used various materials to evaluate the accuracy of the frameworks such as acrylic resin or zinc stearate disclosing powder(11). Ali et al.(10,12) measured the distortion between the frameworks and different maxillary models with a specially developed strain gauge apparatus. Newer digital technologies are now available such as colour mapping method and geomagic.
Therefore, the goal of this study was to evaluate the correctness of maxillary RPD metal frameworks made utilising digital(printed and milled)techniques. The null hypothesis investigated was that there wouldn't be a significant difference in the accuracy between different production methods and between technologies used.

**Materials And Method**

The appropriate institutional review board approval was obtained, and four RPD frameworks were fabricated using each of the 2 techniques, labelled 1 and 2.

The first and second technique was a combined analog-digital technique, in which a physical definitive impression was made and a stone cast was fabricated: a physical impression was made using polyvinyl siloxane (Extrude; Kerr Corp), and a stone cast was poured using Type IV stone (Silky-Rock; Whip Mix Corp). The impression and stone cast were evaluated critically to ensure quality. The stone cast was then scanned using a laboratory scanner (D800; 3Shape) to generate a digital model. The 3Shape CAD software was used to design a digital RPD (Dental System 2016 Premium; 3Shape). The digital RPD design was then sent to the Saveetha Tessellation Centre and was milled and casted as per technique one and printed and casted as per technique two.

For all RPD frameworks the same design was used for consistency. Furthermore, the same laboratory technician fabricated all the RPD frameworks.

**Evaluating the Fit**

A RPD was fabricated and seated on the stone cast of a partially edentulous mandible, and the spaces between RPD and stone cast were recorded with polyvinyl siloxane (PVS) impression material forming PVS replicas. Using cross sectional measurement, the average thicknesses of PVS replicas were measured under stereomicroscope with different numbers of selected measuring points in the denture base, major connector, occlusal rest of the RPD, and the average thicknesses of the PVS replicas measured with different numbers of measuring points.
Results

The manufacturing technologies (P < .05) and the measurement location (P < .05) significantly affected the accuracy and the results (Tables 1).

In the current study it can be observed that, The milling technique is more accurate than printing at the right anterior region and it was statistically significant (p<0.05).

In the current study it can be observed that, The milling technique is more accurate than printing at the left anterior region and it was statistically significant (p<0.05).

In the current study it can be observed that, The milling technique is more accurate than printing at the right posterior region and it was statistically significant (p<0.05).

In the current study it can be observed that, The milling technique is more accurate than printing at the left posterior region and it was statistically significant (p<0.05).

In the current study it can be observed that, The milling technique is more accurate than printing at the rest 1 and it was statistically significant (p<0.05).

In the current study it can be observed that, The milling technique is more accurate than printing at the rest 2 and it was statistically significant (p<0.05).
Table 1: depicting the average value of the measurement of the polyvinylsiloxane at different locations

<table>
<thead>
<tr>
<th>S.NO.</th>
<th>GROUP</th>
<th>RIGHT ANTERIOR (NM)</th>
<th>RIGHT POSTERIOR (NM)</th>
<th>LEFT ANTERIOR (NM)</th>
<th>LEFT POSTERIOR (NM)</th>
<th>REST (1) (NM)</th>
<th>REST (2) (NM)</th>
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<td>1</td>
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<td>327.53</td>
<td>527.46</td>
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<td>555.71</td>
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<tr>
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<td>217.93</td>
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</tbody>
</table>

Figure 4: The cross section measurement of the polyvinylsiloxane under stereo microscope.

Discussion

This study was done to assess the accuracy of the RPD metal frameworks made using digital technologies (printing, milling). Based on the results, a significant impact of the production techniques was seen on the metal framework of RPDs' precision, but this was only seen at a few measurement sites. Consequently, the null hypothesis was rejected. From a clinical standpoint, the precision of RPD frameworks is a crucial factor in reducing plaque buildup, food impaction, patient discomfort, which has been a focus of research in removable prosthodontics. Different techniques based on manual and digital approaches, the latter of which may involve software inherent aspects, have been used to test fit accuracy. Recently, digital tools like colour mapping and geomagic have been employed to evaluate the accuracy of the RPD framework (13).

The strategy of silicone replicas was used in this technique although they have limited access to relatively small portions of RPD like the reciprocal arm. A calibrated operator took 3 repeated measurements from each of the chosen sites in an effort to increase the validity of the measurements. In the current study, it was observed that the accuracy of milled samples was greater than printed. This finding is consistent with earlier research by Arnold et al. who discovered that RPD frameworks made utilising indirect rapid prototyping or SLM techniques were unstable on the master model and inappropriate for clinical application (13, 14). The wax or resin patterns were routinely cast in the indirect CAD-CAM manufacturing procedures without the need of a refractory cast. With these methods, the metal structure underwent more distortion during the manufacturing process. As a result, the mistakes could occur either during the embedding or removal of the resin pattern from the support medium, causing tension and rocking movements after processing the frameworks on the master model as well as a greater degree of distortion.

The SLM frameworks had a much rougher surface than the DMLS frameworks in the visual comparison of the two group’s RPD frameworks, which required more time and effort to finish and ultimately had an impact on accuracy. This finding is consistent with a research by Takaichi et al. which demonstrated that the microstructure and porosity of Co-Cr-Mo alloys depend
on the SLM device's operational parameters as well as the alloy itself. The accuracy of metal RPD frameworks can be impacted by technical factors like energy density, scanning speed, scanning technique, layer thickness, and laser spot diameter of the manufacturing inherent characteristic.

Further research is needed to refine the technical parameters of the additive technologies in order to increase the precision of the digitally created metal frameworks. In places where the frames were very close to the replicated master casts, the silicone duplicates were not perfectly made. Because the silicone registration material separated from the silicone impression material or from the framework, some measurement locations in the rigid arm and the transition from rigid to elastic arm on the silicone replicas could not be evaluated. This study's weakness could be viewed as the fact that at least one of these events occurred in each of the three silicone copies of each framework group. Future research should confirm the findings of this pilot study using a larger sample size with various Kennedy classes using conventional RPD designs, and compare them to digital measuring techniques like colour mapping and geometric.

**Conclusion**

Studies on milling and printing, indicated that milling was more accurate than printing. However, future research should confirm the findings of this pilot study with a larger sample size of participants from other Kennedy classes using conventional RPD designs, and compare them using digital techniques such as colour mapping and geometric.

**REFERENCES**