CO-CR COMPLETE MAXILLARY DENTURE BASES CASTED FROM 3D PRINTED WAX RESIN PATTERNS WITH ONE STABILIZATION BAR AND CO-CR COMPLETE MAXILLARY DENTURE BASES CASTED FROM 3D PRINTED WAX RESIN PATTERNS WITH TWO STABILIZATION BARS FIT ACCURACY COMPARISON

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ABSTRACT
Acrylic resins had been used to manufacture the removable complete dentures bases for many years. However there are many disadvantages connected to the use of this material as a denture base, the reason that makes the researches use metal bases as replacement, there are many ways to make patterns for metal casting in partial and complete dentures bases, recently one of them is rapid prototyping. The design of printed patterns can be very important in the resulted casted metal palate. Different companies suggest different numbers and different diameters for the added stabilization bars used in 3D printed complete or cross the arch removable partial denture castable patterns designs.

Purpose: The purpose of this study was to compare the fit accuracy Co-Cr complete Maxillary denture bases casted from 3D Printed wax Resin patterns with one stabilization bar and Co-Cr complete Maxillary denture bases casted from 3D Printed wax Resin patterns with two stabilization bars.

Materials and Methods: Using 20 replicated master casts obtained by duplicating a metal die representing a fully edentulous maxillary arch, 10 Co-Cr metal plates were casted from 3D Printed Resin patterns with one stabilization bar patterns, and another 10 Co-Cr metal plates were casted from 3D Printed Resin patterns with two stabilization bars patterns, after artificial teeth setting process completed, acrylic resin had been processed, to simulate an ordinary denture base. An injectable additional silicone super light body impression material had been applied between each denture base and metal die and the material was left to set under 5kg weight designed to be used in this experiment, then weighing process of the elastomeric silicone layer was performed to compare adaptation of the two groups of dentures.

Results: The values of the silicone layer weight (in grams) in the Co-Cr complete Maxillary denture bases casted from 3D Printed Resin patterns with two stabilization bars group was smaller than the values of the silicone layer weight in the Co-Cr metal plates were casted from Co-Cr complete Maxillary denture bases casted from 3D Printed Resin patterns with one stabilization bar.

Conclusions: Dentures with Co-Cr metal plates casted from 3D Printed Resin patterns with two stabilization bars fits more accurately than the dentures with Co-Cr metal plates casted from 3D Printed Resin patterns with one stabilization bar.

INTRODUCTION
Dr. Walter Wright (1937) introduced Polymethyl methacrylate as a denture base material which became the major polymer to be used. Since ages, polymethyl methacrylate (PMMA) has been used to fabricate the dentures, and since its introduction as a denture base material, its use has become almost universal.[1-5] On the other hand, this material have many disadvantages as a denture base, such as dimensional changes[2, 3, 6, 7], residual monomer allergy,[5] low thermal conductivity[5, 8], low hardness[5, 8], water sorption,[9] The lack of dimensional stability[2]. Dentures are usually subjected to a combination of compressive, tensile, shearing loads and these forces are increased in ill-fitting dentures and these forces are traumatic to both soft and hard tissue of denture bearing surface.[10] PMMA denture bases have good mechanical, biological and esthetic properties but they may fail because of excessive masticatory...
or functional forces. In such circumstances metal denture base can be used.[11][6, 12]

Various studies have shown that metal dentures were perceived as more comfortable than acrylic resin denture reduces burning sensation, allergic reactions, eliminating microbial colonization, is fracture resistant, thin, comfortable to the patient and gives them a feeling of chewing food naturally.[13] Acrylic denture base materials may serve as a reservoir for microorganisms like candida and bacteria.[14, 15]

In spite of many advantages, metal denture bases do not enjoy widespread use in clinical practice. Metal based dentures are more retentive, have less Occlusal discrepancy, cause fewer sore spots, have a reduced incidence of fracture, feel better to the patient, are better thermal conductors, act as a stable record base, have a thinner palate that aids speech, better preserves the residual alveolar ridge, are less porous, deform less during lateral mandibular function, and are more accurate in tissue detail.[11]

Metal denture base are more tissue tolerant and resistant to deformation than acrylic denture base.[6]

The coefficient of thermal conductivity of PMMA is approximately 0.2 W/min°C; this rate is almost one-third of the coefficient of thermal conductivity of most metals. Due to this difference, in some studies, acrylic denture base has been replaced with metal base.[8]

Metal denture base is effective in decreasing fungal growth in complete dentures and provides to be an alternative dental service for edentulous patients.[16]

For metallic prostheses, the traditional lost-wax casting technique is most commonly used in dentistry. Defects and inaccuracy generated in this labor-intensive casting process, that can take 1 week to complete, call for new methods to satisfy customer needs nowadays.

Recent research achievements in the areas of computer-aided design and computer aided manufacturing (CAD/CAM) technology have created alternative routes to fabricate dental prostheses and dental implants.[17]

The fabrication of computer aided dental prostheses has become common practice in dentistry.[18]

Digital strategies widen the scope of therapeutic applications for partial dentures as a result of improved design and production control, new materials, and improved efficiencies that will likely enhance outcomes and improve patient experiences.[19, 20]

Unlike the existing method, where a wax pattern is made on a definitive cast, a removable partial denture (RPD) is designed on a computer. Based on this design, a 3-dimensional (3D) pattern is printed using rapid prototyping, with a resin that can be eliminated. The pattern subsequently undergoes investment, elimination, and casting, thereby completing the fabrication of a digital framework.[21, 22]

One of the advantages of CAD-CAM related technologies is elimination the need for duplicating impressions and refractory casts required in conventional casting, this digitalization simplifies the fabrication process, reduces material costs, and saves time.

The reproducibility of the fabrication process is also increased while differences in fabrication results among dental technicians are minimized.[23] Additive 3D printing techniques include stereolithography (SLA), digital light projection (DLP), jet printing, fused deposition modeling (FDM), and selective laser melting (SLM).[24] The technique had been used in this study was stereolithography (SLA), to print the wax resin patterns, unfortunately within our limited resources we couldn’t find a study that compares the accuracy of patterns with different no. of stabilization bars.

Different manufacturers recommend different numbers and different diameters for the complete and RPDs printing stabilization bars.

In this study, the researcher compared the fit accuracy of casted metal palates from 3d printed wax resin with: one stabilization bar, and two perpendicular stabilization bars.

**MATERIALS AND METHODS**

A silicon maxillary edentulous cast mold had been used to cast a type 4 gypsum model (Snowrock MUNGYO, Korea), then the land area of the cast on the periphery had been trimmed to facilitate repositioning of the metal casted metal palates, and to make the excess silicone impression material trimming process easier and more precise.

After land areas removal, the gypsum cast converted into an aluminum master cast as in figure 3, then a duplicating flask (Bego, Germany) was used with duplicating silicone material (Elite Double 22, Zhermack Dental, Italy) to duplicate the master cast to 20 working casts using type 4 gypsum.

![Figure 1 silicon maxillary edentulous cast mold](image_url)
patterns, the first group design was supplied with one stabilization bar crosses the arch with 2.5 mm diameter, on the other hand two perpendicular stabilization bars with 2.5 mm diameter were added the second group design.

After the designing process was completed, the design Stl file was send to PreForm software (formlabs, USA) to add the supporting structures and to prepare the design for nesting process, after that the orders were send to the 3D printer (Formlab2, formlabs, USA) to print the patterns design, a castable wax resin cartridge (Formlabs, USA) was loaded into the printer before the printing process.

After printing process completed, the patterns were washed with isopropyl 99% concentration for 15 min, and after that the supporting structures were removed using a separating disc, and the patterns were prepared rapidly for casting, to avoid contraction of the wax resin.[25] patterns were prepared to be casted with Wironit extra-hard Cobalt-Chrome partial denture alloy, (Bego, Germany) according to the manufacturer instructions.

The casts were divided into two groups

1-3 D Printed Resin patterns with one stabilization bar group contains 10 gypsum casts.

2-3 D Printed Resin patterns with two stabilization bars group contains 10 gypsum casts.

The casts were scanned with laboratory scanner (Edge scanner, DOF, Korea), and the scanned Stl file then transferred to the design software (3shape Complete Restorative SOFTWARE, Denmark) to be used in designing the complete maxillary plate.

Figure 2 gypsum model

Figure 3 Aluminum master model

Figure 4 Duplicating the master model

Figure 5 group 1 design

Figure 6 group two design
After the casting process completed for both groups, the artificial teeth had been set on one of the Co-Cr casted plates and the waxing process was completed. Then a mold was made to copy the waxed plate shape to all the other casted metal plates, a copper flask was used to make the mold, type 4 gypsum was used in the lower half of the flask, and in the other half putty silicone (Peakosil Regular set putty, Neosil, Korea) was used to make the wax up mold, each time, a new set of upper teeth was used with all of them at the same type and size (Major Dent, Italy).

After copying the denture wax up process to all the metal plates, the dentures were processed using heat cure acrylic resin (MEADWAY SUPERCURE heat cure acrylic, united kingdom) by compression molded technique, to simulate the real dentures and make the results reliable as possible.

Super light silicone additional impression material (Elite HD+Silicone super Light Body, Zhermack, Italy) was applied using an injection tool which allows an equal distribution of both base and accelerator paste in the denture base. It was spread uniformly over the entire intaglio surface of the metal casted denture base for 30 seconds; the base was then applied on the master metal cast. The base was subjected to a 5000 gram load on top of it for five minutes using a metal bulk made of iron. After setting of the silicone completed, the load was removed and the silicone was trimmed using a scalpel to cope the edges of the denture and the metal cast, then the silicone layer was removed from the denture base. Three silicone layers were recorded for each denture and each layer was weighed on an analytical balance (TE-64 Analytical Balance, Sartorius, USA) the nearest 0.0001 g.

This study took place at the Department of Prosthodontics, Faculty of Dentistry, Hama University- Syria.

**Statistical study**

The data was analyzed statistically using T-Test for independent samples. The significant differences in the average values (in grams) of the silicone layer weights between Co-Cr complete Maxillary denture bases casted from 3D Printed Wax Resin patterns with one stabilization bar and the Co-Cr complete Maxillary denture bases casted from 3D Printed Wax Resin patterns with two stabilization bars were studied, and all values were considered significant at $P \leq 0.05$.

**RESULTS**

Table (1): Super light silicone impression material layer weight mean and standard deviation comparison between the Co-Cr complete Maxillary denture bases casted from 3D Printed Wax Resin patterns with one stabilization bar and the Co-Cr complete Maxillary denture bases casted from 3D Printed Wax Resin patterns with two stabilization bars

<table>
<thead>
<tr>
<th>Super light silicone impression material layer weight</th>
<th>Mean</th>
<th>One stabilization bar</th>
<th>Two stabilization bars</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>1.9507</td>
<td>1.8400</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.000915326</td>
<td>0.000905808</td>
<td></td>
</tr>
</tbody>
</table>
DISCUSSION

Achievement of a denture base highly adapted to the supportive tissues is a key objective in the manufacture of complete dentures. Good denture base adaptation is an important factor in complete denture retention.[26, 27]. The CAD/CAM technique was used to manufacture patterns because it’s easier to design the palate pattern using this technique, and it's more likely to get similar general features by using the same 3D printer and the same wax resin, with the same casting steps. This technique also can save time and labor.[28, 29]

Computer-aided design and computer-aided manufacturing (CAD/CAM) systems are widely used in the design and fabrication of fixed and removable prostheses. RPD frameworks can be directly milled from the metal/polymer. A resin or wax pattern framework can be 3D printed and then processed using conventional fabrication methods.[30]

The author chose the rapid prototyping in this study (RP) because this method has recently gained prominence, providing a variety of new procedures.[31]

Some studies reported that conventional casting frameworks can have a better fit than rapid prototyping printed cad cam frameworks[32], so to improve the fit of such technique, the design should be improved because it plays an important role in accuracy.

Different manufacturers recommend different numbers and different diameters for the complete and across the palate.

Removable partial dentures printing stabilization bars[33, 34], and for this reason the author compared the effect of stabilization bar number on the fit accuracy of the resulted casted metal palate.

The metal palate casted from Cobalt-chromium (Co-Cr) alloys had been used as a complete denture palate in this study because Cobalt-chromium (Co-Cr) alloys have been widely used in dentistry for removable partial dentures, metal frames, and porcelain-fused-to-metal crowns, mainly because alloys are strong, resistant to corrosion, and relatively inexpensive, when compared to gold alloys and some all-ceramic materials, more tissue tolerant and resistant to deformation than acrylic denture base more retentive, have less Occlusal discrepancy, cause fewer sore spots, have a reduced incidence of fracture, feel better to the patient, are better thermal conductors, act as a stable record base, have a thinner palate that aids speech, better preserve the residual alveolar ridge, are less porous, deform less during lateral mandibular function, and are more accurate in tissue detail.[6, 11, 35]

In the current study, the method of weighing the elastomeric silicone layer between each metal casted palate and the metal die was used to study the adaptation of the whole denture base. Shetty.M.S and Shenoy K.K mentioned Vinyl Polysiloxane Impression Material can be used to measure fit accuracy in removable and fixed prosthodontics.[36]

This technique had been used to evaluate dentures fit accuracy in many other researches.[26, 27, 37]

Analysis of the data revealed that Co-Cr casted metal palates casted from 3D printed wax resin patterns with two perpendicular stabilization bars showed a statistically significant difference (P<0.05) in terms of denture adaptation, as the silicone layers was lighter in the dentures made of these patterns (1.8400g) compared with the Co-Cr metal palates casted from 3D printed wax resin patterns with one cross arch stabilization bar (1.9507g).

The findings in this study enlightens the importance of 3D printing design in the resulted printed object accuracy, and this agrees with some studies results that confirm that 3D object design in this object accuracy in the dental field.[38]

CONCLUSIONS

Within the limits of this study, it was concluded that the Co-Cr complete maxillary denture bases casted from 3D Printed Wax Resin patterns with two stabilization bars fit better on the master model than Co-Cr complete maxillary denture bases casted from 3D Printed Wax Resin patterns with one stabilization bar, so we can conclude that 3D pattern stabilization bars no. and design can affect fit accuracy of the resulted Co-Cr casted metal plate.

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