
**ISSN Print:** 2394-7489
**ISSN Online:** 2394-7497
IJADS 2020; 6(3): 480-484

www.oraljournal.com
Received: 30-03-2020
Accepted: 15-05-2020

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# Co-Cr complete maxillary denture bases casted from conventionally waxed patterns and Co-Cr complete maxillary denture bases casted from milled wax patterns fit accuracy comparison

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**DOI:** https://doi.org/10.22271/oral.2020.v6.i3g.996

**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,
**Purpose:** The purpose of this study is to compare the fit accuracy of Co-Cr metal denture bases casted from conventionally waxed patterns to other Co-Cr metal denture bases casted from CAD-CAM milled wax patterns**.**
**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 conventionally waxed up patterns, and another 10 Co-Cr metal plates were casted from CAD-CAM milled wax patterns, after artificial teeth setting**,** acrylic resin had been processed, to simulate an ordinary denture base. After applying injectable addition silicone super light body impression material between each denture base and metal die was performed and let it set under 5kg weight designed to be used in this experiment, 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 conventional waxing group was smaller than the values of the silicone layer weight in the Co-Cr metal plates were casted from CAD-CAM milled wax patterns**.**
**Conclusions:** Dentures with Co-Cr metal plates casted from conventionally waxed up patterns fits more accurately than the dentures with Co-Cr metal plates casted from CAD-CAM milled wax patterns.

**Keywords:** CAD, CAM, metal, cobalt, chrome, wax milling, conventional waxing, fit accuracy, denture base

## 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 preserve 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°K; 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].

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 [18, 19].

## Materials and Methods

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

**Fig 1:** silicon maxillary edentulous cast mold

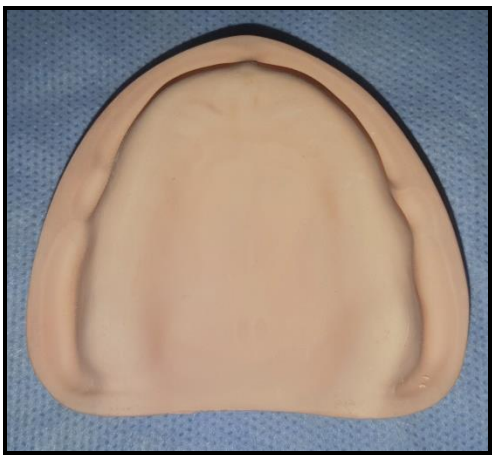


**Fig 2:** gypsum mode

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.

**Fig 3:** Aluminum master cast

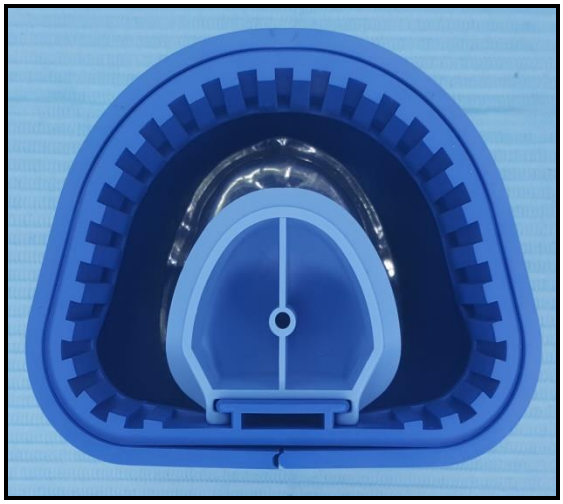


**Fig 4:** Duplicating master cast

The casts were divided into two groups:

1. Conventional wax up group contains 10 gypsum casts.
2. Wax milling group contains 10 gypsum casts.

In the conventional wax up group complete maxillary plate patterns were prepared after duplicating gypsum casts to investment material casts, but in the second group the casts

were scanned with laboratory scanner (Edge scanner, DOF, Korea), and the scanned Stl file then transferred to the design software (3 Shape Complete Restorative Software, Denmark) to be used in designing the complete maxillary plate patterns, then after the designing process, the design Stl file was send to DG shape software to be milled from a wax blank (Diamond, Canada) using DWX-52D 5-Axis Dental Milling Machine (Roland DGA Corporation, USA), the thickness of the patterns on both groups were about 0.5 mm (especially in the palate area), the wax patterns were prepared to be casted, and the spruing method was the same for all the patterns and the investment method was different in one point, that the milled wax patterns were invested without duplicating the master cast like what was done with the ordinary wax up group. All patterns were casted with Wironit extra-hard Cobalt-Chrome partial denture alloy, (Bego, Germany) according to the manufacturer instructions.

**Fig 5:** Conventional wax up pattern

**Fig 6:** Wax milled pattern

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.

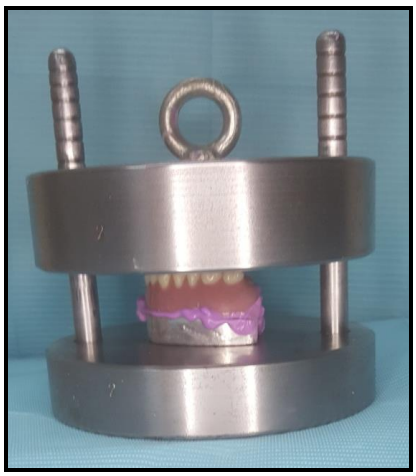


**Fig 5:** The denture with metal plate under the weight

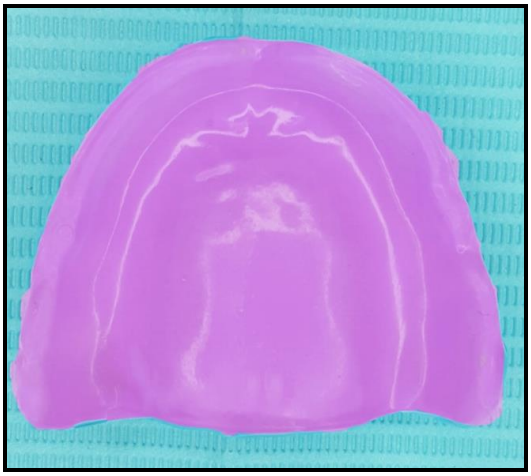


**Fig 6:** Silicone layer before weighing process.

**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 Conventional wax up and the Co-Cr complete Maxillary denture bases casted from Conventional wax up patterns and Co-Cr complete Maxillary denture bases casted from milled wax patterns were studied, and all values were considered significant at $P \leq 0.05$.

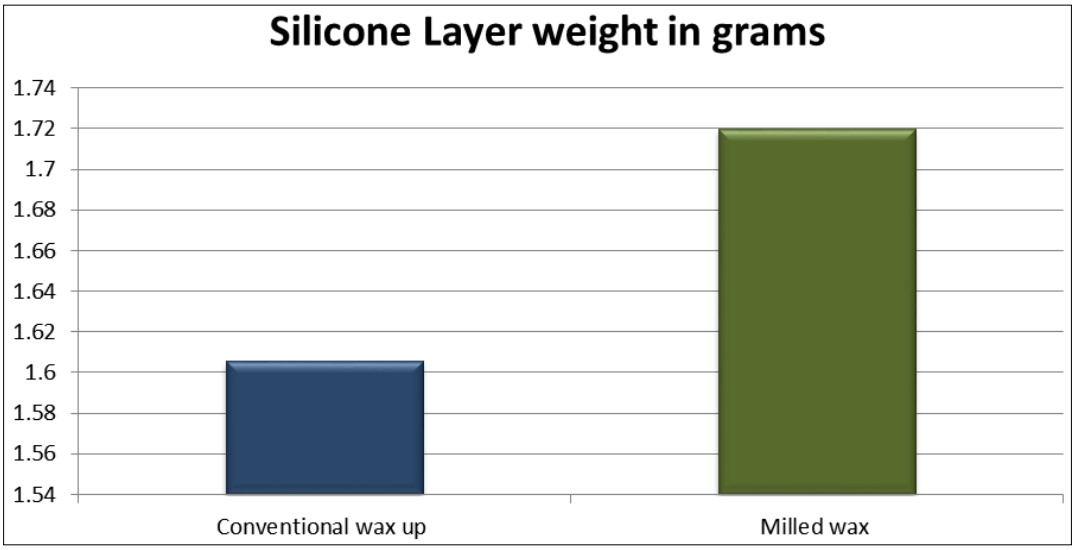
**Results**

Three different silicone layers for each one of the casted metal base dentures were weighed and the arithmetic mean of the weights was recorded. The arithmetic average of the three layers refers to the accuracy of the denture base adaptation. The mean values of the silicone layer weight (in grams) in the Co-Cr complete Maxillary denture bases casted from milled wax patterns group were greater than those for the Co-Cr complete Maxillary denture bases casted from Conventional wax up patterns group of type V (1.). The difference between values was statistically significant ($P<0.001$), that is less than 0.05 (Table 1).

**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 Conventionally wax up patterns and Co-Cr complete Maxillary denture bases casted from milled wax patterns

| Super light silicone impression material layer weight | | |
|---|---|---|
| **Mean** | **Casted Co-Cr from Conventional wax up patterns** | **Casted Co-Cr from Milled wax patterns** |
| | 1.60539 | 1.719763 |
| **SD** | 0.009417325 | 0.00046863 |




**Graph 1:** Super light silicone impression material layer weight mean comparison between the Co-Cr complete Maxillary denture bases casted from Conventionally wax up patterns and Co-Cr complete Maxillary denture bases casted from milled wax patterns

**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 [20, 21].

This study chose to compare conventional wax up to milled wax patterns because most commonly used CAD/CAM manufacturing process is milling [22].

The CAD/CAM technique was used to mill the wax patterns because it's easier to design the palate pattern using this technique, and it's more likely to get the same patterns features by using the same wax blank and the milling machine, with the same casting steps for all metal palates made.

This technique also can save time and labor [23].

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, 24].

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 [25].

This technique had been used to evaluate dentures fit accuracy in many Other researches [20, 21, 26].

Analysis of the data revealed that the maxillary dentures with Co-Cr metal palates casted from conventional wax up patterns showed a statistically significant difference ($P<0.05$) in terms of denture adaptation, as the silicone layer was lighter in those dentures (1.60539g) compared with dentures with Co-Cr metal palates casted from (CAD/CAM) milled wax patterns (1.719763g).

The findings in this study agreed with the study of Vojdani M and his colleagues in 2013,and but their study was applied on fixed prosthodontics [27]. but disagreed with the results of Arnold.C and his colleagues in 2018, but their study had been applied on partial dentures frameworks, and they found that CAD/cast frameworks that had been casted from milled wax RPDs patterns is more accurate in their fit than the frameworks that had been casted from ordinary wax up RPDs patterns [22]. we can explain that by the fact that Arnold study had concentrated on the fit of smaller area in the Rpd, while our study the surface area of the denture metal palate was larger, and that factor maybe increased the distortion of the CAD/CAM milled wax patterns, because its casted without an investment duplicated cast to support it. The results also can be related to the scanner accuracy, and the milling machine used to mill the wax patterns in the milled wax patterns.

## Conclusions

Within the limits of this study, it was concluded that the Co-Cr complete maxillary denture bases casted from Conventionally waxed patterns fit better on the master model than Co-Cr complete maxillary denture bases casted from milled wax patterns, so we still need to improve the CAD-CAM technologies related to castable milled wax patterns.

## Acknowledgement

The authors would like the following labs for their outstanding help and cooperation:

AL BASH Dental Laboratory- D.T. Youssef Mahmoud Bash - Aleppo- Syria.

AL SABBAGH Dental Laboratory- D.T Ahmad Mohammed Yasser Al Sabbagh- Hama-Syria.

AL Hindi Dental Laboratory- Eng.: Anas Ahmad Bangaly- Hama- Syria.

CAD-CAM designing: D.T. Rami Seif-Tartus-Syria

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