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In-Vitro Retention of High-Arch Maxillary Dentures Made from Conventional, Thermoformed, And Milled Cad/Cam Resins

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ABSTRACT

The purpose of the study was to evaluate the Retention of high-arched maxillary dentures constructed from conventional, thermoformed, and milled CAD/CAM resins. **Materials and Methods:** An edentulous patient with high -arched palate was selected from the outpatient clinic, Department of Prosthetic Dentistry, Faculty of Dentistry, Minia University. The patient was seeking complete denture treatment. Using the master cast of this case to duplicate thirty stone casts that were numbered and randomly arranged into one of three study groups, each group contain 10 casts. The three groups are; a conventional technique, thermoformed technique, milling technique (CAD/CAM)

The results: There are a statistical significant difference between all groups .The thermoformed group displayed the highest numeric retention mean**. Conclusions:** Based on the limitation of this in vitro study, the following conclusions were drawn: The thermoformed maxillary dentures provided the greatest retention based on mean values. The CAD/CAM milled dentures performed better than conventional heat-cured but lower than thermoformed dentures.

Keywords: Retention, Denture Base, Conventional, Thermoformed, Milled Cad/Cam Resins.

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INTRODUCTION

Retention is regarded as one of the major factors that govern the success of a complete denture, which is also enhanced by excellent adaptation and tissue adaptation .This study compared the retention force of thermoformed complete denture bases, milled versus a conventionally manufactured control, and investigated whether retention varies after being wetted by artificial saliva. According to **(Mubaraki, M. Q., et al. 2022)**, CAD CAM milling of complete dentures was selected as the preferred method of manufacturing because the retention provided by milled pre-polymerized computer-engineered complete denture (CECD) bases with polymethyl methacrylate can be greater than that of traditional heat-polymerized denture bases**.**. The maximal adherence of flexible acrylic resin to the underlying mucosa may be the reason for the thermoformed full denture's greater retention as demonstrated by **(Hssan, Sanad et al. 2016)** as compared to the standard heat-cured acrylic resin. The null hypothesis was that the retention force of denture bases would not be affected by the fabrication method.

Materials and Methods

A total of 30 specimens were divided into conventional heat polymerized PMMA group I (10), Cad Cam milled group II (10), and thermoformed group III (10) the study protocol was approved by the local research ethics committee. The Participant with Completely edentulous maxillary(v-shaped highly arched palate and class III soft palate) and mandibular with a firm and healthy covering mucoperiosteum were selected from the outpatient clinic, Department of Prosthetic Dentistry, Faculty of Dentistry, Mina University. The patient was seeking complete denture construction. The approval was taken from the patient before the beginning of the work.

1. SAMPLE SIZE AND FABRICATION OF THE MASTER CAST:

For sample size determination, it was determined that nine samples (increased to ten samples to c ompensate for dropout samples) in each group would be adequate to detect a large effect size (d = 1.624), achieving an actual power (1-β error) of 0.95 (95%) and a significance level (α error) of 0 .05 (5%) for a two-sided hypothesis test.
Primary impressions were made using alginate impression material in correctly chosen and adjust ed stock trays. Special trays were examined extra orally, disinfected by with 2.5% glutaraldehyde for Fifteen minutes, and rinsed under running tap water.

The borders of the tray were trimmed 2-3 mm shorter than the full depth of the vestibule. Makin g border molding with putty. Border molding was done using putty consistency in addition silico ne impression material and the final wash impression was made using medium consistency polye ther impression material. (SILICONE DENTAL MATERIAL ELITE HD+ ZHERMACK ITALY) Definitive impression was boxed then poured to obtain master cast.

fig (1): definitive impression

2. DUPLICATION OF THE MASTER CAST:

The three mold of the modified master cast were poured to produce 30 stone casts (TYPE IV DENTAL STONE ZHERMACK ELITE ROCK TYPE 4 X-HARD STONE ITALY) which will be used to construct the denture bases. Three molds were made from polysilicate duplicating material to avoid the deformity of any of the molds. The temperature of the water and quantity of powder of dental stone were measured and using distilled water according to manufacturer instructions. The 30 duplicated modified master casts were numbered and randomly divided into three study groups, each group contained 10 casts. **(KAZANJI and REJAB 2020)**

mold of master cast fig (2)

3. GROUPING:

Three groups were randomly divided and defined according to the material of the denture base fabricated and fabrication techniques:
Group I conventional technique constructed = 10 denture bases.
Group II thermoformed technique = 10 denture bases.
Group III milling technique (CAD/CAM) constructed = 10 denture bases.

4. THE GEOMETRICAL CENTER OF THE MAXILLARY ARCH:

This step was done before the beginning of the scanning and designing processes. A midline on the maxillary cast was drawn from the center of the incisive papilla and extended posteriorly till it met the midpoint on a line connecting the two hamular notches. A midpoint was marked on this midline to represent the center of the arch. **(AlHelal, AlRumaih et al. 2017, Faty , Sabet et al. 2022)**

5. ACRYLIC CAST MODEL CONSTRUCTION:

One of the three molds was used to construct an acrylic cast which will be used to measure the retention. The wax model cast was constructed according to heat-cured acrylic resin manufacture instructions**.**

6. SIMULATION OF THE MUCOSA COVERING THE RESIDUAL RIDGES:

A series of holes, 2mm in depth, were created in the residual ridge of the model by a number 5 round bur in one side of the model. The acrylic resin between the holes was removed using a cylindrical carbide cutter bar. After modification of the ridge at one side, it was replaced by self-cured soft liner mix (ACROSTONE RELINING MATERIAL MADE IN EGYPT) the mixing of liquid and powder of self-cured soft liner according to manufacture instructions. The model was.Then replaced in the rubber mold and pressure was applied to obtain the proper Thickness. The other side was simulated similarly to previous steps.**(Jamari, Ammarullah et al. 2022).**

Removed Acrylic between Holes fig (4)

Holes 2mm in depth of acrylic cast fig (3)

Cast after modification by soft liner fig (5)

7. CONSTRUCTION OF DENTURE BASE MILLING TECHNIQUE (CAD/CAM):

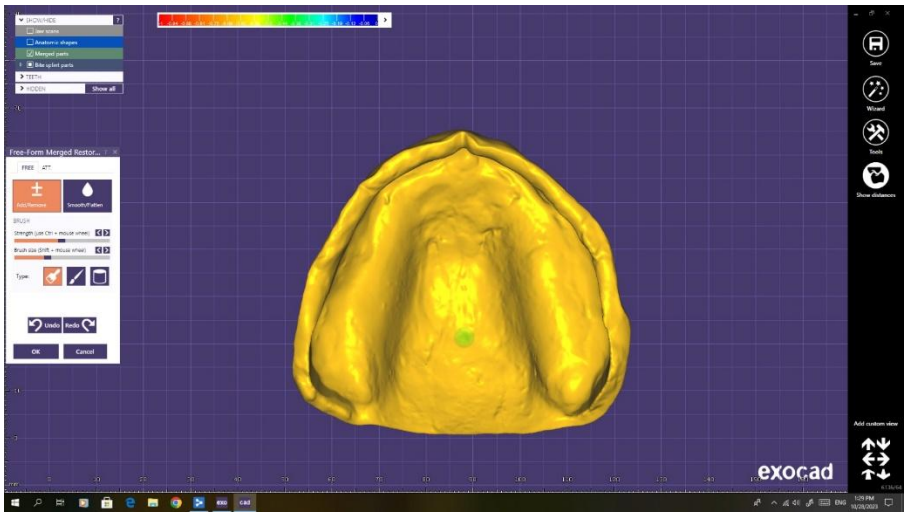
7.1 scanning step:

The master casts were ready for scanning. It was secured to the holder using a special tightening key and placed inside the scanner. (CERAMILL MAP 200+ MADE IN GERMAN)

7.2. designing procedures:

7.2.1 exocad software:

STL file of the denture base with its supporting arms was loaded with pink disc resin to fabricate the milled denture bases with holes on the geometric center of the cast.



scanning of master cast fig (6)

7.3 denture base manufacturing:

The command software of the milling machine produces files for the denture bases manufactured on PMMA discs (IVOCLAR VIVADENT PINK ZOOMJY-047 MADE IN GERMANY) leading to a product of highly adapted denture bases. All denture bases will be immersed in water for 24 hours before the evaluation of retention.

8. CONSTRUCTION OF THE HEAT CURED ACRYLIC DENTURES:

The Cad Cam denture base was sealed with the maxillary cast with base plate wax, and we used the Cad Cam denture base as a pattern for making a conventional denture base on the same thickness. The mix of artificial stone is placed on the ring while the ring of a flask is on the base of the flasks. After setting the stone open the flask and use tin foil to paint all stone surfaces of the casts and flasks stone to prevent resin from adhering to stones. Before packing the acrylic resin ensure the holes of palatal rings appear on the gypsum, at the geometric center. The PMMA was mixed in the ratio of 37.5 g powder to 15 ml liquid by spatula in a clean jar according to manufacturer instructions till the dough stage was reached and then it was packed. After that, an initial trial packing flask closure was done to remove excess acrylic resin, and the final closure was done under a force of 1.250 kg for 5 min using a hydraulic press.

The flasks were secured in a flask Carrier and placed in an acrylic curing unit to be cured by a long curing cycle (74º C for 8 hours) **(AlHelal, AlRumaih et al. 2017).**

9. CONSTRUCTION OF THERMOFORMED DENTURES:

The same steps will be done as in heat-cured acrylic dentures except that: A special flask was used with extra hard dental stone for investing to withstand the double injection procedure of the thermoformed resin. Complete investing of the waxed-up denture was carried out as usual then left for complete setup of the stone material. The microinjection machine was programmed and adjusted at 230°C heating temperature, 13 minutes heating time, 90 seconds injection time, and 7 bar injection pressure**(Fathey, El-kawiM, et al. 2018)**. A 30 gm cartilage of thermoformed denture base material. (TCS I FLEX MADE IN USA) was mounted on the micro-injection machine and injected into the flask according to the manufacturer's instructions. The denture was finished on its cast with finishing burs and stones.

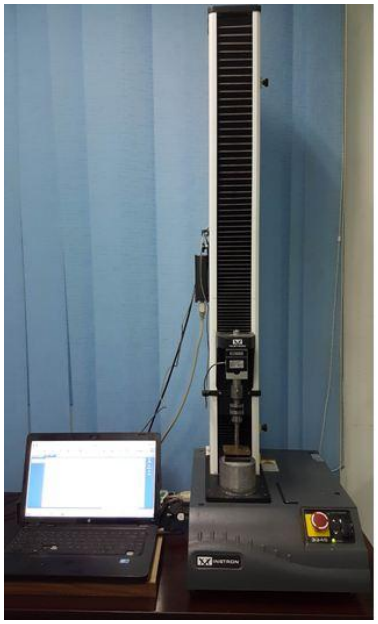
10. ADHERING OF PALATAL RING:

A ready-made metal palatal rings were adhered on the geographic centers of thirty denture bases by self-cure acrylic resin.

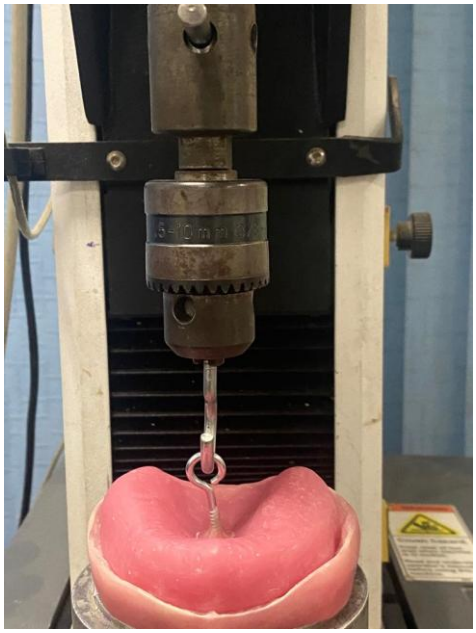
11-MEASUREMENT OF RETENTION:

Retention measured by Materials Testing Machine (MODEL 3345; INSTRON INDUSTRIAL PRODUCTS, NORWOOD, USA) with a loadcell of 5 kN. Data were recorded using computer software (BLUEHILL LITE; INSTRON INSTRUMENTS).

The upper plate of the machine included a specially designed retention measuring metal hook from which the denture was suspended while the lower compartment was attached to the acrylic base via cyanoacrylate glue. Each sample was painted with artificial saliva before being engaged in a modified acrylic cast. The sample was subjected to a slowly increasing vertical load (1mm/min) until total dislodgment of the denture base accompanied by a decline in load-displacement curve recorded by Blue Hill lite software. A pull-out mode of force was applied via a universal testing machine at a crosshead speed of 50 mm/min**.** All these measurements were carried out within 2 weeks of simulated model construction. A period of 5 minutes of rest was allowed between each three successive measurements. Data collection, arraying, and testing the data regarding retention of samples were collected, arrayed, tabulated, and tested.



universal testing machine fig (7)



metal hock engaged on denture base fig (8)

14. RESULTS:

Table (1): Retentive Comparative Statistics Of Maxillary Denture Using One Way ANOVA:

	Group I (Conventional heat-cured)	Group II (Thermoflex)	Group III (CAD/CAM Milled)	P-value
Min	1.074	3.839	3.224	0.0053*
Max	6.211	10.73	8.042	
M	3.232	5.576	4.888	
SD	1.407	1.717	1.370	

Min; Minimum, Max; Maximum, M; Mean, SD; Standard Deviation, P; Probability Level
*; Significant Different

This table presents the results of Tukey's post hoc comparisons between three maxillary denture fabrication techniques - conventional heat-cured, Thermoformed, and CAD/CAM milling.

The 95% confidence intervals and p-values allow conclusions about statistical significance. The comparison between conventional and Thermoformed dentures shows a confidence interval from -3.680 to -1.007. Since this interval does not include zero, there is a statistically significant difference between these groups at the 0.05 level, confirmed by the p-value of 0.0003. Conventional dentures have higher retention than Thermoformed.

Similarly, the interval of -2.992 to -0.3197 for conventional versus CAD/CAM comparison excludes zero, indicating a significant difference (p=0.0120). Again, conventional dentures are superior in retention to CAD/CAM. However, the confidence interval for Thermoflex versus CAD/CAM ranges from -0.6484 to 2.024, straddling zero. The high p-value of 0.4308 confirms a lack of significance. Therefore, Thermoformed and CAD/CAM dentures have statistically equivalent retention.

Discussion:

Sample size calculation was based on a continuous response variable derived from matched pairs in a prior study by ***Yamane K*** **2023**

Retention is the most successful factor that governs the success of a complete denture. CAD CAM milling of complete denture was chosen following the planned manufacturing steps **(Mubaraki, Moaleem, et al. 2022)**due to The retention offered by a milled pre-polymerized computer-engineered complete denture (CECD) bases with polymethyl methacrylate can be higher than that offered by conventional heat-polymerized denture bases.

The retention of the thermoformed complete denture was higher than that of the conventional heat-cured acrylic resin, this may be attributed to the maximum adhesion of flexible acrylic resin to underlying mucosa. The universal testing system, which is a standardized precision measuring instrument for retention, was used to measure retention.

Conclusions:

Based on the findings of this in vitro study, the following conclusions were drawn: The thermoformed maxillary dentures provided the greatest retention based on mean values. The CAD/CAM milled dentures performed better than conventional heat-cured but lower than thermoformed dentures.

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