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EFFECT OF USING TWO DIFFERENT TECHNIQUES OF DENTURE BASE FABRICATION ON RETENTION OF MAXILLARY COMPLETE DENTURE: AN IN VIVO COMPARATIVE STUDY

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KEYWORDS

CAD/CAM Denture Base, Digitally Milled, Maxillary Conventional Heat-Polymerized

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ABSTRACT

Introduction: Complete denture is used to replace the entire dentition and restore mastication, speech, and aesthetics. All other tooth-supported solutions have been exhausted. Because Computer-Aided Design/ Computer-Aided Manufacturing (CAD/CAM) dentures are milled from pre-polymerized Polymethyl Methacrylate (PMMA) blocks that do not display polymerization shrinkage, they can eliminate the laboratory processes of acrylic processing (setting up of teeth, try-in, flasking and de flasking). **Aim:** to compare the retention values of maxillary conventional heat-polymerized denture bases with digitally milled denture bases**. Materials and Methods:** Sixteen totally edentulous patients participated in the study, which was divided into two groups (n=8) (A) and (B). Patients in the group (A) received traditional heat-cured acrylic resin dentures with a long cycle water path curing procedure, in group (B) received dentures created using the CAD/CAM technique. For both groups, a metallic hook affixed to the geometric center of the maxillary dentures was pulled by a digital force-meter gauge to measure retention. **Results:** The mean retention values were recorded for both groups, tabulated, and statistically analyzed; the following results were obtained. Regarding group (A), retention values showed a significant increase at the beginning of the study as well as at the end of the study. Regarding group (B), retention values showed a significant initial increase at the beginning of the study, till the end of the study. A significant difference was revealed between the mean retention values of the two tested groups, with clear superiority of the retention of the CAD/CAM acrylic resin dentures (group B) than that of the conventional heat-cured acrylic resin dentures (group A). **Conclusion:** CAD/CAM acrylic resin dentures were superior in terms of maxillary denture retention compared to conventional heat-cured acrylic resin dentures. Retention was increased gradually over time in both two studied groups.

INTRODUCTION

The preservation of the remaining oral structures and consideration of the psychological alterations brought on by the loss of all-natural teeth must be emphasized in their design [(1)].

Historically, removable complete dentures have been made from materials such as bone, wood, ivory, vulcanite rubber, porcelain, metals, and polymers. Currently, PMMA, which is poly methyl methacrylate, is utilized the most. PMMA complete denture bases are currently made

utilizing a variety of methods, including light, heat, chemicals, microwaves, milling, and computer numerical control (CNC). Traditional complete denture construction by heat curing method can be challenging at times and involves several phases [2].

CAD/CAM dentures are milled from pre-polymerized PMMA blocks. So, digital dentures can simplify the production process by eliminating laboratory procedures of conventional acrylic processing (setting up of teeth, try-in, flasking, and deflasking). So, resulted dentures don't exhibit polymerization shrinkage [3].

Adhesion, cohesion, air pressure, as well as extrinsic forces resulting from oro-facial musculature, all have an impact on the retention of dentures. The interfacial surface tension caused by the saliva layer that is present between the base of the denture and the soft tissue supporting it is the most significant of these physical elements [4].

This study was made to evaluate the effect of using two different techniques of denture base fabrication (conventional heat-curing and cad/cam) on the retention of maxillary complete denture by comparing the retention values that were measured with a digital force gauge of maxillary conventional heat-polymerized with digitally milled denture bases.

MATERIALS AND METHODS

This research was achieved in alignment with the principles of the Declaration of Helsinki. Approval was given by the ethical committee of the Faculty of Dentistry, Suez Canal University (approval number: 86/2018).

All selected patients were informed about the details of the study and signed an informed consent approval of the Research Ethics Committee before starting the study.

The sample size was calculated to be 8 patients for each group according to the following formula, with a confidence level of 95% and a confidence interval of 2.5.

$$\text{Sample size} = \frac{Z^2 \text{ X } (P) \text{ X } (1\text{-}P)}{C^2}$$

Where: Z=Z value, P=proportion of the population having the attribute, C=confidence interval, expressed as decimal.

Inclusion criteria:

- Age ranged from 45- 65 years.
- Free of any systemic or neuromuscular conditions (such as Parkinson's disease, hemiplegia, or diabetes mellitus) that could impair the ability of the masticatory muscles to effectively chew food.
- Unaffected by any temporomandibular joint conditions.
- Class I Angle's ridge relationship.
- The mucoperiosteum should be solid and the patient's ridges should be well-developed.
- The patients must have been toothless for at least six months.

Exclusion criteria:

- Patients with unusual tongue size or behavior.
- Individuals who experience xerostomia or excessive salivation.
- Patients who have had radiation treatment to the head and neck region.
- Patients with significant ridge undercuts, flat or flabby ridges, or both.

Diagnosis:

Along with the intra- and extra-oral examinations, the patient's medical history was documented.

A. Personal history: This included the patient's name, age, sex, and occupation.

B. Medical history: All systemic diseases were examined, and each patient's whole blood count and blood pressure were measured.

C. Dental history: Patients were asked about the etiology of teeth loss as well as the duration of being edentulous.

D. Clinical examination and mouth preparation: An intra-oral examination was performed to look for any inflammatory conditions. The tongue, mucous membrane, and remaining ridges of the oral cavity were also examined.

Fabrication of the complete dentures:

1. Upper and lower primary Impressions of the stone plaster were made with alginate (Zhermack hydrogen rapid set, Italy) (Zhermack Elite dental Stone, Italy).
2. Then, special acrylic trays were made on the primary casts.
3. 2ry impressions were made by using zinc oxide & eugenol [Cavex Holland BV, Netherlands]
4. Occlusion blocks were built for jaw relation records.
5. The lower cast was mounted on the semi-adjustable articulator in centric relation using the check bite technique, acrylic anatomic teeth were set with a bilateral balanced occlusion scheme with a cusp angle of 45 degrees.
6. Clinical and laboratory remounting was done to overcome the errors that might happen during processing.

For 16 patients who were split into two groups (n=8), the steps from steps 1 through 5 were repeated 16 times to create 16 occlusion blocks that were then used to create 16 acrylic full dentures.

Patient grouping:

According to the type of denture base material, patients were divided into two groups (A) and (B), each with eight patients.

Complete dentures with a traditional heat-cured acrylic resin denture base were given to group (A).

Complete dentures were given to Group (B) using a CAD/CAM milling method for acrylic resin discs.

Group (A): The articulator and patient's mouth were carefully examined for occlusion after the dentures were waxed up and tried on. They were flasked, packed, and processed in the traditional heat-cured acrylic resin material using the long cycle curing technique (by heating the water bath containing the flask for 7 hours at 70 °C followed by 3 hours at 100 °C). Occlusion was verified using pressure indicating paste both in centric and eccentric positions.

Final dentures were polished with soap and paste to smooth out any surface roughness after being manually finished with burs, sandpaper discs, and rubber wheels.

The patients received their final acrylic dentures along with post-insertion instructions.

Wax-coated occlusion blocks and master castings were scanned in Group (B) using a unique scanner [Shining 3D Scanner, China] that made a duplicate

of the final casts from all angles before milling the occlusion block in all directions (Fig. 1).

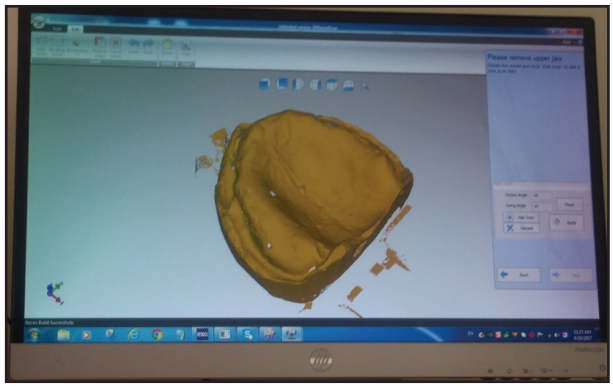

Fig. (1) Scanning of the master casts.

Then, special acrylic resin prefabricated discs (vipi block mono color 98x25mm) (Fig.2-a) were milled in a special milling machine (Milling machine (vhf. k4 edition / Germany)) (Fig.2-b) that is attached to the computer, and the acrylic denture teeth were milled and fixed to bases using special luting material. These special denture bases were made by a special computer CAD/CAM system (Exocad) [EXOCAD 2016 programmed for designing complete dentures.

Final CAD/CAM acrylic dentures were mechanically completed with burs, sandpaper discs, and rubber wheels. Any remaining surface roughness was then polished using soap and paste.

Patients received their final CAD/CAM dentures along with post-insertion instructions.

Evaluation methods:

All patients in both groups (A) and (B) were permitted to wear their dentures for the full week necessary for complete seating and adaption.

A force gauge tester meter [Rongsheng-biz, China] was used to measure the retention force.

At the point of denture base center, special stainless-steel snap hook attachments with uniform weight and dimensions were applied to the polished surfaces of the maxillary denture bases for groups (A) & (B).

By noting the center of the labial frenum (point A) and the pterygomaxillary fissures, this point was determined on the maxillary master cast that was obtained (points B&C).

The mid-posterior border of the denture base was delineated as the halfway point between points B and C. (point D).

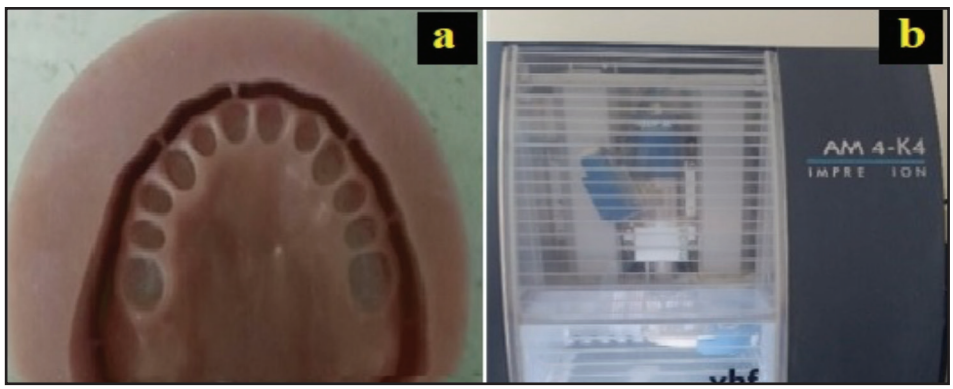

Fig. (2) Shows: (a) the Prefabricated acrylic resin disk (b) the milling machine

At last, the denture base's center—halfway between points A and D—was identified (point E).

During a morning appointment, each patient was instructed to sit comfortably in the dentist's chair with their heads resting on the headrest and their maxillary teeth's occlusal plane parallel to the floor. The denture base was given a minute to stabilize and find its balance.

For improved settling and adaption, dentures were left in the patient's mouth for two hours prior to measuring. After that, each upper denture was secured with a hook screw and its nut in the geometric center so that it could be detached from the patient's mouth and the amount of force needed to dislodge it could be measured. Each acrylic type's maxillary dentures were attached to the pull end of the digital force gauge gadget, which was then pulled vertically until the dentures dislodged.

To ensure that there were no errors in the testing system, the device was always automatically calibrated before and after each test session. The force needed to remove conventional acrylic or CAD/CAM acrylic denture bases from maxillary ridges was measured 10 times for each patient in both groups A&B, and average values were taken as a record one week after denture insertion, one month after denture delivery, after three months, and at the end of the follow-up period (6 months). Excessive values were not included.

Statistics were computed, tabulated, and applied to the data of each group.

Statistical Analysis

- Data presented as mean and standard deviation (SD).
- Explored for normality using Kolmogorov–Smirnov test.
- Data showed parametric distribution.
- Repeated measure ANOVA used to compare between tested groups and follow-up periods followed by multiple comparisons with Bonferroni correction.
- The significance level was set at $P \leq 0.05$.
- Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, and USA) Statistics Version 25 for Windows.

RESULTS

The mean and standard deviation (SD) for Retention (N) for different tested groups were presented in Table (1). The mean retention values of both groups were presented in Newton.

Table (1) *Differences in the mean retention values (N) between the two tested groups at different follow up periods.*

	Group A		Group B		p-value
	Mean	SD	Mean	SD	
Delivery	13	1	15	1	≤0.001*
1 Month	14.75	0.89	17.63	1.30	≤0.001*
3 Months	16.88	0.83	19.50	1.07	≤0.001*
6 Months	18.75	0.71	22.00	1.07	≤0.001*

**= Significant, NS=non-significant*

From table (1), the mean Retention for Group A which representing patients using "Conventional acrylic resin complete dentures " showed a lower value compared to Group B which represents patients using "CAD/CAM complete dentures" for all follow-up periods at p≤0.001. At the beginning of the study (delivery), the mean retention values for groups A and B were (13±1N) and (15±1N),

respectively. At the second follow up interval (1 month follow-up), the mean retention values of groups A and B were (14.75±0.89N) and (17.63±1.30N), respectively.

At the third follow up interval (3 months follow-up), the mean retention values for groups A and B were (16.88±0.83N) and (19.50±1.07N), respectively. At the end of the study (6 months follow up), the mean retention values for groups A and B were (18.75±0.71N) and (22.00±1.07N), respectively.

Statistical analysis showed that there was a significant difference between the mean retention values of the two tested groups at the end of all the recorded intervals standard.

Mean and standard deviation (SD) for Retention (N) for different follow-up periods for each group were presented in table (2) and Figure (3).

The mean retention values of both groups were presented in Newton. Regarding the significance in the difference, it was considered at p=0.001.

For group A patients the mean retention value at the beginning of the study (Delivery) was (13±1N) and after (1-month follow-up) was (14.75±0.89N) and after 3 months follow-up it increased to (16.88±0.83N), while by the end of the study (6 months follow up) the mean retention value increased to (18.75±0.71N).

Table (2) *Mean and standard deviation (SD) for Retention (N) for different follow-up periods for each tested group.*

	Delivery		1m		3m		6m		p-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Group A "Conv.CD"	13[a]	1	14.75[b]	0.89	16.88[c]	0.83	18.75[d]	0.71	≤0.001*
Group B "CAD/CAM"	15[a]	1	17.63[b]	1.30	19.50[c]	1.07	22.00[d]	1.07	≤0.001*

Different letters within each row indicate significant difference **= Significant, NS=non-significant*

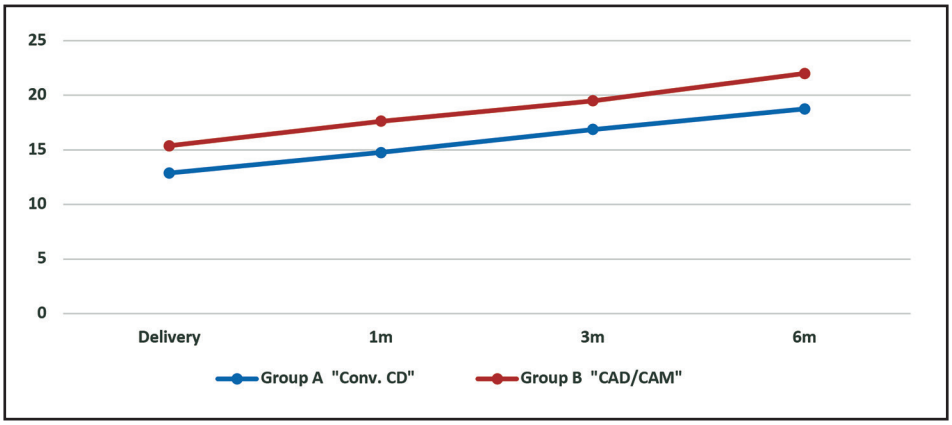

Fig. (3) Line chart showing the mean Retention (N) for follow-up for different tested groups.

Statistical analysis showed no significant increase between the first and second follow-up intervals and between the second and third follow-up intervals as well as between the third and the fourth intervals. But showed a significant increase between the first and the fourth follow-up intervals.

For group B patients the mean retention value at the beginning of the study (Delivery) was (15±1N) and the second follow-up interval after (1-month follow-up) was (17.63±1.30N), and at the third follow-up interval after (3 months follow up) it increased to (19.50±1.07N), while by the end of the study (6 months follow up) the mean retention value increased to (22.00±1.07N).

Statistical analysis showed a significant increase in mean retention for both groups ($p \leq 0.001$) after one month followed by a significant increase after 3 months followed by a further increase after 6 months.

DISCUSSION

The success of a full denture depends heavily on retention. To enable for close adaptation of the denture to the underlying tissues to accomplish retention, the denture base should be an exact reproduction of the patient's mouth.

In this study, the effects of two alternative denture processing methods—the cad cam method and the traditional heat curing method—on the preservation of maxillary full dentures were examined. With ages ranging from 45 to 65, 16 male patients with total edentulousness were chosen. The majority of edentulous patients fall within this age range; hence this range was chosen. Additionally, very elderly patients were not included since, in addition to the natural alveolar bone loss that comes with aging, they also tend to have more systemic health issues, have slower healing rates, and have a harder time keeping up with dental cleanliness. Additionally, patients above the age of 50 were chosen in order to prevent senility-related muscular atrophy because aging affects the muscle's efficiency [5-8].

Parkinson's disease and hemiplegia were not considered in the selection of patients since they could have an impact on denture retention. We ruled out any tempro-mandibular joint anomalies since they could lead to prosthetic failure because of a lack of neuromuscular control [9].

Patients with aberrant tongue size, behavior, or excessive salivation while taking drugs that alter salivary flow (such as diuretics) were excluded. Patients with abnormal salivary content or nature were also excluded. Patients with systemic illnesses that could alter saliva production or consistency, such as uncontrolled diabetes mellitus, were also disqualified since any abnormality in saliva consistency would compromise the stability and retention of dentures [10,11].

Patients who had undergone irradiation to the head and neck were not included since radiation can cause hypo-vascularity, xerostomia, mucositis, hypoxia, fibrosis, and, most dangerously, osteoradionecrosis in the oral cavity [12,13]. Patients with significant bony undercuts were also not included since they might be misled about denture retention. To avoid the impact of hormonal fluctuations, men were chosen as patients. In order to increase denture stability and retention, the edentulous ridges used for this investigation had normal morphology without severe undercuts or bony spicules. To prevent discomfort that could force the removal of the dentures for a period of time and perhaps impair the outcomes, the mucosa was free of any indications of irritation [14].

In order to decrease denture base movement across rebound tissues, which could impact denture

base stability and lead to erroneous results while testing the retentive quality of the denture, patients with firm mucoperiosteum covering the ridge were chosen as patients [15].

Due to the mandible's unfavorable surface areas and the difficulty in centralizing forces caused by the presence of the tongue, a clinical study was conducted to compare the retention of conventional heat-polymerized denture bases and pre-polymerized milled denture bases in the maxilla rather than the mandible [16].

Remounting in the lab and on patients was done to correct any mistakes that might have occurred during the heat-curing procedure [17,18]. All patients were permitted to wear their dentures for the full week necessary for complete seating and adaption of full dentures. For better settling and adaption, the dentures were left in the patient's mouth for two hours before the measurement [18].

The patient was instructed to position their body in the dental chair so that the mandibular teeth's occlusal plane is parallel to the ground. During the measurements, patients were instructed to keep their heads fixed because any adjustments to head position could vary the length and direction of traction [19].

The use of the metallic hook enabled gauge attachment during the application of force for the retention test. The geometric center of the denture base, which was thought to be the most reliable area for assessing retention, was fastened to this hook [20].

Each reading was recorded ten times for each patient during the same follow-up visit to ensure the correctness of the results and the elimination of any measurement-related error. The average measurement was then calculated and recorded [21]. To avoid any measuring inaccuracies, the measuring device was automatically calibrated before and after each measurement session.

The goal of this study was to determine which denture base material was more effective at improving the seal and overall retention of the maxillary denture: standard heat-cured acrylic resin or CAD/CAM acrylic resin denture bases.

This study aimed to compare the retention of traditional heat-cured maxillary complete dentures with that of maxillary complete dentures made using CAD/CAM manufacturing techniques. From the start of the trial to the end of the study period, the mean retention values reported for the maxillary dentures in both groups increased significantly and independently (6-month period). This might be explained by the fact that both dentures have settled on the patient's robust mucosa and by their greater neuromuscular adaptation to the denture.

Despite the denture base processing approach, the patient's neuromuscular control over their dentures is represented by the action of the tongue and cheek forces, which therefore act to maintain the integrity of the border seal and gradually develop over time [22].

It was clear that between the first and second follow-up intervals and between the third and fourth follow-up intervals, the mean retention values in group (A) increased statistically significantly. This improvement in retention was likely caused by the underlying tissues' ongoing adaptation to the denture over time, which produced a final superior peripheral seal and improved denture retention [23].

Since CAD/CAM dentures have better qualities than those made traditionally, it was clear that the initial mean of retention value in group (B) increased statistically significantly in comparison to the initial mean of retention values in group (A) [24].

Between the first and second follow-up intervals, the third and fourth follow-up intervals, and from the first follow-up interval until the end of the study, the mean retention values in group (B) demonstrated

a statistically significant increase. The milling procedure utilized in CAD/CAM dentures was the source of the increase in retention. The denture base no longer experiences processing-related volumetric variations because it is now machined to its final dimension from a block of industrially pre-polymerized resin. Due to adequate settling and time, the final denture bases had great retention records in the patient's mouth [24-26].

When both groups' retention was evaluated at each follow-up interval (dentist delivery, one-month following denture placement, three months, and six months), it was discovered that group (B) had statistically significantly higher mean retention values than group (A) at each follow-up interval. This may be related to the milled CAD/CAM dentures' greater initial adaptability and maximal adherence to the underlying mucosa, which would increase retention; this was in line with the study's findings, which showed similar outcomes [25,26].

The effective initial peripheral seal and the close contact between the denture base and the underlying supporting structures, which enhance the action of atmospheric pressure and resist the dislodging forces applied to the dentures, may be responsible for the higher retention values recorded in the CAD/CAM acrylic resin dentures [24].

The higher retention values seen in group (B) may be because of the use of the subtractive CAD/CAM processing approach, which makes up for acrylic resin's polymerization shrinkage that occurs during denture production using the traditional heat-curing methodology. On the other hand, the higher water sorption that the traditional acrylic resin exhibited may be the cause of the lower retention values observed in group (A). According to various investigations, water sorption was linked to dimensional alterations that had an adverse effect on denture adaption, border seal, and retention [26].

Additionally, the lower retention values observed in group (A) may be a result of polymerization shrinkage, which is more pronounced in the posterior palatal region, and plaster hygroscopic expansion during processing, both of which have an impact on palatal adaptation and posterior palatal seal and denture retention [27].

CONCLUSION

1. Maxillary denture retention was better with CAD/CAM acrylic resin dentures compared to traditional heat-cured acrylic resin dentures.
2. In the two groups that were being investigated, retention gradually rose over time.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Authors contribution

All authors are equally contributed.

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