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Cover Page Footnote

First and foremost, I thank ALLAH, the most beneficent, the most merciful and the giver of all knowledge for granting me the perseverance to accomplish this work. This research is dedicated to my wonderful, amazing, the most encouraging and the most giving family. To the great woman who is the reason after Allah why I am standing here today and to my lovely sisters and brothers.

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Retention of Rapid Prototyped Complete Dentures Using Two Different Types Liquid Resin

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ABSTRACT

Objectives: Comparing the retention of upper complete denture manufactured using two different denture base materials, both of them were manufactured using rapid prototyping method.

Methods: Nineteen patients were selected. For both groups, the dentures were manufactured using Rapid prototyping method following the next steps, a preliminary impression was made & trial denture bases were constructed on the primary casts for the upper & lower arches for a jaw relation record. A facebow record was used to mount the upper cast, while the lower cast was mounted using a centric relation record. Setting of artificial teeth was performed, then the denture was tried in patient`s mouth. Functional impression was taken during the try in stage. CBCT scanning of the try in with the functional impression was done to obtain STL file then denture manufacturing was done by 3D printing.

Results: results showed that there is no significant difference between the two groups.

Conclusion: Complete denture retention is not significantly affected by the material used for denture construction.

Clinical significance: This in-vivo cross over study introduces a novel approach for digital construction of upper complete denture using recent materials and gives an idea about their retentive values.

1. INTRODUCTION

Edentulism is a definitive condition that is the endpoint of periodontal disease and dental caries. Dental caries is considered to be the main cause of edentulism in ages < 45 years, while periodontal disease is the primary cause of tooth loss in older ages. [1] Other factors such as oral hygiene practices, nutritional habits, and socioeconomic inequalities have been suggested as being stronger driving factors. [2]

The success of a complete denture relies on three basic factors: retention, stability and support; and these three factors play an important role in the satisfaction of the complete denture patient. Retention relates to the forces that are necessary to completely remove the denture from its basal seat. [3] this is why One of the most common causes of conventional complete denture failure is their inaccuracy & their non-retentive properties due to the dimensional changes which were found to be due to processing technique.

In an attempt to overcome the disadvantages of conventional processing digital technologies including 3D-printing were introduced to provide the clinician with alternatives to traditional processed complete denture.

3D-printing is one of two main categories of Computer aided manufacturing, which are additive and subtractive. Subtractive manufacturing is based on milling the designed restoration from a larger blank by a computer numeric controlled (CNC) machine. While Additive manufacturing (AM) is defined as the process of joining materials to make objects from 3D model data, usually layer upon layer.[4]

The main benefit of AM techniques is that the medical models can be produced with undercuts, voids, internal details and anatomical landmarks such as sinuses and neurovascular canals. The AM model is currently employed to improve medical diagnosis and to provide a precise surgical treatment plan. The frequent technologies that are used in dental practice are stereolithography (SLA), digital light processing (DLP), inkjet-based system, liquid crystal display (LCD), multi-jet printing (MJP), continuous liquid interface production (CLIP), two-photon 3D printing (TPP), selective laser sintering (SLS), and fused deposition modeling (FDM). While various materials can be employed in these technologies; wax, plastics, ceramics, and metals. [4] [5]

2. MATERIALS AND METHODS

A- Patient history and clinical examination:

Precise medical and dental history were taken from all patients through a direct interview. Extra oral examination was performed following routine procedures to detect any facial abnormality. The Angle classification of the maxilla-mandibular relationship was identified for each patient by examination of his profile. Also, observation of the patient's physical

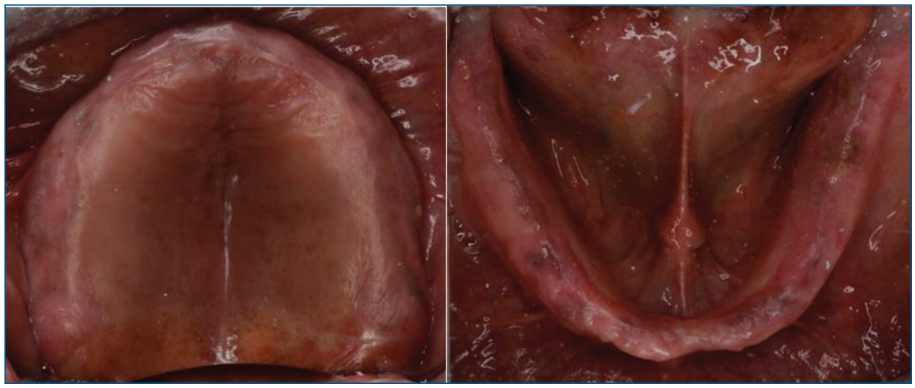

Figure (1&2): Intra-oral examination of maxillary and mandibular alveolar ridges

abilities, motor skills and level of coordination was done as this may be the first indication of a bone, joint or muscle problem. Full intra-oral visual and digital examination was performed thoroughly to examine the denture bearing area particularly in the maxilla to evaluate the covering mucosa, shape of the palatal vault, median palatine raphe, presence of torus palatinus and the extent of the development of the residual ridge and the maxillary tuberosity. These procedures were important to ensure the recruitment of patients who fulfilled the previously mentioned inclusion criteria.

B- complete denture construction:

For each patient two upper dentures were constructed. Thus, two groups were defined according to the type of resin used, Group I: Dentures were constructed by rapid prototyping using denture base liquid resin and Group II: Dentures were fabricated by rapid prototyping technique using temporary tooth colored liquid resin.

B1-Primary Impressions and jaw relation:

Upper and lower primary impressions were taken in properly selected and modified stock trays using alginate impression material* then, the impressions were poured.

Trial denture bases Fabrication of uniform thickness over the diagnostic casts were done. The borders of the trial denture bases were trimmed 2-3 mm shorter than the depth of the vestibule then a wax rim Using utility wax** was added to the upper and lower trial denture bases then Jaw relation records were taken using check-bite technique.

A facebow record was used to mount the upper cast, while the lower cast was mounted using a centric relation record.

B2-Try-in stage:

The articulator was sent to the laboratory for setting up of the teeth. Setting of artificial teeth was performed by the lab technician, then the Trial dentures were tried inside patients' mouth to ensure extension, retention, stability, midline, occlusal plane orientation, centric relation, vertical dimension, esthetics, phonetics and facial support.

B3-Secondary Impressions:

Once the trial dentures were approved, wax-up was finished on the study cast then, Functional impression was taken during the try in stage; after checking the borders extension and the adaptation of the trial denture base intraorally border tracing was done using green stick compound***.

* Alginate, Tropicalgin, Normal setting, Zhermack, Italy

** Modelling wax, Cavex set up regular, Netherlands

*** Modelling wax, Cavex set up regular, Netherlands

B4-Construction of the dentures:

Data acquisition and designing process for the dentures was done through CBCT scanning of the upper trial denture base with the functional impression was done to obtain DICOM file, the scanning was done at faculty of oral & dental medicine Cairo university, exposure parameters were 90 Kv, 10 mA, and 13.4 s.

DICOM file was imported into 3D Slicer software (DICOM viewer processed the 3D morphological STL format data for the complete denture) for segmentation.

Determination of the geometrical center was done to aid in outcome measurement. The STL file was imported into blender software version 2.81. Blender is a software used for 3D modeling, animation, and rendering, this software has a feature that determines the center of any given 3D object, which is used to apply different directional forces to that object to be able to move in any direction.

After determining the center of the denture, a hole was engraved exactly to coincide with this center. The new object was selected and was exported into STL format and sent back to the laboratory for printing purposes.

The STL file of the upper denture base was imported to CHITUBOX V1.6.3 software to create the supporting arms generating a new STL file of the denture with its supporting arms.

The last STL file was imported to the printing machine - (LCD) technology

B4-1- The First Group: rapid-prototyped dentures were constructed using denture-base liquid resin:

The tank of the machine was loaded with denture base liquid resin (pink in color) – and an order was given to start the printing process. It took about 90 minutes to complete printing the dentures. The layers were formed in a thickness of 100 microns.

B4-2- The Second Group: rapid-prototyped dentures were constructed using Tooth-colored liquid resin:

The tank of the machine was loaded with Tooth colored resin– photocurable and an order was given to start the printing process. It took about 90 minutes to complete printing the dentures. The layers were formed in a thickness of 100 microns.

For the two groups, the platform was removed from the printing machine after the printing process has been completed, then the dentures were separated from the platform using a large metal spatula. The printed dentures were rinsed twice in a 96% in an ultrasonic bath, A first rinse of 3 minutes was followed by a second rinse for approximately 2 minutes. The dentures were then inserted in a post curing unit for 20 minutes for further polymerization.

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The support structures were then removed and the outer surface of the printed dentures were finished and polished.

C- Outcome measurement:

The retention of the maxillary denture was tested by measuring the force required to dislodge the denture from the basal seat using digital forcemeter. Digital forcemeter**** was ana advanced type of forcemeter device. to read the force, required to dislodge each denture base from the edentulous ridge. Forcemeter, also called push-pull gauges or tension gauges, measure the tensile (pull) or compression (push) force applied to an object. It is characterized by high precision, ease of operation and carry. It has different types of testing heads that can be used. N (Newton), kg (Kilogram) or lb (Pound) are three measuring units that can be used.

In the first follow up visit, after settling of the dentures, retention Was recorded as the primary outcome. Detailed procedures required for measuring the outcome are explained in the next coming session. Each denture base was inspected, wetted and seated intraorally, Adjustments were made using pressure indicator paste to detect areas of impingement and then relieved. Participants were asked to also provide verbal feedback regarding areas of discomfort, and those areas were identified with pressure indicator paste and relieved. The wet denture base was then firmly seated over the foundation and was kept in position for 5 minutes for settling. They were instructed to close in maximum, inter-cuspation for 5 minutes, after which vertical downward and lateral pulling forces were applied by the fingers on the anterior teeth to test the seating before the metallic ring was engaged. A stainless-steel hook attachment with standardized weight and dimensions was fixed in the center of the denture base, using auto polymerizing acrylic resin from the polished side, so that it almost assumed a perpendicular relation to the palate, for 10 minutes in 43 C water according to the manufacturer's instructions. The wire hook attached at the center of denture base was then engaged by wire loop of nylon fishing line.

The digital force gauge was prepared first, the unit of measurement was chosen in kilograms and the peak hold option was selected. The display before each measurement was adjusted to zero via the zero button.

Dislodging force was applied to the denture base by rotating the hand in clockwise direction, the required force was created and applied slowly on the denture base till the maxillary denture base was dislodged. a dislodging force was then created and applied at right angle to denture.

The measuring procedures were repeated 3 times at 5 minutes intervals for each denture base and the average value was recorded and collected in a table.

One month following denture insertion, the maxillary dentures were taken from the patients for a wash out period of 2 weeks, after which, the retention of the other denture was tested, and its values were recorded.

D- Statistical Method:

Data was analyzed using IBM SPSS advanced statistics (Statistical Package for Social Sciences), version 21 (SPSS Inc., Chicago, IL). Numerical data were described as mean and standard deviation or median and range. Categorical data were described as numbers and percentages. Data was explored for normality using Kolmogrov-Smirnov test and Shapiro-Wilk test. Comparisons between before and after treatment for normally distributed numeric variables was done using the paired t-test while for non-normally distributed numeric variables was done by Wilcoxon sign test. Comparisons between categorical variables was performed using the chi square test Mcnemar test. A p-value less than or equal to 0.05 was considered statistically significant.

**** Extech 475055 High-Capacity Force Gauge

3. RESULTS

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

Table (1)— Independent sample t-test comparing retention between 3d printed denture using denture base resin versus using tooth colored resin (unit: kg)

	First group (M±SD)	Second group (M±SD)	P value
Retention values in kg	5.845±2.090	6.476±1.704	**.184 N. S**

**: Statistically significant (p<0.05) NS: Statistically not significant (p>0.05)*

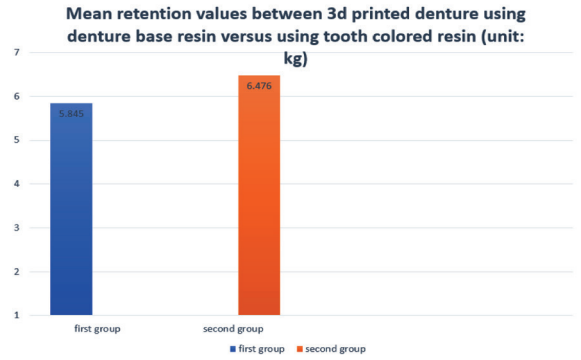

Figure (1) —Bar chart of Mean retention values comparing retention between 3d printed denture using denture base resin versus using tooth colored resin (unit: kg)

4. DISCUSSION

Patient recruitment was carried out following strict inclusion criteria such as the involvement of completely edentulous patients with normal facial symmetry and well-developed ridges preferably U-shaped palatal vault as retention value was found to be greatest in the U-shaped type and least in the tapered type. [6] and [7]

To simplify the construction of digital dentures CBCT scanning was used because it allows acceptable spatial resolution of the image, minimizes the data acquisition time, resulted in a great shift from 2D to 3D approach of data acquisition and image reconstruction allowing dentist to fabricate digital dentures without the need to buy a specific software. [8]

Photocurable acrylic resins are available for fabricating the dentures using 3D printers. Up to date, there are a few products licensed for use in patient's mouths. The fluid resins***** used in this study is FDA approved. The safety of these 3D printing acrylic materials is being tested and they are being assessed for long-term use.

No significant difference between the two groups may be attributed to several reasons:

- The retention as a main outcome depends mainly on case selection including arch form, presence or absence of saliva ...etc. rather than it's dependance on the material used for construction.
- The main drawbacks of 3D printing technique such as the involvement of several sequential steps, discrepancies can be incorporated in each step of the process, including designing in the CAD software, slicing procedure in the printing software, and during the printing process ...

***** Photopolymerizable PMMA liquid resin of crown and bridge work was supposed to be a temporary restorative material that can last for maximum 6 months & NEXTDENT denture base resin

all these factors may lead to discrepancies in the printed dentures which affect its retentive values.

- The retentive value depends mainly on the technique of curing rather than depending on the used material.

To sum up, we can say that although retention measuring techniques are better standardized in in-vitro studies, and despite of the variables that might affect the accuracy of the intra-oral measurements the present results of this study would help when selecting the most appropriate denture base material and technique of construction, despite the fact that some of the limitations of this study is the small sample size, and the absence of a follow-up sessions to record the retentive values so our recommendation for future clinical trials to be done with larger sample size and with approtiate follow up period this will result in better results and conclusion.

5. CONCLUSIONS

This study showed that:

1. Different types of liquid resin may end by dentures with similar characteristics.
2. Changing the type of curing for the resin may affect the denture's characteristics way more pronounced than changing the liquid resin.

6. RECOMMENDATIONS

Further investigations over a longer period of time should be evaluated.

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