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Evaluation of retention and patient satsifaction for maxillary complete denture constructed by 3D printing technique and conventional technique

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Abstract:

Purpose: Evaluating retention and patient satisfaction for maxillary complete denture fabricated by 3D printing technique compared to conventional denture. **Material and Methods:** Subject group of ten completely edentulous patients were selected from the outpatient clinic of removable prosthodontics department, faculty of dental medicine for girls, Al-Azhar University. Each patient received maxillary and mandibular dentures fabricated by conventional technique besides maxillary denture fabricated by 3D printing technique. The ten patients were divided equally to two groups. First group patients received conventional dentures first then 3D printed ones. Second group patients received 3D printed dentures and conventional dentures later. **Results: T**his study showed that 3D printed dentures exhibited statistically significant higher retention and patient satisfaction at ($P \leq 0.05$) compared to conventional dentures. **Conclusion:** Utilizing 3D printing technique in complete denture fabrication yields better retention and patient satisfaction compared to conventional technique.

Keywords: Complete denture; 3D printed Dentures; Retention; Patient Satisfaction.

Introduction

Despite the vast abundance Despite the vast abundance of treatment methods for edentulous patients, conventional complete denture treatment still prevails (1). Nevertheless, problems may arise after insertion of complete dentures. Such problems are often complaints of insufficient retention, inadequate stability, tissue irritation, ulceration, and faulty esthetics (2).

One of the most used materials in complete dentures is Poly methyl methacrylate (PMMA) (3). Besides the great benefits such material offers, there are some downsides that restrict its use such as high polymerization shrinkage, dimensional instability, and complicated processing procedures. Such downsides in turn affects denture retention, mastication and speaking ability (4,5). Thus, needs were raised for novel techniques to overcome complete dentures downsides.

Incorporating CAD/CAM technology into complete dentures design and fabrication enhances dentures' quality and reduce lengthy laboratory work and procedures. CAD/CAM fabrication of complete dentures is attained by either subtractive computerized numerical control (CNC) milling manufacturing, or by additive manufacturing via three-dimensional (3D) printing known as rapid prototyping (RP) (6,7).

The subtractive manufacturing utilizes end-milling of solid block materials in order to produce physical model via CNC machinery. Despite the subtractive method is effective in complete denture fabrication, it exhibits some draw-backs. Such downsides materialize in large amount of wasted material while milling. Additionally, the milling tools are exposed to high abrasion and wear. Moreover, it cannot be used in deep undercut (8).

On the other hand, additive manufacturing is a process which entails layer by layer joining to produce models relying on computerized three-dimensional data (3D). This technology was introduced in late 1980s and has been used in the medical field for production of anatomical 3D models for surgeries since 1990s (9,11).

Additive manufacturing using 3D printers has drawn attention in the field of prosthetic dentistry. Such technique showcased the ability to mold material based on CAD data influencing; the overall quality, the mechanical properties of printed parts, and the manufacturing time (12).

MATERIAL AND METHODS:

Paper scope was based on ten completely edentulous patients. The patients were selected from the outpatient clinic of removable prosthodontics department, faculty of dental medicine for girls, Al-Azhar University. Participants in this study were informed about the treatment steps, methodology, and written consent was granted accordingly. The tar-geted age range was from 55 to 60 years besides being free from any systemic and oral diseases. Each patient received two maxillary dentures; conventional and 3D printed, besides one mandibular conventional denture. The ten com-pletely edentulous selected patients were divided into two equal groups, five patients each.

Group 1: Patients in this group received their conventionally fabricated denture first then were asked to take it off for 2 weeks as wash out period. Following to that they wore their rapid prototyped denture.

Group 2: Patients in this group wore their 3D printed denture first then asked to take it off for 2 weeks as wash out period. Following to that they wore their conventional denture

3D Printed Denture Construction:

To get 3D printed denture, the below sequence was undergone per patient.

Data acquisition: data obtained by scanning upper and lower master casts by extra-oral scanner. The occlusion blocks were sprayed by scanner spray then were fitted on their master cast. Following to that step the same device was used to scan the blocks.

Designing procedures: files in .STL format of master casts and jaw relation records were imported to Exocad™ soft-ware platform. The software enabled virtually simultaneous mounting and aligning. This in turn allowed further analysis and designing to be completed. Each denture had two STL files that were printed separately; one for denture base, and one for the teeth using 3D printer.

Manufacturing procedures: the designed dentures STL files were sent to the 3D printer software. The dentures were printed according to Digital Light Projection (DLP) technology using desktop 3D printer. Consequently, teeth were attached in the denture base through fitting them in recessed pockets in denture base via resin, and finally finishing was done.

Retention measurements:

Retention was measured by universal testing machine by getting denture resistance corresponding to vertical dis-placement force. Each denture was modified to install two small metal tubes (3 mm in diameter). The tubes were mounted few millimeters above the laterals in maxillary dentures by self-cure acrylic resin. Both distances between the right tube to the geometric center and left tube to the same center were of similar values. The exact distance for each tube was verified by the aid of orthodontic wire. Each patient was seated in an upright position, while properly fixing his chin on a support. The device's bar was firmly connected to the denture and in accordance the attachment part of the universal machine was adjusted. The device gradually exerted steps of increasing vertical load (10mm/min) until the denture came totally out of place. The load at dislodgment point is indicated by an audible tuck sound. Also, it is characterized by an abrupt drop in force plot in the recorded computer software data. (Nexyge- MT-4.6; Lloyd Instruments). The same test was repeated five times to obtain five records.

Patient's satisfaction:

Patient satisfaction was evaluated for both conventional and 3D printed dentures after 1 and 3 months follow up through a validated questionnaire. That questionnaire was given to the patients in Arabic to obtain relevant data for assessment. It entailed five domains: functional complaints, overall masticatory ability, masticatory ability for different types of food, effect on mental and daily life and overall denture satisfaction. Evaluation of patient satisfaction took place by scoring system and visual analog scale (VAS) in which patients provided their answers as a mark on a scale from 0 to 10 cm (low/worst to high/best).

RESULTS:

Retention: Two-way repeated measures ANOVA results reflected that the two variables (denture type regardless of time, and time regardless of denture type) are independent. Regarding effect of different interactions on retention, it was found that at base line, after one as well as three months; 3D printed dentures showed statistically significantly higher mean retention than conventional denture (P-value = 0.028, Effect size = 0.432), (P-value = 0.026, Effect size = 0.442) and (P-value = 0.017, Effect size = 0.489). With both denture types, there was a statistically significant change in mean retention values by time (P-value <0.001, Effect size = 0.947) and (P-value <0.001, Effect size = 0.89). Pair-wise comparisons between follow up times revealed that there was a statistically significant increase in mean retention values after one month as well as from one to three months.

Table 1. The mean, standard deviation (SD) values and results of two-way repeated measures ANOVA test for comparison between retention values with different interactions of variables

Time	**3D Printed**		**Conventional**		***P*-value (Between dentures)**	**Effect size *(Partial eta squared)***
	Mean	**SD**	**Mean**	**SD**		
Base line	20 ^{C}	3.2	15.5 ^{C}	4.3	0.028*	0.432
1 month	22.5 ^{B}	3.2	18 ^{B}	3.9	0.026*	0.442
3 months	24.3 ^{A}	3.8	20 ^{A}	3.8	0.017*	0.489
***P*-value (Between times)**	<0.001*		<0.001*			
Effect size *(Partial eta squared)*	0.947		0.89			

*: Significant at P ≤ 0.05, Different superscripts in the same column indicate statistically significant change by time.

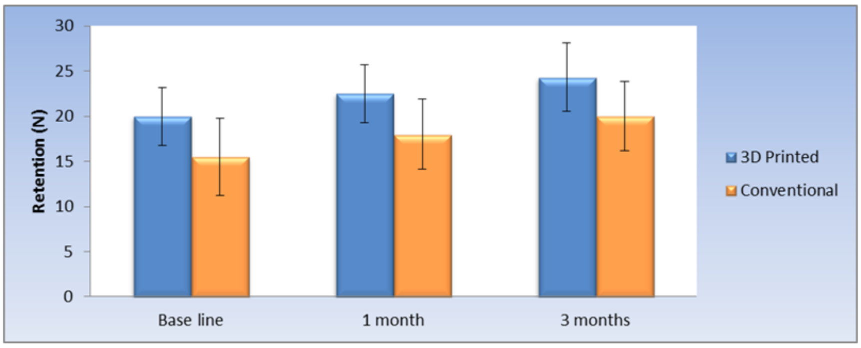

Figure 1-Bar chart representing mean and standard deviation values for retention with different interactions of variables

Patient Satisfaction: Patient Satisfaction surveyed after one month exhibited no statistically significant difference between each item of satisfaction scores with the two denture types. Nevertheless, 3D printed dentures showed statistically significantly higher median overall satisfaction score than conventional denture (P-value = 0.039, Effect size = 4.737).

Patient satisfaction conducted after three month showed no statistically significant difference between each item of satisfaction scores with the two denture types, however; 3D printed denture showed statistically significantly higher median overall satisfaction score than conventional denture (P-value = 0.042, Effect size = 4.355).

Table 2. Descriptive statistics and results of Wilcoxon signed-rank test for comparison between patient satisfaction scores with the two denture types after one month

Item	Time	3D Printed		Conventional		*P*-value	Effect size *(d)*
		Mean (SD)	Median (Range)	Mean (SD)	Median (Range)		
Functional complaints	1 Month	1.44 (0.25)	1.29 (1.21-1.79)	1.64 (0.32)	1.5 (1.29-2.07)	0.500	0.632
Overall masticatory ability		1.09 (0.36)	1 (0.86-1.71)	1.83 (0.54)	1.86 (1-2.43)	0.078	2.556
Masticatory ability with food types		1.1 (0.14)	1 (1-1.25)	1.3 (0.33)	1.25 (1-1.75)	0.157	1.633
Effect on daily life		1.7 (0.14)	1.75 (1.5-1.88)	1.63 (0.32)	1.5 (1.38-2.13)	0.581	0.509
Overall satisfaction		8 (0.2)	7.86 (7.86-8.29)	5.83 (0.19)	5.71 (5.71-6.14)	0.039*	4.737
Functional complaints	3 Month	1.23 (0.2)	1.21 (1.07-1.57)	1.54 (0.36)	1.5 (1.07-2)	0.279	1.109
Overall masticatory ability		1.06 (0.37)	0.86 (0.86-1.71)	1.77 (0.52)	1.71 (1-2.43)	0.104	2.116
Masticatory ability with food types		1.1 (0.14)	1 (1-1.25)	1.3 (0.33)	1.25 (1-1.75)	0.102	2.138
Effect on daily life		1.58 (0.11)	1.5 (1.5-1.75)	1.55 (0.23)	1.5 (1.25-1.88)	0.705	0.343
Overall satisfaction		8.34 (0.16)	8.29 (8.14-8.57)	6.37 (0.3)	6.43 (6-6.71)	0.042*	4.355

*: Significant at P ≤ 0.05.

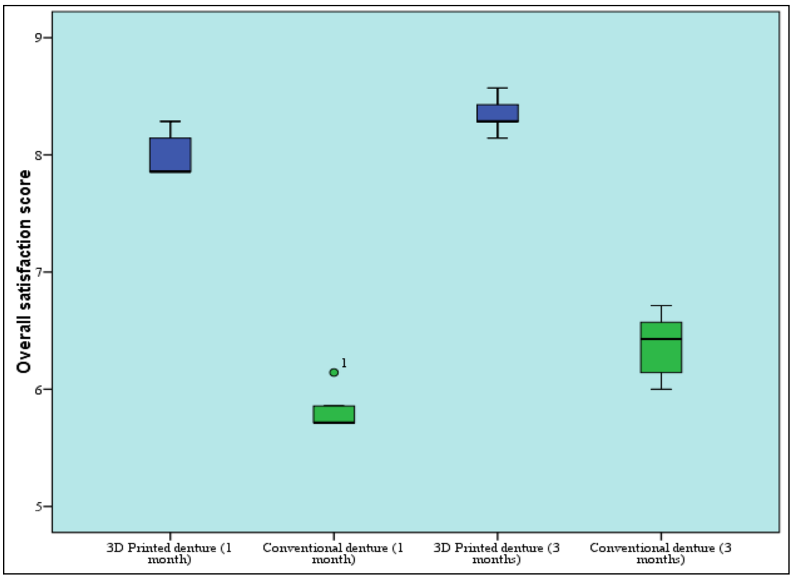

Figure 2 Box plot representing median and range values for overall satisfaction scores of the two denture types (Circle represents outlier).

DISCUSSION:

In this study retention and patient satisfaction for two different manufacturing techniques of complete dentures, printed and conventional, were compared. Retention is an inherent factor that greatly influences patient satisfaction. Nonetheless, patient satisfaction is considered as an important outcome that enables better evaluation of success of any prothesis in terms of retention, stability, function, esthetics, and psychological comfort. Thus, both were recorded together (13).

Several studies have proven that the dentures fabricated from conventional processing techniques suffer from dimensional changes due to polymerization shrinkage and release of internal stresses. That resulting distortion compromises retention besides support and stability of the denture, which lead to adverse consequences on the patient's satisfaction. This in turn substantiated the need for advanced techniques in fabrication of complete dentures. (14-16).

The result of this study showed superiority in terms retention of the 3D printed dentures over the conventional dentures. This is could be attributed to utilized denture construction technique. This technique was attained by additive manufacturing methods that created the object by successive layering of photosensitive resin, then UV light polymerizing it. This technique was used because it allows material conservation and exhibits the ability to print complex geometries with reasonable dimensional accuracy. The dimensional changes of each layer are compensated for by addition of the successive resin layer (17).

In accordance with the findings of the study, other recent studies indicated that 3D printed dentures exhibited better retention compared to conventional dentures. The main reason was that 3D printed dentures revealed less shrinkage and distortion, along with consistent better adaptation compared to conventional dentures. (17-19).

The prolonged success of prosthesis is pivoted on the fit accuracy incurred between denture base and mucosal tissue. A recent study that used surface matching software focused on accuracy of the denture revealed comparative feedback. The study evaluated denture bases manufactured by three methods: injection molding, milling, and rapid prototyping. The findings depicted that highest deformation was in the conventionally made dentures, whilst least deformation was associated with rapid prototyped dentures.

Regarding patient satisfaction, 3D printed dentures showed enhanced overall satisfaction with respect to conventional dentures. This aligned with former research concluding improved surface quality of printed dentures along with better patient satisfaction (20,21). Additionally, a systemic review reflected that digitally fabricated dentures had more positive impact rather than conventionally fabricated dentures (22).

CONCLUSION:

With respect to constraints of the subject study, it was concluded that 3D printed dentures exhibit better retention and patient satisfaction. However, further studies need to be conducted.

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