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ASSESSMENT OF RETENTION AND OCCLUSION OF DIGITALLY MANUFACTURED COMPLETE DENTURES

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ABSTRACT

Purpose: The aim of this study is to compare retention and occlusion of digital dentures versus conventional dentures.

Materials and methods: Ten fully edentulous patients were selected to participate in this study. Two dentures with balanced occlusion were constructed for each patient. The first one was manufactured using the conventional technique while the second was manufactured using a digital workflow. The dentures were delivered and then retention and occlusion were assessed to evaluate the competency of the digitally manufactured denture.

Conclusion: digitally manufactured dentures show a promising alternative to conventionally manufactured ones, in terms of retention and occlusion.

INTRODUCTION

Complete dentures are defined as removable dental prosthesis which compensate for the lost whole human dentition with the related structures of the mandible and maxilla.(1) Digital dentures are a complete prosthesis which is manufactured by automation and digitization using CAD/CAM.(2)In CAD/CAM data is collected and oriented before application to a design that is manufactured later on.(3,4)

Conventional complete dentures are the most common form of prosthesis used to rehabilitate edentulous patients. They have many disadvantages like the need for many visits and numerous laboratory steps. The final dentures may not obtain an intimate fit with the underlying soft tissues this can be attributed to the polymerization shrinkage of the acrylic resin used in the manufacturing. If a denture is lost or broken, it requires repetition of all the steps to make a new one and there is no data saved for future duplication of the old denture.(5-7) Traditional complete dentures will always be the standard of oral health care of edentulous patients. But we must look for newer methods to simplify the manufacturing process and to eventually obtain more accurate results. (8)

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The use of computer-aided design and computer-aided manufacturing (CAD/CAM) process in dentistry over the past forty years has proved its success in the fabrication of full coverage crowns, fixed dental prostheses and suprastructures for natural teeth and dental implants[5,9,10] complete denture fabrication using CAD/CAM presents a new era in the field of removable prosthodontics. Advantages of digital dentures include decrease in the number of appointments, the ability to customize tooth shape and occlusal scheme setting, verification of steps before denture try-in, the production of a clinically predictable prosthesis that needs minimum intraoral adjustments and the ability to save the information for future need [11,12].

But the question remained as to whether digital dentures can be considered a viable alternative to conventional dentures?

The null hypothesis was that no differences in retention and occlusal force distribution would be found between conventional and digital dentures.

MATERIALS AND METHODS

Sample size

Before the study, the number of patients required in each group was determined after a power calculation according to data obtained from (Ahmed et al 2021). In the study, by comparing the two groups there was a significant difference between them in biting force distribution where (SD) values for biting force difference posteriorly between the right and left posterior segments for centric occlusion was significantly higher for Group I (20.52±7.99) than Group II (14.45±7.33), with mean difference 29.6%; So it can be relied upon in this study, based on this assumption through a this previous study, the effect size was large (f = 2.2). A sample size of 10 patients in the study was determined to provide 80% power for independent samples T test at the level of 5% significant and Confidence interval 95% using G.*Power 3.19.2 software.

This study was approved by the ethical committee of the faculty of dentistry Ain Shams university under the approval number (FDASU-RecIR112215).

Ten completely edentulous patients were recruited from the department of oral and maxillofacial prosthodontics, Faculty of Dentistry, Ain-Shams University.

Each patient was given two sets of complete dentures a conventionally manufactured denture and a digitally manufactured denture.

Patient selection is an essential consideration when choosing the patients eligible for this procedure. The patient must have had well-formed ridges with adequate bone to stabilize the bases and must have been free from TMJ problems.

Steps for the conventional denture included the obtaining of primary impression using alginate (Cavex alginate, Cavex, Holland); then a stone cast was poured for the construction of a special tray. This was followed by making of a secondary impression obtained by border molding using green stick compound (Pyrax tracing sticks, India) and a zinc oxide (CAVEX OUTLINE, Cavex, Holland) final wash. Four occlusion blocks were used to record centric, protrusive and lateral jaw border movements. Casts were then mounted on a fully adjustable articulator. Fully anatomic denture teeth were set in a balanced occlusal scheme. Try in of the complete denture was done to confirm the occlusion and esthetics. Processing was done using conventional method.

For the digital denture a different approach was adopted. An intraoral scanner (Trios 3 wired, 3Shape, Copenhagen, Denmark) was used to scan the edentulous arches. Composite markers were used to facilitate scanning procedures (Figure 1). Special trays were designed and printed. A medium rubber base impression wash (Elite Soft Medium Body – Zhermack) was taken for both arches. The handles of the trays were cut off and the wax rims

(Cavex Set Up Regular, Modelling wax, Cavex, Holland) were attached to the printed trays. Height and contour of wax rims were adjusted to conform to proper esthetics and phonetics.

ARCUS digma (ARCUS digma II, Kavo, Germany) was used to record the jaw relations for the digital dentures (Figure 2). The steps were clearly explained. The tracing screw was attached to the maxillary denture base and the guiding plate for gothic-arch tracing was attached to the mandibular trial denture base. This assembly was adjusted in the patient's mouth at the predetermined correct vertical dimension of occlusion. The para-occlusal clutch was attached to the buccal aspect of the mandibular tray. Clearance of the wax rims was done to allow space for the inter-occlusal material. Face bow was attached to the patients head and the spatial position of the maxilla was determined while the patient was sitting in an upright position. The transfer angles were recorded by asking the patient to perform the protrusive, right and left movements three times to ensure reproducibility. Gothic arch tracing was then done and centric relation position was confirmed on the screen during the application of bite registration

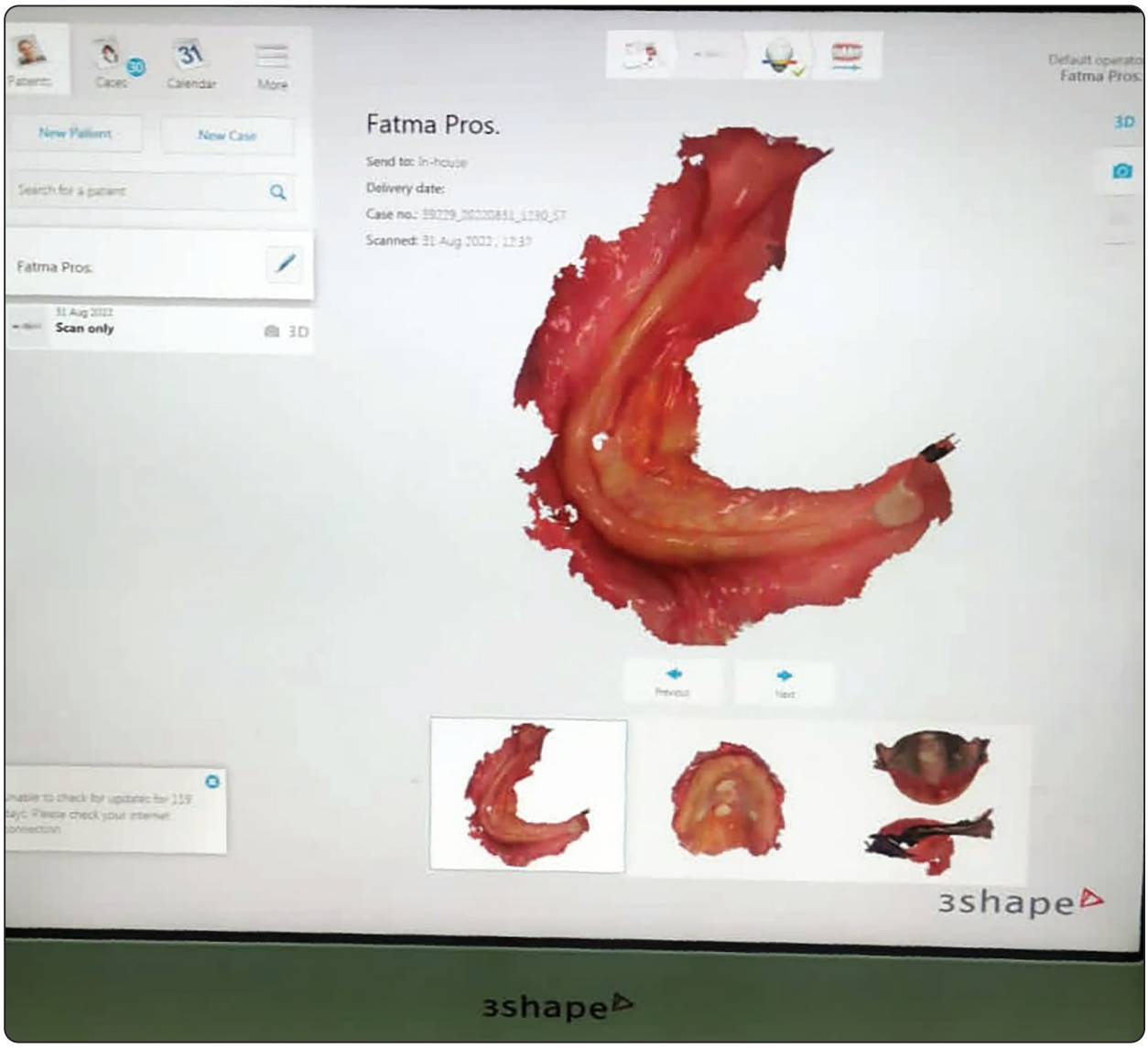

Fig. (1)

material (CharmFlex® Bite) to ensure accuracy of the recorded position. Upper and lower impressions were poured to produce master casts. Desktop scanner (D850, 3Shape, Copenhagen, Denmark) was used to scan the master casts and the occlusion blocks locked in centric position.

Fig. (2)

A CBCT scan was done for the patient. Next all the acquired data, STL files of the upper and lower casts, the bite scan and CBCT were imported to Exocad design soft ware. Upper and lower casts and the bite scan were superimposed over each other to virtually mount the casts in proper centric relation. The CBCT was introduced to the software and the upper cast was superimposed over the maxilla while the opening axis of the virtual articulator was superimposed over the terminal hinge axis of the patient. The records obtained from the ARCUS digma were used to program the articulator. Upper and lower dentures were designed and the Occlusal contacts were adjusted in both types of dentures to be equally distributed between both sides in the centric position. While in the eccentric positions, occlusal contacts on the working side were adjusted to be double its number on the balancing side. Printing of the denture was carried out using DLP 3D printer.

Evaluation of the retention of the maxillary dentures

The retention of the maxillary dentures was evaluated using A digital force gauge (HF-100 Digital Force Gauge, Jinan Hensgrand Instrumentation Co., Ltd., Jinan, China). A metallic ring was attached to the polished surface of the denture at the position of its geometric center to be engaged by the tip of the digital force gauge. The digital force gauge was used to dislodge the maxillary denture from the patient's mouth and the maximum force in Newton needed to dislodge the denture was recorded and considered as the retentive force of the denture.

The measurement procedures were repeated 5 times at 5 minutes intervals for each denture base and the average value was recorded. All measurements were performed by the same operator.

Evaluation of the occlusion of the dentures

Occlusal evaluation was done by T-Scan III occlusal analysis system using a sensor that converts electric resistance to images on the screen analyzing different parameters of the occlusion including the distribution of the occlusal contacts (Figure 3). Occlusal analysis was done in centric and eccentric positions for each denture. In centric positions occlusal contacts were adjusted to be equally distributed between both sides, occlusal forces were supposed to be equally distributed between both sides. Differences between occlusal forces on both sides were recorded and statistically analyzed.

The higher the difference the less accurate the distribution of occlusal forces was considered. In eccentric positions, occlusal forces on working sides were supposed to be double its value on the balancing side (67% and 33% respectively). The differences between actual occlusal forces on balancing side and planned occlusal forces (33%) were calculated for each eccentric position and statistically analyzed.

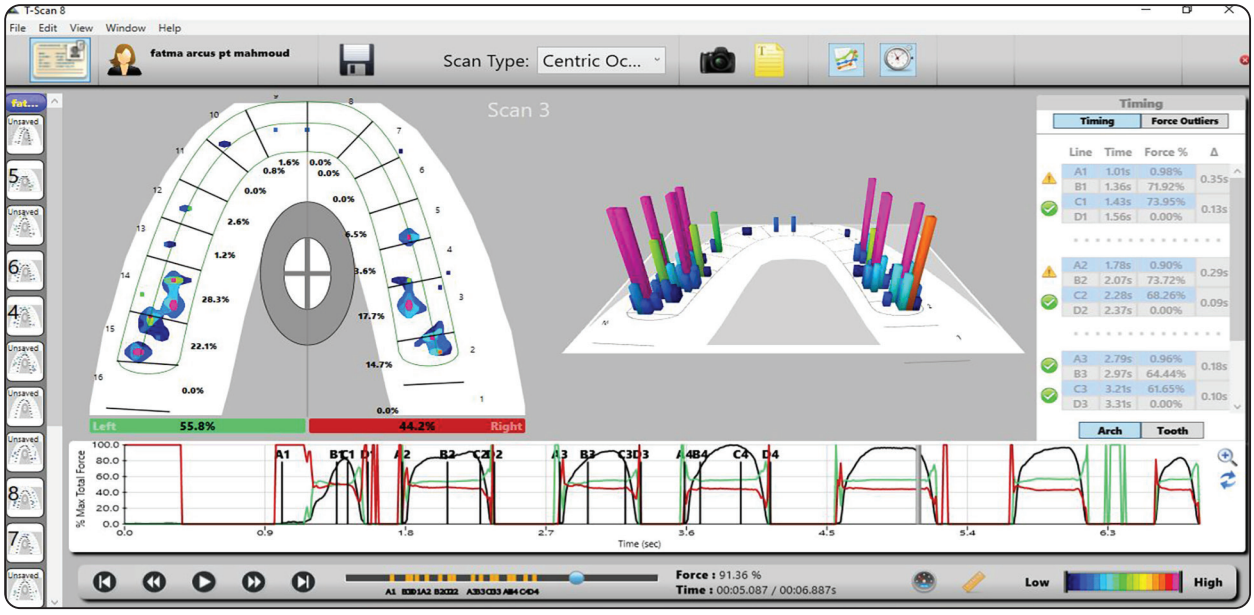

Fig. (3)

RESULTS

The mean values and standard deviation of the measured data were statistically analyzed by Microsoft® Excel® for Microsoft 365 MSO **(Version 2210 Build 16.0.15726.20188) 32-bit. T-test** was used for comparison between the two groups. The significance level was set at $\alpha = 0.05$.

The results of this study led to rejection of the null hypothesis and confirmed that digital dentures have better retention and occlusal force distribution than conventional dentures.

1 - Retention of the dentures

Statistical analysis showed that the digital dentures had higher retentive values than the conventional dentures and the difference was statistically significant (p= 0.035) as shown in table I.

TABLE (I) Mean, standard deviation and p value of t-test of the retentive values in Newton of the two groups.

	Digital	Conventional
Mean	34.13	29.89
Std. Deviation	4.399	5.21
P value	0.031	

2- Occlusal analysis of the dentures

a. Centric occlusion

Statistical analysis showed that the difference in occlusal forces between both sides was significantly higher in the conventional denture group than the digital denture group (p= 0.001) as shown in table II.

TABLE (II) Mean, standard deviation and p value of T-test of the difference in the percentage of occlusal force between both sides in the centric position.

	Digital	Conventional
Mean	9.08	22.31
Std. Deviation	8.04	8.25
P value	0.001	

b. Eccentric occlusion

Occlusal forces on balancing sides showed higher deviation from the planned occlusal force distribution in the conventional denture group than the digital denture group in the protrusive position (p= 0.001) as shown in table III. While there were no statistically significant differences between the two

groups regarding the difference of occlusal forces on the balancing sides from the planned occlusal force distribution in both right and left lateral positions (p= 0.18) (p= 0.12) as shown in tables III and IV respectively.

TABLE (III) Mean, standard deviation and p value of T-test of difference of occlusal forces on the balancing sides from the planned occlusal force distribution in the protrusive position.

	Digital	Conventional
Mean	6.08	17.68
Std. Deviation	4.56	8.23
P value	0.001	

TABLE (IV) Mean, standard deviation and p value of T-test of difference of occlusal forces on the balancing sides from the planned occlusal force distribution in the right lateral position.

	Digital	Conventional
Mean	14.06	17.16
Std. Deviation	6.60	8.02
P value	0.18	

TABLE (V) Mean, standard deviation and p value of T-test of the difference of occlusal forces on the balancing sides from the planned occlusal force distribution in the left lateral position.

	Digital	Conventional
Mean	14.18	19.9
Std. Deviation	15.01	10.76
P value	0.12	

DISCUSSION

The overall success of complete dentures depends on two main factors and those are the recording of the functional impression and the registration of the jaw relationship. [13] The retention, stability as well as the denture support can be only achieved by a precise functional impression. [14] Moreover accurate jaw relation is essential to achieve the correct level and position of artificial teeth in harmony with the patient's temporomandibular joint and muscles and for obtaining good function and esthetic outcomes. [13]

Maeda et al, manufactured the first removable complete denture by the use of 3Dprinting technology.[15] later on in 1997, Kawahata et al, used a block of wax using a computerized milling technology. [16] Busch et al used anatomic averages and dimensions to set denture teeth.[17] Katattadiyil et al. produced a CAD software which processed an automatic setting of denture teeth, along with a semiautomatic aesthetic scheming technique, esthetic gingival recontouring and manufacturing of the denture base. [18]

Kanazawa et al. used CBCT with prototyping or milling to manufacture digital complete dentures.[19]

The ARCUS digma allows the recording and analysis of mandibular movement in a three-dimensional manner. This is accomplished using an ultrasonic electronic sensor in order to directly measure the patient's condylar guidance on a computer. Real time reproduction of mandibular movement is directly recorded and shown on a monitor, and the patient's condylar and anterior guidance can be identified. Moreover, verification of the accuracy and reproducibility of centric relation and mandibular movement is made possible with the use of this system. [20]

Balanced occlusion has the advantage of increasing denture stability and reducing alveolar bone restoration to compensate for the instability. The use of a fully adjustable articulator is mandatory for the development of balanced occlusion. With

the advancements in dental technology virtual articulators have replaced mechanical devices. [21] The advantage of using virtual articulators include individualized measurements and avoidance of problems of mechanical devises like material dimensional inaccuracy and errors in orientation and simulating the 3D patient data. [22,23] The main challenge of using Arcus digma in the digital workflow is usually the orientation of the maxilla in relation to the opening access of the virtual articulator as it was the only missing data needed for programming the virtual articulator. This challenge was solved by taking CBCT for the patients as explained before. This led to favorable occlusion when tested.

T-Scan is an objective assessment tool used to evaluate the occlusion of a patient. Unlike articulating paper, which can only determine location, T-Scan can identify both force and timing, two of the most fundamental parameters for measuring occlusion.

It was shown in this study that retention of digital dentures was comparable with that of conventional dentures. This is in alignment with several studies which stated that the retention of digital dentures can be higher than conventional heat polymerized dentures.[24-27] These digitally manufactured bases are more accurately fitted and have superior retention. Steinmassl et al [28], claimed improved retention, fitting, with higher dimensional accuracy, extension, and stability. [29-31]. Some authors stated the need for rebasing, but we preferred taking a wash impression to alleviate the need for chair side relines and obtain more stable results. [32] Traditional methods for denture construction require many steps and materials, this comes with the risk of inaccuracy and dimensional changed, so the described digital workflow helped to alleviate the draw backs of the conventional system while giving comparable retention in the final denture.

This study proved that digital workflow could provide complete dentures with balanced occlusion. Moreover, it provided more accurate and predictable results regarding the distribution of occlusal forces than the conventional workflow, especially in the centric and protrusive position.

Several variables in the occlusal forces related to digital dentures in previous studies were researched. Digital dentures allowed better design of occlusal schemes. Bilateral balanced occlusal schemes gave superior force centralization, improved distribution, and adequate occlusal forces. [33] This is of ultimate importance as improper occlusion may lead to TMJ problems over time and instability of the denture. (34)In this study the occlusal scheme was adjusted to allow good stress distribution. [35]

In this study we aimed to obtain 67% of occlusal forces on the working side and 33% on the balancing side to allow good stress distribution as stated by a previous study[35].

CONCLUSION

Digital dentures give a promising alternative to conventional dentures. It gave better results in retention and occlusion. Digital work flow helps to easily and predictably obtain balanced occlusion.

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