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Effect of using teeth positioning guides on the accuracy of CAD/CAM complete dentures: an in-vitro study

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Aim: is to evaluate the effect of using teeth positioning guides on the accuracy of CAD/CAM complete dentures.
Materials and methods: Twelve denture bases were digitally designed using the Exocad software and 3D printed upon an educational maxillary edentulous model. In group I, six printed upper complete dentures were fabricated, and the teeth were manually positioned in the recesses of the denture bases, while in group II, six printed upper complete dentures were fabricated, and the teeth were positioned in the recesses of the denture bases using a teeth positioning guide.
Results: Group II showed higher deviation and less accuracy when compared to group I regarding the accuracy of the positions of the centrals and the first molars. The differences between both groups were statistically significant.
Conclusion: The accuracy of the teeth positions in printed complete dentures was reduced by the use of teeth positioning guides.

Keywords: Digital, Dentures, Exocad, Printing, Teeth positioning guide

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Introduction

CAD/CAM technology has been used since the early 80s in fixed prosthodontics. On the other hand, the use of this technology in removable prosthodontics was not so popular until a few years ago.(1)

The main disadvantages of digital technology in complete denture include the needed time to master it and the high initial cost.(2)

Digital dentures have better fit and strength compared to conventional dentures. This is attributed to the reduced polymerization shrinkage of PMMA whether the dentures are printed or milled.(3,4) Also teeth positions were found to be more accurate in digital dentures compared to those manufactured by the conventional techniques. (3)

Additive manufacturing (AM) depends on fabricating objects layer by layer, where the design to be manufactured is sliced into cross sections and successive layers are laid down from the bottom up and each layer is fused to the previous one either by a binding agent or by sintering.(5-8)

The process of AM may be either direct or indirect. In direct AM, the object is manufactured by the 3D printer, while in indirect AM, a mold is prepared using a 3D printer then the object is cast in the mold. Objects manufactured by direct AM are usually more accurate and have less dimensional changes than indirect AM.(8)

One of the problems that faced the technicians, and the clinicians is the process of positioning the artificial teeth in the recesses of the denture bases. This process usually has some discrepancies since teeth may not be properly placed in the sockets of the dentures leading to some occlusal errors. Studies found that there is still no certain technique whether a conventional or CAD/CAM that can entirely eliminate denture teeth movement.(9,10)

Materials and methods

- This in-vitro study was applied on an educational maxillary edentulous model made of dental stone.
- In this study, denture teeth were set using two different techniques in twelve upper complete dentures. Thus, two groups were defined.

Group I: Six printed upper complete dentures were fabricated, and the teeth were manually set into the recesses of the denture bases.

Group II: Six printed upper complete dentures were fabricated, and the teeth were set into the recesses of the denture bases using a teeth positioning guide.

- Upper and lower casts were scanned respectively, then the occlusion blocks were secured to their corresponding casts and scanned.
- The three scans were superimposed together by "best fit match" option to properly align them and to virtually mount the upper and lower casts according to the jaw relation record.
- The designing process was done using the Exocad software.
- The same steps were done to design the denture bases and teeth for both groups.
- Then for group II, the STL file of the finished upper denture with the teeth is imported to the Exocad software.
- A teeth positioning guide was designed to extend on the palatal part of the denture base and the occlusal surfaces of the teeth without extending beyond the height of contour. (Fig. 1)
- The denture bases and the teeth were fabricated by the rapid prototyping (RP) technique.
- The denture bases, teeth and the teeth positioning guide were all printed. After the printing process was completed, they were rinsed twice in a 96% ethanol solution in an ultrasonic bath for 5 mins, then the denture

bases were then inserted in a post curing unit (Post curing unit, Mogassam, Egypt) for 20 minutes for further polymerization.

Fig. 1: Teeth positioning guide with the teeth placed over the denture base.

Evaluation of the accuracy of the teeth position in the denture base

Group I:

Each tooth was bonded to the denture base after being positioned in its corresponding recess using PMMA resin (NextDent Base, NextDent, Soesterberg, Netherlands), then the denture base with teeth were placed in the post curing unit for 20 minutes to ensure complete polymerization of resin used for bonding of teeth.

Group II:

- Each tooth was first placed in the teeth positioning guide in its corresponding position, then the teeth positioning guide, with the teeth inside it, is placed over the denture base and bonded using PMMA resin.
- Then both dentures were sprayed using the anti-glare spray, and then scanned using the 3shape desktop scanner, generating STL files.
- The STL files were imported to the surface matching software (Geomagic® Control X , 3D systems, USA.) to evaluate the accuracy of the teeth position in the dentures in the two groups.
- The STL file of each denture with teeth was superimposed with the original STL file of the design.
- Deviation was labeled at the incisal edges of the central incisors and at the mesio-buccal cusp tips of first molars. Surface matching represented by 4 points for each denture. (Fig. 2)

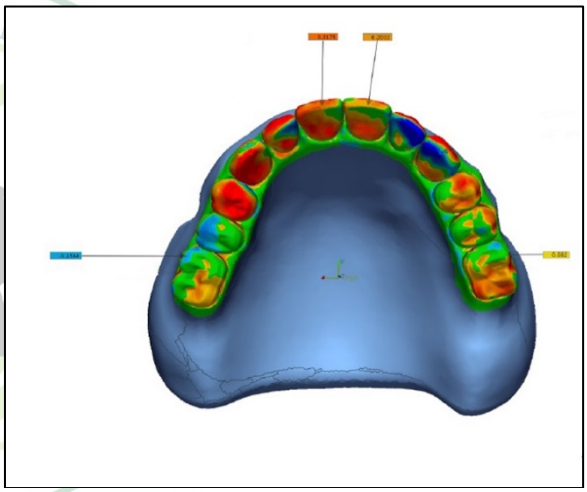

Fig. 2: The 4 selected points at which deviation will be measured.

All data of the current study were collected, and statistical analysis was performed with IBM SPSS statistics version 20 for windows. Student's t test was used to compare between the groups. A probability level of <0.05 was considered statistically significant.

Results

I. Comparison between the accuracy of the centrals' positions in the two studied groups:

Concerning the accuracy of the centrals' positions between the two groups; table I showed that group II (teeth set with teeth positioning guide) has the highest deviation and least accuracy (0.36296 ± 0.0695733) compared to group I (teeth set manually)

which has the lowest deviation (0.229168 ± 0.0494415). Student's t test showed that this difference was statistically significant.

Table I: Mean, Standard deviation, and P value of student's t-test for the comparison between the deviation of the centrals' positions in the two groups.

	Mean	Std. Deviation	P value
Group I (Teeth set manually)	0.229168	0.0494415	< 0.0001
Group II (Teeth set with teeth positioning guide)	0.36296	0.0695733	

II. Comparison between the accuracy of the 1st molars' positions in the two studied groups:

Concerning the accuracy of the canines' positions between the two groups; table II showed that group II (teeth set with teeth positioning guide) has the highest deviation and least accuracy (0.285124 ± 0.0531118) compared to group I (teeth set manually) which has the lowest deviation (0.1382 ± 0.0132445). Student's t test showed that this difference was statistically significant.

Table II: Mean, Standard deviation, and P value of student's t-test for the comparison between the deviation of the 1st molars' positions in the two groups.

	Mean	Std. Deviation	P value
Group I (Teeth set manually)	0.1382	0.0132445	< 0.0001
Group II (Teeth set with teeth positioning guide)	0.285124	0.0531118	

Discussion

Accuracy of teeth positions in the denture base is of great importance. Any change in the teeth positions can lead to errors in occlusion, change in the vertical dimension of occlusion and esthetics too.[11,12,13]

The digital technology was used in this study since it is more accurate and percise compared to the conventional techniques. It is believed that the digital dentures will eventually replace the conventionally manfactured dentures in the near future. This is attributed to the speed, accuracy and the comfort of the patients with digitally manfactured dentures compared to the conventional ones.[14-16]

In group II, the teeth positioning guide was designed to rest on the hard plate so that it act as an end point to verify the seating of the guide.[17] Also, the guide was designed not to extend beyond the height of contour of the teeth to allow the ease of insertion and removal of the teeth from the guide and to avoid any engagement of the teeth undercuts.

In both groups, the denture bases and the teeth were fabricated by additive manufacturing (rapid prototyping). This technology is characterized by its flexibility due to the wide range of available machines. It has the advantages of the presence of a small amount of wasted raw material, the ability to print complex geometries and its low cost. The main problems with this technique are the staircase effect, low reproducibility, and the necessity of addition of numerous supporting structures which in return require utilizing additional material and time.[18]

The teeth positions in group I were more accurate, and the statistical analysis of the digital measurements confirmed this finding.

In group I, teeth were set in denture bases recesses manually after placing the bonding resin in the recesses. Only two factors were present, the denture base and the teeth. Therefore, errors of printing in this group were confined only to these two factors.

In group II, a third factor was used which is the teeth positioning guide. This could probably increase the margin of error, since this guide was manufactured by the printing technology which has some limitations that might lead to inaccuracies within the guide.

One of the reasons that may lead to the increased deviation in group II is that the

internal surface of the teeth positioning guide can't perfectly fit the anatomy of the teeth on which it is placed. Errors due to 3D printing or minor errors on the internal surface of the guide can cause premature contact with the occlusal surface. The occlusal surface consists of fine and complex anatomy, such as grooves, which may interfere with the correct seating of the guide.[19-21]

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