EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
Vol. 68, 677:682, January, 2022
Print ISSN 0070-9484 • Online ISSN 2090-2360
Fixed Prosthodontics and Dental Materials
Submit Date : 11-09-2021 • Accept Date : 20-10-2021 • Available online: 30-01-2022 • DOI : 10.21608/edj.2021.95425.1788

ACCURACY OF FIT OF ALL ON-FOUR PROSTHESIS CONSTRUCTED FROM 3D PRINTING AND MILLING TECHNOLOGIES

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ABSTRACT

Introduction: Milled and 3D printed PMMA restorations are widely used in fabrication of all on-four prosthesis, as the traditional process needs many complicated steps. These steps may leads to inaccurate prostheses with poor fit.

The aim of this study was to evaluate the accuracy of fit of CAD/CAM milled and 3D printed PMMA resin all on-four prosthesis.

Material and methods: Eight patients rehabilited with all on-four implants supported prosthesis. Computer-guided surgical procedures were followed for insertion of the implants. Each patient received an immediate temporary resin all on-four prostheses. CAD (Computer Aided Designed) was used to design the prosthesis. Manufacturing CAM (Computer Aided Manufacture) of the prosthesis was carried out with two technologies. 3D printing and milling technologies were used to fabricate the resin prosthesis for each patient. The accuracy of fit of the two manufactured resin prosthesis was evaluated virtually using geomagic software.

Results: The results shows a statistically significant difference of the milled group when compared with the 3D printed group. ($p = < 0.000$)

Conclusion: Milled showed better fit than 3D printed restoration in resin temporary prosthesis for all on-four implant supported prosthesis.

KEYWORDS: all on-four, immediate prosthesis, 3D-printed prosthesis, milled prosthesis.

INTRODUCTION

One of the options for restoring a patient with a full set of teeth is all four concepts. This concept is considered to have the same success rate as normal implant-supported dentures, whether it is done with delayed implantation or immediate implantation with immediate loading. [1, 2]

In the case of immediate implantation with immediate loading, the prosthetic manufacture and design are considered the key to success. Besides other factors, the material in this scenario is PMMA (polymethyl methacrylate). [3-4]

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This PMMA prosthetic option can be manufactured by conventional, milling or 3D printing techniques. However, most dentists nowadays use milled and 3D printed prostheses, as the traditional process needs a lot of work and steps with human errors, which leads to inaccurate prostheses with a miss fit and a long time for the dentist to trim and grind the prosthesis. [5]

Another reason why dentists prefer milling and 3D printing options is that most cases are pre-planned and done by a CAD/CAM, which means the planning for the implant placement and prosthetic shape are made before the operation. [6, 7]

In the subtractive CAD/CAM or milling procedure, the designed prosthesis is milled out from a pre-polymerized PMMA blank. This blank is manufactured under high pressure. Therefore, it is claimed to be more hygienic, have superior mechanical properties, and have fewer residual monomers.[8]

On the other hand, 3D printing, considered one of the additive manufacturing processes, is a process in which the final designed part is manufactured by adding multiple layers of material on top of each other.[9]

Nowadays, additive manufacturing offers several advantages compared to subtractive methods, additive manufacturing can reduce waste materials by almost 40%, and it can shape structures. Unlike subtractive methods, which are limited by milling bursts, additive methods can handle complex geometry.[10,11] The machine's diameter and the milling axes of the machine It can also produce structures of bigger sizes while the milling machines are limited by the size of the block from which the structure is milled.

Another main advantage is passive production where no force is exerted during manufacture, while in milling, surface cracks can be introduced during hard machining. [12, 13] therefore, as digital and new technologies are widely used nowadays.

The aim of this study was to evaluate the accuracy of fit of CAD/CAM milled and 3D printed PMMA resin all on-four prosthesis.

MATERIAL AND METHODS

This study was a comparative study using geomagic control x software to calculate the deviation between 3D printed and milling temporary restoration from the virtual designed

Patient selection:

Eight patients with an average age ranging from 30-50 years old with few remaining lower teeth indicated for full lower arch immediate implant placement with immediate loading were selected.

All the patients were medically free and non-smokers. Patients were selected and diagnosed by (CBCT) and enrolled in the trial from the outpatient clinic of the Faculty of Dentistry, with bone density ranging from D1 to D2.

Thirty-two implants were installed using a computer-guided all on four procedure with immediate implantation and immediate loading using temporary full arch prosthesis after the remaining teeth were extracted.

Surgical technique

• ***Implant planning & placement:***

Cone beam The topography was computed of the patients was taken by x-ray machine (The Vatech PaX-i Green CT panoramic plus cone beam system delivers a 15 x 15 cm large field of view cone beam) to create a DICOM file of the patient. Intraoral scanning of the working arch, the opposing arch, and bite registration using Medit i500 to create STL files of the patient's arches.

Digital setting of missing teeth followed by digital articulation were done using Exocad software to accomplish prosthetically driven implant planning. Super imposition of the patient CBCT &

STL using real guide software. The surgical guides were created and two straight anterior implants in the anterior region and two tilted posterior implants in the premolar region (sky implant 3.5*10mm for anterior implants and 4.5*14mm for posterior implants) were virtually placed according to the designed prosthesis. After that, all the surgeries were done in the mandible using surgical guides and copious irrigation.

Temporary Prosthesis design

Digital immediate lower full-arch prosthesis with computer-guided implant placement was carried out for each patient in the following steps:

• ***Digital data collection:***

(Medit t 710) lab scanner and exported in STL (Standard Tessellation language files) (fig. 1)

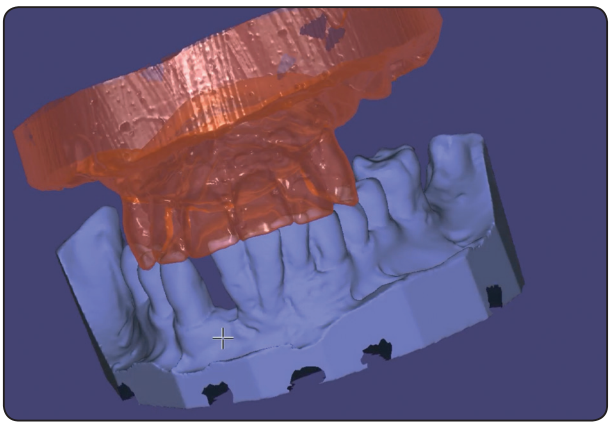

Fig. (1) : Digital data in the correct jaw relation.

• ***Temporary Prosthesis digital design:***

Eight temporary prostheses were designed for each patient. Each design was milled and 3D printed for each patient.

• ***Steps of digital design.***

Upper and lower jaw STL files in the proper jaw relationship were exported to exocad software (exocad GMBH Dental CAD software; Germany).

Anatomic pontic with virtual gingival design module was chosen to set teeth. Virtual teeth extraction was carried out using model editing in the expert mode, and then the teeth placement wizard was used, including the options to (move, rotate, and scale teeth).

The prosthesis borders were drawn according to the anatomy using a gingival design wizard and the denture polished surface was finished and smoothed. The final restoration teeth are saved in the form of an STL file to be used later. (Fig. 2)

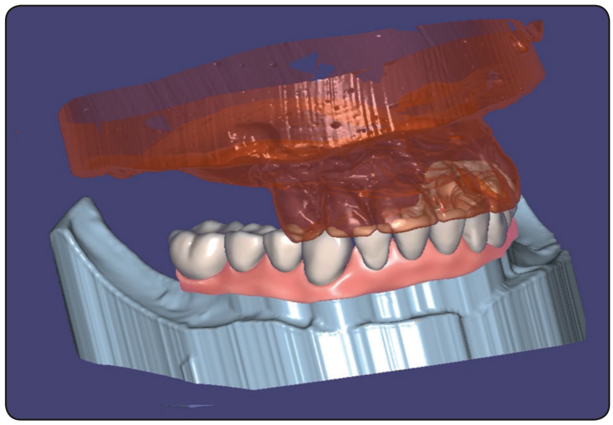

Fig. (2) : final temporary prosthesis

Computer-guided implant placement was chosen using a computer-guided surgical stent to ensure placement of the implants in the predetermined position.

A stackable surgical guide was designed using Real Guide 5.0 software (3DIEMME; Italy) (Fig. 3).

• ***3D printing and milling of the designed prosthesis***

Eight temporary prostheses for each patient were 3D printed in mammoth resin using a Phrozen 3D printer.

The resultant prosthesis was finished by removing the supporting arms, placing it in the ultrasonic washer, cleaning it with alcohol to remove excess monomers, and then placing it in the ultraviolet curing unit for 30 minutes.

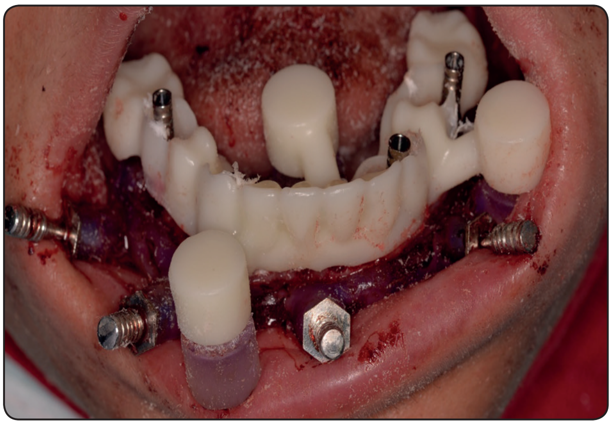

Fig. (3): Temporary prosthesis with stackable guide

Eight temporary prostheses for each patient were milled from mammoth resin blocks using a 3D milling machine.

Comparison of the accuracy of milled and 3D printed prostheses,

Each printed and milled prosthesis was scanned using a Medit T 710 lab scanner and the data was exported in an STL file.

The STL file of the designed prosthesis, 3D printed and milled prosthesis were imported to (geomagic control x software). The designed prosthesis was set as reference data, superimposition was done between the 3D printed and designed files using best fit and 3D comparing was done. The previous steps were repeated for the milled prosthesis. (Figures 4, 5)

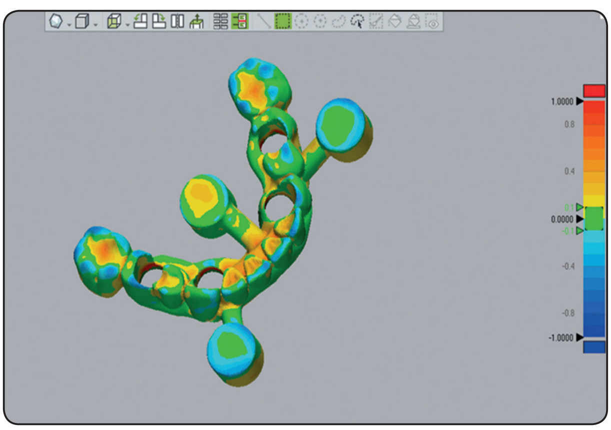

Fig. (4) 3d comparison between 3D printed and designed prosthesis

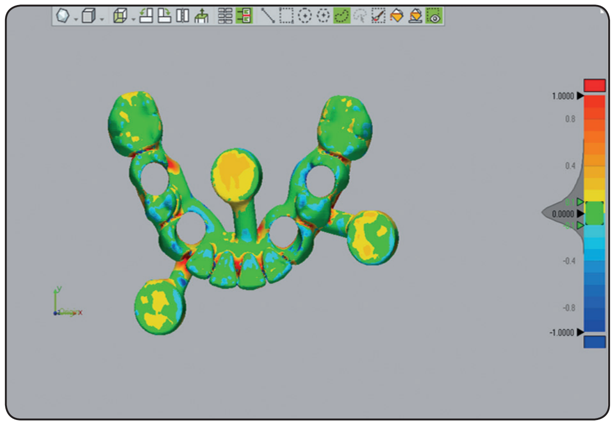

Fig. (5) 3d comparison between milled and designed prosthesis

RESULT

In the present study, the total deviation in readings compared the designed file group with the milled group with a mean value of **0.171467±.01**mm and 95% CI, and with the 3D printed group with a mean value of **0.405800±.009** and 95% CI., The milled group showed a statistically significant difference when compared with the 3D printed group. (p =.000) (Table 1).

TABLE (1): The total deviation in specimens between Milled group and 3 D printing group.

	Milled full arch restoration (M±SD)	3D printed full arch restoration (M±SD)	P value
RMS (root mean square)	0.171467±.01	0.405800±.009	0.000*

DISCUSSION

In all prostheses, accuracy is the most important issue for success. For the accuracy of prosthesis manufacturing, it is necessary to check the deviation and overall size from the raw designed (virtual) file.

Furthermore, in all four cases with screw-retained prostheses, accuracy and fitness are the most important issues because the holes of the screws in the prosthetic area determine the prosthesis's passivity on implants. Lack of passivity may lead to failure of the implant or remanufacture of the prosthesis. [14,15]

In this study, the milled group showed higher accuracy when compared with the 3D printed group, although both techniques utilize a digital image file designed by CAD software to manufacture.

These results coincide with Galeva's that stated the milling method yields better results than 3D printing for fixed prostheses [16.]

In addition, Nicole, in his study, stated that milling prostheses show superior accuracy than rapidly prototyped complete dentures.[17]

They may be due to the differences between one another in the fabrication process. In the milling, the prosthesis is fabricated from a pre-polymerized blank manufactured under high pressure. The RP (rapid prototyping) technique uses photosensitive liquid resins; they are repetitively layered on a support structure and polymerized by an ultraviolet (UV) or a visible light source. 3D printing precision and resolution, 3D printing materials, manufacturer's parameters, and post-curing process have a role in the accuracy of the printing process.

In addition, in 3D printing technology, if any manufacturing parameter is modified, it leads to a change in the accuracy and the time; this may lead to internal stress at the post-curing step and deformation of the prosthesis. For example, the horizontal resolution is affected by the diameter of the light source, and vertical resolution is affected by layer thickness. [18]

CONCLUSION

Milled showed better fit than 3D printed restoration in resin temporary prosthesis for all on-four implant supported prosthesis.

REFRENCES

1. Misch CE. The Completely Edentulous Mandible: Treatment Plans for Fixed Restorations, in Dental Implant Prosthetics. St. Louis, Missouri: Elsevier Mosby. 2015. 605–12 p.
2. Misch CE. Maxillary Arch Implant Considerations: Treatment Plans for Partial and Complete Edentulous Fixed and Overdenture Prostheses, in: Misch CE, editor. Dental Implant Prosthetics. St. Louis, Missouri: Elsevier Mosby. 2015. 625–6 p.
3. Aalam AA, Nowzari H KA. Functional restoration of implants on the day of surgical placement in the fully edentulous mandible: A case series. Clin Implant Dent Relat Res. 2005;7:10–16.
4. Capelli M, Zuffetti F, Del Fabbro M TT. Immediate rehabilitation of the completely edentulous jaw with fixed prostheses supported by either upright or tilted implants: A multicenter clinical study. Int J Oral Maxillofac Implant. 2007;22:639–644.
5. Hinze M, Thalmair T, Bolz W WH. Immediate loading of fixed provisional prostheses using four implants for the rehabilitation of the edentulous arch: A prospective clinical study. Int J Oral Maxillofac Implant. 2010;25:1011–1018.
6. Del Fabbro M, Testori T, Francetti L, Taschieri S WR. Systematic review of survival rates for immediately loaded dental implants. Int J Periodontics Restor Dent. 2006; 26:249–263.
7. Tealdo T, Bevilacqua M, Pera F et al. Immediate function with fixed implant-supported maxillary dentures: A 12-month pilot study. J Prosthet Dent. 2008;99:351–360.
8. Steinmassl PA, Wiedemair V, Huck C, Klaunzer F, Steinmassl O, Grunert I DH. Do CAD/CAM dentures really release less monomer than conventional dentures?. Clin Oral Investig. 2016;21:1697–705.
9. Torabi, K., Farjood, E., & Hamedani S. Rapid prototyping technologies and their applications in prosthodontics, a review of literature. J Dent. 2015;16(1):1.
10. Dawood A, Marti BM, Sauret-Jackson V DA. 3D printing in dentistry. Br Dent J. 2015;216:521–9.
11. Liu Q, Leu MC SS. Rapid prototyping in dentistry: technology and application. Int J Adv Manuf Technol. 2006; 29:317–35.
12. Alharbi, N., Osman, R., & Wismeijer D. Effects of build direction on the mechanical properties of 3D-printed complete coverage interim dental restorations. J Prosthet Dent. 2016;115(6):760–7.

13. Anadioti E, Aquilino SA, Gratton DG, Holloway JA, Denry IL, Thomas GW et al. Internal fit of pressed and computer-aided design/computer-aided manufacturing ceramic crowns made from digital and conventional impressions. J Prosthet Dent. 2015;113:304–9.

14. De La Cruz JE, Funkenbusch PD, Ercoli C, Moss ME, Graser GN TR. Verification jig for implant-supported prostheses: a comparison of standard impressions with verification jigs made of different materials. J Prosthet Dent. 2002;88:329–336.

15. Michalakis KX HHGPdc-. retained versus screw-retained implant restorations: a critical review. Int J Oral Maxillofac Implant. 2003;18:719–728.

16. H Galeva, T Uzunov, Y Sofronov and G Todorov; Accuracy evaluation of fixed prosthetic constructions made by,milling and printing technologies and the influence of temperature changes Journal of Physics-2021; 18:59 01-2064

17. Kalberer, Nicole; Mehl, Albert; Schimmel, Martin; Müller, Frauke; Srinivasan, Murali. CAD-CAMmilled versus rapidly prototyped (3D-printed) complete dentures: An in vitro evaluation of trueness.Journal of Prosthetic Dentistry, 2019;121(4):637-643.

18. Zhou JG, Herscovici D CC. Parametric process optimization to improve the accuracy of rapid prototyped stereolithography parts. Int J Mach Tool Manufact. 2000;40:363–79.