

Dimensional Accuracy of CAD-CAM Milled and 3D Printed Acrylic Resin

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Abstract

Background: There is a lack of information on the dimensional changes in acrylic resins that have been fabricated using CAD CAM and 3D printing.

Aim: The purpose of this in vitro study was to compare the accuracy of resins fabricated by using CAD-CAM-milled and 3D-printed techniques.

Materials and Methods: 6 specimens of size 10 mm diameter and 7 mm thickness were designed using Geomagic software. These were then milled and printed. The milled and printed specimens then scanned using a laser scanner and then superimposed to the original STL file.

Conclusion: It is found that CADCAM milling although more wasteful, is far more accurate to its STL file than 3D printing

Keywords: CAD- CAM, PMMA Block, Deformation

Introduction

The computerized design of the prosthesis using CAD software is the common starting point for milling and 3-D printing, but the steps involved in manufacturing are fundamentally different. A PMMA block and a computer-controlled five-axis milling machine are utilised in the subtractive method. In the 3-D printing procedure, photosensitive liquid resins are poured layer by layer over a support framework and are then exposed to light to create the final denture. It may be possible to avoid porosities and shrinkage brought on by resin polymerization by milling full dentures from pre polymerized PMMA blocks. As a result, the material's characteristics would improve and the quantities of leftover monomer would drop. However, when compared to traditional complete dentures, it has been revealed that the milled complete dentures' residual monomer content has not significantly decreased.

Complete dentures are created using the 3-D printing technique from unpolymerized resin, and after processing each layer, a final light polymerization step is meant to finish the process. Due to the inadequate polymerization of the dentures prior to the final stage, polymerization shrinkage is a potential side effect of the Manufacturing process of 3-D printing. While removing the partially polymerized prosthesis from the construction platform, deformation may occur. Contrarily, the use of 3-D printing technology has some benefits, including fewer waste of raw materials and affordable infrastructure.

Materials and Methods

This in vitro study was conducted in the Lab of Department of Prosthodontics and Dental Research Institute.

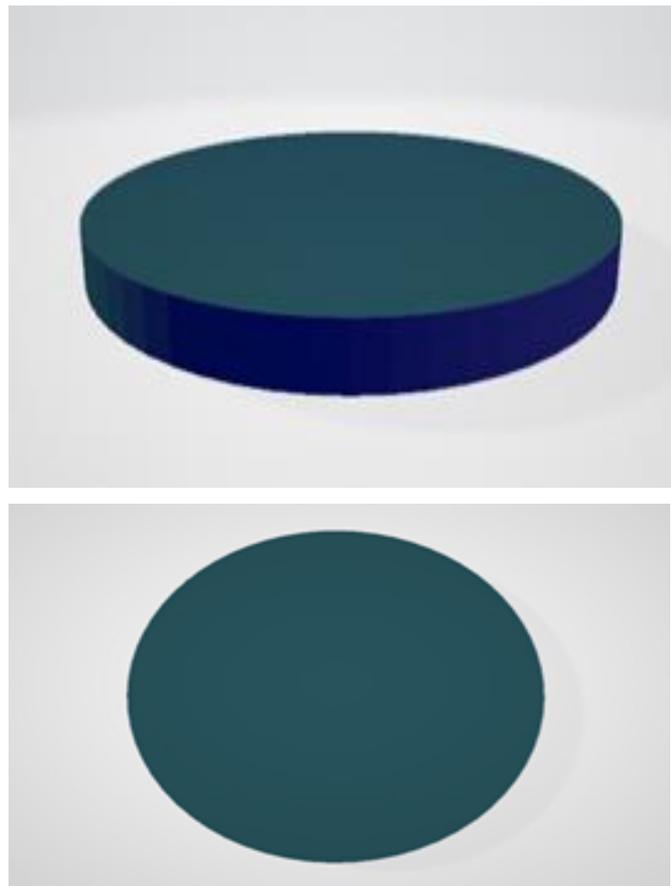


Figure 1: Design of STL File

Geomagic software was used to design cylinders of size 10mm diameter and 5 mm thickness were designed. These STL (Standard Tessellation Language Files) were exported for milling and printing

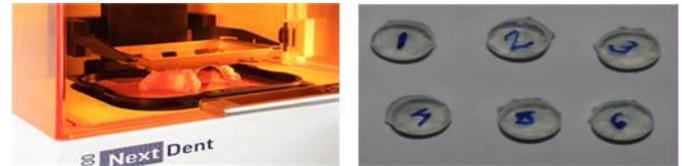


Figure 2: 3D printing of specimen

3D Printing was done using Next Dent 3-D Printer



Figure 3: CAD CAM Milling

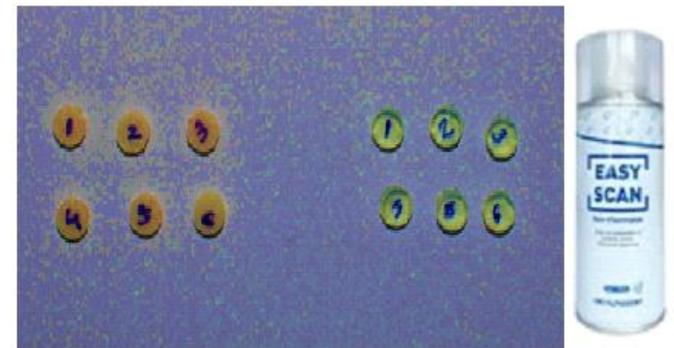


Figure 4: Easy scan



Figure 5: Scanning

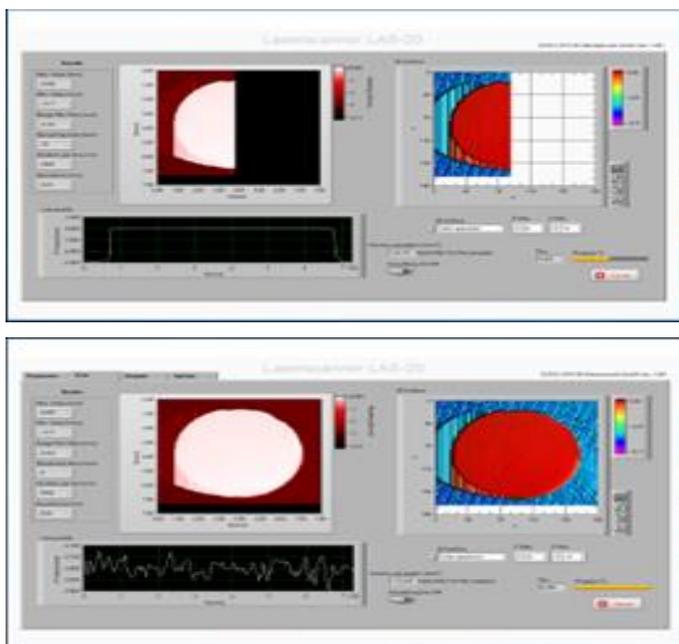


Figure 6: Superimposition

In all prostheses manufacturing, accuracy is the most important issue for clinicians. Shrinkage from polymerization has been inevitable since the introduction of polymer into the manufacturing of denture bases. For accuracy of prosthesis manufacturing, it is necessary to check the overall size and the fit of the intaglio surface. There was no statistical significance in the amount of deformation of the base in the horizontal direction through the measurement of the distances between notches on the ridge. There was no difference in the accuracy of the overall size for each method, and the RP method, which has not been studied much, has not disclosed much deformation when making the complete denture base.

Discussion

In the present study, the discrepancy was measured on the 2nd upper premolar, the center of anteroposterior distance, the 2nd upper molar, posterior region, points crossing, and the midpalatal suture. Recently, many studies have compared the accuracy between CAD/CAM milling and conventional methods.

CAD/CAM milling systems had higher congruence with denture-bearing tissues than compression molding methods. In conventional and almost all CAD/CAM systems, alveolar ridge and palate is the most accurate fit region, and posterior palatal seal and anterior and lateral seal regions showed the largest extent of misfit.²⁴ In injection molding method, as mentioned in many previous researches, the misfit due to the polymerization shrinkage and the internal stress after the polymerization is relatively high in the midpalatal suture area because of the shape and the position. While conventional methods using PMMA should consider polymerization shrinkage, the milling method is processed by subtraction of an industrially pre-polymerized PMMA blank (puck) that has final dimension.

All CAD/CAM denture systems have some problems in reproducing the anterior and lateral denture border area that often include undercut regions below the alveolar crest. Stereolithography is one of RP methods. The advantage of this technology is flexibility due to the range of available machines, low percentage of wasted raw material, and ability to print complex geometries. The main problems of printing method are staircase effect, low reproducibility, and the necessity of supporting structures.

Light-cured acrylic resins for fabricating the denture base are available on the 3D printer. There are a few products licensed for use in patients. The Next Dent Base used in this study is FDA approved. The safety of these RP acrylic materials is being tested and these materials are being assessed for long-term use. In this base material, post curing is done for 30 minutes under certain conditions following the instructions for use. However, in this study, 15 minutes was performed with different polymerization conditions in order to correct the accuracy. In the case of less polymerization, the

leakage of residual monomers or decreasing strength and the color of the fabricated denture may be insufficient. However, there was sufficient polymerization in the confirmation of the denture base color in this study. However, effects by each fabricating method on two points measured in this study were almost equal. According to McLaughlin et al., the effect of the palate depth (palatal depth of 12 mm and 18 mm classified by Johnson et al. 20) on the misfit by manufacturing method (conventional method and CAD/CAM milling method) was not observed.¹⁹ In the present study, the palatal depth of the cast was 12 mm and the palatal depth did not influence the results. The misfit in conventional measuring method is determined by measuring the actual misfit after cutting²¹ or using a device such as computed tomography after fitting the denture on the cast.²³ The development of CAD software makes it possible to easily identify the cross-section of the desired region of the program. The measurement of the misfit using the CAD software sometimes displays a negative value, which is different from the conventional method because the denture base image is fitted to the cast based on the reference points. In this study, statistical analysis was performed for absolute values of the measurement to eliminate errors due to negative values. Because this method is different from fitting the denture to the patient, it is difficult to interpret clinically. However, it is more meaningful in measuring the accuracy of the fabricated denture itself. By measuring the discrepancy, it is possible to improve the convenience and perfection of the clinical procedure by fabricating more accurate dentures and predicting areas where errors may occur. In comparison with the degree of palatine rugae resolution of the intaglio surface of the base, the injection molding method was found to be the most precise method. The accuracy of the 3Shape

D800 scanner was 7 - 8 μm . When light was used for scanning, specific areas in the palatine rugae of the cast might not have been scanned. In the milling method, the size of milling bar and undercuts for the axis of milling bar are limited. The intaglio surface of a CAD/CAM milled denture is not as smooth as the intaglio surface of the base fabricated by conventional method and is rather layered than conventional method. Goodacre et al.'s study also has shown similar texture on the intaglio surface images.^{18,34} This surface shape is inevitable because milling bar is larger than the size of stone particle. The resolution of the Bio3D. W11 DLP 3D printer used in this study was 57 μm and 50 to 100 μm for the one layer. The resolution is the smallest or the finest degree that could be reproduced by the 3D printer and it is specific for each 3D printer. The resolution should be defined in μm or dots per inch (dpi) for each x, y, and z-axis and generally, the z-axis corresponds to the thickness of the layer.³⁵ These resolutions can be confirmed simply by the shape, but in this study, the vertical distance between the highest point and the lowest point was measured and quantified. The limitation of this study includes difficulty in confirming the error in each stage of the 3D printing procedure because of complicating factors. Future research is needed to confirm the error in each stage and overcome it.

Conclusion

Clinicians who are concerned with the CAD/CAM milling and 3D printing technique for fabricating a complete denture may obtain clinically acceptable fit accuracy and retention. With generally equivalent fit accuracy between the milling and RP methods of the CAD/CAM work flow, other factors such as cost, mechanical property, risk of the residual monomer, color stability, ease of fabrication, and clinical application

might need to be considered. Future studies should evaluate these factors in order to use CAD/ CAM technology more stably and accurately. Conclusion There was no significant difference in the overall deformation in the horizontal direction among the three methods through comparison of distances between the 4 notches of the ridge. Comparison of fit accuracy between the cast and the maxillary complete denture base was evaluated on the 2nd upper premolar and the 2nd upper molar crossing the midpalatal suture, showing relatively high deformation in the conventional method due to polymerization shrinkage and the internal stress. The mean value of discrepancies was the lowest in the RP method, followed by that in the milling J Adv Prosthodont 2019;11:55-64 The Journal of Advanced Prosthodontics 63 method and the injection molding method.

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