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Comparative Evaluation of Accuracy of CAD CAM Milling and Rapid Prototyping: An In vitro Study

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KEYWORDS
digital denture,conventional complete denture,complete

Statement of Problem: There is insufficient information on the dimensional changes in acrylic resins that have been fabricated using CAD CAM milling and three dimensional printing
Aim: The purpose of this study was to compare the accuracy of standard tesselation files fabricated by using milled and rapid prototyped techniques

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denture,3d printing,milling,digital denture

Materials and Methods: 6 specimens of size 10mm diameter and 7mm thickness were designed. These were then CADCAM milled (Group 1) and 3 D printed(Group 2). 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.
Scope for the Future: 3D printing being subtractive, would turn out to be far more cost effective, and also would provide full control of both function and esthetic to the clinician. Time would be saved, and processing errors can be avoided, if the workflow of complete dentures is made digital.

INTRODUCTION

For individuals who are edentulous, complete dentures continue to be the most widely used treatment option . Over the past 100 years, denture materials and techniques have changed with the main goal of resolving the poor retention sometimes experienced by polymerization shrinkage. (1)Over the years, we have experienced unwanted shrinkage caused by the use of polymethyl methacrylate (PMMA) along with a compression moulding(flasking) technique leaking to the invention of the newer manual techniques, which had some disadvantages like the subsurface porosities caused during fabrication and improper bond between the acrylic baseplate and teeth (2).Following this, the injection moulding method was used, which was regarded as an improvement because it considerably decreased shrinkage.(3)

The digital designing of theSTL file using CAD software is the common starting point for milling and rapid prototyping, but the steps involved in manufacturing are fundamentally different. One using additive technology, and one using subtractive. Complete dentures can now be made using the 3-D printing technique from unpolymerized resin, and after processing each layer, a light curing 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 drawback of the manufacturing process of 3-D printing(4) . 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. The aim of this study is to check for the deviation of proportions from STL file created. (5)

MATERIALS AND METHODS

This in vitro study was conducted in Saveetha Dental College, Chennai, Tamil Nadu.

This study was done after getting approval from the Institution's Ethics Committee of Saveetha Dental College (IHEC/SDC/PROSTHO).

G*Power^{R} software 3.1.9.7 was used to calculate the sample size for this study, considering a previous study conducted by Lee et al. as a reference . (2,6)

The total sample size obtained was 12 (6 samples in each group).(6)

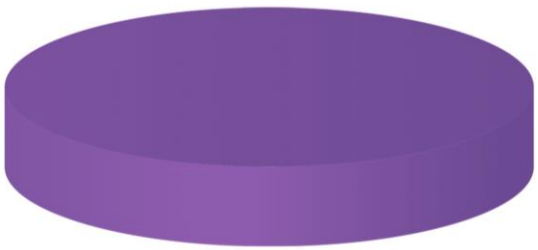
The samples were fabricated in house at Saveetha Tessellation Centre,using IMES iCORE 350i^{R} milling machine and FORMLABS^{R} 3D printers and all specimens were tested at the White Lab, SDC.

Geomagic software version X was used to design cylinders of size 10mm diameter and 6 mm thickness as demonstrated in Figure 1 and Figure 2 . These STL (Standard Tessellation Language Files) were exported for milling and printing.

The specimens were then labelled for ease of testing. (Figure3, Figure4)

Easy Scan was used to spray the specimens to ensure accurate surface scan of the specimens. (figure 5)

FIGURE 1: DESIGN OF STL FILE



Three dimensional view of specimen of 10mm diameter and 6 mm thickness

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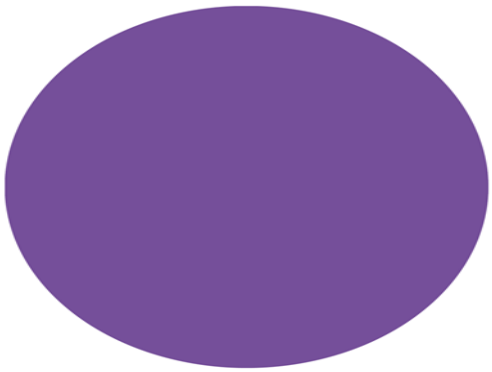
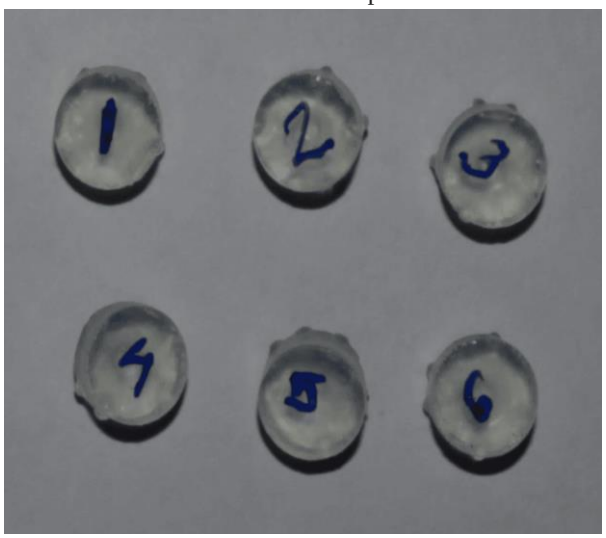
FIGURE 2: Top View of Specimen



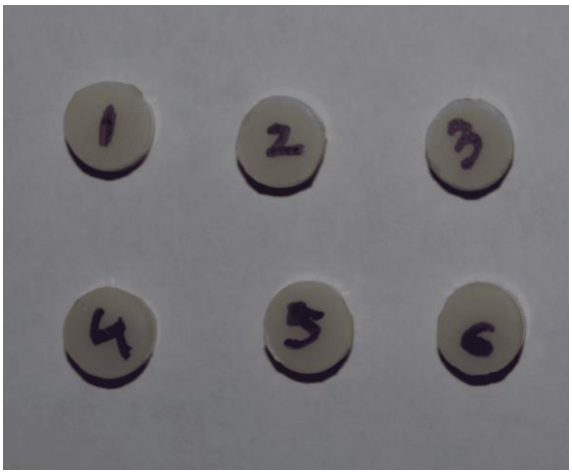
10 mm diameter disc

FIGURE 3 : Three Dimensional Specimens Printed



Specimens labelled post curing

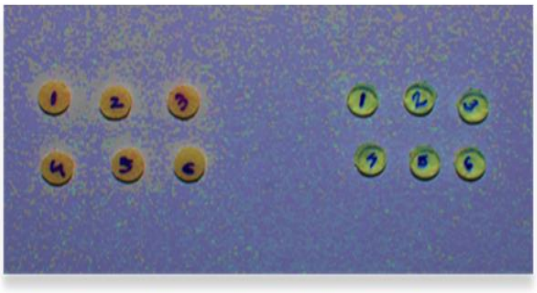
FIGURE 4 :CADCAM milled specimen



Milled specimens labelled post polishing

A PMMA block and a five-axis IMES iCORE 350i milling machine the are utilised in the subtractive method.

Figure 5: Use of Easy Scan



Application of easy scan allows for accurate scanning

FIGURE 6: LAS 300 scanner set up at the White Lab at Saveetha Dental College

FIGURE 7:Ongoing laser scanning

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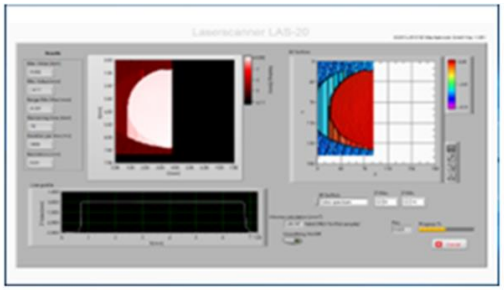
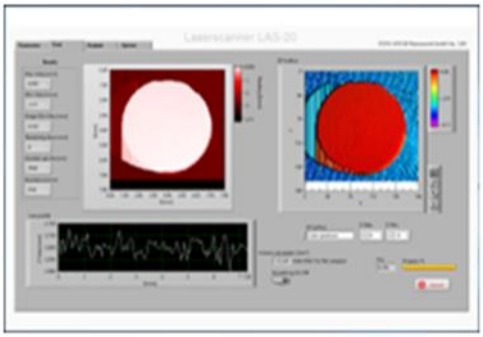


FIGURE 8: Processing of specimen



STEP 5: SUPERIMPOSITION

Superimposition was performed using geomagic software. The STLs of the CADCAM MILLED and rapid prototyped specimens were superimposed using geomagic software. The measuring tool was used for the measurements of new STL.

RESULTS

The values were tabulated in Microsoft Excel (Microsoft Corporation, Redmond, WA) and transferred to SPSS Statistics version 22.0 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.) for statistical analysis

An ANOVA test was done, which showed statistically insignificant deviation.

GROUP	MEAN	STANDARD DEVIATION
Milled	0.056	0.004
Rapid prototyping	0.078	0.0072

Table 1: Mean and Standard Deviation of milled and printed specimens

DISCUSSION

The most crucial factor for clinicians in prosthetic production is accuracy. Since the use of polymer in the production of denture bases, shrinkage from polymerization has been unavoidable. Checking the overall size and fit is crucial for accurate prosthetic fabrication. The sample's quantity of variance did not have any statistical significance. The precision of the total size was the same for both the less-studied RP method and the CADCAM method The aim for this research , was to identify the deviation in STL size, after the same file was milled and printed.(7)

The slight difference in size was owing to the difference in processing method.

Over the years, PMMA was found to have satisfactory properties, both esthetic and functional. Owing to the polymerization shrinkage of resins , dimensional changes can be seen (8)

According to the short study, A maxillary denture foundation was created on an ideal cast, and the degree of misfit varies by location, The polymerisation shrinkage of the resin during curing, with a tendency of internal stress toward the central region of the denture base, can affects the space between the denture base and the cast (1)

In the upper baseplate, which included the denture border, the hard palate, the PPS, and the crest of the residual alveolar ridge, the milling method demonstrated more accuracy than the injection molding method, according to the study by Goodacre et al.

In different areas of the maxillary full denture, Steinmassl et al. examined the consistency of the manual flasking process and different milling systems. Compared to compression molding techniques,milling systems demonstrated greater tissue contact with denture-bearing tissues. Residual slopes of Alveolar ridge and hard palate are the most accurately fitted regions in traditional and nearly all CAD/CAM systems, whereas PPS and anterior and lateral seal regions exhibited the greatest misfitting tissue.

The aerosol sprays, used for accurate scanning, as scanners cannot detect shiny surfaces accurately, have fine particles of roughly 5 m, can also cause a deviation in the results. Non clinical investigations with this coating powder have demonstrated that surface pre-treatment with powder does not significantly impair the scanning accuracy. Even though this error cannot be accepted fixed prosthodontics, a small amount of micrometer errors are regarded as clinically acceptable in removable prosthodontics, this theory has to be supported by scientific evidence. The aerosol used her was easy scan.

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A milling machine, the burs that are being used, aging of the bur, the characteristics of the region to be milled, and the machining axis can all have an impact on the milling process, taking the cause of further misfit into consideration.

PEEK has also been introduced as a routinely used material, due to its strength as well as esthetic. (9)

One of the RP techniques is stereolithography. Due to the variety of machines that are accessible, the low amount of raw material waste, and the capability to print intricate shapes, this technology has the benefit of flexibility. The staircase effect, poor repeatability, and demand for supporting structures are the primary drawbacks of the printing process. Additional resources and effort are required for these supporting structures. The light source is the primary distinction between stereolithography and DLP. The picture in DLP is produced using an arc lamp, a digital micromirror device, and tiny micromirrors arranged in a matrix on a semiconductor chip. One or more pixels from the projected picture are reflected by every micromirror. The ratio of the number of micromirrors to the picture resolution.Each phase of the RP approach, including designing in CAD software, the printing program's slicing process, and printing, can accommodate variations. The degree of light, the direction and angle of printing, the number of layers, the software, shrinkage between layers, the quantity of supporting structure, and post-processing all have an impact on the accuracy of printed objects. comparing the precision of denture bases made using fast prototyping, CAD/CAM milling, and injection molding.

Each 3D printer's material has a unique activation window, wavelength, exposure period, and intensity. Additionally, not all printing materials are compatible with all 3D printers. Due to the intricacy of printing and uncontrolled recovery of multiple mistakes, it is currently uncertain exactly which procedure the error occurs in.

The probability of using the 3d printing method and achieving good results was confirmed by this research. Photopolymerized PMMAs for fabrication of the acrylic baseplates are commercially sold. 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 following the instructions for use.

It is important to assess the colour stability of digital dentures in comparison with conventionally fabricated dentures. (10)

In this short study, 30 minutes of post processing was performed with different polymerization conditions as recommended by the manufacturer.If a shorter cycle is run, the leakage of residual monomers is possible.A gradual decrease in strength and the color leaching of the resin could also occur. Surface roughness for various resins could also differ. (11)

Future research is required to overcome the errors in every step and find solutions for the same.

With no statistical significance between the CADCAM milling and 3 D printing methods, other things to take into consideration like finances, mechanical properties, percentage of monomer content, esthetic , long term wear and ease of fabrication need to be considered. More research must be conducted to furthur evaluate these factors so digital methods can be used more reliably(12)(13)

CONCLUSION

Within the limitations of the study,

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

2)Although rapid prototyping appears to give a slight deviation, milled groups show the most homogenous distribution of adaption.

3)For dimensional changes during processing, the 3DP group's materials and methods yielded inconsistent results.

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