

Comparison of Dimensional accuracy of stereolithography and fused deposition modeling 3D printers

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ABSTRACT

Background: The aim of this study is to compare and validate the dimensional accuracy of two widely used 3D printing techniques: Stereolithography (SLA) and Fused Deposition Modelling (FDM) by Using 3D printed mandibular models based on cone beam computed tomography (CBCT) scan data.

Materials and Methods: In order to compare SLA and FDM, the mandibular model was scanned using an CBCT scanner. The DICOM file produced by the scanner was converted to STL format. SLA and FDM printing methods were used ten times apiece to manufacture the digital 3D model. Using a digital calliper, ten linear measurements of the printed models were compared with the reference model. Measurement discrepancies between FDM and SLA printers will be examined and contrasted in terms of accuracy and truth.

Results: The independent t test was used to compare the mean differences of SLA and FDM over all distances, and the results showed that the mean difference of FDM was significant. The χ^2 test was used to compare the mean relative differences between SLA and FDM over all distances, and the results were not statistically significant.

Conclusion: The notable accuracy provided by both SLA and FDM printers demonstrates their capacity to generate precise 3D models. Because low-cost FDM printers showed no clinical dimensional inaccuracy, they can be utilized in place of expensive SLA printers.

Keywords: 3 D Printing, CBCT, Printed Models.

INTRODUCTION

Additive manufacturing is defined as “a procedure of joining materials to create objects from 3D model data, usually layer upon layer.” The objective of the study is to compare and validate the dimensional accuracy of Stereolithography (SLA) and Fused Deposition Modeling (FDM) printers, using 3D printed mandibular models using Cone Beam Computed Tomography (CBCT) scan data. Fused deposition modelling printer- K/a fused filament fabrication (FFF) This work by extruding thermoplastic filaments, such as ABS, to the heated

nozzle, then the heated nozzle melts the material, and plastic is applied layer by layer to build a platform, and each layer is laid down one at a time until the part is complete. Stereolithography printer- Begins drawing layers of support structures followed by the part itself, With an ultraviolet laser aimed onto the surface of liquid thermoset resin. After one layer is imaged on the resin surface, The build platform shifts down, and then the recoating bar moves across the platform to

Received: Apr. 1, 2024; Accepted: May. 12, 2024

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apply the next layer of resin. This process is repeated layer by layer until the build is complete.

MATERIALS AND METHODS

Mandibular bone, Carestream 9300 CBCT machine, STRATUS FDM 3D printer, ABS filament, ANYCUBIC SLA 3D printer, Thermoset Resin, Chitubox software and Digital Vernier Calliper

Study design

To compare SLA and FDM printers, Ten composite markers were placed on the mandibular model before scanning, and then the Mandibular model was scanned using a CBCT scanner, which generated a DICOM file. The DICOM file was Converted into an STL model into a thin no. of slices through slicer software (CHITUBOX V1.9.0), then into the STL file into a G-code file, which is understandable by 3D printers; then both 3D printers started printing layer by layer form of material And diffuse together to form final product.

Each printer was used to print the 3D model 10 times, and 10 linear measurements of the printed models were compared with the reference model using a digital caliper. Differences between measurements were analyzed and compared for the trueness and accuracy of both FDM and SLA printers.

Post-processing In SLA printer model is kept in a Wash bin with isopropyl alcohol 100% and a Curing station where UV light is passed for complete resin curing and FDM only Support structures removal.

Allocated linear measurements

D1: Intercondylar distance- From the tip of the right condyle to the tip of the left one.

D2: Intercondylar distance- From the tip of the right coronoid to the tip of the left one.

D3: Intermandibular notch distance- From the lowest point of the right notch to the lowest point of the left one.

D4: Length of right ramus- From the tip of the right condyle to right angle of the mandible.

D5: Length of left ramus- From the tip of the left condyle to left angle of the mandible.

D6: Length of body of mandible at midline- From crest of ridge to inferior border of mandible at midline.

D7: length of the mandibular body at area of right last molar- from the crest of the ridge to the inferior border of the mandible at the area of last right molar

D8: Length of the mandibular body at area of left first molar- From crest of ridge to inferior border of mandible at area of first left molar

D9: Right condyle- left coronoid distance- From tip of right condyle to tip of left coronoid.

D10: Left condyle- right coronoid distance- From tip of left condyle to tip of right coronoid.

Table 1: Comparative assessment of Mean Relative Difference and Mean Absolute difference between SLA and FDM printer.

Measurement Method	Mean Relative Difference	Mean Absolute Difference
SLA	0.50%	0.08 mm
FDM	-1.20%	-0.60 mm



A

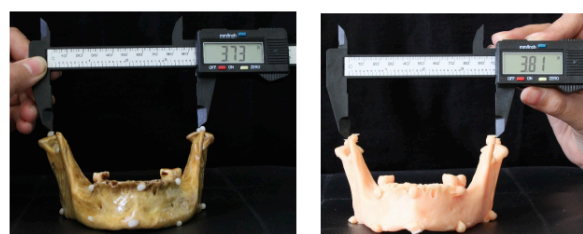


Figure 1: A. Composite markers noted on mandibular model, B & C Intercondylar distance from tip of right condyle to tip of left condyle.

RESULTS

The mean differences of SLA (SLA reference) and FDM (FDM reference) were compared in all distances using the independent t-test, which revealed that the FDM mean difference was significantly lower than the SLA mean difference. Regarding the mean difference in overall distances, the independent t-test revealed an insignificant difference ($P > 0.05$). Comparison between the mean relative differences of SLA and FDM was performed in all distances by using the χ^2 test, which revealed a significant difference between them. where the mean relative difference is (0.50%) and (-1.20%), and the mean absolute difference is (0.08 mm) and (-0.60 mm) for SLA and FDM, respectively.

The statical Differences between measurements were analyzed and compared, and it became evident that SLA offered notably more accuracy than FDM.

DISCUSSION

As 3D printing technology is widely spreading across the dental field, evidence-based evaluation should be readily accessible to dentists to allow a fair comparison of the performance of available printers.

The current study compared the dimensional accuracy of SLA and FDM. The statistical analysis of the collected data showed a statistically significant difference in the dimensional error of both techniques in comparison to the reference model, where the mean relative difference is (0.50%) and (-1.20%) and the mean absolute difference is (0.08 mm) and (-0.60 mm) for SLA and FDM, respectively. Comparing the dimensional error of the utilised 3D printing techniques with each other showed no statistically significant difference. However, the mentioned dimensional errors are within the accepted range and have no clinically significant difference. According to several studies held by George et al. Kim et al. and Rebong et al. in 2018 in addition to Jaber et al. later in 2020, the clinically significant difference between the models was defined as a measurement discrepancy of greater than 0.5 mm. In other words, a difference in dimensions between models equal to or less than

0.5 mm is unlikely to have a significant clinical impact.

Various studies have evaluated the dimensional accuracy of 3D printing technologies separately and collectively in comparative studies. Recently in 2020, Yao et al. reviewed the accuracy of SLA using a digital comparison approach. The reported dimensional error was 0.14 mm, which is almost identical to the one reported in the current study, affirming the reliability of SLA for accurately printing 3D models.

Unkovskiy et al., in 2021, questioned the accuracy of SLA. They reported a dimensional error of 0.132 mm. The results of this contemporary study were very much aligned with the current study findings. Similarly, in 2020, Metlerski et al. evaluated presurgical models made by FDM. Similar to the current study, FDM models exhibited shrinkage but with significant dimensional error. After comparison with previous similar studies, it could be concluded that the current study offered a comprehensive approach to 3D printing accuracy assessment

CONCLUSION

These findings indicate that both printers are suitable for dental applications, with SLA printers potentially offering a level of accuracy similar to FDM printers. Additionally, CBCT provides high-resolution, precise images that can be effectively utilized alongside 3D printing technology to create dependable models. As additive manufacturing evolves, defining acceptable dimensional errors and criteria for labeling a system as "accurate" should be based on the latest researched values. More studies could focus on evaluating the accuracy of newer printers like Digital Light Processing (DLP) and Liquid Crystal Display (LCD) printers.

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