

Comparison of the accuracy of 3-dimensional printed dental models manufactured with different additive technologies

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Abstract

The purpose of this in vitro study was to assess the accuracy of 3D printed dental models and models with removable dies manufactured with different 3D printers and additive techniques as scan LED technology (SLT), stereolithography (SLA) and digital light processing (DLP).
Materials: A digital upper jaw model serves as a reference. In the initial model, the 15 and 16 teeth are missing, the 11, 14, 17 and 27 teeth are prepared for fixed prosthetic appliance. To standardize the measurements 16 markers (1 mm diameter) were created on the digital model. After designing the reference markers the model was sectioned to get a model with removable dies. Furthermore two types of models were created with hollow and solid model settings.
The physical solid dental models were printed 2 types of 3D printers and printed 5-5 times with each printer. 1. SLA technology (FormLabs Form2 printer, Dental Model Resin, with layer thicknesses 50 µm). 2. SLT technique (Dreve, MediTech D30 printer, FotoDent Model material, layer thickness 50 µm). The hollow dental model and model with removable dies were printed using DLP technology (NextDent 5100, Modell 2.0 Resin, with layer thicknesses 50 µm).
Results: The mean deviation (SD) of unsectioned models printed by Dreve is 0.076 mm (0.008), Dreve sectioned models 0.087 mm (0.021), unsectioned models printed with Formlabs Form2 printed is 0.116 mm (0.009), Formlabs sectioned models 0.134 mm (0.009) and printed unsectioned models by NextDent is 0.073 mm (0.013), NextDent sectioned models 0.071 mm (0.008).
Conclusions: Within the limitation of this study it was concluded that SLT the tested additive technologies are able to fabricate a clinically acceptable physical model that is essential for construction of high-precision fixed prosthetic appliances.

Introduction

Additive manufacturing technologies are present in all areas of dentistry and are being used more and more widely. With the advent of digital dentistry, these technologies are being applied daily in the field of orthodontics, implantology and prosthetics. There are several different types of three-dimensional 3D printing technology that are appropriate for constructing dental models. The accuracy of 3D printed dental models is affected by many factors such as printing technology, material used, post-treatment, and storage conditions.

The purpose of this in vitro study was to assess the accuracy (precision and trueness) of 3D printed dental models and models with removable dies manufactured with different 3D printers and additive techniques as scan LED technology (SLT), stereolithography (SLA) and digital light processing (DLP). Furthermore the aim of this study was to compare the accuracy of 3D printed models with hollow and solid designs using 3-dimensional printing techniques.

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1. figure: 3D printed, solid dental model



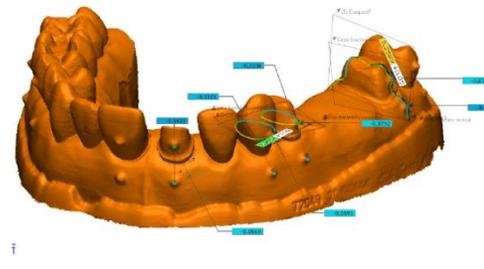
2. figure: 3D printed, solid dental model with removable dies

Materials & Methods

A digital upper jaw model serves as a reference. In the initial model, the 15 and 16 teeth are missing, the 11, 14 and 17 teeth are prepared with supragingival chamfer preparation for fixed prosthetic appliance. The 26 tooth was prepared for inlay. To standardize the measurements 16 markers (1 mm diameter) were created on the digital model. After designing the reference markers the model was sectioned to get a model with removable dies using 3Shape Model Builder program. Furthermore two types of models were created with hollow and solid model settings.

The physical solid dental models were printed 2 types of 3D printers and printed 5-5 times with each printer. 1. SLA technology (FormLabs Form2 printer, Dental Model Resin, with layer thicknesses 50 µm). 2. SLT technique (MediTech D30 printer, FotoDent Model material, layer thickness 50 µm). The hollow dental model and model with removable dies were printed using DLP technology (NextDent 5100, Modell 2.0 Resin, with layer thicknesses 50 µm).

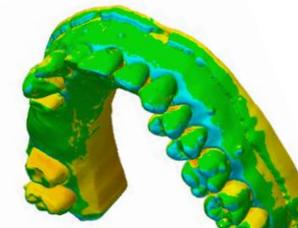
The 3D printed hollow and solid models and sectioned models were scanned using a high-resolution dental 3D scanner within two weeks after printing. The resolution of 3D scanning is less than 0,05 mm. The accuracy is of 3D scanner is less than 8 micron. The scanned models were saved as stl format and imported into the Geomagic Control X software to analyse the precision and trueness of 3D printers. After the superimposition, the whole deviation and distances between predefined reference points were measured with a digital calliper. Linear measurements were carried out between the gingival and coronal reference points on 17, and between coronal markers on 13 and 14. The deviation on eight predefined marker point was also evaluated. Measurements for the 3 types of printed models were compared with the initial digital model. The deviation of 50 and 80 µm has been defined as the allowed deviation interval in prosthetic aspect.



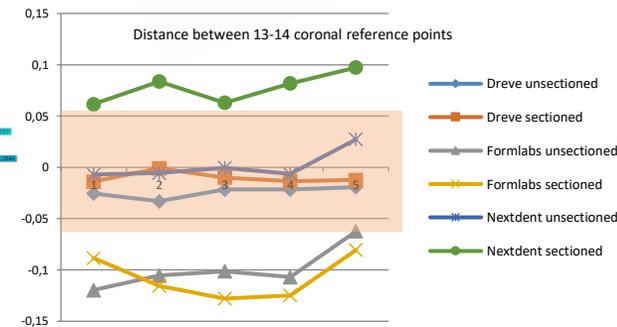
3. Figure: Digital calliper measurements points and distances

Results

The mean deviation (SD) of unsectioned models printed by Dreve is 0.076 mm (0.008), Dreve sectioned models 0.087 mm (0.021), unsectioned models printed with Formlabs Form2 printed is 0.116 mm (0.009), Formlabs sectioned models 0.134 mm (0.009) and printed unsectioned models by NextDent is 0.073 mm (0.013), NextDent sectioned models 0.071 mm (0.008). Models printed by Formlabs Form2 printer are less accurate than Dreve and NextDent models. The analysis did not reveal differences between hollow and solid 3D printed models. There was no significant differences between unsectioned and sectioned 3D printed models, except models of NextDent regarding the linear and vertical distances. Evaluation of linear and vertical measurements of the various models shows that the models printed with Dreve are more accurate.



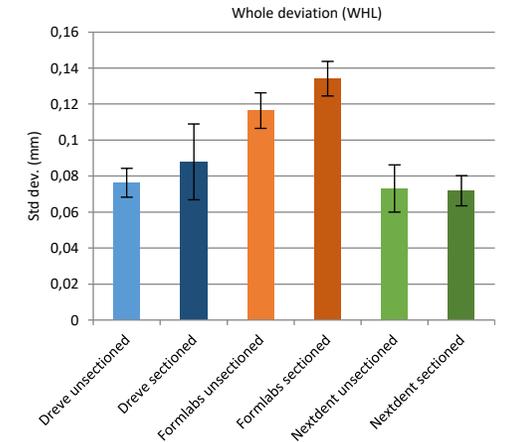
4. Figure: Colored deviation view of superimposition



5. Figure: Distance measurements between 13-14 coronal marker

Conclusion

Within the limitation of this study it was concluded that SLT and DLP technologies are able to fabricate a clinically acceptable physical model that is essential for construction of high-precision fixed prosthetic appliances.



6. Figure: Whole deviation (3D compare)

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