Evaluation of Dimensional Accuracy of 3D printed mandibular model using two different Additive Manufacturing Techniques based on Ultra-Low Dose Multislice Computed Tomography scan data

Noran Mohamed Hesham (noran145@hotmail.com)
Cairo University

Hossam Kandel
Cairo University

Iman Ismail Dakhli
Cairo Univeristy

Method Article

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Abstract

Article Type : Research article

Corrective and reconstructive cranio-maxillofacial interventions are a challenging area of surgery that requires careful pre-operative planning. To accommodate the need for precision pre-operative planning, surgeons frequently need guidance such as a 3D model to display complex cranial structures. 3D model is a manufactured model made by a 3D printer using digital imaging and communication for medicine (DICOM) data from a CT scan, and then, converted into computer-assisted design (CAD) data. Image acquisition is a very important step in generation of 3D objects as the quality of the object depends on the quality of the data. MSCT is widely applied for rapid prototyping because image post-processing is less complex for MSCT data.This aim of the present study is to evaluate the dimensional accuracy of the 3D printed mandibular models fabricated by two different additive manufacturing techniques using highly precise one as selective laser sintering (SLS) and low-cost one as fused filament fabrication and whether they are both comparable in terms of precision.

In this diagnostic accuracy study , 7 mandibular models will be recruited for the study, 10 linear measurements will be determined on the models. MSCT scanning of the model will be performed. afterwards 3d printing of the scanned image will be done using SLS and FFF 3d printers. the predetermined 10 linear measurement will be measured on the printed models to be compared with the reference standard measurement to determine the accuracy of the 3d printers in dental applications like surgical guides, orthodontic appliances, fixed prosthodontics appliances and other many dental applications. The study is scheduled to be done by october 2020

Article Type : Protocol for diagnostic accuracy study

Introduction

Minimization of times for surgical intervention and patient recovery are pivotal in reducing financial burdens on healthcare providers/patients, whilst also improving patientcare. This goal has led to considerable research interest in the area of patient specific technologies. Modern design techniques and additive manufacturing are beginning of positively impact areas of pre-operative planning (Mohammed et al., 2017)

3D printing involves creating a real-world physical 3D model from a computer model. When printing from computed tomography (CT) data, CT slices can be printed sequentially as two-dimensional (2D) layers, and these can be arranged to create the 3D model.(Dawood et al., 2015)

Custom-fitted medical devices such as craniomaxillofacial prosthetics, surgical guides, and other implants have also been developed from 3-D image data. And there are multiple steps in the model derivation process that influence the geometric accuracy of the printed constructs. (Rengier et al., 2010; Ogden et al., 2015)

MSCT images are most commonly used for 3D printing because of the wide spectrum of applications and relative ease of image postprocessing. The high contrast, signal-to-noise ratio, and spatial resolution, enhance structure differentiation and minimize partial volume effects that could limit 3D printing. (Chaudhary et al., 2018)

Multidetector computed tomography (MDCT) is considered one of the most accurate modalities in production of computer-aided design (CAD) models of the jaws. However, the increasing use of MDCT is considered one of the causes for the increasing collective dose of ionizing radiation to populations; therefore, MDCT protocols with reduced or lower doses and which do not adversely affect diagnostic accuracy should be used whenever possible. Using MDCT images produced with an 88% reduction in dose (compared to a standard clinical protocol) obtained accurate CAD models of the jaws. (Al-Ekrish et al., 2018)

Nowadays, multiple additive manufacturing techniques can be used to manufacture dental models. Some of these techniques are highly professional such as: stereolithography (SLA) and selective laser sintering (SLS). And others are more commercial like direct light projection (DLP), material jetting, fused filament fabrication (FFF). Each with their own advantages and disadvantages. Although, professional 3D printers require a high initial set-up cost, it was stated that low cost 3D printers can provide similar quality products.(Baciu et al., 2017)

Reagents

Mandibular jaw models (Implant Bone Model: M450)

Radio-opaque markers of gutta-percha balls (size 80)

Equipment

Digital Callipar

Philips Brilliance 64 channel MSCT

FORMIGA P110 (by EOS, Germany) 3D printer

Ultimaker 3 (by Ultimaker Company, Netherlands) 3D printer

OnDemand3D software (by Cybermed Inc., South Korea)

“3shape dental system” software

Procedure

1- Recruiting mandibular models

2. Placment of Gutta percha markers

3- recording 10 predetermined linear measurement using digital calliper (Ten linear measurements (5 long distances: Inter-condylar, inter-coronoidal, inter-mandibular notch, length of left ramus, length of right ramus; as well as 5 short distances: Length of the body of the mandible at midline, length of the body of the mandible in the area of last left molar, as well as that of the last right molar, the distance between the tip of right condyle to the tip of the right coronoid, as well as that of their left counterparts)

4- Performing MSCT for the models

5- Transforming DICOM file to STL format

6- using STL file for 3d printing models using two different printer SLS and FFF one

7- Recording same predetermined 10 linear measurments on the printed models

8-comapring the recorded measurement of the reference standard vs 3d printed models

Troubleshooting

Time Taken

October 2019 till October 2020

Anticipated Results

To find out if FFF dimensional accuracy is comparable to SLS

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