Maximizing Precision in 3D Printing: The Importance of Choosing the Right Printing Angle

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INTRODUCTION

In the recent years we have witnessed great development in the field of Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) in dentistry. Different methods of CAM have been established such as subtractive methods-milling or additive manufacturing methods-3D printing. 3D printing is becoming more common in daily dental practice and is used in multiple disciplines of dentistry for fabrication of models, surgical guides, temporary and final crowns, removable prostheses and others.[1] There are different parameters that can influence the results of 3D printing and the printing angulation is one of them.[2] Therefore, it is important to evaluate the effect of printing angulation on the precision of 3D printed models. This poster aims to evaluate the effect of printing angulation on the precision of 3D printed dental models.

MATERIALS & METHODS

Four typodonts were utilized for the purpose of this study and intraoral scans of those typodonts were obtained. Two maxillary arches and two mandibular arches from the scanned typodonts were 3D printed in three different angulations of 0, 30 and 60 degrees using the FormLabs 3B+ SLA 3D printer with V3 model resin. Each printed model was scanned within 24 hours[3] and compared to the original Stereolithography (STL) file of the typodont using Oqton Control X CAD software by superimposition (Figure 1, 2). 3D, 2D and point compare tool were utilized with a tolerance set to 0.5mm. For each model, their general total model accuracy was measured alongside two selected teeth (one incisor and one molar) to be measured in their general accuracy and three individual points in their facial, incisal/occlusal and lingual surfaces. A total of nine measurements were made compared to the original STL scan. Statistical analysis was completed with one-way ANOVA and Tukey post-hoc test.

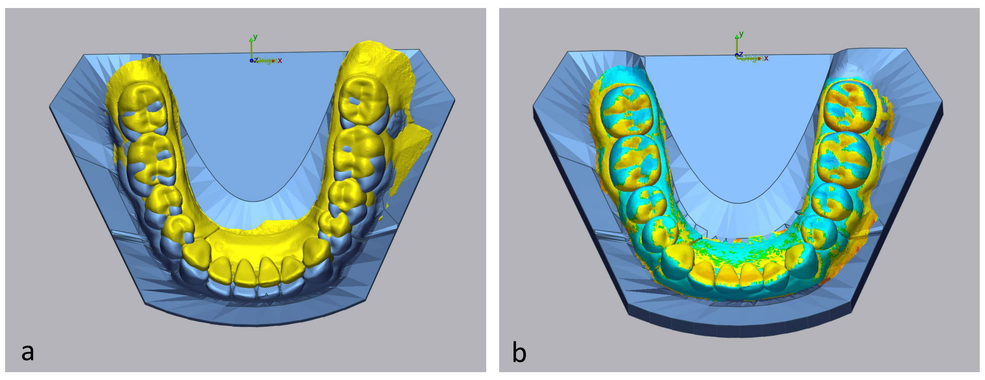

Figure 1. (a,b)Oqton Control X alignment of control model with model 1 at angulation 0

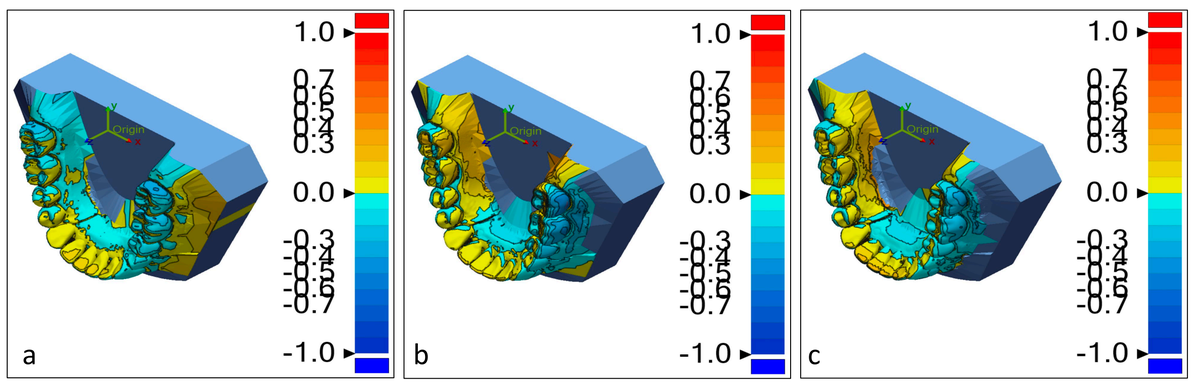

Figure 2. Superimposition of control model and models 1 at (a) 0 , (b) 30 and (c) 60 degrees.

RESULTS & DISCUSSION

Using the 2D compare software tool, the printing accuracy of incisors and molars was measured (Figure 3, 4).

The highest accuracy for incisors was found to be for models printed at 0 degrees, followed by 30 degrees and lastly, 60 degrees.

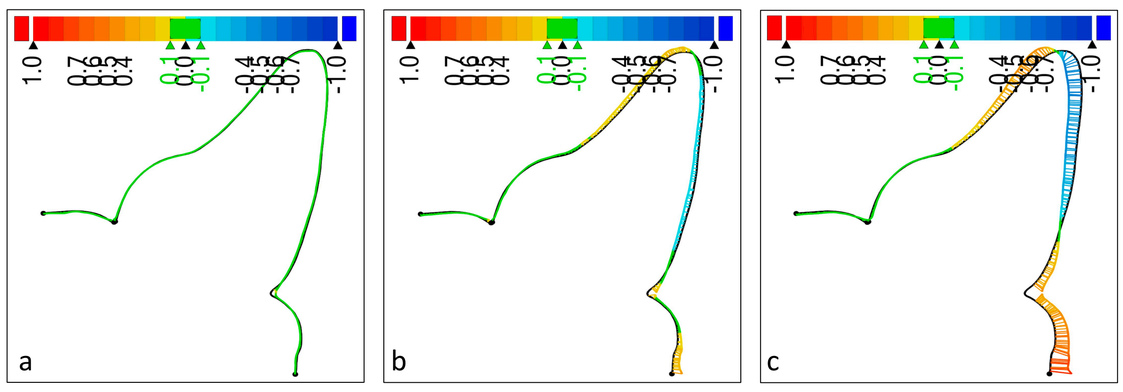

Figure 3. Cross sections of incisors for model 1 at (a) 0, (b) 30 and (c) 60 degrees.

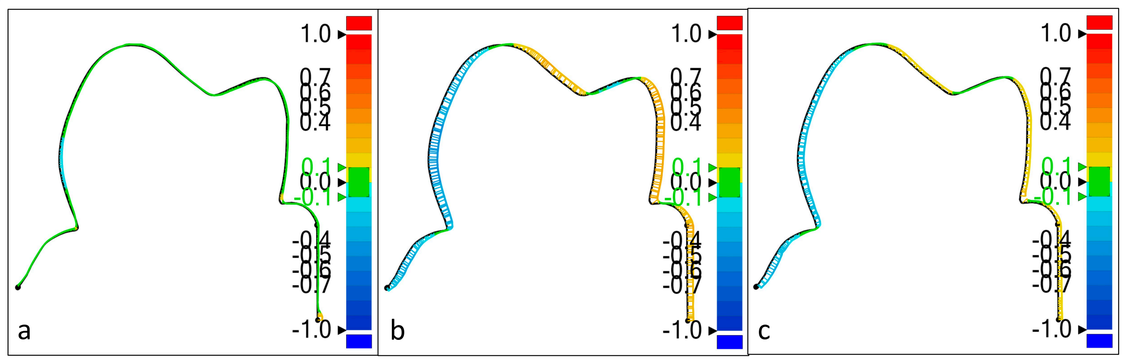

Figure 4. Cross sections of molars for model 1 at (a) 0, (b) 30 and (c) 60 degrees.

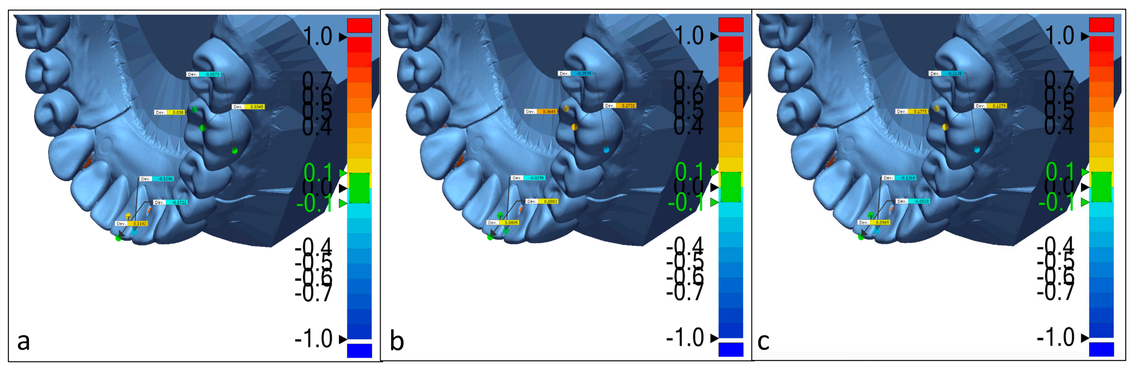

Figure 5. Individual point measurements for model 1 at (a) 0, (b) 30, (c) 60 degrees.

Groups	Mean Diff	SE	p
0-degree vs 30-degree	0.049	0.01299	0.012*
0-degree vs 60-degree	0.039	0.01299	0.036*
30-degree vs 60-degree	0.01	0.01299	0.753

Table 1: Volumetric comparison between angle groups (*p<0.05).

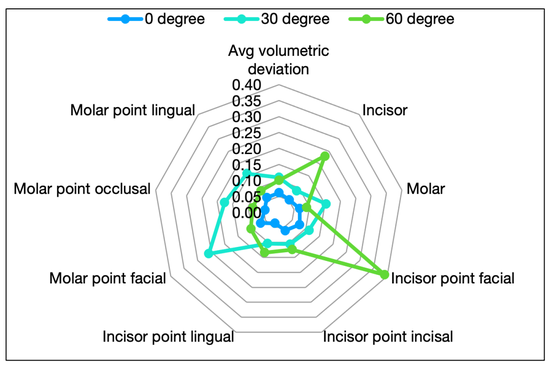

Table 2: Multi-point Polygon analysis.

The highest accuracy for molars was for models printed at 0 degrees, followed by 60 degrees and lastly, 30 degrees.

Accuracy of different points (facial, incisal, lingual) in incisors was highest in models at 0 degrees, followed by 30 degrees and lastly 60 degrees . Printing accuracy of different points (facial, occlusal, lingual) in molars was highest in models at 0 degrees, followed by 60 degrees and lastly 30 degrees (Figure 5).

Finally, using the 3D compare software tool, from the superimposition of the full models obtained, the data demonstrated that the highest accuracy was obtained on models printed at 0-degrees with a statistically significant difference compared to the other angulations (Table 1).

Printing accuracy in general for all nine measured parameters, was highest in models printed at 0 degrees, followed by 30 degrees and lastly 60 degrees (Table 2).

From the results obtained from this study, the 3D printing of models at 0 degrees displayed to be most accurate overall.

Previous studies have also shown that maintaining and angulation <20˚ appears to produce the most accurate 3D printing results for models.[4]

CONCLUSIONS

Within the limitations of this study, printing angulation appears to have a significant effect in the accuracy of 3D printed models. This holds a clinical significance as it can affect any subsequent clinical applications (i.e. orthodontic appliances, retainers, surgical guides etc.). Therefore, printing angulation should be considered as a source of variability affecting accuracy and requires further research.

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