Accuracy of digitized dental stone models using cone beam computed tomography compared to extraoral scanned models (An in vitro study)

Original Article

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ABSTRACT

For accurate treatment planning, virtual surgical planning makes use of clinical data, image testing, plaster models of dental arches, and clinical pictures. Plaster model scanning can be done in two ways: using an extraoral scanner or cone-beam computed tomography (CBCT).The aim of this study was to assess the accuracy digital dental stone models obtained using cone beam computed tomography and extraoral scanner. Materials and methods: The control group was the measurement performed on 20 plaster models by digital caliper. The same 20 models were scanned through extraoral scanner and CBCT in order to compare the dimensional accuracy. Six measurements were performed on each model between reference points. Results: There was no statistically significant difference in dimensional accuracy between digital models obtained by CBCT scanning and extraoral scanning compared with digital caliber measurements with higher accuracy for extraoral scanned models. Conclusion: CBCT and extraoral scanning digitized models have acceptable dimentional accuracy.

Key Words: Digital models,CBCT, Extraoral scanning, Digitization.

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INTRODUCTION

The creation of digital models to replace plaster casts is a new breakthrough in the field of dentistry known as digitization. Many researchers have tried to improve the accuracy of digital models in an effort to reduce the requirement for traditional laboratory work. As a result, a great deal of earlier research has tried to evaluate the accuracy of digital models created in different methods. Comparing computerized models to the real dental arch is a challenge in terms of accuracy evaluation. The most popular method for obtaining digital or virtual models is extraoral laser scanning of stone or plaster molds. The extraoral optical scanner-generated digital model or the dental cast model were considered the gold standard in earlier research. [1,2,3,4]

An extra-oral digitizing technique called an optical scanner (OS) projects a white light onto a plaster dental model. Subsequently, the projected pattern is recorded by a high-resolution camera, enabling the production of a three-dimensional model image. Optical digitizers are frequently preferred by dental labs because they require less acquisition time for scan creation [5,6]. Cone-beam computed tomography (CBCT), a data collecting technology that rapidly scans the entire volume of any object without being impacted by the quantity of undercuts in the deep proximal areas, is another way to obtain a virtual model [7]. Refinement of CBCT resolution from 0.4 to 0.07 mm has recently taken place to improve 3D viewing of the craniofacial region [8,9,10,]. However, there is still a problem with distortion in scans of the entire dental arch. [11,12,13]

Creating digital models from CBCT scans of patient impressions and casts offers a non-irradiation-related substitute for intraoral or desktop scanning. Furthermore, certain places may be devoid of information for both extraoral and intraoral optical scanners due to light sources' difficulty accessing regions such complex-angled surfaces or proximal undercuts.[14]

Many studies have looked into whether different scanning techniques are precise enough to obtain digitalized models, however evaluating accuracy is hampered by a number of factors. It might be difficult to obtain accurate and repeatable measurements of digital models. [15]

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Aim of the study

This study aims to determine the accuracy of digital dental stone models obtained using cone beam computed tomography compared to extraoral scanned models.

MATERIALS AND METHODS

Models selection

20 dental stone demonstration models of completely dentulous cases were selected for this study.

Control group

A digital caliber was used to measure six mesiodistal linear measurements in each model (mesiodistal width for the four incisors and intercuspal distance between premolars) using the incisal angles for incisors and buccal cusp tips of first and second premolars as reference points then measurements recorded in mm .Figure 1

CBCT scanning and measurements

Each model was scanned using CBCT machine cranex 3D,Soredex,Finland using the parameters 10mA,90KvP and FOV 6*8 cm with a voxel size of 200 µ. Data was imported to ONDEMNAD 3D software and the mesiodistal linear measurements for same teeth was measured using linear measurement tool between same reference points. Figure 2

Extraoral scanning and measuements

Models were scanned using extraoral scanner (inEos, Dentsply, Sirona, USA) and then STL file imported to Freecad software and measurements were applied for the same teeth using the same reference points. Figure 3

Figure 1 showing tooth linear measurements using digital caliber

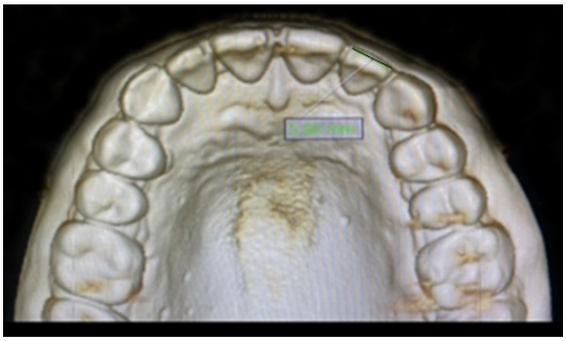

Figure 2 showing tooth linear measurements on CBCT scanned model

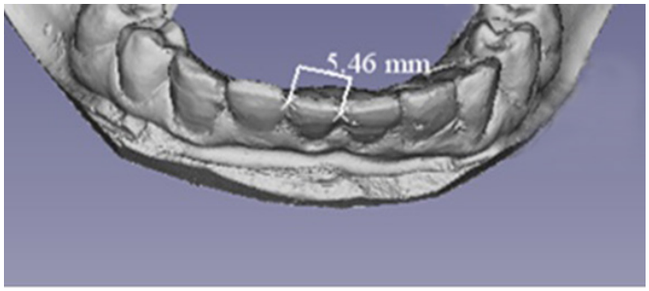

Figure 3 showing tooth linear measurements on extraoral scanned model

RESULTS

IMB SPSS software was used for data analysis, the mean and standard deviations for both groups were calculated and compared to the control group.
The study groups were compared using one way ANOVA test.
Accuracy of both groups was calculated and represented.

Comparison between the two groups (digital models linear measurements in mm).

Teeth linear measurements were 7.576 ± 2.73 in CBCT models and 7.917 ± 2.83 in extraoral scanned models compared to 8.185 ± 2.79 for the control group.Table 1

The results showed no statistically significant difference P > 0.05 between linear teeth measurements of both CBCT and extraoral scanners compared to the control group . Table 2

Mean mesiodistal linear teeth measurements for the control and studied groups were represented. Figure 4

CBCT models showed 92.5% accuracy while extraoral scanned models showed 97% accuracy. Figure 5

Table 1 showing mean and standard deviation of linear teeth measurements in mm

	n=20 Mean	Std. Deviation	Minimum	Maximum	Std. Error of Mean
Control	8.185	2.79	7.09	9.373	2.353
CBCT	7.576	2.73	6.44	8.591	2.329
Extraoral	7.917	2.83	6.92	8.941	2.371

Table 2 showing comparison between linear measurements of the study groups

	Sum of Squares	df	Mean Square	F	Sig P-value
Between Groups	7.054	3	2.993	3.063	0.079
Within Groups	12.71	11	0.977		
Total	19.764	14			

*Significant at $p < 0.05$

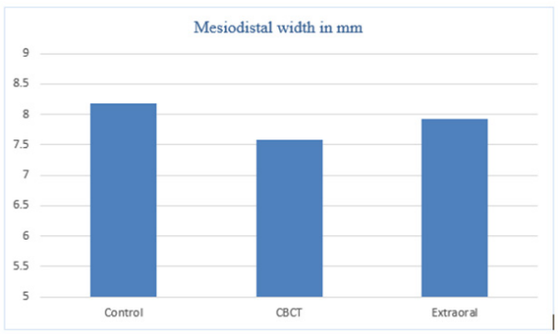

Figure 4 showing mean mesiodistal linear measurements in mm

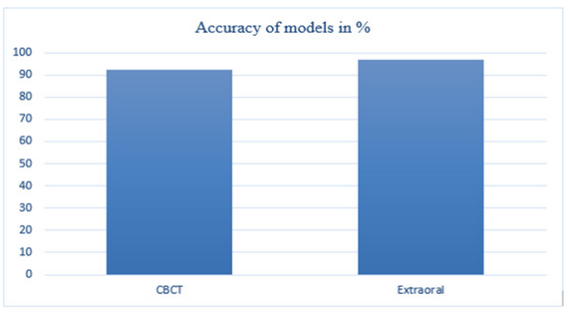

Figure 5 showing accuracy of CBCT and extraoral scanned models in %

DISCUSSION:

Digital dental arch models have emerged as a significant dental trend in recent years. A growing number of imaging technologies are now on the market that allow digital data to be acquired from plaster models and imprints. The acquisition of precise virtual 3D models has become crucial as dental practices integrate digital workflows. Higher productivity is associated with digital workflows, which also make data storage, repeatability, and treatment documentation easier. They can also inspire novel treatment ideas. However, the market's constant influx of new devices with technical advancements has complicated physicians' task of choosing the right tool. [16]

As a result, numerous earlier researches have evaluated the accuracy of digital models [17,18,19,20,21].

Several studies assessed the precision of digital models created by scanning plaster models using different tools or compared the linear dimensions of digital models to the equivalent values of plaster castings [22,23,24,25] In this study, linear measurements were compared between the models; in prior research, surface precision data were examined. [26,27,28,29].

We believe that results from evaluations of surface precision are highly likely to be distorted. Small surface imperfections like bubbles and pearls formed during the taking of impressions or pouring of plaster models can occur during the development of digital models. If surface irregularities are present, scanning may result in an increase in the model distortion. Smoothing, a postprocessing technique for STL data, also overestimates errors because of surface roughness. [30]

Our study showed no statistically significant difference in accuracy between CBCT and extraoral scanned models, this coincides with Emara et al [31] who concluded that CBCT digital models are an extremely accurate replacement to extraoral scanned models.

Our results also reported higher accuracy for extraoral scanned models compared to CBCT models in agreement with Kim et al [32] who reported that there was no statistically significant difference, however the digital model created using the extraoral scans had less variation than the other digital models created using the intraoral scanner and CBCT scans. These results also coincides with Emara et al [31] who suggested that with no statistically significant variations from the other digitization techniques, extraoral scanning is a very dependable digitization instrument. Our results are similar to the findings reported by Becker et al who stated that however CBCT accuracy lower than that of the reference desktop scanner, it is still clinically acceptable. [33]

In agreement with several studies reported in the literature, our results confirm that the accuracy of extraoral scanned models was within an acceptable range. [34,35,36] In addition to Mandelli et al [35] who reported that Extraoral scanned models showed acceptable accuracy. As reported in previous studies, In most cases, the computerized models displayed measurement values that were lower than the actual data. Researchers have proposed that the partial volume effect during scanning or the conversion software's algorithms may be to blame for this "downsizing" tendency in digital models. If clinicians use digital models created by item scanning technologies, they should be informed that the models may be reduced in size. [37,38]

CONCLUSION

Digitized dental models using both CBCT and extraoral scanners have acceptable dimensional accuracy.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

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