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Research Article

Accuracy and Reliability of CBCT Scan in Obtaining Digital 3D Model from Dental Plaster Model for Orthodontic Space Analysis: Diagnostic Accuracy Study

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Abstract

Objective: This study was conducted to evaluate accuracy of CBCT derived digital models in terms of linear measurements compared to direct measurements on dental plaster models for orthodontic space analysis.

Methods: 16 plaster models were digitized using Planmeca Promax 3D mid CBCT machine and 28 anatomical landmarks were identified on both the plaster models and their digital counterparts. Linear measurements were taken for the inter-molar, inter-canine and mesio-distal teeth width on plaster models using digital caliper and they were considered as the gold standard in the study. Then, the same measurements were taken on digital models using third party software (In Vivo 5.3.1 Dental Software) for comparison.

Results: The statistical analysis of the recorded measurements showed a mean value of 0.14 mm (SD. 0.34) for the inter-molar width, 1.55 mm (SD. 4.03) for the inter-canine width and 0.11 mm (SD 0.1) for the mesio-distal teeth width. There was neither statistical significant nor clinical relevant difference regarding the inter-molar width. On the contrary, the mesio-distal teeth width showed statistical significant difference yet, this difference did not translate to clinical relevance. Finally, the inter-canine width showed a non-statistically significant difference which did translate to clinical relevance.

Conclusion: CBCT derived digital models provide accurate and reliable linear measurements for orthodontic space analysis except for the inter-canine width measurements.

Keywords: CBCT; Digital Models; Plaster Models; Orthodontic Space Analysis; Linear Measurements

Introduction

For the orthodontic treatment to be successful, proper diagnosis and treatment planning should be done [1]. For several years the gold standard for the orthodontic diagnosis has been the plaster study model as it is essential for proper presentation of the case, keeping the records and evaluating the treatment progress [2]. Also, space analysis can be done on the study models to evaluate the mesio-distal teeth width, the amount of crowding and spacing [3].

Although the plaster study models have been used for a long time yet, they have several drawbacks. For Medico-Legal purposes the long term storage of the casts is required which may create storage space and data retrieval problems. Also, they may be

subjected to physical damage [4,5]. With the growth in the dental technology, the idea of 3D digital models evolved and it seemed to be very promising [6]. Digital models offer the advantages of easier consultation, better patient education and follow up with reduced time, laboratory costs and storage space [7].

Digital models can be obtained either directly by CBCT or laser scanning of the human dentition and then a 3D reconstruction is done or indirectly by CBCT or laser scanning of the impression or the poured plaster cast [8,9]. However, the reliability of the digital measurements yielded by CBCT scanning of the plaster cast is yet to be evaluated thoroughly.

Materials and Methods

This study was conducted on 16 plaster models and their digital counterparts.

Plaster models

Archived plaster models made of type IV extra hard stone were obtained from the Department of Orthodontics, Cairo University. On each plaster model, 28 anatomical landmarks were identified.

Digital models

Digital models were obtained by CBCT scanning of the plaster models using Planmeca Promax 3D mid machine model capture mode, all CBCT images were taken at 80 kVp, 12.5 mA and 0.15 voxel size with 5 seconds exposure time. Digital models were then obtained and exported as an STL file.

Measurements

Linear measurements were taken for the mesio-distal teeth width, inter-canine and inter-molar width on both the plaster models and their digital counterparts (Figure 1). As for the plaster models, measurements were taken using digital caliper and were considered to be the gold standard in the study. It was confirmed before taking any measurement that the caliper is being held perpendicular to the occlusal plane.

Regarding the digital measurements, the STL file of the digital model was imported to a third party software (*In vivo* 5.3.1 Dental Software), orientation of the digital models were adjusted for proper measurements taking. Also, for standardization purposes the starting and ending points of the measurements were also fixed using the same anatomical landmarks identified on the plaster models.

Figure 1: Measurements on digital model showing inter-canine and inter-molar width (A) while, (B) is showing the mesio-distal teeth width.

The measurements were done by 2 oral radiologists blinded to the results of each other to assess the inter-observer reliability, one of them took the measurements twice to assess the intra-observer reliability.

Statistical methods

Data was analyzed using IBM SPSS advanced statistics (Statistical Package for Social Sciences), version 21 (SPSS Inc., Chicago, IL). Numerical data was described as mean and standard deviation or median and range. Data was explored for normality using Kolmogrov-Smirnov test and Shapiro-Wilk test. Comparisons of the 3 groups for normally distributed numeric variables was done using the ANOVA while for non-normally distributed numeric variables were done by Kruskal Wallis test. A p-value less than or equal to 0.05 was considered statistically significant. All tests were two tailed.

Results

There was very good inter-observer agreement regarding all measurements with Cronbach's alpha values ranging from 0.878 to 0.923. There was also very good intra-observer agreement regarding all measurements with Cronbach's alpha values ranging from 0.899 to 0.943.

The statistical analysis of the recorded measurements showed a mean value of 0.14 mm (SD. 0.34) for the inter-molar width, 1.55 mm (SD. 4.03) for the inter- canine width and 0.11 mm (SD 0.1) for the mesio-distal teeth width. There was neither statistical significant nor clinical relevant difference regarding the inter-

molar width. On the contrary, the mesio-distal teeth width showed statistical significant difference yet, this difference did not translate to clinical relevance. Finally, the inter-canine width showed a non-statistically significant difference which did translate to clinical relevance. Table 1 and figure 2 summarize the results.

Measurement	Min.	Max.	Mean	S.D.
Inter-Molar Width	-0.45	0.17	-0.14	0.34
Inter-Canine Width	-2.17	5.28	1.55	4.03
Mesio-Distal Teeth Width	-0.21	-0.02	-0.11	0.1

Table 1: Showing the overall mean and standard deviation for all the measurements.

S.D. = Standard deviation. Min = Minimum Value.

Max = Maximum value.

Figure 1: Bar chart representing mean and standard deviation values for all the measurements.

Discussion

Plaster and digital study models are considered to be essential orthodontic diagnostic tools. Besides diagnosis and treatment planning, they can be used for space analysis purposes 10. The most common measurements taken in space analysis are the mesio-distal teeth width, inter-canine and inter-molar width. So, they have been all used in our study for comparison between plaster models and digital models in terms of linear measurements.

This study was designed as an in-vitro one on dental plaster models based on ethical concerns of not exposing human subjects to such unnecessary radiation doses. Also, the literature showed few studies addressing the accuracy of linear measurement taken on digital models obtained from CBCT scanning of the plaster models.

Searching the literature for similar studies, we found only three studies measuring the accuracy of linear measurements on CBCT derived digital models for orthodontic purposes and there were diversity in the results. (Lippold., *et al*. 2015) [11] assessed the methodological accuracy of digital and manual model analysis in orthodontics. In agreement with our study, the mean difference for inter-canine width showed a clinically relevant value, while the inter-molar width showed a clinically irrelevant value. The mesio-distal width of the teeth was not assessed in their study.

Likewise, (Şakar., *et al*. 2017) [12] evaluated the accuracy of linear measurements on 3D models obtained with CBCT and compared it with analog dental plaster casts. The mean difference for the inter-molar and mesio-distal teeth width showed a clinically irrelevant value as our study. While, the mean difference for all the inter- canine width showed clinically irrelevant values. It is worth mentioning that inter- canine width mean values in their study were still the highest among all measurements and just below the clinical relevant values which confirms the difficulty in locating the canine cusp tips.

On the other hand, (Bariar., *et al*. 2018) [13] assessed the validity and reliability of digital models obtained by Cone Beam Computed Tomography Imaging and their results were contradicting with ours. The mean difference for the mesio-distal teeth width was above the clinical relevant limit. The possible explanation for this partial dis-agreement could be related to different software used for linear measurement assessment.

Conclusion

Linear measurements obtained from CBCT derived digital models are accurate and reliable for orthodontic space analysis purposes except for the inter-canine width measurements. However, CBCT serves as a good digitization tool for plaster models as it provides perfect combination of accuracy, reproducibility and time efficiency.

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