Evaluation Of A Digital Method Of Study Model Analysis

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Abstract

Aim: The purpose of this study was to evaluate the accuracy and reliability of study model measurements using Nemotec Digital Imaging Software. **Materials and method**: The study was conducted on 25 sets of study models having all permanent teeth till second molars completely erupted, selected from the pretreatment patient records. The mesio-distal tooth widths of all the permanent teeth till the first molars and arch length from mesial of the first molars of both the sides was measured using both the manual and digital methods. The measurements were taken twice by the same and by another examiner at an interval of two weeks to determine the intra-examiner and inter-examiner error. Bolton's and Carey's analysis was done using both manual and digital measurements. **Results**: The data obtained was subjected to statistical analysis by using SPSS version 15 statistical analysis software. All the correlations between the first and second observations were strong (r>0.9) showing good reproducibility of measurements. The means, standard deviations and ranges were determined and the manual and digital measurements were compared using a paired t-test. Statistically significant differences were found for the tooth size and arch length, with the digital measurements being smaller than the manual measurement. The differences were small and clinically insignificant. Bolton's and Carey's analysis showed no statistically significant difference between both the methods. **Conclusion:** The Nemotec Digital Imaging Software may be used reliably for study model analysis.

Keywords: Study models, digital measurements, software.

INTRODUCTION

Successful orthodontic treatment is based on comprehensive diagnosis and treatment planning. Study model analysis is an integral part of diagnosis and treatment planning. Nowadays, many orthodontists tend to digitize orthodontic records and use the computer to assist in diagnosis and treatment planning.[1] Proffit stated that one advantage of digitizing tooth dimensions for space analysis is that the computer can quickly provide a tooth size analysis.[1] The increasing use of digital models has highlighted the need to evaluate the accuracy of these new computerized software programs and compare them with traditional manual measurement techniques. While the digital copies of study models eliminate storage and retrieval issues of plaster study models, they may not be as accurate as measurements made on traditional study

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models.[2] One of the factors contributing to this may be the accuracy of the software used for the measurements. Hence, the present study was done to evaluate the accuracy of a computerized method of study model measurement and analysis using Nemotec digital imaging software.

MATERIALS AND METHODS

Twenty-five sets of study models were selected from the pre-treatment patient records of the department. All the models had all permanent teeth till the second molars completely erupted. The study models were in good condition with no voids or blebs. Models with missing permanent teeth (except third molars), malformed teeth, teeth having fractures, caries, restorations, crowns or bridges were not taken for the study.

Method:

Mesio-distal tooth widths of all the teeth till the first molars and the arch length were measured by two methods i.e. manual and the computerized method.

Manual method:

Mesio-distal tooth width measurement- A vernier caliper with a digital micrometer with a least count 0.01 mm was used to measure the maximum mesio-distal widths of all the teeth from the first molar of one side to the first molar of the opposite side. The measurements were done from the anatomical mesial contact point to the anatomical distal contact point of each tooth. (Fig.1)

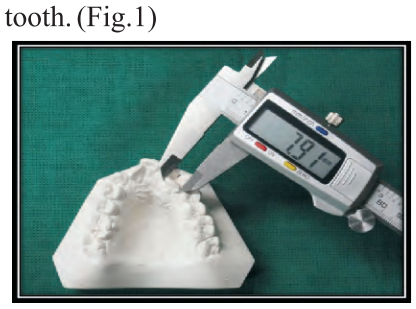

Fig1. Mesio-distal tooth width measurement using vernier caliper

Arch length measurement- The arch length was measured by adapting a malleable brass wire of 0.05mm from the mesial surface of the first permanent molar on one side to the mesial surface of the first permanent molar on the other side, shaped over the buccal cusps of the premolars and molars and the incisal edges of the anterior teeth, then straightened and measured. (Fig.2)

Fig.2. Arch length measurement using a brass wire

The values were recorded on a custom sheet.

Digital method:

Digital images of the occlusal surfaces of all the maxillary and mandibular study models were taken by a digital camera (Nikon D-70, 8Mega Pixel, SLR) which was placed at a distance of 20 cm from the base of the model. In order to calculate the magnification of the system, a scale was placed at the level of the occlusal surfaces of the casts while taking the images. (Fig.3)

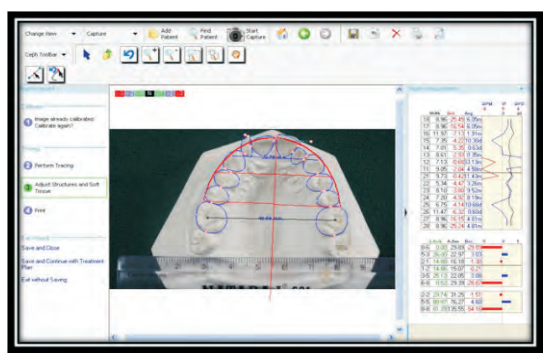

Fig.3. Digital tracing performed using software program

The images were imported to a digital image tracing software (Nemotec, version 6). After calibrating the images, digital tracing was performed on each study model.

Mesio-distal tooth width measurement : The mesial and distal points were plotted on each tooth from the first molar of one side to the first molar of the opposite side.

Arch length measurement- After plotting the contact points for each tooth, the software displayed the occlusogram on the screen with an arch line. The arch line was repositioned over the buccal cusps of the premolars and molars and incisal edges of the anterior teeth to simulate the manual method.

The tooth widths and arch length measurements generated by the software were recorded on the custom sheet.

Model Analysis

Bolton's analysis:

The over-all and anterior proportions existing between the sum of the mesio-distal diameters of the maxillary and mandibular teeth and the amount of discrepancy were calculated by the manual and digital methods.[3] The discrepancy was recorded as a negative value if there was mandibular tooth material excess and positive in case of maxillary tooth material excess.

Carey's arch analysis:

Carey's arch analysis was performed for all the mandibular study models and Carey's arch perimeter analysis for all the maxillary study models. This analysis was done to determine the tooth material arch length discrepancy by calculating the difference between the sum of mesio-distal tooth widths of all the teeth from second premolar of one side to the second premolar of the other side and the space available (arch length). The discrepancy was recorded as a negative value if there was tooth material excess and positive in cases of excess space available in the arch.

The data obtained was subjected to statistical analysis using SPSS (Statistical Package for Social Sciences) Version 15.0 statistical analysis software. Descriptive statistics including means, standard deviations, maximum and minimum values and standard error of means were calculated. Paired sample statistics was applied to compare the manual and digital methods. The level of significance was set at $p \leq 0.05$. All the measurements were repeated by the same operator and by a second operator at an interval of two weeks to determine the method error.

RESULTS

Table 1 shows the intra-examiner and inter-examiner variability of measurements repeated at an interval of two weeks by the same and another examiner for the two methods investigated. Variability of the differences was reflected in the correlation coefficients, which were found to be strong ($r>0.9$) for all the measurements.

Table 1: Intra and Inter-examiner reproducibility of Manual and Digital measurements

Error	Parameter	Manual		Digital	
		Difference (mean ±SD)	Correlation coefficient	Difference (mean ±SD)	Correlation coefficient
Intra-examiner	Mesio-distal tooth width	0.63±1.49	0.970	0.15±.51	0.996
	Arch length	0.97±1.88	0.958	1.03±1.94	0.964
Inter-examiner	Mesio-distal tooth width	0.55±1.38	0.972	0.63±1.19	0.978
	Arch length	0.85±2.32	0.955	0.49±2.4	0.949

Table 2 shows the comparison of the manual and digital measurements for total mesio-distal tooth widths and arch length. The mean difference was found to be statistically significant (p=0.000).

Table 2: Comparison of total mesio-distal tooth widths (1st molar to 1st molar) and arch length by both the methods

Parameter	n	Manual	Digital	Mean diff.±SD	Std. error of mean Diff.	95% Confidence Interval of the Difference		T value	P value
		Mean±SD	Mean±SD			Lower	Upper		
Mesio-distal tooth width	50	92.89±5.9	91.18±5.6	1.70±1.01	.144	1.41	1.99	11.8	.000
Arch length	50	67.44±6.39	66.37±6.52	1.07±1.20	.170	.724	1.408	6.261	.000

Table 3 shows the comparison of Bolton analysis for both the manually and digitally obtained measurements. The mean difference was found to be 0.34±1.68 and 0.31±1.5 for anterior and overall Bolton ratios between both the methods, which was not statistically different (p>.05).

Similarly the mean difference was observed to be 0.05±.97 and 0.32±1.29 for anterior and overall tooth material discrepancy by both the methods with no statistically significant difference between both the methods (p>.05)

Table 3. Bolton analysis for manual and digital measurements

S.no.	Parameter	n	Manual	Digital	Mean diff.±SD	Std. error of mean Diff.	95% Confidence Interval of the Difference		T value	P value
			Mean±SD	Mean±SD			Lower	Upper		
1.	Anterior ratio	25	79.9±3.28	80.2±3.16	.34±1.68	.34	-1.03	.35	-1.02	.317
2.	Overall ratio	25	91.0±2.74	91.39±2.89	.31±1.5	.30	-.93	.31	-1.03	.313
3.	Anterior discrepancy	25	1.30±1.53	1.25±1.38	.05±.97	.19	-.45	.35	-.247	.807
4.	Overall discrepancy	25	.41±2.82	.092±2.81	.32±1.29	.26	-.21	.85	1.24	0.225

Table 4 shows the comparison of Carey's analysis for upper and lower models by the manual and the digital methods. The mean difference in the arch length tooth material discrepancy for the maxillary models was 0.67±1.78 mm and .34±2.10 mm for the mandibular study models between the manual and the digital methods, which was statistically insignificant.

Table 4. Comparison of Carey's analysis by both the methods

Parameter	n	Manual	Digital	Mean diff.±SD	Std. error of mean Diff.	95% Confidence Interval of the Difference		T value	P value
		Mean±SD	Mean±SD			Lower	Upper		
Maxillary study models	25	2.66±5.16	1.99±5.39	.67±1.78	0.36	-.063	1.409	1.89	.071
Mandibular study models	25	4.33±2.9	3.99±3.44	.34±2.10	0.42	-.522	1.211	0.82	0.420

DISCUSSION

There were statistically significant differences in the tooth width measurements between the traditional and the digital methods. Similarly, there was a statistically significant difference in arch length measurement by both the methods. The digital measurements for all the parameters were smaller than their manual counterparts. Santoro et al[4], Goonewardene et al[5], Redlich et al[6], Watanabekanno et al[7] and Mullen et al[2] reported that the digital measurements were smaller than the manual measurements, as found in the present study. Tehranchi et al[1] also found similar results as in this study. Digital model measurements obtained with AutoCAD software were smaller than manual measurements in their study. They stated that the major factors causing differences were the assessment of the actual proximal contact point which varied from time to time and when a three dimensional dental cast was converted to a two-dimensional digital image, convex structures of teeth, curve of Spee, inclination and rotation might have influenced the measurements. Hence, the potential operator differences when clicking the mouse pointer on tooth locations may have caused differences in the measurements. The results of this study also agree with those of Quimby et al[8] and Champagne et al[9] who found significant differences between the two methods in arch length measurements. Despite the differences between the manual and digital measurements being statistically significant for tooth size and arch length, they were small (in the range of 0.05 to 1.70mm) and clinically insignificant[1].

Although there were significant differences between both the methods for mesio-distal

tooth widths and arch length, there was no significant difference in the overall and anterior Bolton ratios as well as the tooth material arch length discrepancy (Carey's analysis) determined by the two methods. This may have been due to the fact that both the tooth sizes as well as the arch lengths generated by the software were consistently smaller and hence a significant difference was not reflected in the Bolton's and Carey's analysis. Comparison of Bolton tooth size analyses has been performed on digital and plaster models by Mullen et al[2], Stevens et al[10] and Tomassetti et al[11]. Acceptable agreements were found in all the three studies between both the methods, which were similar to the results of the present study.

The findings of this study are in agreement with several previous studies which have evaluated the differences between manual and digital measurements of study models. Malik et al[12] conducted a study on 2D photographs of study models for the purposes of medico-legal reporting and they concluded that the same orthodontic information can be obtained from study models and 2D photographs of study models. Schirmer and Wiltshire[13] compared measurements made manually on plaster study models and photocopied study models using a computer program and concluded that the computer-aided measuring system was reliable, but accurate mesio-distal measurements could not be made from photocopies of dental models.Garino[14], Rheude[15] and Oliveira et al[16] also found that the measurements made from digital models were clinically acceptable.

CONCLUSION

1. There was a significant difference between the digital and manual measurements for mesio-distal tooth size and arch length.
2. The Bolton's tooth size analysis and the Carey's analysis done with the manual and digital method were comparable and did not show a significant difference.
3. Nemotec Digital Imaging Software may be used reliably for model analysis as part of the diagnostic work-up of orthodontic patients.

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