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To cite:
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J ContempOrthod 2021;5(2): 26-30

Received on:
05-05-2021

Accepted on:
22-06-2021

Source of Support: Nil

Conflict of Interest: None

A Comparative Analysis of Exactitude and Efficacy of Conventional Method Vs 3d Software for Analyzing Orthodontic Study Models

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ABSTRACT

Objective: To compare 3D digital study models with respect to their efficiency in reproducing the details when compared with conventional methods.

Materials and Methods: Sixty orthodontic study models were measuring Bolton's analysis, ideal arch analysis and tooth width analysis both in conventional and digital methods. In conventional method Vernier caliper and brass wire were used while in digital method 3D E3 digital scanner and OrthoAnalyzer 2019 software program were used for model analysis.

Results: To analyze the difference between measurement values, t-test was used for data with normal distribution. There was no significant difference between the conventional and digital methods in boltons analysis,ideal arch analysis and tooth width analysis.

Conclusion: There was no difference between the efficacy of conventional and digital methods. Both the methods are as reliable in assessing the study models.

Keywords
Model analysis, Bolton's ratio, Digital Scanner, Conventional method, digital method, study models

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INTRODUCTION

Successful orthodontic treatment is based on a comprehensive diagnosis and treatment planning. One of the diagnostic and treatment planning tools used to determine the degree of obliquity and the incompatibility between the arch shape and tooth dimensions are orthodontic models. They are also used for three-dimensional (3D) documentation of the dental arches in pre-treatment, progress, and post-treatment records.[1]

Traditionally, information was gathered from plaster orthodontic models. electronically, and retrieved with a computer. In comparison to other methods of documenting treatment records, plaster models require a significant amountof effort to be produced and a storage space because of their size and weight.[2] Despite these disadvantages and the risk of models being lost or damaged, plaster models continue to be the gold standard and preferred method in clinical and scientific applications.[1]

But recent technological advances have allowed the generation of digital dental models that can be saved and viewed three dimensionally on a computer. Digital models solve many problems encountered with conventional plaster study models. OrthoCAD™ and e-models™ will be compared relative to the technology used to generate these models, software capabilities, additional services,and available research. Digital models seem to be a clinically acceptable alternative to stone casts for the routine measurements used in orthodontic practice. Measuring plaster models by hand is the traditional method of assessing malocclusion. Recent technologic advances now allow the models to be digitized, measured with software tools, stored.[3]

One of the most recent innovations in the field of orthodontics is the introduction of 3D digital scanner. A solid CAD/CAM system that combines scanning with design software is the only way to meet the future demands. 3Shape lab scanners provide high ISO documented accuracy, high speed and many advanced scanning features.

Comparisons of digital models and plaster models have been made with respect to diagnostic accuracy and measurement sensitivity. The space analysis and Bolton analysis are the most commonly used analyses for orthodontic diagnosis and treatment planning in the majority of studies that have compared the digital models and plaster models. The space analysis is traditionally made according to the difference between the mesiodistal dimensions of the teeth in the arch from the mesial

of the left molar tooth to the mesial of the right molar tooth and the length of the line forming the parabola of these teeth. The Bolton analysis was first used in 1958 with the establishment of two ratios using the total of the mesiodistal widths of the maxillary and mandibular teeth of patients with ideal occlusion.[1]

Bolton analysis provides clinicians with information about the incompatibility of the tooth size and the amount of deviation from the ideal ratio of the arch dimension. Although systematic reviews in the literature could not find any clinically relevant significance of both of these analyses, there were statistically significant differences in the Bolton analysis in some studies. Furthermore, due to the continuous updating of digital modelling methods, examining the importance of reliability, and especially the assessment of time duration, is still ongoing.[4]Therefore, the purpose of the present study was to evaluate and correlate the effect of different coronal cement bases and its thickness on the fracture resistance of endodontically treated teeth. The two hypotheses considered were that there was no significant difference between the two methods with respect to space analysis, that there is a statistical difference between the two methods in the proportional comparison in the Bolton analysis.

Table 1: Descriptive tables showing the mean standard deviation and standard error mean

Group Statistics					
	group	N	Mean	Std. Deviation	Std. Error Mean
Bol AR	A	30	.7960	.04628	.00845
	B	30	.7900	.05433	.00992
Bol OR	A	30	.9223	.06089	.01112
	B	30	.9367	.05927	.01082
Ideal Upper	A	30	80.7000	7.97042	1.45519
	B	30	83.5507	7.62627	1.39236
Ideal Lower	A	30	70.6167	7.78779	1.42185
	B	30	69.6387	6.61125	1.20704
TWA upper	A	30	79.6200	8.31104	1.51738
	B	30	79.0753	5.59059	1.02070
TWA lower	A	30	71.6667	7.89951	1.44225
	B	30	73.7240	4.88223	.89137

METHODS

The study included 60 orthodontic study modelsof (Patient of age group 15 – 30 years) those were collected from theDepartment of Orthodontics and Dentofacial orthopaedics.The study approval was granted by theClinical Research Ethics Committee.Following are some inclusion and exclusion criteria for selection of the orthodontic study models for this study:

Inclusion criteria:

- Adult male/female with permanent dentition
- Patient of age group 15 – 30 years

Exclusion criteria:

1. Presence of dental anomalies.
2. Grossly decayed tooth
3. Patients with retained deciduous teeth
4. Patients with grade II or grade III mobility

All orthodontic study models were used for measuring Bolton's analysis, ideal arch analysis and tooth width analysis in both conventional and digital method.

In the digital method bolton's ratio was calculated using 3D E3 digital scanner and OrthoAnalyzer 2019 software program. Digitization was carried out by placing the plaster study casts on the scanner (3D E3 digital scanner, Unicorn Denmart Ltd, Delhi). Digital images were opened in the software and tooth widths were measured by marking "set points" and measuring the mesial and the distal point distance. Maximum mesiodistal diameter of each crown was measured between the anatomic contact areas when the teeth were correctly aligned. The anterior Bolton ratio and the overall Bolton ratio were then calculated for each digital model using Bolton's formula. Tooth width analysis was done by opening the digital images in the software and tooth widths were measured by marking "set points" and measuring the mesial and the distal point distance. Then the

software designed for this purpose automatically calculated the tooth width analysis. Ideal arch analysis done by opening the digital models in the software and ideal arch analysis option were given and retrieved the values.

length.

Statistical analysis

The data for this study was analyzed using the independent sample t test. The mean value, standard deviation and standard error of mean of the measurements were found. To analyze the difference between measurement values, the t-test was used.

Table 2: Results of the Independent samples t test between group 1 and group 2

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	P-value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Bol AR	Equal variances assumed	.355	.553	.460	58	.647	.00600	.01303	-.02008	.03208
	Equal variances not assumed			.460	56.571	.647	.00600	.01303	-.02010	.03210
Bol OR	Equal variances assumed	.069	.794	-.924	58	.359	-.01433	.01551	-.04539	.01672
	Equal variances not assumed			-.924	57.958	.359	-.01433	.01551	-.04539	.01672
Ideal Upper	Equal variances assumed	.000	.983	-1.415	58	.162	-2.85067	2.01401	-6.88215	1.18082
	Equal variances not assumed			-1.415	57.887	.162	-2.85067	2.01401	-6.88232	1.18099
Ideal Lower	Equal variances assumed	.691	.409	.524	58	.602	.97800	1.86510	-2.75541	4.71141
	Equal variances not assumed			.524	56.511	.602	.97800	1.86510	-2.75751	4.71351
TWA upper	Equal variances assumed	1.116	.295	.298	58	.767	.54467	1.82873	-3.11594	4.20528
	Equal variances not assumed			.298	50.784	.767	.54467	1.82873	-3.12705	4.21638
TWA lower	Equal variances assumed	2.479	.121	-1.213	58	.230	-2.05733	1.69547	-5.45118	1.33652
	Equal variances not assumed			-1.213	48.334	.231	-2.05733	1.69547	-5.46569	1.35103

*Significance level p≤0.05

In the conventional method Bolton's anterior ratio and overall ratio were calculated by the measurements of the upper and lower arch length in the plaster models were done using digital Vernier calliper. The mesiodistal width of incisors, canines, premolars, and first molars were measured between the anatomic medial and distal contact points, parallel to the occlusal plane. The anterior and overall Bolton ratios were calculated by dividing the total of the widths of the maxillary teeth by the total of the widths of the mandibular teeth. The tooth width analysis was done with digital Vernier caliper. Maximum mesiodistal diameter of each crown was measured between the anatomic contact areas of each teeth, both in the upper and lower arch using Vernier caliper. Sum of that values in each arch were calculated. Ideal arch analysis done by the measurements of the upper and lower arch ideal arch analysis in the plaster models with the aid of a brass wire from mesial surface of right 1st molar to the mesial surface of left 1st molar. Then the length of brass wire was measured to get the ideal arch

RESULTS

The descriptive statistics of the measurements taken from upper and lower arches in the conventional measurement and digital measurement groups are shown in **Table 1.**

Results show that the mean Bolton's Anterior Ratio in the conventional measurement group was .7960 while in the digital group it was .7900 and the The mean Bolton's overall Ratio in the conventional measurement group was .9223 while in the digital group it was .9367. In the conventional measurement group, the mean Bolton's ideal arch was found to be 80.7000 in the upper arch and 83.5507 in the lower arch, while in the digital measurement group, these values were 70.6167 and 69.6387 respectively. The mean total tooth width of upper arch was 79.6200 in the conventional measurement group and 79.0753 in the digital group, while in the lower arch 71.6667 in the conventional measurement group and 73.7240 in the digital

group.

To analyze the difference between measurement values, the t-test was used for data with normal distribution. A value of $p<0.05$ was accepted as statistically significant.

- Bolton's Anterior Ratio in conventional measurement group and digital group was statistically nonsignificant.
- Bolton's overall Ratio in conventional measurement group and digital group was statistically nonsignificant.
- Bolton's ideal arch analysis values of upper and lower in conventional and digital groups were nonsignificant.
- Tooth width analysis of upper and lower arch in conventional and digital groups were nonsignificant.

DISCUSSION

Orthodontic diagnosis and treatment planning depends on the analysis of tooth size discrepancies. Orthodontic study models are the main criteria for diagnosis and treatment planning. Tooth size discrepancy is defined as the disproportion between the sizes of the individual teeth. It is considered as the important variable especially in the anterior segment and has even been described as the seventh key of occlusion. In the early period, many authors like Neff, Ballard and Lundstrom had attempted to quantify this relationship however it was Bolton in 1958 who denoted the specific ratios of the mesiodistal width that exists between maxillary and the mandibular dentition both from canine to canine and from first molar to first molar in order to obtain an optimum occlusion.[5]

According to Bolton the purpose of the tooth size discrepancy ratio as a diagnostic aid is to gain insight into the function and esthetic outcome of a given case without the use of kesling's diagnostic setup. Though Bolton's analysis is considered as the gold standard for predicting inter-arch tooth size discrepancies.[5]

Smith et al[6] stated that the parameters considered as normal for the Bolton Index can only be applied to white females, basing this on comparative studies on populations of different races and genders, while other authors found that discrepancies in the Bolton Index are seen more frequently in patients with Class III malocclusions.Haiazonetis DJ[7] states that, a discrepancy in the Bolton Index coefficient does not necessarily mean a size discrepancy, nor does a coefficient within the limits considered as 'ideal' guarantee an ideal occlusion; there are a series of factors, such as the curvature of the dental arch or the thickness of the incisal edges, that can change this ratio.

Digital imaging technology in the field of dentistry has emerged as one of the most important aspects of diagnosing and treatment planning. The biggest problem faced by orthodontists is the storage of dental casts for future reference. Digital imaging is much more advanced than plaster models in storage, retrieving and sharing of information.[8]

Since the introduction of 3D digital modelling, its use has been increasing in the field of dentistry. However, only few studies that compared the conventional method with the digital modelling method have used 3D scanning and an analysis software program interface from the same manufacturer and is used in the study done by Saleh WK et al[9], Tomassetti et al[10], Wiranto MG et al[11], Czarnota J et al[12]etc. Henceforth this study aims in comparative analysis of exactitude and efficacy of conventional method vs 3d software for analyzing orthodontic study models.

In this study comparative analysis of exactitude and efficacy of conventional method vs 3D software for analyzing orthodontic study models were done. To analyze the difference between measurement values, the t-test was used for data with normal distribution. There was no significant difference between the conventional and digital methods in boltons analysis,ideal arch analysis and tooth width analysis

Dental cast analysis plays a vital role in clinical orthodontic practice for both diagnosis as well as for predicting and assessment of the treatment outcome. Wiranto MG et al[13]stated that there are no universal standard for defining the accuracy of a study model. With the advancement of technologies orthodontists are exposed to new tools that help in providing more accurate diagnosis and treatment planning. In present era with nearly every other aspect of health records becoming important. Digital attempt was made for digitalization of orthodontic study model. Though the diagnostic information from plaster models that are converted to digital files is highly accurate.

The digital models obtained from that 3D E3 scanner eliminate the inherent problem related to model storage. They also have further potential benefits such as:

- Instant accessibility of 3D information without need for retrieval of plaster model from storage area.
- Ability to perform accurate treatment planning and diagnostic set ups for various orthodontic cases.
- Virtual images can be transferred anywhere in the world for referral and consultations Wiranto MG et al[13]

The working principle of the 3D E3 scanner used in this study is the basic principle of cone focal microscope. Light rays emitted parallel on to the surface to be scanned are backscattered in the same optical path and in proportion of the focus to object distance are displayed on different depth field levels with corresponding sharpness. This in turn allows the 3D calculation

of scanned object.

One of the limitations of the study was that the comparison of the two methods in terms of the duration of analysis did not take into account the total chairside time, which is an important factor for clinicians. Another limitation was that the operator experience and ability were not equal in both measurement methods. In addition, the speed of the digital modeling software program may vary, depending on the version and different hardware specifications. Digital modeling methods and analysis programs are constantly updated and accelerated. Stevens DR et al[14]also stated the same when they conducted a study to evaluate validity, reliability, and reproducibility of plaster vs digital study models.

Therefore, from the present study it was found that the digital method is as reliable as the conventional model analysis method. Although some difficulties may be experienced in the manipulation of the digital model analysis software, this method can be sufficient in diagnosing and treatment planning. The major advantages of the digital model software include quick reassessment of the measurements and an easy access to data required for analysis. Inspite that there is no difference between the efficacy of conventional and digital methods. Both the methods are as reliable in assessing the study models.

CONCLUSION

The digital analysis method is as reliable as the conventionalmodel analysis method. Although some difficulties may be experienced in the manipulation of the digital model analysis software, this method can be sufficient in diagnosing and treatment planning. The major advantages of the digital model software include quick reassessment of the measurements and an easy access to data required for analysis. Therefore, more importance should be given to digital modelling methods and software for clinicians to be able to use them easily.

ACKNOWLEDGMENT

The authors would like to acknowledge all the members of the IRB and the statistician Dr Varghese Suresh for their help in conducting the research.

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