

Accuracy of Digital Models in Bolton Analysis for Angle Class I Malocclusion Group

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Abstract:

Objective: This study aimed to test the accuracy and reliability of measurements using digital models versus plaster models. **Materials and Methods:** Thirty patients were recruited in the study. Impressions were taken for all patients by alginate impression material and poured immediately using certain dental plaster with good dimensional accuracy and surface details reproduction. All casts were trimmed and polished for obtaining high quality study models. Bolton analysis was done by manual and digital techniques for all casts. Intra-operator reliability testing and Paired-samples t-tests was used to compare the measurements within groups. **Results:** There was an excellent intra-operator reliability for both techniques for manual and digital measurements of teeth width (ICC values are 0.998 and 0.987, respectively). paired-samples t-test for overall ratios by both techniques showed no significant difference (p value is 0.139). **Conclusions:** Measurements made from digital models are accurate and reliable as manual measurements.

Introduction:

Study model represents an essential and basic diagnostic record in our daily orthodontic practice. Complete evaluation of the patient's occlusion, pretreatment conditions, treatment progress, and the final treatment results are all documented using orthodontic models.¹

Plaster models have many limitations due to the brittle nature of plaster and their potential damage. Continuous use of plaster model can wear away plaster and can affect accuracy of measurements. Storage and preservation of plaster models represent a great problem as they require massive storage area.^{2,3}

Analysis of the relative size of upper and lower teeth should always be included in orthodontic diagnosis, particularly in the anterior region, where the overbite, overjet, crowding, and spacing are affected by relative teeth size.⁴ To establish accurate interdigitation and optimal occlusion, The maxillary and mandibular teeth must have certain dimensional relationships.⁵

One of the most popular techniques for detecting inappropriate tooth size is Bolton analysis. It can be used to help in both diagnosis and therapy planning. Overall Bolton ratio should be 91.3 ± 0.26 percent, which is calculated by dividing the sum of width of the 12 lower teeth by the sum of the width of the 12 maxillary teeth. The anterior ratio is calculated by dividing the total of the widths of the six mandibular anterior teeth by the sum of the widths of the six maxillary anterior teeth, and it should be 77.2 ± 0.22 percent.⁴

Classic methods for assessing mesiodistal dimensions of teeth on study cast can be done manually using Boley gauge.⁴ Shellhart et al. discovered that the Vernier caliper was marginally more exact than needle point dividers for measuring Bolton ratios.⁶

The expanding use of new technologies at all levels of modern society has resulted from rapid and continuous breakthroughs in computer sciences. This phenomenon has also had an impact on orthodontics, so computerized records are used. Many drawbacks of plaster models are eliminated with digital models.⁷

Digital models in orthodontics have become a good alternative to traditional models for some diagnostic measurements, such as tooth size, arch width, overjet, overbite and arch length.⁸

This study was done to test validity of measurements performed on digital models with those measurements done on plaster models regarding Bolton analysis in Angle Class I malocclusion (MO) group.

Materials and Methods:

Sample size calculation

Sample size was calculated by Power Analysis and Sample Size (PASS) Software (version, 15, 2017). NCSS, LLC. Kaysville, Utah, USA.

We hypothesized a good reliability between manual and digital measurements in class I casts with an intraclass correlation coefficient (ICC) of 0.8 .

A sample size of 30 subjects with 2 observations per subject achieves 90% power to detect an intraclass correlation of 0.80000 under the alternative hypothesis when the intraclass correlation under the null hypothesis is 0.5 using an F-test with a significance level of 0.05.

Participant selection

This study was performed on 30 orthodontic study models with Angle Class I malocclusion (MO) group from the Department of Orthodontics, Faculty of Dentistry, Mansoura University, Egypt. An informed consent from patients/parents was taken for approval to be included in the study and they were informed that their personal data would be confidential.

Inclusion criteria

Participants were selected with: (1) All permanent teeth

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present except, second and third permanent molars; (2) Absence of any teeth deformities; (3) No partially erupted teeth; (4) Free of impacted teeth except, the wisdom teeth; (5) Absence of proximal teeth abrasion, caries or restorations affecting mesiodistal dimensions of teeth; (6) No prosthetic restorations; (7) No history of orthodontic treatment; (8) Class I MO group: diagnosed by the presence of class I canine and molar relationship. One investigator was responsible for examining the patients, determining their eligibility.

Procedures

Metallic trays with proper size were used for impression taking for all patients with inclusion criteria. High quality Alginate impression material (Cavex; Haarlem, Netherlands) was used in our study and poured immediately using certain dental plaster (Hard Dental Stone, Dentaurem, Ispringen, Germany) with good dimensional accuracy and surface details reproduction. All casts were trimmed and polished for obtaining high quality study models.

Manual and computerized techniques are used for measurements of maximum mesiodistal (MD)

dimension of teeth in all models. Three-dimensional (3D) model laser scanner (E13D-scanner, 3Shape A/S, Copenhagen, Denmark) was used in digital technique. Digital models were analyzed using Ortho Analyzer software of the same company. Bolton ratios were calculated automatically, (Figure 1). Manual technique involved using electronic digital caliper was for measuring the maximum MD width of each tooth from right first permanent molar to the left first permanent molar in upper and lower arches for each study model, (Figure 2).

The measurements in both techniques were used in this study to calculate both Anterior and overall Bolton ratios for each study cast. To ensure measurement accuracy, 4 weeks later, 3 study models were selected randomly and their measurements were done again by the same examiner for both techniques.

Anterior Bolton ratio is the percentage obtained by dividing the sum of width for the six lower anterior teeth by the sum of width for the six maxillary anterior teeth. Overall Bolton ratio is obtained by dividing the total width of the 12 mandibular teeth by sum of the width of the 12 maxillary teeth.

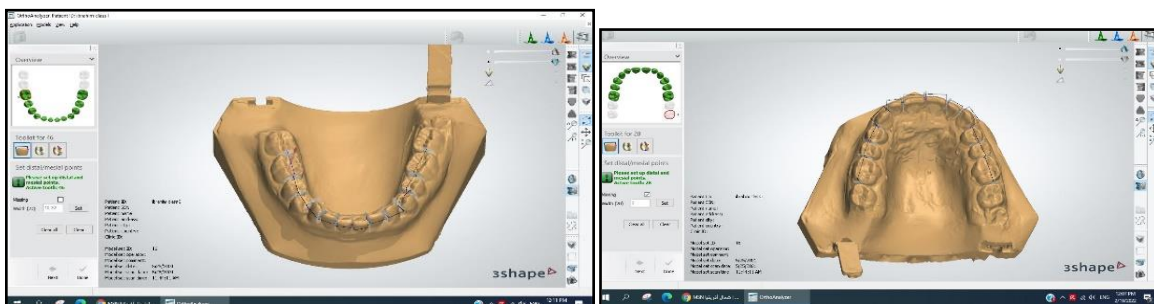


Figure 1: Digital technique for measuring mesiodistal teeth dimension to calculate Bolton ratios

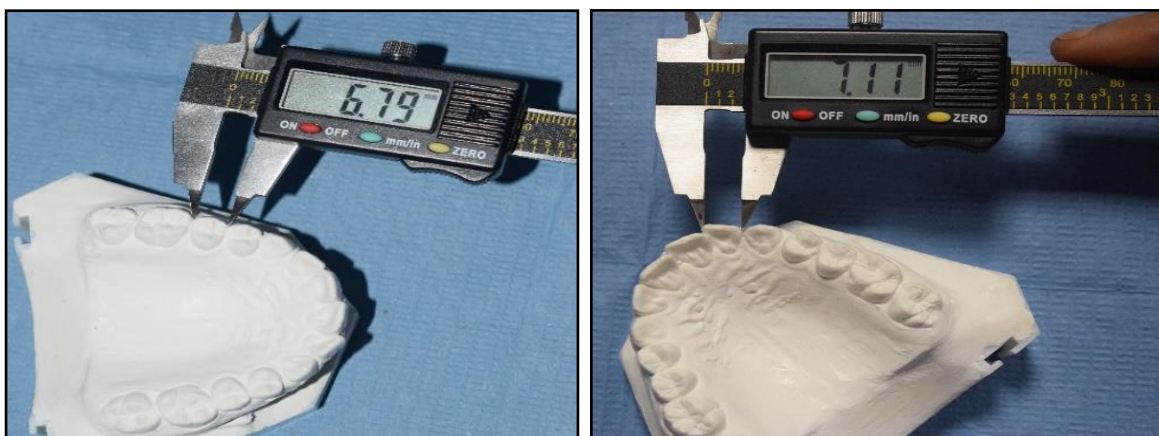


Figure 2: Digital caliper used for manual measurements of mesiodistal teeth dimension.

Statistical analysis:

Data were entered and analyzed statistically using Statistical Package for Social Science (SPSS IBM, Chicago, IL, USA, version 21). In the normally distributed variables, a student t-test was used for comparison between groups.

Intraclass correlation coefficient (ICC) were determined. ICC values less than 0.5 are indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability.

Conflict of Interest: There was no conflict of interest in our study.

Results:

Intra-operator reliability testing

An excellent intra-operator reliability, (Table 1) (test-retest) for both techniques was found with ICC values

0.998 and 0.987 for manual and digital techniques, respectively.

paired-samples t-test for overall ratio by both techniques

There was no statistically significant differences between manual and digital techniques regarding overall ratio calculation (P value =.0139).

Table 1: Intra-operator reliability testing for individual teeth width measurements

Technique	ICC	95% CI of ICC	P value	Grading
Manual	0.998	0.997-0.999	<0.001	Excellent
Digital	0.987	0.978-0.992	<0.001	Excellent

ICC = Intraclass correlation coefficient. CI = Confidence interval.

Table 2: Results of paired-samples t-test for overall ratios by both techniques

Class	N	Manual	Digital	Paired differences		Paired t-test	
		Mean (SD)	Mean (SD)	Mean	95% CI	t value	P value
I	30	92.17 (2.43)	92.53 (2.75)	-0.36	-0.84 to 0.12	-1.521	0.139

Data expressed as mean \pm SD. SD:standard deviation. CI:confidence interval.

Discussion:

Rapid and continuous improvements in computer sciences have resulted in rising use of new technologies at all levels of modern practice in dentistry. This phenomenon has already had an impact on orthodontics in terms of diagnosis, treatment planning and evaluating post treatment results. Digital models are becoming more widely available, and they deliver high-quality diagnostic images with low cost.⁹ Bolton analysis is commonly used in our daily orthodontic practice for detecting abnormal teeth size so, It was a must to test accuracy and repeatability of digital models for performing Bolton analysis.

Our sample size seemed to adequate for studying accuracy and reliability of digital models for performing Bolton analysis since the sample size was more than the estimated minimum, and because earlier studies for digital models had similar sample size.^{7, 10-12}

Precise definition of points to be identified on the digital model with proper training of the examiner for digital cast analysis had to be established to reduce errors in digital analysis method. Digital cast analysis can be more or less accurate than traditional models, depending on the orthodontist's training.^{9, 11}

Digital technique for cast analysis involves accurate placement of points on scanned cast. It was essential to prepare high quality plaster models to have well defined digital models and to test the quality of the laser scanner that was used in this study. Poor quality stone models were excluded from our sample.

Our study showed high degree of intra-operator reliability for repeated measurements of teeth width by both techniques. The results were in agreement with the results reported by Quimby et al⁹, who found that repeated measurements acquired by both techniques showed a high degree of repeatability. This means that

measurements taken with both digital and plaster models are quite repeatable.

On the other hand, Mullen et al.⁸ observed that repeated measurements made with digital models differed slightly more than repeated measurements taken with conventional models. They explained that the difference was due to the second measurements were performed using a different version of software. In our study, we performed repeated digital measurements with the same version of software.

Regarding Bolton anterior and overall ratios by both techniques showed no statistically significant differences. This agreement between results of both techniques indicates high reliability of digital models for Bolton analysis. Our results are in agreement and support other studies for digital cast analysis.¹²⁻¹⁴

Conclusions:

According to the results of our study, the following conclusions were obtained:

- 1- It is accepted clinically to use digital models for performing Bolton analysis.
- 2- Digital models showed high degree of accuracy and repeatability of their measurements.

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