

Tooth Size Discrepancy – Digital vs Manual Measurement

SUMMARY

Background/Aim: The aim of this study was to determine the accuracy of overall and anterior Bolton's ratio measurements obtained with an intraoral scanner compared to standard caliper measurements on plaster models. **Material and Methods:** This study included 33 subjects (18 female and 15 male), aged 12 to 18 years. All subjects were taken impression for the purpose of making study plaster models. In addition, all subjects underwent intraoral scanning for the purpose of creating digital models. Tooth width was measured with a caliper on plaster models, while digital models were analyzed using Cerec Ortho SW 2.0.2 software. The overall and anterior Bolton ratios were derived using both methods. Statistical data processing was performed using an independent t-test. **Results:** The results obtained using these two methods for measuring the anterior and overall Bolton ratio showed that there was no statistically significant difference in the measurements obtained on plaster models and the measurements obtained by intraoral scanning. For the overall Bolton ratio, T-test was 0.828 and is not statistically significant ($p < 0.05$). The value of T-test for the anterior Bolton ratio was 0.001 and it was also not statistically significant ($p < 0.05$). **Conclusions:** Determination the overall and anterior Bolton ratio using an intraoral scanner is an accurate and acceptable method for clinical work in orthodontics.

Key words: Tooth Size, Discrepancies, Bolton Ratio, Digital Model, Vernier Caliper

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Introduction

In order for orthodontic treatment to be successful and satisfactory, it is necessary to perform a detailed analysis of dental models. Measuring the mesiodistal widths of the maxillary and mandibular teeth as well as measuring their relationship is an important diagnostic treatment in orthodontics. Bolton analysis of intermaxillary discrepancy in tooth size has been widely accepted in orthodontic practice for more than half a century. This analysis is universally employed to determine tooth size discrepancies for diagnostic and treatment planning purposes¹.

In 1958, Bolton evaluated patients with ideal occlusions and established two ratios using the sums of mesiodistal widths of maxillary and mandibular teeth².

It has been recommended that the tooth widths should be measured and a Bolton analysis performed for each orthodontic patient³. Bolton analysis allows clinicians to determine tooth size discrepancy and extent of difference from the ideal ratio. Most orthodontists use plaster models obtained by pouring a previously taken impression and on these plaster models the mesiodistal diameter of the tooth is measured with a caliper and the Bolton analysis is done manually. Numerous studies have demonstrated that calipers are accurate and reliable^{4,5}. Therefore, they are widely used and have been accepted and regarded as the gold standard for tooth-width measurements^{6,7}. However, plaster models are not suitable for storage and preservation. Recently, the use of digital scanners has increased in all branches of dentistry, including orthodontics. The development of digital models

has several advantages that include reduced storage requirement, rapid access to 3D diagnostic information, and easy transfer of digital data for communication with professionals and patients⁸⁻¹¹.

The aim of this study is to compare anterior and overall Bolton ratios on conventional (plaster) and digital models.

Material and Methods

This study included 33 subjects, with no history of orthodontic treatment, from the Faculty of Dentistry with Dental Clinical Center, University of Sarajevo, Department of Orthodontics. The study was approved by the Ethics Committee of Faculty of Dentistry with Dental Clinical Center, University of Sarajevo (02-3-4-19-4-3/2022). The criteria for selecting subjects were: that the subjects have permanent dentition and erupted teeth from the first molar on one to the first molar on the other side, all subjects had normal crown morphology and without features that would alter mesiodistal or buccolingual crown diameter, such as restorations, caries, attrition and fracture. The age of the subjects was from 12 to 18 years, and the gender distribution is 18 female and 15 male subjects. Plaster and digital study model were made for all subjects.

For the production of plaster models, impressions were taken with alginate impression masses in perforated trays. After taking the impressions, the position of the central occlusion is recorded using wax. The heated wax was adapted to the upper dentition with the fingers and placed in the molar area, after which the patient bit into the position of central occlusion. Casting of impressions in plaster and making a study model was done in dental laboratory. The study models obtained by casting the impressions were undamaged. Measurements with vernier caliper (Dentaurum) were performed on study models. Mesiodistal tooth widths from the first molar to the first molar of the maxillary and mandibular arch were measured, and anterior and overall Bolton ratio was made after the measurement. All measurements were performed by one examiner.

The Cerec Primescan Dantspaly Sirona intraoral scanner was used to obtain digital models. The maxillary and mandibular arches were scanned separately, after which the teeth were scanned in central occlusion. After a successful scan, the digital models were processed in the corresponding Cerec Ortho SW 2.0.2 software and an anterior and overall Bolton ratio was obtained.

Statistical analysis

All measurements were recorded in an Excel spreadsheet. Data were analysed using statistical parameters: mean value, standard deviation, coefficient of

variation and T-test. The level of significance was set at 5% ($p < 0.05$). The Statistical Package for Social Sciences (SPSS, version 20.0) was used for data analysis.

Results

The results obtained using digital and conventional methods for measuring the anterior and overall Bolton ratio showed that there was no statistically significant difference in the measurements obtained on plaster models and those obtained by intraoral scanning (Table 1).

Table 1. Scanner versus caliper measurement of anterior and overall Bolton index

	N	Anterior Bolton Index		Overall Bolton Index	
		Scanner	Caliper	Scanner	Caliper
M	33	0.7826	0.7690	0.9106	0.9116
SD	33	0.03162	0.03628	0.02404	0.02486
Coefficient of variation	33	4.04%	4.72%	2.64%	2.73%
t-test	33	0.00195		0.82805	
t		2.10		2.73	
p-value		$p < 0.05$		$p < 0.05$	

Legend: N – number of subjects; M – mean; SD – standard deviation;

Standard deviation - the average deviation from the average scanner in the anterior Bolton ratio is 0.03162, while the average deviation from the average caliper measurement in the anterior Bolton ratio is 0.03628. For overall Bolton ratio standard deviation from the average scanner is 0.02404, while the standard deviation from the average caliper measurement in the overall Bolton ratio is 0.02486.

Coefficient of variation - the relative measure of scanner dispersion in the anterior Bolton ratio is 4.04%, while the coefficient of variation of the caliper measurement in the anterior Bolton ratio is 4.72%. In the overall Bolton ratio the coefficient of variation is 2.64%, while the coefficient of variation of the caliper measurement in the overall Bolton ratio is 2.73%.

In the anterior Bolton ratio, the t-test indicates that the difference is not statistically significant because the obtained t is lower than the set and optimal limit of $p < 0.05$.

In the overall Bolton ratio, the t-test indicates that the difference is not statistically significant because the obtained t is lower than the set and optimal limit of $p < 0.05$.

Results obtained using these two methods for anterior and overall Bolton ratio measurements have shown that there is no statistically significant difference in the measurements obtained on plaster models and measurements obtained by intraoral scanning. For the

overall Bolton ratio, the t-test is 0.82805 and is not statistically significant as it does not exceed the set value of the test. The t-test value for the anterior Bolton ratio is 0.00195 and is also not statistically significant which also does not exceed the set value of the test.

Discussion

Technological advances and digitalization have greatly facilitated diagnostic measurements in orthodontics. Intraoral scanning as well as scanning of plaster models is increasingly used. There are many advantages of digital models such as improved efficiency, faster measurement and data analysis, easier and faster data transfer, cost savings, no need to store plaster models and no risk of damaging or losing the plaster model. However, despite all these advantages, the exclusive use of digital models in daily practice is not yet a routine as it also features some disadvantages in its application, namely: data loss in case of degradation of electronic storage, dependence on third parties, time-consuming software support, need to learn the operating system, and high cost of equipment^{6,12}. Although plaster models have a few drawbacks, their accuracy for dental measurements, often directly made with rulers or callipers is still regarded as the gold standard for orthodontic diagnosis and research⁹.

This study showed that there is no statistically significant difference in the measurement of the Bolton relationship between intraoral scanning and its associated software with measurement on plaster models. Although the mean of the anterior Bolton ratio was slightly higher while the mean of the overall Bolton ratio was slightly lower on digital models than on plaster models (Table 1.) these differences were in a practically acceptable range. According to Naidu D and Freer TJ reported absolute mean differences in tooth widths between plaster and digital models vary from 0 to 0.384mm¹³. In our study, the difference in mean values between digital and plaster models in the anterior Bolton ratio is 0.0136mm while in the overall Bolton ratio is 0.001mm.

According to a study by Naidu and Freer thirty subjects were compared using plaster models and iOC/OrthoCAD (digital models) and they found that there was a statistically significant difference between mean tooth widths from the digital method and the caliper. Nevertheless, it appears that these discrepancies were clinically insignificant and the iOC/OrthoCAD system is a clinically acceptable alternative to callipers and stone casts for making tooth-width measurements and calculating Bolton ratios¹³. Likewise, according to Nalcaci et al. statistically significant differences were found between measurements obtained for the width of 6 anterior teeth and 12 overall teeth using plaster and digital

models; however, these differences were not within the clinically significant range (~0.27-0.30mm) and had no negative effects on Bolton ratios¹⁴. Furthermore Wiranto et al. conducted a study on 22 subjects where they used three methods of measurement an intraoral scan, digital scan of plaster models and caliper measurements on a plaster models¹⁵. Tooth-width measurements on the digital model and the intraoral scan were compared with those on the corresponding plaster models (gold standard). They found that the tooth-width measurements of each tooth on the digital models and the intraoral scans did not differ significantly from those on the plaster models ($p > 0.05$). The overall and anterior Bolton ratios from the 2 types of digital models differed significantly from the gold standard ($p < 0.05$). However, the differences never exceeded 1.5mm; this could be regarded as clinically insignificant¹⁵. In a study conducted by Stevens et al. although they found statistically significant difference when comparing the reliability of tooth size measurements obtained using plaster and digital models none was clinically significant. Likewise, no measurement associated with Bolton analysis made on plaster vs digital models showed a clinically significant difference¹⁶. Atia et al. conducted a study which consisted of 40 patient's intraoral scans were taken as well as duplicate impression using alginate. All scans were recorded using a Trios-3shape intraoral scanner and a D 700 extraoral scanner those scans were analysed by Orthoanalyzer 3 shape software, while plaster models were measured using a vernier digital calliper. They found that tooth-width measurements on digital models were generally smaller than their plaster models counterparts, however these differences were considered clinically insignificant¹⁷. Results of studies Camardella et al. and Kardach et al. also confirmed that the accuracy of measurements on digital models is clinically acceptable^{18,19}.

Digital models represent a new generation of diagnostic tools in orthodontics, which opens up new possibilities for consultations and a multidisciplinary approach to solving problems, regardless of the distance between the teams.

Although the results of this study are positive and support our thesis that there is no significant difference between the intraoral scanning of the tooth arch with manual measurement on plaster models of the anterior and overall Bolton ratio, however there are several limitations in our research. One of our concerns is relatively small number of subjects included in the study. Furthermore, this study we did not include subjects older than 18 years, in addition only one type of scanner and its associated software was used. Moreover, for obtaining plaster models, only hydrocolloid impression material namely alginate was used but not elastomeric, like silicone-based materials, in addition in this study manual vernier caliper was used but not the digital vernier caliper.

Conclusions

The results of this study showed that it is clinically acceptable to measure the Bolton ratio using intraoral scanner and associated data analysis software. The use of intraoral scanner appears to be a clinically acceptable alternative to traditional measurements using a caliper in orthodontic practice.

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