Van Dentistry Journal
Van Diş Hekimliği Dergisi
Cilt 2 (2021) ~ Sayı 2 Sayfa: 01-10
ISSN(Online): 2757-6868 e-ISSN: 2757-6868

Araştırma Makalesi/Orginal Article

Comparison of Linear Measurements and Bolton Analysis on the Model Obtained from Conventional Method with OrthoCAD Software

Konvansiyonel Yöntem ile Model Üzerinde Elde Edilen Lineer Ölçümlerin ve Bolton Analizinin OrthoCAD Yazılımıyla Karşılaştırılması

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ABSTRACT: The aim of this study is to compare the arc length deviation, arc length, Bolton analysis, overjet and overbite values obtained from OrthoCAD software of plaster models, transferred to the three-dimensional environment with the iTero Element 2 intraoral scanner, with conventional methods. The study included plaster model obtained from a total of 30 individuals aged 18-25 years old, Angle Class I, Angle Class II and Angle Class III who obtained for orthodontic treatment. Models were digitized with iTero Element 2 intraoral scanners. To determine the arc length deviation, arc length, Bolton analysis, overjet and overbite, measurements were carried out on the models. The measurements were repeated 30 days apart from each other. For the characteristics considered, descriptive statistics are expressed as mean, standard deviation, minimum and maximum value. In terms of these characteristics, the paired sample t-test was used to compare the first and second measurement differences. In terms of arc length deviation, overjet, and overbite values, there was no statistically significant difference between the groups. A statistically significant difference was found between the two methods for lower arch length measurements. A statistically significant difference in the anterior ratio was found in the Bolton analysis, while no statistically significant difference in the overall ratio was observed. When compared to traditional approaches, the values obtained on the models obtained with the iTero 2 Element 3D scanner and the OrthoCAD software are thought to be accurate and alternative.

Keywords: Digital scanning, plaster model, accurate

ÖZET: Bu çalışmanın amacı iTero Element 2 ağız içi tarayıcısıyla üç boyutlu ortama aktarılan alçı modellerin OrthoCAD yazılımı ile elde edilen ark boyu sapması, ark boyu, Bolton analizi, overjet ve overbite değerlerinin konvansiyonel yöntemler ile karşılaştırmaktır. Araştırmaya ortodontik tedavi amacıyla başvurmuş 18-25 yaş arası Angle Sınıf I, Angle Sınıf II ve Angle Sınıf III olmak üzere toplam 30 bireyden elde edilen alçı model dahil edilmiştir. Modeller iTero Element 2 ağız içi tarayıcıları ile dijital ortama aktarılmıştır. Modeller üzerinde ark boyu sapması, ark boyu, Bolton analizi, overjet ve overbite değerlendirilmesi amacıyla ölçümler gerçekleştirilmiştir. Ölçümler 30 gün ara ile tekrarlanmıştır. Üzerinde durulan özellikler için tanımlayıcı istatistikler; ortalama, standart sapma, minimum ve maksimum değer olarak ifade edilmiştir. Bu özellikler bakımından birinci ve ikinci ölçüm farklarını karşılaştırmada eşleştirilmiş t testi kullanılmıştır. Gruplar arasında ark boyu sapması, overjet ve overbite değerleri bakımından istatistiksel olarak anlamlı bir fark gözlenmemiştir. Ark boyu ölçümlerinden alt ark boyu ölçümleri için iki yöntem arasında istatistiksel olarak anlamlı fark bulunmuştur. Bolton analizinde ön oranda istatistiksel olarak anlamlı fark tespit edilirken tüm oranda istatistiksel olarak anlamlı fark gözlenmemiştir. Üç boyutlu tarayıcı iTero 2 Element ile elde edilen modeller üzerinde OrthoCAD yazılım değerleri konvansiyonel yöntemler ile kıyaslandığında güvenilir olduğu ve bir alternatif olabileceği düşünülmektedir.

Anahtar Kelimler: Dijital tarama, alçı model, güvenilirlik

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INTRODUCTION

For effective orthodontic treatment, proper diagnosis and treatment planning are critical. In addition to the clinical examination of the individual, some records are needed for treatment planning. These records routinely include extraoral and intraoral photographs of the patient, panoramic and cephalometric radiographs, and dental models (1).

Dental models provide three-dimensional information about the individual's occlusal relationships. This allows the clinician to make a more detailed assessment of malocclusion than the clinical examination. Besides, it is more convenient and practical than intraoral measurements for analyses that must be performed on working models (2). It has been accepted as the "gold standard" for many years with its advantages such as acquiring dental models using a traditional technique, ease of production, being economical, precision, ease of measurement, providing three-dimensional operation by fixing to the articulator, and assessment of occlusion from the angles that are difficult to see during a clinical examination (1,3).

However, in addition to the advantages of dental models, they also have disadvantages, such as breaking easily, the possibility of loss, abrasion, difficult archiving in a busy clinical environment, and the need for space for archiving (1,4). Dental models can be produced from patients using digital methods such as photographs and x-rays thanks to developing technology, whereas in the past the only way to created dental models was in the form of plaster using the traditional method. For this purpose, various methods and devices are currently being developed (4,5). Initially, digital three-dimensional models were collected by cone-beam computed tomography as well as laser surface scanning systems scanning direct measurements, while in recent years intraoral scanning systems have been developed and have begun to take their place in clinical practice (5-7).

With the use of direct intraoral scanners, need for dental impression on the patient has disappeared. Three-dimensional digital models are created using this method by directly transferring intraoral images into a computer environment (5,7).

The operating scheme of digital intraoral scanners is based on the principle of reflecting energy from laser light or white light through the scanner onto the object and returning it to the scanner's sensor (8). Today, many devices manufactured by commercial companies using different techniques are offered on the market with analysis programs for use by clinicians (8,9). Linear measurements and analyses that can be performed on a dental model using conventional methods may also be performed using software created by companies over intraoral scanner models (8).

In light of this knowledge, our study aims to compare the reliability and reproducibility of linear measurements and analyzes routinely used in orthodontic diagnosis and treatment planning on dental models and digital models acquired with an intraoral scanner compared to the conventional method. The null hypothesis of our study is that there is no difference between the linear results collected from plaster models and the values acquired with OrthoCAD plaster model software transferred to the three-dimensional setting with the iTero Element 2 intraoral scanner.

MATERIALS AND METHODS

Our study was conducted on plaster models of individuals who applied for treatment purposes to Van Yüzüncü Yıl University, Faculty of Dentistry, Department of Orthodontics. Individuals signed an informed consent form prior to participating in the study. Study was initiated after obtaining approval from the Van Yüzüncü Yıl University Faculty of Medicine Clinical Research Ethics

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Committee (Ethics committee number: 2021/02-10).

A total of 30 subjects with 10 Angle Class I, 10 Angle Class II, and 10 Angle Class III malocclusion were included in the study. Inclusion criteria have been determined as the permanent dentition period of all dental models and the complete eruption of all teeth, the prominence of all teeth, and the clear selection of anatomical points, the absence of fractures or cracks in the models, the absence of the individual's teeth with crown or bridge prosthesis, congenital tooth deficiency or the absence of shape anomalies in the teeth. Individuals with excessive substance loss due to caries or parafunctional habits, those who had recently undergone orthodontic treatment, and those with a systemic disorder, congenital anomaly, or syndrome were all excluded from the study.

Dental models used in the study were prepared with alginate impression material (Zhermack, Polesine Badia, Italy) and dental impression trays, and type IV hard plaster was cast into the impressions and then made into orthodontic models. The measurements on the models were made with a 150 mm digital caliper with a precision of 0.01 mm (Mitutoyo Corp., Kanagawa, Japan).

Orthodontic plaster models produced from individuals were scanned using an iTero Element 2 (Align Technology, Inc) intraoral scanner, and three-dimensional digital models were acquired (Figure 1). The resulting scan images were transferred to OrthoCAD software (Align Technology, Inc) and digital measurements were made in this program (Figure 2). Orthodontic plaster models measured with a digital caliper using a conventional method were accepted as the "gold standard" and all parameters were compared with the data received from the OrthoCAD software. Besides, the measurement methods of the digital caliper and the digital OrthoCAD (Align Technology) model will be compared concerning the consistency of all parameters within the groups.

Measurements were carried out on the models to evaluate the arch node deviation, arch length, Bolton analysis, overjet, and overbite. The arch length was calculated separately for the upper and lower jaws. The length of the upper arch was calculated as the sum of the distance between the mesial contact point of the upper central incisors and the mesial contact point of the upper right first molar and the distance between the mesial contact point of the upper central incisors and the mesial contact point of the upper left first molar. The lower arch length was calculated as the sum of the distance between the mesial contact point of the lower central incisors and the mesial contact point of the lower left first molar, and the mesial contact point of the lower central incisors and the mesial contact point of the lower right first molars.

The arch length deviation was calculated in mm by subtracting the required arch length from the available arch length in the mandible and maxilla. The available arch length was calculated using a thin separation wire on the plaster model. By giving the form of a wire arch, it was so placed as to pass through the mesial contact point of the first molars, the contact points of the premolars, the tubercular ridges of the canines, and the incisal edges of the most normal incisor or incisors. Then the wire was straightened and its length measured, the required arch length was calculated by measuring and summing the mesiodistal dimensions of the premolars, canines, and incisors using a caliper gauge. The same measurements were made on digital models by determining the named points for the current arch shape and marking the mesial and distal points of the teeth for the required arch length.

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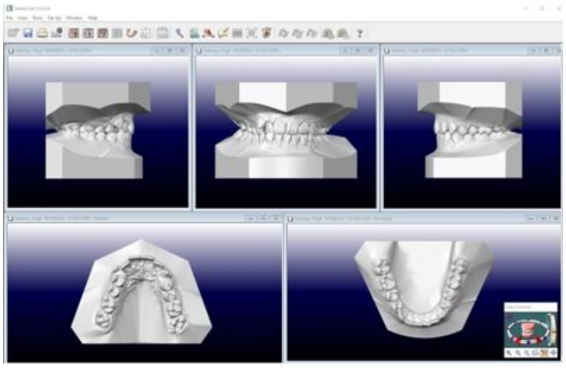

Figure 1. An intraoral scanner was used to produce three-dimensional digital models.

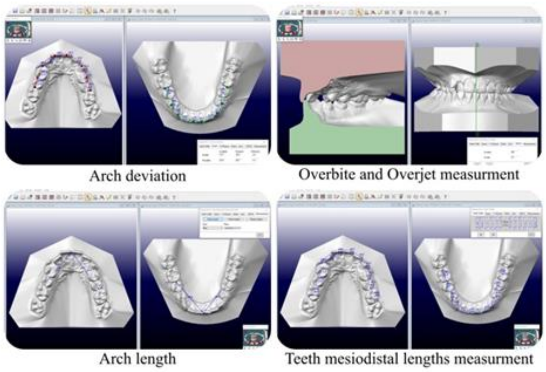

Figure 2. OrthoCAD software was used to transfer measurements from three-dimensional models

Bolton analysis was calculated as the anterior Bolton ratio and the overall Bolton ratio. The anterior Bolton ratio, which is the ratio of the total mesiodistal widths of the lower anterior six teeth to the total of the upper anterior six teeth mesiodistal widths, was calculated. The overall Bolton ratio was calculated as the ratio of the sum of the lower twelve teeth mesiodistal widths to the sum of the upper twelve teeth mesiodistal widths. The widths of the teeth whose mesial and distal points were marked were calculated in the OrthoCAD by measuring in the same way.

The overjet is calculated as the distance parallel to the base plane between the vestibular surface of the lower central incisor aligned with the midpoint of the incisal edge of the upper central incisor that is most anterior. The overbite was calculated as the vertical distance between the cutting edge of the upper central incisor and the cutting edge of the lower central incisor. The value of the tooth with a higher coverage amount will be recorded. For the manual measurements, a paper ruler was used, and for the digital measurements, the data were taken from the overjet and overbite measurement features of the program. All measurements were repeated 30 days later and all measurements were made by a single investigator (SK).

The analysis of the data was performed using SPSS 22 package program (IBM Corp. Released 2013 IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.) Descriptive statistics for the features emphasized are expressed as Average, Standard Deviation, Minimum and Maximum value. A paired sample t-test was used to compare the first and second measurement differences in terms of these features. For the reliability coefficient between measurements, the Intraclass correlation coefficient was calculated. The statistical significance level was set at 5% in calculations and SPSS statistical software was used for calculations.

RESULTS

Intraclass correlation coefficients between the first and second measurements of the mandible and maxilla were found to be 0.798 in the overall Bolton group in the plaster model and three-dimensional model groups and greater than 0.90 in the other measurements. No significant difference was observed between the values in terms of the repeatability of the measurements (Table 1).

When the arch length deviation, overjet, and overbite values in the lower and upper circles were examined, no statistically significant difference was found between the groups. Lower arch length measurements were found to be 59.92±3.49 mm in the

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Table 1. Results of group comparisons and descriptive statistics.

Measured Parameters	Groups	Number of Model(n)	Mean±SD	Minimum	Maximum	*p*
Overjet	Plaster model	30	2,93±3,44	-2	11	,25
	Digital model	30	2,87±3,36	-2,2	10,6	,25
Overbite	Plaster model	30	3,30±2,46	-1	10	,53
	Digital model	30	3,12±2,37	-1,1	9,5	,53
Space Analysis (Upper)	Plaster model	30	-0,57±3,98	-9	8	,875
	Digital model	30	-0,56±3,93	-9,5	8,3	,875
Space Analysis (Lower)	Plaster model	30	0,29±2,95	-4	8	,742
	Digital model	30	0,32±3,06	-4,9	8,5	,742
Bolton (Anterior Ratio)	Plaster model	30	1,32±0,91	0	2,7	,004
	Digital model	30	1,10±0,74	0,1	2,7	,004
Bolton (Total Ratio)	Plaster model	30	1,68±0,81	0,1	3,1	,194
	Digital model	30	1,52±0,79	0,3	2,9	,194
Arch Length (Upper)	Plaster model	30	68,66±5,02	60,5	77	,323
	Digital model	30	68,49±4,77	61,8	77,98	,323
Arch Length (Lower)	Plaster model	30	59,92±3,49	53,76	67,55	,000
	Digital model	30	60,45±3,42	53,6	67,5	,000

conventional method and 60.45±3.42 mm in OrthoCAD software. The difference between the groups in terms of lower arch length was found to be statistically significant (Table 2).

When the measurements were made on the plaster model in the antrerior Bolton ratio, the average was found to be 1.32±0.91, while the average was 1.10±0.74 in the OrthoCAD software. While a statistically significant difference was found in the anterior Bolton ratio, no statistically significant difference was found in the overall Bolton ratio (Table 2).

DISCUSSION

Plaster models obtained for orthodontic purposes are also important in terms of the positions of the teeth in the dental arch, malposition, mesiodistal distance of the teeth, and some linear measurements on them besides being diagnostic and diagnostic tools and providing the opportunity to evaluate the beginning and end of the treatment (1, 10). Despite their disadvantages in terms of abrasion, fracture, loss, and archiving, plaster models have been routinely used by clinicians for many years due to their benefits such as being procured with a simple technique, ease of model acquisition, being inexpensive, precision, easy measurability, three-dimensional operation in the articulator, and measurement of occlusion from angles that are difficult to see in clinical examination (1, 3, 11).

In the 2000s, systems for developing digital orthodontic models were introduced (12). Although touted as a good alternative to the disadvantages of plaster models, some disadvantages of systems that produce digital orthodontic models are believed to prevent

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Table 2. Property intra-class correlation coefficients.

Measured Parameters	Groups	Intra-Class Correlation Coefficient	*p*
Overjet	Plaster model Digital model	0,997	0,001
Overbite	Plaster model Digital model	0,980	0,001
Space Analysis (Upper)	Plaster model Digital model	0,996	0,001
Space Analysis (Lower)	Plaster model Digital model	0,993	0,001
Bolton (Anterior Ratio)	Plaster model Digital model	0,942	0,001
Bolton (Total Ratio)	Plaster model Digital model	0,798	0,001
Arch length (Upper)	Plaster model Digital model	0,991	0,001
Arch length (Lower)	Plaster model Digital model	0,983	0,001

widespread use when they are first introduced to the market. The learning of the technique, the learning time, the equipment licensing costs in the first and subsequent years, and the resulting costs if the system is inefficient are all disadvantages of three-dimensional scanning systems (13–15). In addition, it is stated that although developing technology makes our life easier, individuals can resist new developing technologies and can be an obstacle to its spread (16).

Today, the use of digital orthodontic model technologies is spreading rapidly, particularly with the advancement of the ease of learning and the cost of digital orthodontic model technologies, in addition to the minimal storage space and cost, quick access, and transition of models to any location (17). At this point, the digital orthodontic models were compared with the plaster models, which are admitted the golden standart of model analysis, due to measure the reliability and repeatability of them in our study.

Various methods can be used to produce an orthodontic plaster model with the conventional method. In their study, White et al. (18) compared the values of polyvinylsiloxane and alginate impression materials in digital measurements and found that there was no significant difference between the two impression materials and that they could be used in digital modeling. Due to its low cost, easy manipulation, hydrophilic properties, easy removal of saliva and blood from its surface, alginate is the most commonly used impression material in orthodontics for making a model (18). Considering the studies stating that there are negligible changes in dimensional stability concerning model acquisition time, the models created in our study were made with alginate impression material and they were produced by pouring plaster of type II immediately without waiting for the measurements related to dimensional stability (19, 20).

Among the scanning technologies of intraoral scanners, it is stated that systems with

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parallel confocal scanning technology have advantages due to their characteristics such as no powdering, scanning speed, and color recognition (8). Trademarks incorporating this scanning technology include iTero Element 2 (Align Technology) and 3Shape (Copenhagen, Denmark). For the evaluation of the planning and software data, the iTERO Element 2 (Align Technology) as the intraoral scanner was selected due to its cloud storage function and increased integration with the transparent plate manufacturers that have become widespread in recent years (8).

In the literature, there is no consensus on evaluating the individuals included in studies comparing model and intraoral screening methods according to the amount of crowding. While some researchers make comparisons concerning a single malocclusion (12, 21, 22), other researchers argue that increasing the amount of crowding can make the points difficult to identify and affect the results (11,23). Therefore, in our study, it was aimed that the amount of crowding of individuals with different malocclusions was minimally affected by including a total of 30 individuals with 10 Angle Class I, 10 Angle Class II, 10 Angle Class III malocclusions.

In considering the values examined, preference was given to those most commonly required for orthodontic model analysis, such as arch length deviation, arch length, Bolton analysis, overjet, and overbite. To prevent the reliability of the digital system and the differences that may occur in certain parameters, both linear and proportional measurements have been compared. Digital calipers were preferred for measurements on the plaster model in our study, as they were in many others in the literature (24–26). OrthoCAD (Align Technology) software provided with the iTERO Element 2 (Align Technology) scanner was used for measurements on digital models.

In studies evaluating the repeatability of measurements made on digital models, in-class correlation coefficients were generally found to be high and it was stated that this method was reproducible (7, 21, 26–28). Abizadeh et al. (11) in their research where they compared model scanning with the conventional method, found statistically significant differences between repeated measurements but stated that the difference found was clinically insignificant. No significant difference was found between the groups in terms of the repeatability of the values compared in our study.

In the first study comparing arch length deviation values, Leifert (29) used 25 models with Angle Class I malocclusion in his research comparing the arch length deviation values obtained from conventional and different software. In this study, he stated that the accuracy of OrthoCad software in the evaluation of arch length deviation with digital models is clinically acceptable and reproducible compared with conventional model analysis. In the second, Asguith (30) examined the mesiodistal crown diameter, arch length, overjet parameters in his study on 10 digital models and stated that the measurements were reliable. He also reported that the model analysis values of models with class I, II, and III malocclusions are independent of the type of malocclusion. In our study, there was no statistically significant difference between the groups in terms of arch length deviation, and similar results were observed when compared with both studies.

In literature, in the studies comparing plaster models acquired using three-dimensional scanners, it has been observed that the repeatability of anterior and overall Bolton ratios is lower than that of linear measures and that the results vary between studies. The reason for this is that while the mesiodistal diameters of the twenty-four teeth are not affected by themselves for each tooth, the results may be affected when Bolton is

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evaluated for the anterior and overall ratio (31). Stevens et al. (25) state that there is no significant difference in terms of Bolton ratio in their research, in which 24 individuals evaluated the plaster and digital models with three different researchers. Nalçacı et al. (32), in their study evaluating Bolton ratios on 20 models, found that there was no statistically significant difference between the two methods in the provisional and all proportions, but there could be differences between the methods in the mesiodistal tooth dimensions of the teeth, but the margin of error in the tooth widths would not be affected by the equal distribution of the Bolton ratio. Wiranto et al. (7) stated that there was no significant difference between the mesiodistal widths of the teeth, but there was a statistically significant difference between the anterior tooth and overall Bolton ratios. He states that this difference is 1.5 mm and is within clinically acceptable limits. In our study, while no statistically significant difference was found in the overall ratio, a statistically significant difference was observed in the anterior ratio. In addition, it is thought that attention should be paid to determining the mesial and distal points of the teeth in models with a high amount of crowding and the circumferential discs in the software allow the contact points of the teeth to be obtained exactly. We think that the differences in researches may be due to the type of malocclusion in plaster models, method, software, and individuals' use of software programs.

Reuschl et al. (33), in their studies comparing overbite and overjet values, in which two different individuals compared digital methods with traditional methods, found a statistically significant difference in the analysis of 19 plaster models in the permanent dentition, but there was no statistically significant difference for the overbite. The differences between the methods compared were not found to be clinically significant. In our study, no significant difference was observed between the groups in terms of overjet and overbite values. Despite the fact that our study's limitations include the degree of crowding and tooth inclination, the null hypothesis was accepted in light of current findings.

CONCLUSION

OrthoCAD software values on models obtained with the iTero 2 Element three-dimensional scanner (Align Technology) are considered reliable and represent an alternative compared with conventional methods.

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Gönderim Tarihi: 26 Nisan 2021; Kabul Tarihi: 4 Ekim 2021