

# Investigating the accuracy of data obtained with two types of intraoral scanners

Gergana Gurgurova<sup>1</sup>, Iliyan Kostov<sup>2</sup>

1. Orthodontic practice GreOrtho, Sofia, Bulgaria
2. Department of Administration and Management, IBSEU-Sofia

## Abstract

The new technologies incorporate every sphere of life, change the daily work of the orthodontist, providing an easier way to maintain and store detailed medical documentation. The way of performing biometric analysis is contemporary and digitalized and the virtual treatment outcomes tool make possible to visualize and predict clinical results at the end of treatment.

**Materials and methods:** The upper jaws of 130 patients were clinically scanned with two models of intraoral scanners Planmeca–Emerald and Medit i700. Biometric measurements between reference tooth points were made on the 260 virtual models created from the scan. The measurements were made using the orthodontic panel Planmeca Romexis 3D Ortho studio and Medit Design app 2.1.4, Measurement Mode.

**Aim:** The study aim to verify whether there is a clinically significant difference in measuring biometric parameters on digital models created and processed with different software.

**Results and discussion:** The results obtained show a statistically significant difference between the values measured in mm: Emerald – 44.87mm and Medit i 700 – 44.77mm.

**Conclusion:** The size of the average deviation of 0.1mm from a mathematical point of view has its statistical significance, but from a clinical point of view this is an absolutely negligible value with no real clinical significance.

**Keywords:** intraoral scanner (IOS), digital software, orthodontic measurements, Medit i700, Planmeca Emerald, digital orthodontics

## Introduction

Virtual models document the dental arches and occlusion of patients in three dimensions. Their accuracy surpasses plaster versions, which have been shown to be prone to errors that lead to deviations along the way: changes in the alginate impression, during its transportation to the laboratory, when casting it from plaster, shrinkage or other physical changes. All these disadvantages are complemented by the increasing problems of their storage: damaged models, required physical storage space, etc. (1-3). Intraoral scanners are a valuable alternative to plaster models and their use in orthodontics is increasing in more and more practices. Their advantages are: quickly obtained data that can be easily sent to the dentist, laboratory or patient, easy storage, ensuring exceptional accuracy when making orthodontic appliances on them. Contemporary orthodontists use technologies to overcome barriers and optimize treatment plans, design and manufacture of treatment appliances (4). Three-dimensional (3D) printing provides increased precision and more accessible customization of orthodontic appliances (5). Another aspect in which orthodontic models are used is biometric analysis (6-8). The analysis that identifies changes in the position of the teeth requires

stable reference structures (bone points). Quite often, the palatine folds are used as such, which must therefore be clearly visible (9). Digital models obtained by intraoral scanning facilitate not only treatment planning, but also improve communication between patients and doctors, as well as between dentists themselves. Communication with patients is also improved through intraoral impressions. They are a powerful tool for informing the patient, visualizing the goals of treatment, presenting possible clinical options and providing him with an informed choice. Virtual impressions are a means by which the patient is as involved as possible in the treatment process, and the conversation with him is more effective, illustrated and understandable (10). Intraoral scanning allows simultaneous capture of central and structural occlusion, which saves clinical time and allows faster fabrication of the treatment appliances (11). The digital image is visualized on the screen during the scanning process, which involves the patient as a direct participant in the process. He can see the therapeutic condition of his own dentition, as well as the level of his personal oral hygiene (12). Intraoral scanning is possible at any time during the patient's treatment. It allows for strict control and reassessment during the treatment process (13).

After receiving the digital models in STL format, various software are used to process the models, apply various analysis software, and use CAD systems to design the orthodontic appliances. The choice of these software by orthodontists is a function of the digital training of the orthodontic team, the price of the product, and its availability. The digitalization of orthodontic practices increasingly begins with the inclusion of intraoral scanning as a routine in daily practice (14). In the application of software for digital analysis of virtual models, orthodontists use AI to guide them to the probable diagnosis, but the final decision is made by the orthodontists themselves (15). In this process of digitalization of orthodontic practices, dentists are faced with a choice of the type of intraoral scanners, which are offered by many companies, in combination with different software, with different characteristics of their technological capabilities. Doctors are mainly interested in the accuracy of the scanned models and whether it differs between the different intraoral cameras offered on the Bulgarian market. This question provoked the team to conduct a study on this issue.

## Aim

The aim of the study is to verify whether there is a clinically significant difference in measuring biometric parameters on digital models created and processed with different software.

## Material and methods

Clinically scanned upper jaws of 130 patients with two models of intraoral scanners Planmeca–Emerald and Medit i700. Biometric measurements between reference tooth points were made on the 260 virtual models created from this scan. The measurements were made using the orthodontic panel Planmeca Romexis 3D Ortho studio and Medit Design app 2.1.4, Measurement Mode. Both software have technical capabilities for measuring the indicators included in the study. This allows for planning a comparison between the capabilities of different software when analyzing the same objects (digital orthodontic models). Both software used allow the measurement of any parameters set by the clinician. There are no restrictions for measuring permanent and deciduous teeth in the software used. The intermolar distance between the first upper molars was measured with both software. The same operator measured the width of the upper jaw – marked with MM, on 130 virtual models first with one and then with the other software.

The data were entered and processed with the statistical packages IBM SPSS Statistics 25.0. and MedCalc Version 19.6.3. The significance level at which the null hypothesis is rejected was  $p < 0.05$ .

Results

The results obtained from the IOS-Emerald and IOS-Medit software show a statistically significant difference between the values measured in mm: Emerald – 44.87mm and Medit i 700 – 44.77mm. (Table 1)

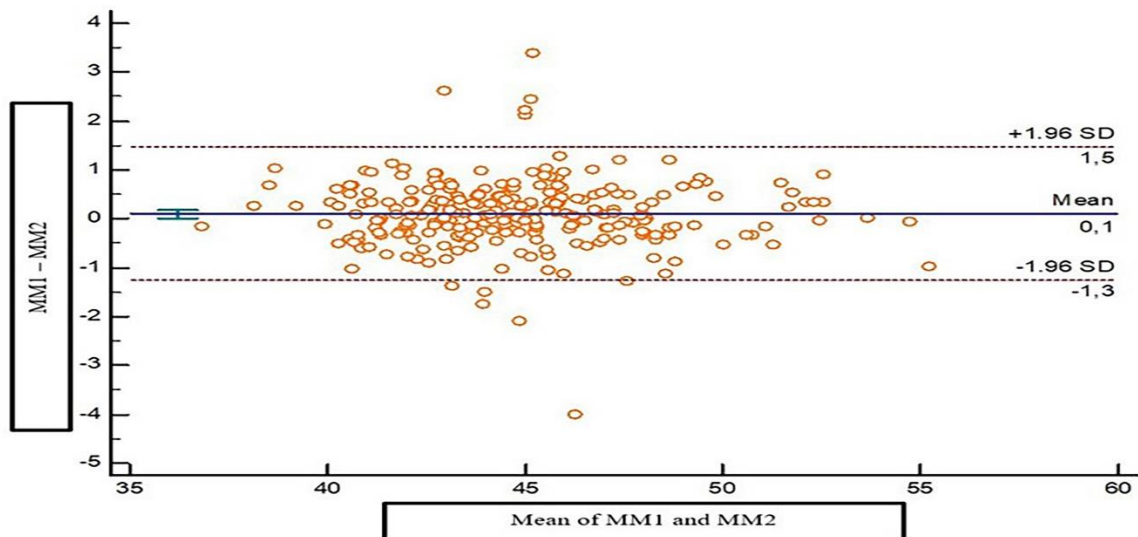
**Table 1. Comparative analysis of the results obtained with Emerald and Medit scanners. The values in the table are reported in millimeters.**

n	Emerald (MM2)		Medit i700(MM2)		P
	$\bar{X}$	SD	$\bar{X}$	SD	
259	44.87	3.10	44.77	3.12	0.004

The average difference in measurements obtained with both software ranges from (-4.02 mm) to (+3.39 mm). The entire range of the interval of the difference in measurements between the two scanners is 7.41 mm, and the average value is only 0.1 mm, which is an insignificant value for practice. (Table 2)

**Table 2. Analysis of variance of the difference in results obtained with the Emerald and Medit i700 scanners. The data in the table are in millimeters.**

n	$\bar{X}$	SD	Min	Max	Range
259	0.10	0.69	-4.02	3.39	7.41

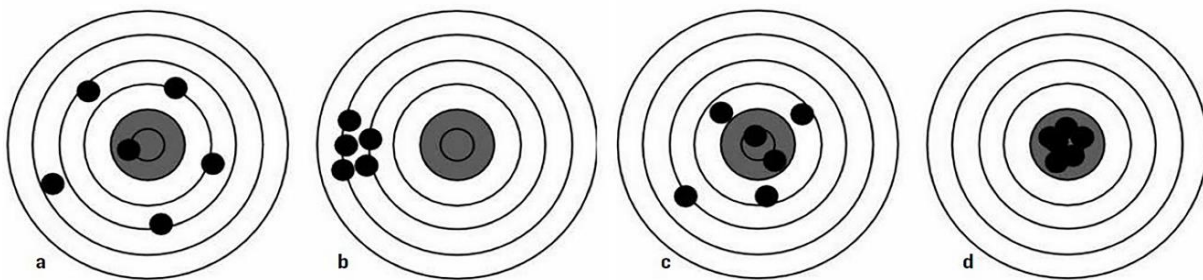


**Figure 1. Bland-Altman plot of measurement agreement between MM1 and MM2.**

The Bland-Altman graphical analysis for measurement consistency between the measurements of the two scanners found that the arithmetic mean of the differences in the measurements (Mean) has a value close to zero, which gives us reason to claim that there is consistency (identity) between the results of the two scanners. (Figure 1)

## Discussion

In metrics and engineering, accuracy is defined as “the closeness of correspondence between a measured quantity value and the true quantitative value of a measurand”. Accuracy is the sum of the reality and precision of the image.(16) A real or true digital image means the measurement exactly matches an already measured (known) quantity, while precision indicates the possibility of this measurement being repeated consistently. Therefore, for a scanner to be accurate, it must give consistent results even if it is used for different measurements of the same object. Thus, the scanner detects all the details of the print and generates a virtual 3D model that is as close as possible to the original image. A real or true image is “the closeness between the expectation of the result and the true value”.(17-19)



**Figure. 2 Correlation between truthfulness and precision. (a) Low trueness and low precision. (b) Low trueness but high precision. (c) High trueness but low precision. (d) High trueness and high precision. (Mutwalli) (20)**

Mutwalli (20) very clearly illustrates the difference between trueness and precision. (Figure 2) In a study Michelinakis (21) comparing the accuracy of IOS in in vitro studies reported an accuracy of 56  $\mu\text{m}$  for Emerald and an accuracy of 16  $\mu\text{m}$  for the IOS Medit i500. Dutton (22) reported an accuracy of 53  $\mu\text{m}$  for Emerald and 29  $\mu\text{m}$  for Medit i500. Mennito (23) reported an accuracy of 90  $\mu\text{m}$  for the Emerald scanner. In a 2023 study Falih (24) compared eight IOS, including the Emerald Medit i500 and Medit i700. He reported that the Medit i700 had the highest accuracy and trueness of the image.

## Conclusion

Results obtained with Planmeca Emerald scanner have higher average values by an average of 0.1, compared to those made with Ortho studio and Medit Design app 2.1.4, Measurement Mode, on digital models generated with Medit i700 scanner. The size of the average deviation of 0.1 from a mathematical point of view has its statistical significance, but from a clinical point of view this is an absolutely negligible value with no real clinical significance. The different softwares are reliable enough and give reliable results, with which clinicians can work comfortably in their daily practice.

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**Corresponding author:**

Gergana Gurgurova,  
Orthodontic practice GreOrtho, Sofia, Bulgaria  
email: gerganagurgurova@gmail.com



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