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Comparing the Accuracy of Intraoral Scanner Digital Models and Plaster Models

Alberto Teramoto Ohara[1,2], Marisol Almeida González[3], Salvador Angulo Preciado[3], Airy Teramoto Iida[1]

1. Profesor del Departamento de Ortodoncia. Universidad Nacional Autónoma de México
2. Profesor del Departamento de Ortodoncia. Universidad Tecnológica de México
3. Ortodoncista egresada del Departamento de Ortodoncia. Universidad Tecnológica de México

Corresponding author:
Airy Teramoto Iida
E-mail: airyteramoto@gmail.com

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ABSTRACT

Introduction: The use of intraoral scanners in dentistry has been increasing in recent years, the reasons for this are the elimination of impression materials, but mainly the speed and convenience of the records obtained. **Objective:** To present the comparison of dental arch models obtained from two conventional impression methods (alginate and polyvinylsiloxane) and intraoral scanning to determine if there are discrepancies in size. **Materials and methods:** An observational, analytical, prospective, cross-sectional study was carried out in which 15 patients (9 males, 6 females) were selected from the Faculty of Dentistry of the Universidad Tecnológica de México. For each patient, study models were taken with three different methods. Method 1: Impression with alginate, Method 2: Impression with polyvinylsiloxane, Method 3: Intraoral scanning. Subsequently, plaster models were obtained from Methods 1 and 2, and 3D models were

printed based on Method 3. With a digital vernier, the models were manually measured at five transverse distances and the results were analyzed with ANOVA for independent samples ($p>0.05$). **Results:** There are no significant statistical differences between the upper and lower inter canine, upper and lower first premolar, upper and lower second premolar, upper and lower first molar, upper and lower second molar transverse distances in Method 1, Method 2, and Method 3. **Conclusions:** The intraoral scanning system in conjunction with 3D printing technology is a reliable system to be able to reproduce the transverse discrepancies of the measurements of the dental jaws, however depending on its final use other factors such as the type of 3D printing technology should be taken into consideration for its correct clinical application.

Keywords: scanner, digital impressions, alginate, polyvinylsiloxane.

INTRODUCTION

The concept of the impression-taking process in dentistry began in the mid-19th century. Dentists realized that both detailed capture of oral tissues and plaster models were required. To achieve these goals, impression materials were essential[1].

Among the most common impression materials in dentistry was alginate, which was patented as early as 1920[2]. Subsequently, addition silicones (PVS), elastic impression materials based on vinyl-terminated silicones, hydrogen-terminated silicones, and a catalytic chloroplatinic acid, were invented. They exhibit almost 100% elastic recovery and generally offer good tear resistance[3]. In both materials, to obtain a physical model, it is necessary to obtain the positive of this negative reproduction by pouring plaster into the impression. This process poses a possibility of error in obtaining a faithful copy of the original model. In dentistry, plasters such as calcium sulfate dihydrate ($CaSO_4$) have been used for dental purposes. For their handling, they depend on a correct water/powder ratio, spatulation, and correct water temperature.

The first antecedents of CAD/CAM technology in dentistry date back to 1971, when François Duret[4] published a paper on the operation of a CAD/CAM system for dental use. The development of the technology in the mid-1990s introduced the possibility of obtaining digital dental models[5]. These are a diagnostic alternative which offers multiple advantages such as cost reduction, ease of consultation with other professionals, cleaner processing, ease of acquisition and storage, export for simulation processes, predetermination, and determination of measurements for diagnostic use or research[6].

To obtain a digital model it is necessary to have an intraoral scanner. The intraoral scanner is a digitizing device that is responsible for obtaining and digitizing images or information of all types of objects for reading and making use of it. The purpose of the intraoral scanner is to record the three-dimensional geometry of an object. Individual images or videos are recognized as points of interest and the software compiles them. The first two coordinates (x,y) of each point are evaluated in the image and then the third coordinate (z) is calculated[7].

The intraoral scanner for dental use according to ISO 12836 (2015) is defined as *"a digitization device in dentistry for data acquisition of custom-made indirect tooth surfaces, used to record the topographic characteristics of teeth and dental tissues by analog or digital methods"*[8]. It is a device capable of performing three-dimensional scans of tooth surfaces, creating a digital model of information to be fed directly into the CAD/CAM chain using a computer. The scanning

can be performed in the mouth or on a model and/or impression, and they are classified as intraoral and extraoral. These can be further subdivided according to the working concept and technology they use[9] (Figure 1). Intraoral scanners consist of a handpiece or head called a feeding interface, reconstruction software, and a computer. Outside the dental field, they are used in industrial design, orthopedics, reverse engineering, 3D printing, CAD manufacturing, quality control, and object documentation[10]. Therefore, this study aimed to determine whether there are transverse discrepancies in the dental measurements of physical models of the upper and lower arches obtained with three methods: alginate impressions, PVS impressions, and intraoral scanner.

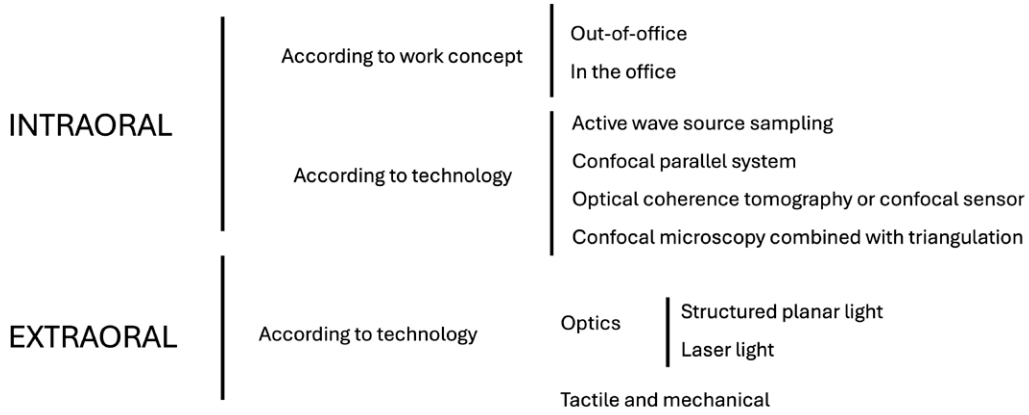

Figure 1. Classification of scanners in orthodontics.

MATERIALS AND METHODS

An observational, analytical, prospective cross-sectional study was performed; 15 patients were selected from the Orthodontics Postgraduate Clinic, Facultad de Odontología de la Universidad Tecnológica de México (UNITEC) Marina Campus.

The patients were selected under the following inclusion criteria regardless of gender: over 18 years of age with complete upper and lower permanent dentition up to the second molar. The exclusion criteria were patients with genetic anomalies and/or syndromes, patients who had systemic diseases, or missing teeth. Three methods (M) were applied to the 15 subjects. M1: Impressions with alginate (Super Gayz - Laboratorios Gayz S.A. de C.V.); M2: Impressions with PVS (3M™ Express); M3: TRIOS 3 Wireless intraoral scanner (3Shape A/S). A maximum of 1000 images per arch were obtained when scanning each patient's mouth (Figure 2). For M1 and M2, with the impressions made with alginate and PVS, dental study models were made using Velmix type IV plaster (WhipMix® Silky-Rock). For the M3, scanned digital models were converted for printing to an STL format and printed using Object30 OrthoDesk (Stratasys).

In the upper and lower arches, 5 transverse measurements were made respectively in M1, M2, and M3 with a Truper digital vernier caliper (Figure 3). The measurements were as follows: 1) Intercanine distance: cusp of the right canine to cusp of the left canine, 2) First bicuspid distance: buccal cusp of the right first bicuspid to buccal cusp of the left first bicuspid, 3) Second bicuspid distance: buccal cusp of the right second bicuspid to buccal cusp of the left

Figure 2. 3Shape intraoral scanner.

second bicuspid, 4) First molar distance: mesiobuccal cusp of the right first molar to mesiobuccal cusp of the left first molar, and 5) Second molar distance: mesiobuccal cusp of the right second molar to mesiobuccal cusp of the left second molar. To measure the intra-subject error of each examiner (MG/SP), each model was measured twice with an interval of two weeks and the results of each of the examiners were compared. Standardization obtained a kappa of 89% (MG) and 91% (MG).

The data were collected and recorded on the computer in a Microsoft® Excel spreadsheet and were subsequently exported to the IBM® SPSS® V.24 program for statistical analysis. Then the ANOVA test for independent samples was applied to determine if there was a difference between the averages obtained by each of the three methods with a reliability level of 95%.

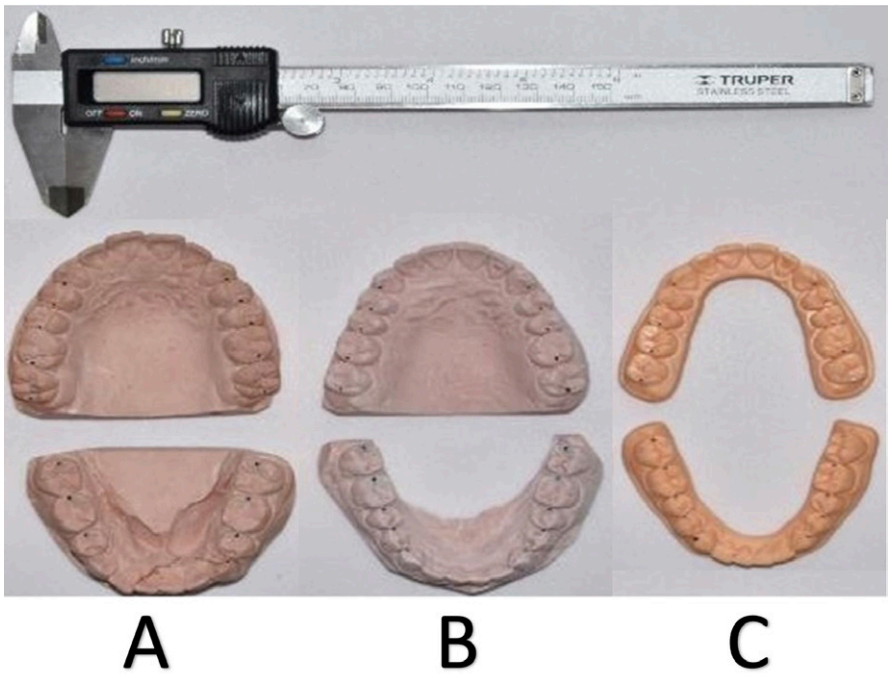

Figure 3. Truper digital vernier and models. A: Representative plaster model of the M1 (Alginate impressions). B: Representative model of M2: Impressions with PVS. C: Representative model of the printed digital models of M3: Intraoral scanner.

RESULTS

A total of 15 patients were included, of which 60% (n=9) were male and 40% (n=6) were female. Regarding age, the general average was 25.6 ± 3.18 years.

The values obtained by the three methods were very similar, so no statistically significant differences were identified, for example, in the case of the intercanine distance the values obtained with M1 were 3.71, M2 37.62, and M3 37.19 (p=0.873); the rest of the values are shown in Table 1. This implies that there were no transverse discrepancies in the dental measurements of the models measured by M1, M2, or M3.

Table 1.
Mean and standard deviation of transverse measurements.

	Upper arch	M1 Alginate (mm)	M2 PVS (mm)	M3 Intraoral scanner (mm)	P
		Media ± D.S.	Media ± D.S.	Media ± D.S.	
1	Intercanine distance	37.71 ± 2.87	37.62 ± 2.83	37.19 ± 2.94	0.873
2	First bicuspid distance	45.23 ± 2.89	45.32 ± 3.07	44.88 ± 3.06	0.917
3	Second bicuspid distance	51.85 ± 5.02	52.21 ± 4.25	50.36 ± 5.42	0.556
4	First molar distance	55.45 ± 4.37	55.38 ± 4.27	55.38 ± 4.33	0.999
5	Second molar distance	61.74 ± 3.91	61.43 ± 3.62	61.37 ± 4.01	0.962
	Lower arch				
1	Intercanine distance	28.86 ± 3.01	28.32 ± 2.78	28.72 ± 3.34	0.885
2	First bicuspid distance	35.34 ± 2.31	35.79 ± 2.50	35.22 ± 2.12	0.775
3	Second bicuspid distance	45.60 ± 7.74	46.15 ± 8.29	44.10 ± 4.31	0.976
4	First molar distance	44.54 ± 4.78	44.56 ± 5.65	44.10 ± 4.31	0.954
5	Second molar distance	50.76 ± 3.87	50.54 ± 3.71	50.13 ± 4.11	0.909

Table caption: M1: Impressions with alginate, M2: Impressions with PVS, M3: Intraoral scanner, P: statistical significance

DISCUSSION

Stone models have been considered the gold standard in research of most dentition studies and have been used successfully in dentistry for over 100 years[6]. The plaster models are a copy of the dentition, however, these are not completely exact since they may present some alterations when compared to natural teeth due to possible dimensional changes during their manufacture, which may happen in the impression material with alginate or PVS and/or pouring up the plaster.

A finding of this study was that the lower arch was much more susceptible to the effects of contraction and deformation compared to the models obtained from the upper arch. We may assume that the impression tray of the lower arch is horseshoe-shaped and the impression material has a smaller base whereas the upper arch has a much broader base since it covers the hard palate, favoring less contraction and deformation of the impression materials and therefore, the most precise study models of the structures are those of the upper arches[11].

One of the great advantages of the intraoral scanner is that it is a very comfortable method for the patient since records of the teeth can be obtained very quickly. Taking an alginate or PVS impression of the upper and lower arch takes an average of eleven minutes, while with an intraoral scanner with some training, it can be done in approximately one minute, this has made scanners more accepted by patients[12]. However, since it is a relatively new technology, the cost of a scanner can become a limitation, even more so if we consider the cost of a 3D printer and the maintenance that these devices require.

It is important to consider that depending on the final clinical application of the models, some special considerations must be taken[13]. Some studies show that there are limitations to registering acute angles and they suggest making rounded and smooth endings first to facilitate their registration[14]. The resolution of the 3D model printing also plays an important role in obtaining a digital model[15].

Although digital models have several advantages compared to plaster models, such as ease of data storage and data transmission, the clinician must go through a learning curve in the practice of handling the intraoral scanner and become familiar with the advantages offered by this technology, ranging from diagnosis, treatment plan, and development of orthodontic appliances.

When adding all the values of the transverse measurements of the upper and lower arch of the three methods, we found that the mean values of the differences between the intraoral scanner and alginate measurements were 0.44mm, while those of the scanner and PVS were 0.23mm. These values show us that from the clinical point of view for their final use as study models they are acceptable since a difference range of 0.50 is considered clinically acceptable[16]. These findings are in accordance with those obtained by Camardella and collaborators, who determined that the study models printed with the intraoral scanner are sufficiently precise for the needs of orthodontic treatment. In this study, some differences were found in the transverse measurements found in the plaster models compared to the printed and digitally scanned models. However, the accuracy and reliability of the digital models are clinically acceptable except for overbite, thus concluding that digital models can be used for treatment planning and device manufacturing in orthodontics[17].

According to the results obtained from the five transverse measurements with alginate impressions, PVS impressions, and intraoral scanner, we can determine that there are no significant differences between the three methods. We may conclude that the intraoral scanner method is accurate and viable for a precise diagnosis, as well as for the various treatments used in orthodontics.

One of the limitations of this study is that it was based on a relatively small sample. However, it can be considered representative. In a power study, applying the formula described by Pandis assuming an 80% power and an alpha of 0.05, it shows that 10 pairs of printed dental models for each group are necessary to show statistically significant differences[18].

CONCLUSIONS

The results showed that there are no significant statistical differences between M1: Impressions with alginate, M2: Impressions with PVS, and M3: Intraoral scanner. With these results we conclude that the intraoral scanning system in conjunction with 3D printing technology is precise enough to be able to reproduce both the dental structures and the dental arches, which is why it is extremely useful for the diagnosis and the manufacture of certain devices in

Dentistry. However, it is important to know what the final clinical application of the printed digital model will be; depending on this it will be necessary to complement it with an adequate 3D printing technology.

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