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Conventional and digital impressions for complete-arch implant-supported fixed prostheses: time, implant quantity effect and patient satisfaction

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PURPOSE. To evaluate and compare the effect of impression type (conventional vs digital) and the number of implants on the time from the impressions to the generation of working casts of mandibular implant-supported fixed complete-arch frameworks, as well as on patient satisfaction. **MATERIALS AND METHODS.** 17 participants, 3 or 4 implants, received 2 types of digital impression methods (DI) and conventional (CI). In DI, two techniques were performed: scanning with the scan bodies (SC) and scanning with a device attached to the scan bodies (SD) (BR 10 2019 026265 6). In CI, the making of a solid index (SI) and open-tray impression (OT) were used. The outcomes were used to evaluate the time and the participant satisfaction with conventional and digital impressions. The time was evaluated through the timing of the time obtained in the workflow in the conventional and digital impression. The effect of the number of implants on time was also assessed. Satisfaction was assessed through a questionnaire based on seven. The Wilcoxon test used to identify the statistical difference between the groups in terms of time. The Mann-Whitney test was used to analyze the relationship between the time and the number of implants. Fisher's test was used to assess the patient satisfaction (P<.05). **RESULTS.** The time with DI was shorter than with CI (DI, $\tilde{x}$=02:58; CI, $\tilde{x}$=31:48) (P<.0001). The arches rehabilitated with 3 implants required shorter digital impression time (3: $\tilde{x}$=05:36; 4: $\tilde{x}$=09:16) (P<.0001). Regarding satisfaction, the DI was more comfortable and pain-free than the CI (P<.005). **CONCLUSION.** Digital impressions required shorter chair time and had higher patient acceptance than conventional impressions. [J Adv Prosthodont 2022;14:212-22]

KEYWORDS
Patient comfort; Patient preference; Dental impression technique; Intraoral digital; Workflow

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INTRODUCTION

An accurate impression to transfer the position of the implants is essential to obtain precise master casts and for the fabrication of passively fitting implant-supported fixed complete arch prosthesis frameworks.[1] Implant impressions are affected by impression techniques and materials,[2,3] operator experience, and the number and angulation of the implants,[2,4] in addition to the stone handling and mold leakage technique, which can result in the failure of the final prosthesis.[5]

The introduction of intraoral scanners can be a viable alternative to conventional impressions, offering speed, the ability to store information and transfer digital images to the dental laboratory.[6] In addition, digital systems and equipment contribute to increased patient acceptance,[7] eliminating or reducing the amount and distortion of impression materials, visualization of three-dimensional images in real-time,[8] potential cost reduction, and increased time efficiency.[6] In view of the advantages of these devices, some disadvantages can also be observed, such as the difficulty in detecting edentulous arches and multiple implants,[9] increasing the scanning time, learning curve[10-13] and cost for acquisition and maintenance.[14-16]

In the quest to improve the accuracy of intraoral scanners in digitizing edentulous arches with multiple implants, previous studies have developed union devices to capture the position of the implants more quickly.[17,18] However, none of these studies have shown the use of virtual images obtained with such devices for the construction of framework. Other studies developed techniques that allowed the creation of passive framework, configuring a partial[17] or total digital flow.[19] From this perspective, the simplification of the conventional method directly impacts the time of the dental consultation and patient satisfaction.

Previous studies have evaluated the time and patient satisfaction for prostheses with single implants,[20-24] fixed implants,[7,25] orthodontic patients,[26] and completely edentulous situations.[6] Although there is evidence of a preference for conventional impressions, with reports of increased ease and speed,[27] the majority demonstrated that digital impressions required shorter time than conventional impressions.[25] Furthermore, from the patient perspective, a conventional impression caused discomfort in the mouth,[24] difficulty in breathing, and fear of repeating the procedure.[28] Meanwhile, a digital impression provided increased comfort, reduced pain, and practicality.[26]

However, clinical studies evaluating time when performing conventional and digital impressions for implant-supported fixed complete-arch prostheses, the influence of the number of implants, and patient satisfaction have not yet been reported. Thus, the aim of the present study was to compare the effect of impression type (conventional vs digital) and the number of implants on the time from the impressions to the generation of working casts of mandibular implant-supported fixed complete-arch frameworks, as well as on patient satisfaction. The null hypothesis was that impression type (conventional or digital) and the number of implants would not have an effect on the working time (chairside + laboratory for conventional and chairside for digital methods) and patient satisfaction.

MATERIALS AND METHODS

This non-randomized controlled cross-sectional study carried out at the Department of Dentistry of the Federal University of Rio Grande do Norte (UFRN) was approved by the Research Ethics Committee (CEP-UFRN/protocol 3.673.666) and followed the recommendations of the Declaration of Helsinki of 1975 (revised August 26, 2018). Furthermore, this study considered the guidelines of STROBE (the Strengthening the Reporting of Observational Studies in Epidemiology).[29]

A total of 17 participants, 7 with 3 implants and 10 with 4 implants (Neodent; Straumann, Curitiba, Brazil), were included in this study to receive complete-arch implant-supported fixed mandibular prosthesis. Patients with implant loss and peri-implant disease were excluded. All patients received a detailed description of the procedure, and an informed consent form was obtained before their participation.

The power analysis was calculated for a sample size of 17 patients to compare conventional and digital

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impressions. An average of 2369 seconds was considered for conventional impressions and 473 seconds for digital impressions, with a standard deviation of 324 seconds, corresponding to the comparison between the two impressions. A 95% confidence interval was calculated. The evaluation resulted in a power of 100%, indicating a strong statistical power to identify the differences between the two types of impression methods.

The participants included in this study were subjected to 2 impression methods in the same clinical session: digital (DI) and conventional (CI). The digital impression was performed first to prevent impression materials from getting jammed and interfering with the scan. For each method, the necessary procedures were considered to fabricate the frameworks and the acrylic base of the prostheses. Therefore, it was necessary to create 2 virtual models (in this work sequence): intraoral scanning with scan bodies (SC) and intraoral scanning with a device (SD) for digital impressions and two physical models, and solid index (SI) and transfer impression by the open tray (OT) technique for conventional impressions (Fig. 1). All procedures were conducted by a single experienced operator and guided by the clinical sequence and impression techniques.

The digital impressions used the followed scanning sequence: the occlusal surface of the right end of the arch was scanned followed by the left contralateral area, extending to the buccal surface, and then to the lingual surface. The scan was repeated until proper acquisition of the region of interest was achieved.[30]

Initially, the scan bodies (Neodent; Straumann, Curitiba, Brazil) were positioned on the abutments (Neodent; Straumann, Curitiba, Brazil) (Fig. 2A) and then the first scan (SC) was carried out by using the intraoral scanning technique recommended by the manufacturer of the intraoral scanner (TRIOS; 3Shape A/S, København, Dinamarca). The obtained file was converted into Standard Tesselation Language (STL) (Fig. 2B) format to obtain the working model (Fig. 2C). Then, a device for scanning multiple implants was attached to the scan bodies (BR 10 2019 026265 6).[31] The device consisted of three parts (a ball attachment, fixation support, and cylindrical-connection) to obtain a precise position and angulation of the implants.[30] The ball attachment was inserted in the space corresponding to the entrance of the screws of the scan bodies (Fig. 3A). Then, the fixation support was attached to the ball socket of the ball attachment (Fig. 3B), respecting the angulation of the implants, and this was joined through the hole in the fixation support, with a cylindrical-connection, which was adjusted to respect the distance between the implants

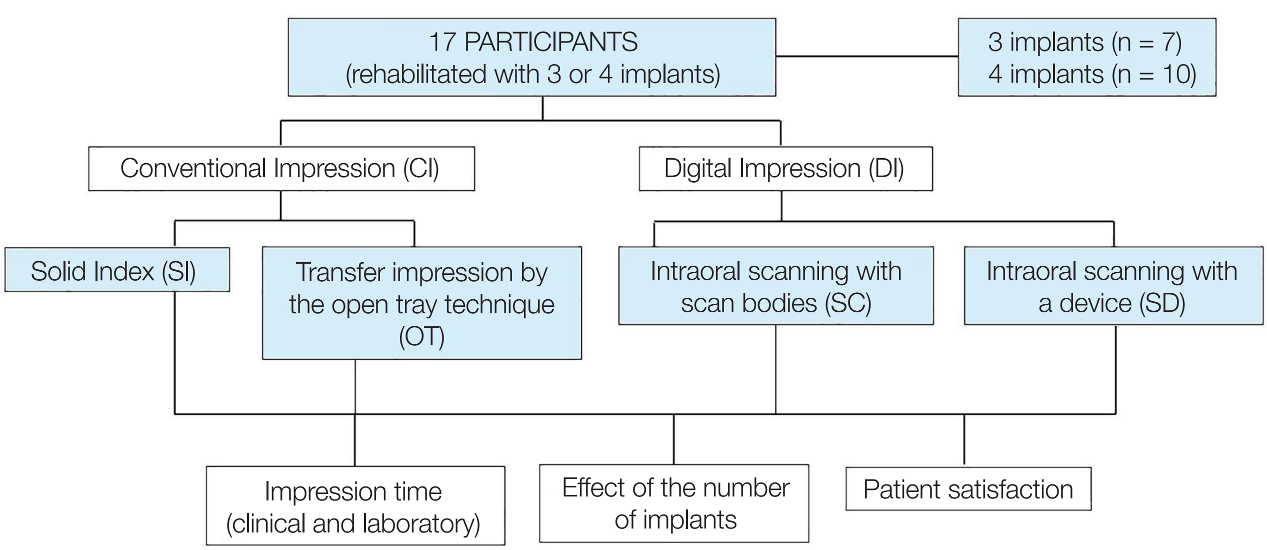

Fig. 1. Study flowchart.

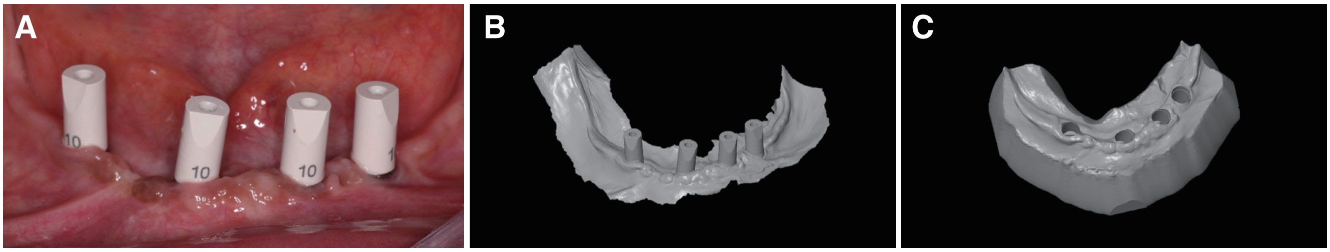

Fig. 2. (A) Scan bodies bolted to abutment-level, (B) File converted to Standard Tessellation Language (STL) format, (C) Digital work model (SC group).

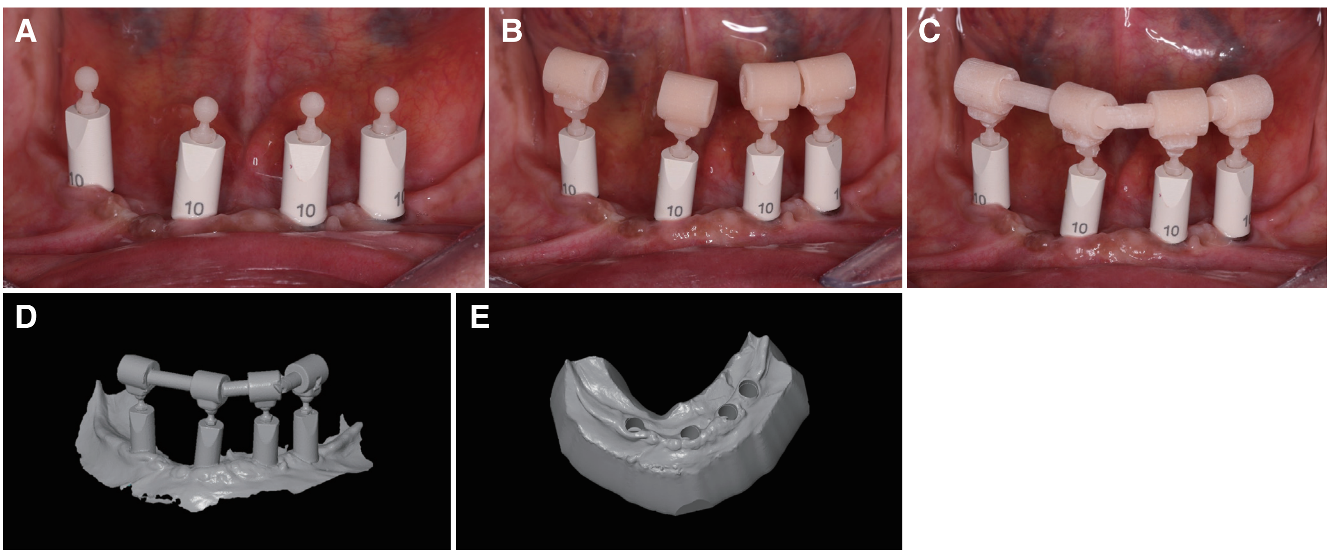

Fig. 3. (A) Ball attachment inserted in the space corresponding to the entrance of the screws of the scan bodies, (B) Fixation support fixed to ball the ball attachment, (C) Union from fixation support through cylindrical-connection, (D) File converted to Standard Tessellation Language (STL) format, (E) Digital work model (SD group).

(Fig. 3C). After assembling, a second scan (SD) was performed. The obtained file was converted into STL (Fig. 3D) format to obtain the working model (Fig. 3E). For both digital impressions, the correct copy of the region corresponding to the implants, as well as the buccal mucosa, was considered as an adequate image.

After digital impressions, conventional impressions were initiated. For the conventional technique SI and OT, the abutment level impression copings (Neodent; Straumann, Curitiba, Brazil) were wrapped with a self-polymerizing acrylic resin (Pattern Resin LS; GC Corporation, Hongo, Japan) extraorally, and then tightened onto the abutments with 10 N·cm torque (manufacturer's instructions) (Fig. 4A). The impression copings were then splinted with rigid metal fragments (tips/drills for dental use) and acrylic resin representing the splinted impression technique (Fig. 4B). To obtain the stone cast, the copings were unscrewed and removed from the mouth (Fig. 4C), the analogs positioned, and then immersed in type IV stone (Dentsply Sirona, Charlotte, NC, USA) (Fig. 4D). After the stone set, the copings were unscrewed from the cast and these were named solid index (SI) (Fig. 4E).

To obtain the stone casts with the OT technique, a plastic tray was used. After the impression copings were inserted and an access window was made to expose the impression copings intraorally, the tray was loaded with heavy-bodied addition silicone (Express XT; 3M, São Paulo, Brazil). A low-viscosity addition silicone (Express XT; 3M, São Paulo, Brazil) was expressed on and around the impression copings, and

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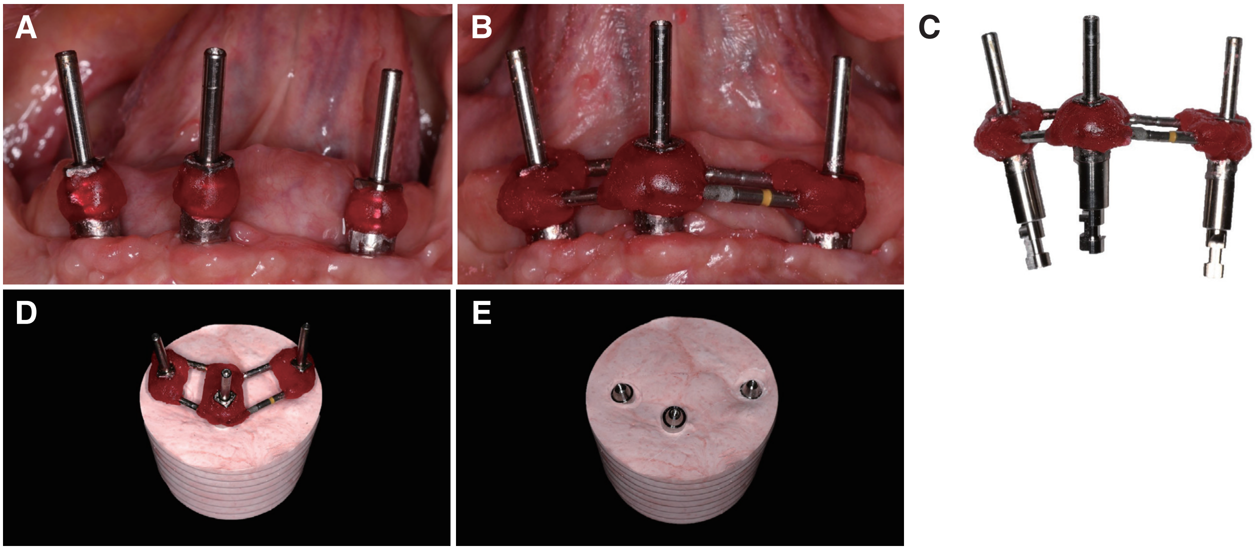

Fig. 4. (A) Impression copings screwed to the abutments, (B) Splinted impression copings with metallic fragments, (C) Copings unscrewed and removed from the mouth, (D) Set immersed in type IV plaster, (E) Finished solid index model (SI group).

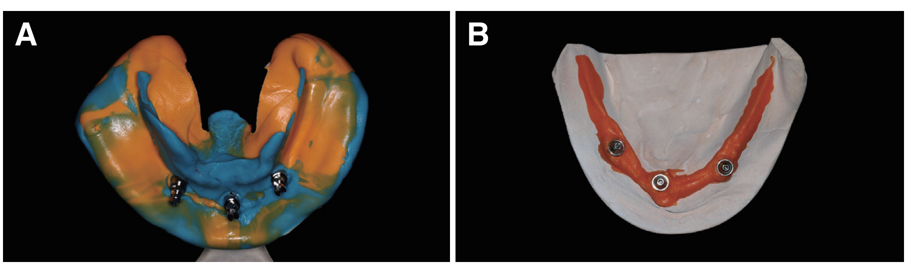

Fig. 5. (A) Obtaining the mold by transfer impression by the open tray, (B) Finished work model (OT group).

the tray was positioned intraorally. After the impression material set, the copings were unscrewed, and the tray and the copings inside were removed from the mouth. The analogs of the copings were placed (Fig. 5A) in the impressions and an artificial gingiva (Zhermack, São Paulo, Brazil) was injected around the platforms of the implants. Then, a type IV stone (Dentsply, São Paulo, Brazil) was poured (Fig. 5B).[30,32]

An operator, independent of the procedures performed, recorded the chairside time required to obtain the digital impressions and virtual models and the clinical and laboratory times for the conventional impressions and stone casts, respectively. The chairside time for digital impression included intraoral scanning, in which the information was extracted from the intraoral scanner software (TRIOS; 3Shape A/S, København, Dinamarca) and the generation of the virtual model. In addition, the device assembly time and positioning of the scan bodies were recorded. These two times were added to each stage (SC and SD), and the device assembly time was added to the SD stage. All described times were then combined to obtain the total time required to perform a digital impression.

For conventional impressions, the chairside time corresponded to the impression time from the preparation of the impression copings to the placement of the abutment analogs in the "resin index" (SI) and impression making with an open tray (OT). The laboratory time consisted of pouring the casts and immersing the "resin index" in the stone until its crystallization. Finally, all times were added to obtain the total working time required for conventional impressions. All times were recorded with the aid of the digital stopwatch (7 CM CR53; Western, São Paulo, Brazil).

The assessment of patient satisfaction was carried out by using an adapted questionnaire design[26] to investigate the patients' experience with the tested impression methods, level of comfort, time, and novelty. The questionnaire consisted of seven questions anchored by adjectives such as "agree" or "disagree." The participants were asked to fill the questionnaire twice to evaluate the digital and conventional impressions, shortly after the end of each impression session.

The data were analyzed by using a statistical software IBM SPSS (Statistics v22.0; IBM Corp., New York, NY, USA). First, the Kolmogorov-Smirnov test was performed to estimate the normality of the data, which did not present a normal distribution. Descriptive analysis was based on the median ($\tilde{x}$) and quartiles 25 (Q^{25}) and 75 (Q^{75}). The Wilcoxon test was used to verify the statistical difference between the impression methods, while the Mann-Whitney U test was used to compare the time between patients rehabilitated with three and those rehabilitated with four implants. Fisher's test was used to search for significant associations between questions and answers about patient satisfaction. For all tests, a *P*-value of less than 0.05 was considered statistically significant.

RESULTS

For fixed implant-supported complete arch prosthesis impressions, the time to obtain casts when using the digital impression was less than that when using the conventional impression ($P < .0001$) (Table 1). To specify the time required to obtain a working model within each impression method (DI and CI), a shorter time was needed to obtain the index (SI) model compared to the OT model ($P < .0001$), as well as for SC when compared to SD within digital impressions ($P < .0001$) (Table 1).

The total working time (chairside and laboratory) to obtain the casts with conventional impressions (Table 2) was longer than that with digital impressions, which did not have a laboratory stage. The total working time for DI is shown in Table 1 ($P < .0001$).

Ten participants received four implants (n = 40) and seven received three implants (n = 21), and statistically significant differences in time were identified for the digital impressions, depending on the number of implants. Arches with three implants required a shorter chairside time ($\tilde{x}$ = 05:36; Q^{25-75} = 04:43-06:42; P < .0001) than arches with four implants ($\tilde{x}$ = 09:16; Q^{25-75} = 07:55-10:40; $P < .0001$) (Fig. 6).

All patients reported having already undergone con-

Table 1. Clinical time required to perform conventional and digital impressions (min:s)

	CI			DI			CI	DI	*P*
	SI	OT	*P*	SC	SD	*P*			
Median	25:36	40:15		02:55	07:36		31:48	04:25	
Q^{25-75}	22:39-27:57	34:52-43:25	< .0001	02:06-03:18	06:06-09:18	< .0001	24:58-40:15	02:55-07:43	< .0001
Mean	25:22	39:29		02:48	07:52		32:25	05:20	

CI (conventional impression); DI (digital impression); OT (conventional molding using the open tray technique); SI (solid index); SC (intraoral scanning with scan bodies); SD (intraoral scanning with a device); (Q^{25} (Quartile 25); Q^{75} (Quartile 75).

Table 2. Clinical and laboratory time of conventional impressions (min:s)

	CI				
	SI	OT	*P*	SI + OT	*P*
Median	27:21	44:06		34:57	
Q^{25-75}	25:06-30:39	38:30-46:52	< .0001	27:09-44:10	< .0001
Mean	27:40	43:04		35:22	

CI (conventional impression); OT (conventional molding using the open tray technique); SI (solid index); Q^{25} (Quartile 25); Q^{75} (Quartile 75).

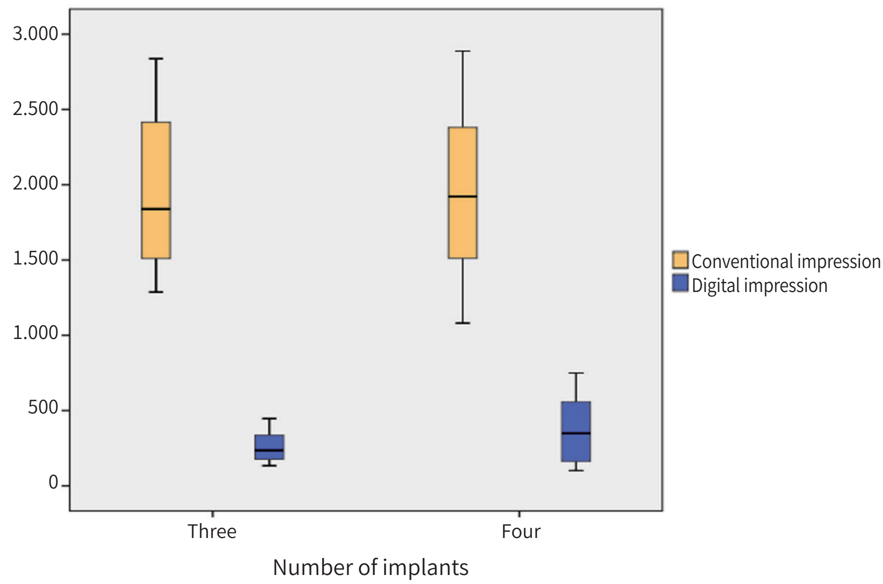

Fig. 6. Comparison between impression types and number of implants.

ventional impressions prior to this study. Regarding satisfaction, digital impression was associated with comfort, being a "painless" procedure, and quick. In addition, participants also considered it important to have new digital technologies in the dental office to obtain working models (Table 3).

DISCUSSION

The null hypothesis that no difference would be found between the conventional and digital impressions was rejected. The chairside and laboratory time required to obtain the working casts for the planning

Table 3. Patient satisfaction between conventional and digital impressions

			Impressions		Overall	*P*
			Conventional n/%	Digital n/%		
1	Having impressions made is comfortable?	Agree	5/14.7	14/41.2	19/55.9	.005*
		Disagree	12/35.3	3/8.8	15/44.1	
2	The impression was painless?	Agree	6/17.6	16/47.1	22/64.7	.001*
		Disagree	11/32.4	1/2.9	12/35.3	
3	The impression made my mouth dry?	Agree	9/26.5	3/8.8	12/35.3	.071
		Disagree	8/23.5	14/41.2	22/64.7	
4	Having the impression made was faster than I expected?	Agree	6/17.6	16/47.1	22/64.7	.001*
		Disagree	11/32.4	1/2.9	12/35.3	
5	The technician that made my impression was skilled?	Agree	16/47.1	17/50.0	33/97.1	.989
		Disagree	1/2.9	0/0.0	1/2.9	
6	Do you believe that having a new technology in the office is important?	Agree	7/20.6	17/50.0	24/70.6	<.0001*
		Disagree	10/29.4	0/0.0	10/29.4	
7	Would you rather go to a dentist who uses digital models than traditional models of alginate and plaster?	Agree	13/38.2	15/44.1	28/82.4	.656
		Disagree	4/11.8	2/5.9	6/17.6	
	Overall		17/50.0	17/50.0	34/100.0	

and construction of passive framework and, later, the acrylic resin base of the implant-supported fixed complete arch prosthesis proved to be less for the digital impression compared with the conventional impression. The number of implants influenced the chairside time, with a shorter time for the arches rehabilitated with three implants for digital impression. Patients reported a greater preference for digital impressions than conventional impressions.

While fabricating implant-supported fixed complete arch prostheses, the impression of the position of the implants and the surrounding tissues is necessary for the determination of parameters, such as the height and thickness of the metallic framework. However, to obtain metal frameworks with an optimal fit, it is necessary to incorporate the SI to eliminate the steps that lead to model distortions, related with impression materials, handling, and mold leakage. Based on this and the results of the study by Mangano *et al*.,[33] in which they indicated the use of the solid index for imprisoning the position of the implants in completely edentulous arches, this model was incorporated into the conventional workflow.

Previous studies have shown the difficulty the intraoral scanners have to accurately scan homogeneous areas, that is, with few anatomical features, such as spaces[9,34,35] and large extensions between implants.[36] Among the various reasons that can justify such a difficulty, the acquisition method is used by intraoral scanners, sending the information to the scanner software to process them through the best-fit algorithm after digitizing the area and then generate a virtual model. However, for this image to be captured accurately, the object to be scanned needs to present a complex geometry to promote fast area recognition and scanning,[36,18] enabling few images to be stitched, minimizing the union errors.

The alternative method found in previous studies was the incorporation of objects with complex geometries.[7,30,37] These are intended for the modulation of surfaces and a path for scanners to make the digitization process fast and accurate.[30,36] Therefore, in the present study, 2 intraoral scans were incorporated, one at the level of the scan bodies and the other with a device. This method was considered to obtain accurate virtual models that allow the fabrication of optimally fitting metal frameworks incorporated in the prostheses. In addition, the digital impression was performed and then the conventional one, in order to prevent remnants of the impression materials from being contained in the oral cavity and influencing the accuracy of the digital impression.

The time to obtain the working models for fixed implant-supported complete arch prostheses was faster with digital impressions compared with the conventional impressions. The results of this study are in line with previous studies regarding the comparison of the clinical time between the two impression methods in completely edentulous arches rehabilitated with multiple implants.[7,25] Therefore, the number of clinical steps that involve conventional impressions justifies the need for an increased time to obtain working models.

Although the results of previous studies have also reported shorter digital impression time compared with conventional impressions, the time for conventional impressions in the present study was longer than that reported by Cappare *et al*.[7] and Gherlone *et al*.[25] This difference may be due to the generation of two working models for conventional impressions in the present study, where their times were added up to obtain the time for conventional method. The verification jig fabrication (SI) was not considered in indicated studies, only evaluating one impression technique for each method. However, the time for digital impressions in the present study was shorter than those in previous studies.[7,25]

The intraoral scanner used to make the scans also differed from those used in previous studies[7,22] that included mandibular scans as in the present study. Imburgia *et al*.[16] compared the accuracy of four intraoral scanners, including the Trios 3Shape, also used by Gherlone *et al*.[25] and in the present study, and the CS600 used by Cappare *et al*.[7] They showed that CS600's trueness was superior to that of Trios 3Shape, while Trios 3Shape's precision was better than CS600's. In view of these results, the shorter time recorded with digital impressions compared with those reported in previous studies may be attributed to the use of a precision scanner, associated with modulation of the digitized surface.

Concerning the chairside time taken for the two

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types of impressions (DI and CI), shorter time was needed to obtain the index model (SI) and SC. Although all models are considered usable to fabricate a fixed implant-supported complete-arch prosthesis framework, either by conventional or digital impressions, as previously discussed, no study evaluated all these methods in one project to date. However, it is clear that the OT model requires more clinical steps than the SI model, which directly affects the time required. From the same perspective, the time necessary to obtain the SC intraoral scan was less than the SD. In the clinical sequence, for both scans, it was necessary to place the scan bodies; however, for the second scan (SD), the device assembly time was involved, which is an additional step, leading to the longest recorded time.

For the total time, including both the chairside and laboratory stages, conventional impressions required more time than digital impressions. The working sequence of conventional impressions includes the following: selection and preparation of the tray, manipulation of the impression material, positioning of the analogs in the impression, handling of the plaster, and casting of the mold. Meanwhile, digital impressions include a "virtual working model" directly from the intraoral scan without any additional factors. By eliminating the intermediate processes that are involved in conventional impressions including the laboratory steps, the working time is reduced in the digital workflow.[6]

The number of implants also influenced the impression time; shorter time was needed with digital impressions of arches with three implants than those with four. However, there was no significant effect of the number of implants with the conventional impressions. The decrease in the number of implants resulted in the reduction of the constituent parts to be digitized by the device, which may be the reason for significant differences found for the effect of number of implants with digital impressions. However, an assessment of working time would not be enough to state that the conventional impression would be recommended for cases with 4 or more implants.

A questionnaire based on the patient's preference between the two impression methods was used to assess patient satisfaction. Although the assessment instrument varied among studies, as well as the type of arch, previous results are in line with our findings,[6,7,28] showing a high digital impression preference by the patients. The elimination of impression materials is one of the main reasons leading to the greater comfort and absence of pain during the transfer of the position of the implants and other anatomical structures to the virtual environment. In addition, the increase in speed while making a digital impression is the result of the reduction in clinical and laboratory steps, leading to a reduction in the procedure and chairside time.

The relationship between the impression time, operator and patient satisfaction (question four (was the impression made faster than I expected?) and question five (was the technician who impressed my jaw skilled?)) reported an agreement among the patients for a fast digital impression and with no difference in the operator's skill. This finding showed that there was no influence of the operator's skill on the conventional and digital impression procedures and, consequently, on the time.

The absence of timing in stages within each impression method is a limitation of the present study. Also, future studies with an increased sample size are necessary to confirm the results of the present study. In addition, the results may be affected when different implant systems and equipment are used. Operator may also have an effect on the time and should be further studied.

CONCLUSION

Digital impression required less dental chair time than the conventional impression when obtaining the working models to manufacture a fixed implant-supported complete-arch prosthesis. The number of implants influenced the working time of digital impressions, with a shorter time for the arches rehabilitated with the three implants than those with four. The patients reported a high preference for digital impressions.

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