CLINICAL ORAL IMPLANTS RESEARCH

Short Communication

Digital vs. conventional implant impressions: efficiency outcomes

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Abstract

Objectives: The aim of this pilot study was to evaluate the efficiency, difficulty and operator's preference of a digital impression compared with a conventional impression for single implant restorations.

Materials and methods: Thirty HSDM second year dental students performed conventional and digital implant impressions on a customized model presenting a single implant. The outcome of the impressions was evaluated under an acceptance criteria and the need for retake/rescan was decided. The efficiency of both impression techniques was evaluated by measuring the preparation, working, and retake/scan time (m/s) and the number of retakes/rescans. Participants' perception on the level of difficulty for the both impressions was assessed with a visual analogue scale (VAS) questionnaire. Multiple questionnaires were obtained to assess the participants' perception on preference, effectiveness and proficiency.

Results: Mean total treatment time was of 24:42 m/s for conventional and 12:29 m/s for digital impressions ($P < 0.001$). Mean preparation time was of 4:42 m/s for conventional and 3:35 m/s for digital impressions ($P < 0.001$). Mean working time including retakes/rescans demanded 20:00 m/s for conventional vs. 8:54 m/s for digital impression ($P < 0.001$). On a 0–100 VAS scale, the participants scored a mean difficulty level of 43.12 (±18.46) for conventional impression technique and 30.63 (±17.57) for digital impression technique ($P = 0.006$). Sixty percent of the participants preferred the digital impression, 7% the conventional impression technique and 33% preferred either technique.

Conclusions: Digital impressions resulted in a more efficient technique than conventional impressions. Longer preparation, working, and retake time were consumed to complete an acceptable conventional impression. Difficulty was lower for the digital impression compared with the conventional ones when performed by inexperienced second year dental students.

Digital Dental Technology (DDT) for fabrication of dental restorations including computer-aided design/computer-assisted manufacturing (CAD/CAM) has been in development since the 1980s (Mormann et al. 1987). Its rapid expansion and incorporation into the field of dentistry has been documented since the beginning of 1990s (Priest 2005; Miyazaki et al. 2009). The digital impressions for conventional fixed prosthodontics play an important role in the development of DDT because they are the first step towards a full digital line of prosthetic fabrication. Benefits of the digital impression have been presented as: (1) improved patient acceptance, (2) reduced distortion of impression materials, (3) pre-visualization of the preparation three-dimensionally, and (4) potential cost and time effectiveness (Christensen 2009). Digital impressions for implant rehabilitations, would allow for: (1) virtual assessment of the implant prosthetic space, (2) depth of restorative interface, and (3) emergency profile configuration before proceeding with laboratory steps (Patel 2010).

A few studies investigated the efficiency and accuracy of the digital impression in tooth-supported fixed prosthesis (Glassman 2009; Persson et al. 2009; Syrek et al. 2010); however, there have not been any standardized and randomized clinical studies looking at the efficiency, accuracy and clinical viability of the digital impression in implant restorations. In this context, scientific validation on DDT and in particular for digital impression for implant rehabilitations is paramount to understand the impact of this new technology on modifying well-established conventional protocols.

The objective of this pilot study was to evaluate the efficiency, difficulty and operator's preference of digital impressions compared

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with conventional impressions for single implant restorations. The null hypothesis was that there is no difference in the efficiency of conventional and digital impression techniques when applied to impression procedure for single-implant restorations.

Materials and methods

This study was approved by the Harvard Medical School Committee on Human Studies (CHS Nr. M20078-101). The study population exclusively consisted of second year dental students at Harvard School of Dental Medicine (HSDM) who had no exposure to either conventional or digital implant impressions. Participants signed an informed consent form and were calibrated by attending to a tutorial session where they watched an introductory video illustrating the investigational sequence for both impression techniques.

Participants performed conventional and digital impressions on a customized maxillary model (Models Plus, Kingsford Heights, IN) containing a single, Bone Level, Regular Crossfit, implant (Straumann, Basel, Switzerland) located at the maxillary left second premolar area. The customized model was mounted on a training laboratory unit to simulate patient position under a clinical situation.

For the conventional impressions, three different sizes of stock trays were provided. The participants selected the best fitting trays and applied the adhesive. The conventional implant impressions were taken by a closed tray impression technique using Aquasil Ultra Monophase/LV (Densply, York, PA) and an implant impression coping (Fig. 1a and b). Impressions of the opposing arch were taken with Penta Quick VPS Alginate Replacement (3M ESPE, St Paul, MN). Handling of all impression materials was performed according to the manufacturers' recommendations.

The digital impressions were taken with i-Tero (Cadent iTero™,, Carstadt, NJ) digital impression system. A scan body (Straumann) was used to digitally transfer the implant position. In average 17 different digital scans including digital bite registrations were taken for the digital impression technique. The digital impression electronic data yielding to virtual implant models were recorded and sent to the fabricant for processing and milling of master casts (Fig. 1d). The sequence of the scans was performed according to the manufacturer's guidelines.

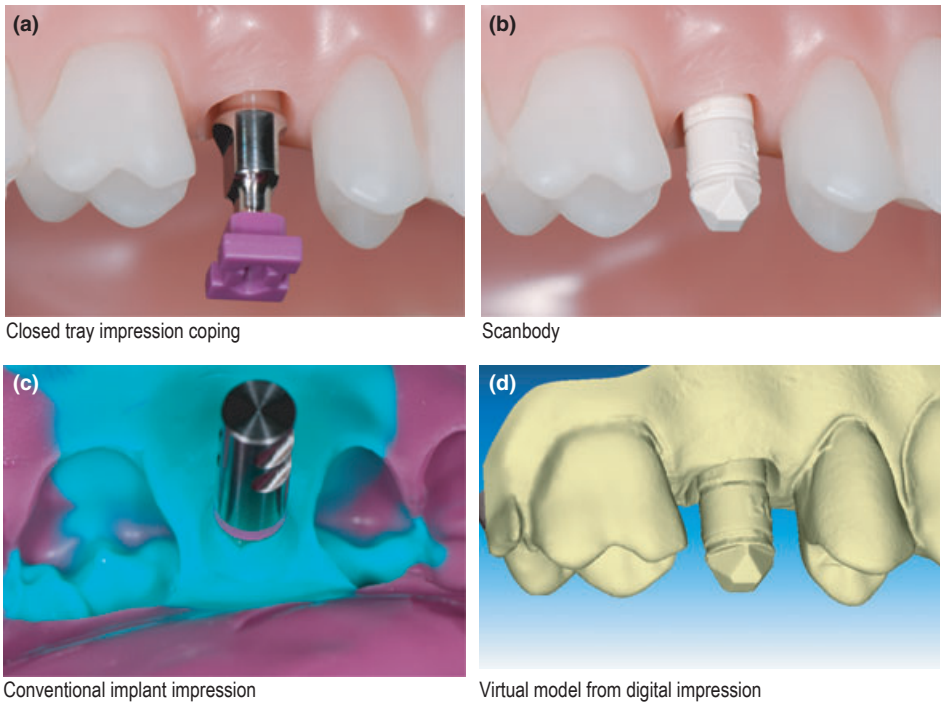

Fig. 1. Conventional and digital impression techniques. (a) Closed tray impression coping; (b) scanbody; (c) conventional implant impression; and (d) virtual model from digital impression.

The following acceptance criteria were used to evaluate the outcome of both impression techniques: (1) accurate imprint of implant areas, (2) absence of voids in the occlusal, buccal, lingual and interproximal surfaces of neighboring teeth, (3) absence of voids in the occlusal surfaces of opposing teeth, and (4) proper reproduction of vestibule up to the mucogingival junction. The impressions which did not meet the criteria resulted in retakes for conventional impression or rescan/additional scans for the digital impressions.

Efficiency

The efficiency of both impression techniques was evaluated by measuring the total treatment time and the number of retakes/rescans needed to obtain an acceptable outcome according to the acceptance criteria. Treatment time was measured in minutes/seconds (m/s) and separately accounted for preparation time and working time (Table 1). Working time was defined as the time needed to achieve an impression meeting the acceptance criteria. When needed, impression retakes (conventional impression) and rescans of the missing areas (digital impression) were recorded as additional working time and number of events for each participant. Statistical analysis by Wilcoxon signed-ranks test was carried out to evaluate the differences in efficiency between the conventional and digital impression using SPSS system (version 15.0; SPSS, Chicago, IL, USA). A P-value of <0.05 was considered statistically significant.

Difficulty

Participants' perception on the level of difficulty for both impressions was assessed with

Table 1. **Phases of treatment used for timing**

	Conventional	Digital
Preparation time	Tray selection Application of adhesives Placement/removal of implant impression coping Assembly of impression coping and implant analog into the impression	Entering patients' information Creating laboratory prescription Placement/removal of scanbody
Working time	Implant Impression taking (maxilla) Opposing arch Impression (mandible) Retakes	Scan of scanbody and neighboring teeth Scan of opposing arch Bite registration Rescans

a Visual Analog Scale (VAS) questionnaire. Answers were recorded by placing a hash mark on a non-numerical 100 mm line ranging from "Not difficult at all = 0" to "Very difficult = 100". Answers were then measured in a numerical format ranging from 0 to 100. Statistical analysis by Wilcoxon signed-ranks test was performed to evaluate the participant's perception of difficulty between the conventional and digital impression using SPSS system (version 15.0; SPSS). A *P*-value of <0.05 was considered statistically significant.

Operator perception on preference, effectiveness and proficiency

The participants were asked to answer a multiple-choice questionnaire on: which was the preferred impression technique, which impression technique was more efficient, and had they more experience, which impression technique would they become more proficient. Multiple choice answers for all three questions were conventional impression, digital impression, or either technique.

The distribution of the answers was analyzed by percentages using SPSS (version 15.0; SPSS). In addition, descriptive analysis was also carried out to assess the association between efficiency measured in time and participants' perception of effectiveness. These results indicate which parameters measured in time were most likely to affect the participants' perception of efficiency.

Results

Efficiency assessments for digital vs. conventional impressions are presented in Table 2. The mean total treatment time was statistically significant ($P < 0.001$), resulting in 24:42 m/s for conventional and 12:29 m/s for digital impression to complete the study. Mean preparation time was of 4:42 m/s for conventional and 3:35 m/s for digital impressions ($P < 0.001$). Comparison of mean working time including retakes/rescans showed statistical significance ($P < 0.001$) demanding 20:00 m/s for conventional vs. 8:54 m/s for digital impression. When accounting for the mean retake time only, additional 6:58 m/s for conventional and 1:40 m/s for digital were needed to obtain an impression meeting the acceptance criteria ($P = 0.003$). Twenty-one conventional impression retakes occurred in 56% of the participants (17 of 30). For digital impressions, 67 additional scans were performed by 96% of the participants (29 of 30).

Table 2. **Efficiency outcomes measured in time and level of difficulty**

	Conventional	Digital	*P*-value
Efficiency			
Preparation time (m/s)	4:42 ± 1:25 (2:50–8:06)	3:35 ± 0:58 (2:24–6:42)	<0.001*
Working time (m/s)	20:00 ± 6:37 (11:18–34:50)	8:54 ± 3:12 (5:34–19:44)	<0.001*
Retake/rescan time (m/s)	6:58 ± 6:56 (0–21:37)	1:40 ± 1:05 (0–5:20)	0.003*
Total treatment time (m/s)	24:42 ± 7:18 (14:28–41:24)	12:29 ± 3:46 (8:16–24:23)	<0.001*
Total number of retakes/rescans	21	67	<0.001*
Retakes/rescans (*N*=participants/%)	17/30 (56%)	29/30 (96%)	–
Difficulty			
VAS (0–100)	43.12 ± 18.46 (0–73.68)	30.63 ± 17.57 (0–77.89)	0.006*

All data are presented as mean ± SD and range in parentheses.
Measured time is recorded as min:sec.
VAS, visual analogue scale.
*Statistical significance $P \leq 0.05$.

Participants' responses (VAS) regarding their perceptions on the level of difficulty with conventional and digital impression technique are presented in Table 2. On a 0–100 scale, the participants scored a mean difficulty level of 43.12 (±18.46) for conventional impression technique and 30.63 (±17.57) for digital impression technique (P = 0.006) (Table 2).

Participant's perception on preference, effectiveness and proficiency is presented in Fig. 2. Sixty percent of the participants preferred the digital impression, 7% the conventional impression technique and 33% preferred either technique. Regarding participants' perception of effectiveness, 77% of the participants feel most effective with digital impression, 10% with conventional impression, and 13% with either technique. The participants expected to be more proficient with more experience in digital (47%) and conventional (10%) impression techniques. Interestingly, 43% of the participants considered that, had they gained sufficient experience, the proficiency would be the same for both impression techniques.

The participants who chose conventional impression (10%) as the effective technique employed less working and retake time than those choosing the digital impression technique (77%) (Table 3). Especially, the participants who chose either technique (13%) had no retakes on the conventional impression and consumed less total and retake/rescan time for both conventional and digital impressions.

Discussions

Digital impressions appears to be appealing when it comes to efficiency and patient satisfaction (Birnbaum & Aaronson 2008). In the

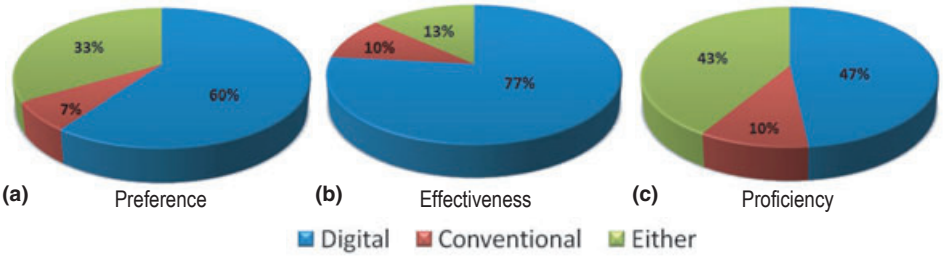

Fig. 2. Perception of preference, effectiveness and proficiency in percentage. (a) Preference; (b) Effectiveness; and (c) Proficiency.

Table 3. **Number of participants who chose the most efficient impression technique and time consumed for the impressions technique**

	Conventional	Digital	Either
N. participants—efficiency (%)	3 (10%)	23 (77%)	4 (13%)
Working time for conventional	21:54 ± 1:52	26:17 ± 7:32	17:38 ± 1:57
Retake time for conventional	2:59 ± 5:10	8:42 ± 6:50	0.00 ± 0.00
Working time for digital	16:33 ± 7:06	12:10 ± 3:18	11:19 ± 2:05
Rescan time for digital	1:03 ± 1:25	1:38 ± 1:06	2:17 ± 0:36

All data are presented as mean ± SD.
Consumed time is recorded as min:sec.

present study, the digital impressions resulted a more efficient technique when compared with conventional impressions for a single implant restoration. Participants in this study included dental students with no exposure to conventional or digital implant impression taking. This homogeneous group allowed investigating the efficiency of these impression techniques in an objective and non-biased manner. This is of particular importance since results from a different study population including experienced clinicians may have been unclear to interpret.

This pilot study represents the first one of a series of well-controlled investigations comparing digital vs. conventional digital impressions. While this investigation addressed only the efficiency and operator's preference on both impression techniques, several other aspects need further investigations. Future research should include assessment of implant impressions accuracy in producing a working model, experienced operator being exposed to DDT, clinical comparison of efficiency and accuracy of both impression techniques, comparison between full-arch and partial impression, and patient feedback from both impression techniques.

This study yielded initial evidence that the digital impression can be successfully applied to the impressions for implant restoration based on efficiency and participants' perception. However, the limitation of the study is that the study was performed in a non-clinical setting which might exclude the effect of patients' satisfaction and perception.

A potential benefit of digital impressions on implant components would be the possibility of intervention before the osseointegration has been achieved. In this context, a digital impression could capture the intraoral situation at early stages of osseointegration without the stressing the implant abutment component. Another advantage of using digital implant impressions is the patients' level of comfort and treatment acceptance. In addition, the advent of digital impressions comes to complete the work flow of DDT by integrating an intraoral scanning with the well-established CAD/CAM systems currently used in implant dentistry.

The present study showed that the digital impression was more efficient than the conventional impression based not only on the amount of time consumed for each impression technique but also on participants' perception. Even though there was greater number of rescans performed in the digital impression, the rescan time of the digital impression was significantly less than the retakes of the conventional impression. Rescans or incorporation of additional scans were mainly due to the difficulty in scanning the interproximal contacts of neighboring teeth next to the implant site and the areas of refection from the laser source. The main difference between retake (conventional) and rescan (digital) was influenced by the possibility of a partial intervention to rescan only the missing or unacceptable areas of the digital impression. On the contrary, the retake of the conventional impression involved repeating the entire impression process. These differences in the process of impression rescan and retake also affected participants' perception of effectiveness. Participants who chose the digital impression as the most effective technique consumed more total treatment and retake time in achieving an acceptable impression with the conventional technique (Table 3).

The level of difficulty judged by participants was significantly lower for the digital than conventional implant impressions. The manipulation of the intra-oral scanner seems to be more user-friendly than the manipulation of impression materials from the conventional impression. In addition, the rescan of the missing areas is more convenient and less cumbersome than retaking the entire impression with a conventional technique. These observations and results presented in this study may explain the main reasons for the participants to select the digital impression over the conventional impression. According to the participants responses had they had more exposure, conventional impressions would require more experience to achieve the same level of proficiency than digital impressions. This suggests that the learning process for digital impressions would be simpler than for conventional impressions.

Conclusions

(1). Digital impressions resulted in a more efficient technique than conventional impressions when assessed by total treatment time. A longer preparation, working, and retake time were needed to complete an acceptable conventional impression compared with a digital one. Therefore, the null hypothesis was rejected.

(2). Digital impressions allows for additional re-scans without the need of repeating entirely the impression technique. This results in a shorter treatment time.

(3). The level of difficulty was lower for the digital impression compared with the conventional ones when performed by inexperienced second year dental students.

(4). Digital impressions were deemed as the most preferred and effective technique according to the participants perception.

(5). Conventional impression would require more experience to achieve the same level of proficiency than digital impressions.

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