ORIGINAL ARTICLE

DIGITAL IMPRESSION TECHNOLOGIES – INTRAORAL SCANNING USED IN RESTORATIVE DENTISTRY

Marina Olimpia Amărăscu[1], Adrian Daniel Târtea[2,*], Dan Subțirelu[3], Sanda Mihaela Popescu[4], Iulia Roxana Marinescu[4], Adrian Marcel Popescu[1], Emma Cristina Drăghici[4]

[1] Department of Oral Morphology, University of Medicine and Pharmacy of Craiova, 200349, Craiova, Romania
[2] Dental Technologies, University of Medicine and Pharmacy of Craiova, 200349, Craiova, Romania
[3] Dentist with private practice, Craiova, Romania
[4] Department of Oral Rehabilitation, University of Medicine and Pharmacy of Craiova, 200349, Craiova, Romania

All authors contributed equally to this work.

[*] Corresponding author: **Adrian Daniel Târtea**, Dental Technologies, University of Medicine and Pharmacy of Craiova, 200349, Craiova, Romania
Email: *danielcetate@gmail.com*

Abstract: In recent years, there have been many technological advances in intraoral scanners. These developments have improved the efficiency and accuracy of intraoral scanning in CAD/CAM. *(1) Background*: The study aimed to compare results obtained in dental impression technology with IOSs to impressions taken with conventional impression materials. *(2) Methods*: the stages of two types of clinical oral rehabilitation (in dentate and edentulous patients) were compared. In each clinical situation, both impressions were taken using the classic impression method and digital impressions by intraoral scanning, one involving fixed prosthetics and the other removable prosthetics. *(3) Results*: During and after taking intraoral impressions using both the classic and digital methods via intraoral scanning, the digital impression produced a more positive perception than the classic impression. The time needed to perform an impression was statistically significantly shorter for digital one in dentate patients but longer in edentulous patients. *(4) Conclusions*: Intraoral digital impression techniques offer significant advantages over conventional methods that use impression material to increase patient comfort and improve communication between patients, dental technicians, and clinicians. These advantages are essential for dentate patients.

Keywords: intraoral scanning, accuracy, precision.

1. Introduction

Although Francoise Duret had been developing a new technology for intraoral scanning since the beginning of the 1970s, the first to introduce digital impression technology in the dental practice were Mörmann and Brandestini more than 10 years later [1].

While in the first decades, the CEREC system was the only commercially available intraoral scanner, in the last decade, many manufacturers have started to provide their solutions. Currently, more scanning technologies are available for digital intraoral impression systems [2].

CAD/CAM systems emerged simultaneous with digital impressions using intraoral scanners within a fully digital workflow. Digital impressions are obtained via intraoral scanners, which collect the information needed by projecting light [3]. The advantages of digital impressions are related to a lower risk of distortion of the physical impression material used in conventional techniques and increased patient comfort [4-6].

Regardless of the technology, intraoral digital scanners assemble 3D models by photographing and stitching together multiple photos taken from the oral cavity. This stitching process, which consists of the alignment of these numerous images, although critical, can be affected by a series of errors that may arise and compromise the overall accuracy of the digital impression [7-9]. An intraoral scanner's most critical mathematical characteristics are accuracy [10,11] and resolution [12].

When discussing digital impression accuracy, the terms "accuracy", "trueness", and "precision" should be distinguished from each other. According to the definition by the International Organization for Standardization (ISO 5725-1) in 1994, "accuracy" indicates the combination of "correctness" and "precision", where "correctness" is defined as "the closeness of agreement between the arithmetic mean of a large number of test results and the true or accepted reference value". Meanwhile, "precision" has been defined as "the closeness of agreement between different test results" [13].

In recent years, hardware and software innovations have driven many technological advances in intraoral scanners. These developments have improved the efficiency and accuracy of intraoral scanning in computer-aided design and computer-aided manufacturing (CAD-CAM). One of the most significant advances is the expansion of their capabilities, from simple intraoral scanning to diagnosis, treatment planning, and patient monitoring [14].

The objective of this study was to assess, comparatively, the advantages and improvements of the dental impression technology taken with IOSs and conventional impressions, as well as the limitations related to the use of the digital impression technique through intraoral scanning and classical impression technique.

2. Materials and method

The study occurred between October 2022 and January 2024 in the Oral Rehabilitation Clinic of the Faculty of Dentistry of Craiova. The study selected participants from the patients presented for oral rehabilitation. All patients gave

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informed consent for treatment and participation in the study. The Ethics Committee of the University of Medicine and Pharmacy of Craiova approved study 197/20.12.2021.

In the impression stage of the oral rehabilitation process, two types of impressions were obtained: the conventional impression and the optical impression. For the traditional impression, we used silicone and standard trays.

Medit i700 intraoral scanner with the Medit Link v.3.2.3 software (Medit, Seoul, Republic of South Korea) was used for the optical impressions. The intraoral scanner was calibrated according to the manufacturer's guidelines.

The stages of oral rehabilitation cases were performed according to the treatment plan, implying fixed or removable prosthodontics.

Working flow for dentate patients

The treatment plan was established and implemented following the patient's history and examination.

Figure 1. Tooth preparations resulting after grinding in a case of oral rehabilitation through porcelain veneers.

After preparing the teeth by grinding (Figure 1), digital and classic impression steps followed.

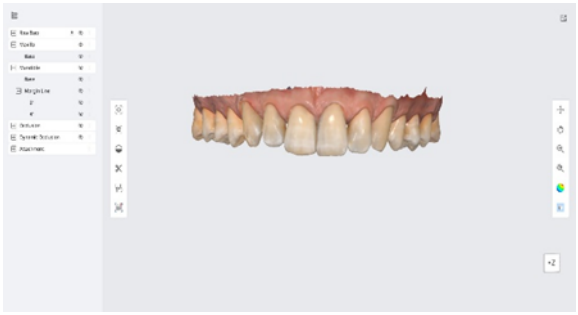

Figure 2. Digital impression of the upper arch.

The digital impression was taken by intraoral scanning with a Medit I700 scanner, consisting in maxilla jaw (Figure 2), mandible jaw (Figure 3) and occlusion (Figure 4).

Figure 3. Digital impression of the lower arch.

Figure 4. The 2 arches in centric relationship.

The materials for conventional impressions of upper and lower dental arches and occlusion were chosen. Standard

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impression trays and silicone were used. After this, the process of taking classic impressions and the occlusion relationship was carried out. For the case in Figure 2.5, addition curing silicone type President Putty and President Regular Body from Coltene (Coltene Holding Ag Switzerland) were used. Jet Blue Bite Fast Coltene (Coltene Holding Ag Switzerland) was used for occlusion impression.

Figure 5. Classic impressions and the Bite.

Figure 6. Plaster models.

The classic impressions arrive at the dental laboratory to obtain the plaster model (Figura 6), then scan it to get the virtual model to design the future dental restoration.

Working flow for the edentulous patients

For all edentulous patients, following the patient's history and examination, the treatment plan was established to rehabilitate the edentulous arch with removable total prosthesis.

For the first phase of the treatment plan, each patient benefited from a check-up and the presentation and acceptance of the treatment plan (Figure 7).

Figure 7. Initial phase.

The digital impression was taken by intraoral scanning with a Medit I700 scanner, consisting in maxilla jaw (Figure 8) and mandible jaw (Figure 9).

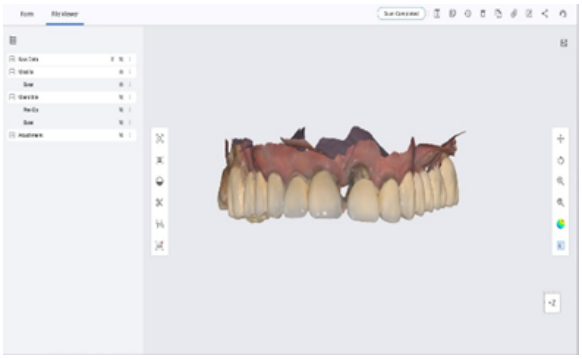

Figure 8. Digital impression of the upper arch.

In the case of completely edentulous patients, it is necessary for the intraoral scan to be supplemented with a classic impression to obtain the marginal areas and virtual model resulting from software overlay of intraoral

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scan and classic impression scan (Figure 9, Figure 10), as well as the scanning of a template (RIM) to establish the occlusion (Figure 11).

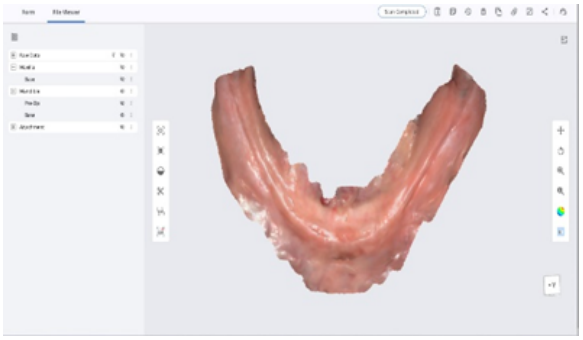

Figure 9. Digital impression of the lower arch.

Figure 9. Classic preliminary impresion scanning.

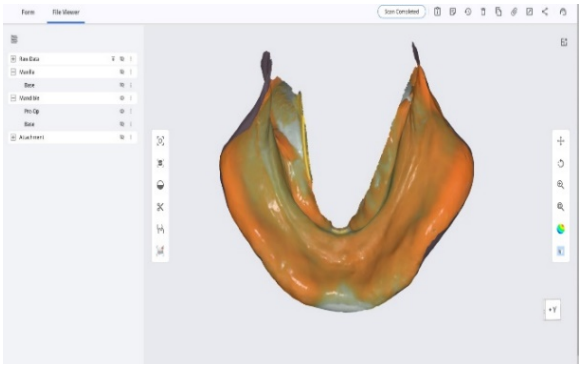

Figure 10. The virtual model.

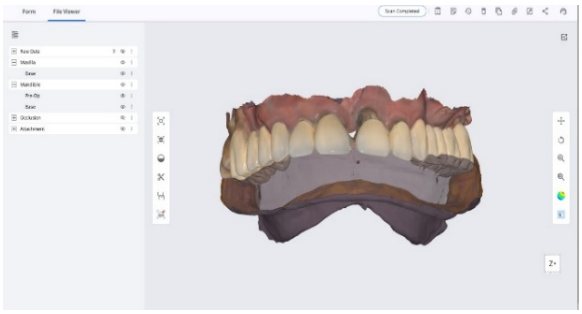

Figure 11. Virtual occlusion resulting from scanning the physical occlusion template (RIM).

To take impressions of the 2 arches, upper (Figure 12) and lower (Figure 13), using the classic method, standard impression trays and the material to be used are chosen. After this, the process of taking classic impressions and the occlusion relationship is carried out using wax template RIM (Figure 14).

Figure 12. Upper arch impression with putty and fluid silicone.

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Figure 13. Upper arch impression with fluid silicone.

Figure 14. Wax Template (RIM).

3. Results

The study included 24 patients, 12 dentate patients, and 12 patients with different types of total edentulism (one jaw mandibular or maxillary or both jaws). Patients included in the study were 12 men and 12 women, and in each group of dentate or edentulism, gender rapport was equal. The median age for the two groups (dentate and edentulous) was 45 for dentate (age between 35 and 55) and 75 for edentulous (age between 65 and 80).

During and after taking intraoral impressions using both the classic impression method and the digital method via intraoral scanning, in terms of perception and comfort generated for the patient, the digital impression via intraoral scanning produced a more positive perception regarding the impression phase in oral rehabilitation and greater ease compared to the impression taken using the classic impression method.

Regarding the execution time in the case of dentate patients, the digital impression method via intraoral scanning required a shorter execution time (20 ± 5.5 minutes), and the impression process via the classical method needed more time (30 ± 7.5 minutes).

Sending the digital impression to the dental laboratory has become easier, with the option of sending it electronically through a specific application or email. This step gives a vital time gain.

Storing the digital impression through intraoral scanning can be done electronically on a local storage device or in the storage space offered by some manufacturers without requiring physical storage space. In contrast, in the case of the classic impression, only the plaster model can be stored for a more extended period, in which case physical storage space is required.

Regarding the execution time of the impression of the edentulous patients, in the case of the digital impression by intraoral scanning, more time was needed (65 ± 10.5 minutes), the impression being taken quite difficult, requiring several attempts due to the lack of anatomical landmarks. In the case of the impression taken by the classical method, it needed a shorter time compared to the digital impression (55 ± 8.5 minutes).

The digital impression by direct intraoral scanning was not sufficient to fully record the

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limits of the mandibular edentulous prosthetic field, requiring an additional scan of the classical preliminary impression and the superimposition of this scan over the digital impression by direct intraoral scanning.

4. Discussions

Conventional impression techniques used to register the 3D geometry of dental arches have been used for more than two centuries. However, this traditional method is prone to errors as it involves using impression materials and dental stones susceptible to volumetric changes and possible damages during the transfer from the dental practitioner to the laboratory. This conventional method requires skill from the dental clinician, the dental technician and an excellent dental laboratory with sufficient expertise [15].

The introduction of the intraoral scanning devices and the development of CAD/CAM technology in the dental practice provide simplified treatment planning, easier case acceptance, better communication with laboratories, and significantly reduced operative time. Also, storage requirements are unnecessary, and treatment attendance has decreased. [16,17].

The technological advances both in software and hardware that intraoral scanners have benefited from in recent years allowed for accuracy as good or better than conventional impressions [18].

Digital intraoral scanning was considered for many years to be a clinically acceptable alternative to conventional impression techniques when dealing with crowns and short dental bridges as restorative options, and less so when a full-arch impression is needed, in which case the conventional impressions are preferred [3].

The defining characteristic of an intraoral scanner is accuracy, a combination of trueness and precision. According to the International Standard Organization (ISO) 5725:1 definition, trueness is defined as the "closeness of agreement between the arithmetic mean of a large number of test results and the true or accepted reference value". In contrast, the precision definition is "the closeness of agreement between different test results" [19,20].

Both early and most recent reviews that analyzed the marginal fit of dental crowns and bridges manufactured using conventional impressions versus digital impression technique show greater marginal accuracy in the latter group [21,22].

The scanning strategy is also a factor often quoted to have an essential role in the success of intraoral scanning, as the chosen strategy is likely to impact the accuracy of the digital scan [23].

According to some authors, the experience of the scanning operator is also a critical factor for the accuracy of the digital scan, as well as the size of the area to be scanned because the stitching process involved in this technology can affect the accuracy of the digital impressions, especially in the case of full-arch impressions [24-27].

The latest software and scanner versions have improved the accuracy levels, even for full dental arch scans [19].

Our study obtained similar results regarding the effects of the two impression methods. Thus, digital impressions by

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intraoral scanning, compared to classical impressions, have a reduced impact on the feeling of vomiting caused by patients, difficulty breathing caused by patients, stress, and anxiety caused by patients, and they generate better results in perception and comfort generated by patients.

While producing a removable complete denture using a digital impression by direct intraoral scanning, registration by the classical method is required to accurately determine the boundaries of the total edentulous prosthetic field, thus challenging the total digital manufacturing flow.

In terms of producing crowns and bridges on prepared teeth, digital impressions

through intraoral scanning have proven their effectiveness.

As for the impression time, it depends on each clinical situation. Thus, the scanning process of the completely edentulous mandible required more time because the edentulous field had an unfavorable anatomy, represented by a resorbed edentulous ridge. At the same time, the soft parts covered this edentulous ridge, requiring more scanning attempts.

Scanning the mandible to produce micro-prostheses was shorter than the time required to take the classic impression because the patient presented a pronounced vomiting sensation, thus becoming an unfavorable scenario for the impression using the classic method.

5. Conclusions

Intraoral digital impression techniques offer significant advantages over conventional methods that use impression material to increase patient comfort and improve communication between the patient, dental technician, and clinician. At the same time, it eliminates all error-prone stages related to the impression material and dental stone deformation, thereby resulting in superior accuracy.

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The authors declare no conflict of interest concerning this study.

Data availability statement

Data will be provided on request.

Ethics statement

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ORCID

Daniel Adrian Târtea: https://orcid.org/0009-0004-8015-0275
Marina Olimpia Amărăscu: https://orcid.org/0000-0002-3394-1486
Sanda Mihaela Popescu: https://orcid.org/0000-0003-3011-6322
Adrian Marcel Popescu: https://orcid.org/0009-0008-9374-9710

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