Using Intraoral Scanning to Fabricate Complete Dentures: First Experiences

Brian J. Goodacre, DDS, MSD1/Charles J. Goodacre, DDS, MSD2

The newest impression techniques use intraoral scanners to capture both the hard and soft tissues. However, with edentulous patients, the accuracy of an intraoral scanner to capture an acceptable impression for the fabrication of a complete denture needs to be evaluated. Therefore, the purpose of this report of two patient treatments is to describe a technique that used intraoral scanning to record mucosal morphology and fabricate computer-aided design/computer-assisted manufacture (CAD/CAM) complete dentures. Int J Prosthodont 2018;31:166–170. doi: 10.11607/ijp.5624

Impressions are a critical step in complete denture fabrication, as their accuracy allows denture bases to exhibit both retention and stability. Historically, multiple impression techniques have been proposed in the literature, including the functional impression technique,1 the mucostatic impression technique,2 and the selective pressure technique.3 In addition, modifications have been made to these techniques over the years with the use of different impression materials.4,5

The newest impression technique eliminates impression materials by using intraoral scanning of both the teeth and soft tissue, but concerns have been expressed regarding its use for digitizing edentulous jaws due to inaccuracies.6 As with other technologic advancements, the process needs to be evaluated clinically to determine if it has potential use in complete denture prosthodontics.

The use of intraoral scanners in dentistry was documented as early as the 1980s.7 There are currently many brands of intraoral scanners that can be used to make digital impressions of dentate arches for the fabrication of both direct and indirect restorations. A report was published in which an intraoral scanner was successfully used to make a digital impression of a partially dentate maxilla for the fabrication of a removable partial denture framework,8 and intraoral scanners have been used in edentulous arches to record the positions of implant scan bodies for the fabrication of complete-arch implant restorations in vitro.9

Computer-aided design and computer-assisted manufacturing (CAD/CAM) of complete dentures has made it possible to fabricate denture bases with improved adaptation,10 leading to improved retention compared to conventional processing techniques.11 While the manufacturing process itself has embraced digital technology, the clinical procedures have remained analog. However, a limited number of articles have been recently published in which digital impressions were taken of edentulous arches.6,8,9,12 One such paper reported on a technique whereby pressure-indicating paste (PIP) mixed with zinc oxide eugenol was proposed as a means of improving accuracy when scanning edentulous ridges intraorally.12 These articles point out the need for more information regarding the ability of intraoral scanners to capture edentulous ridge mucosa as an alternative to conventional impression procedures. Therefore, the purpose of this report of two patient treatments was to describe the use of intraoral scanning for the fabrication of CAD/CAM complete dentures.

Clinical and Technical Procedures

As described below, the technique used with both patients involved intraoral scanning of the edentulous arches combined with use of the Wagner EZ Guide process (AvaDent Global Dental Science LLC). The EZ Guide process involves three appointments and includes use of a Wagner Try-In (WTI) at the second appointment. After desired esthetic customization to tooth positions and vertical dimension at the second appointment, the denture is fabricated.

The first intraoral scanning was performed on a patient with an edentulous maxilla. The use of different surface additives was tested to see if they improved the scanner’s ability to capture the soft tissue. The second patient was edentulous in both the maxilla and mandible, and scanning was used for both arches to describe the technique and determine what challenges

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1Graduate Student in Prosthodontics and Implant Dentistry, Loma Linda University School of Dentistry, Loma Linda, California, USA.
2Distinguished Professor, Loma Linda University School of Dentistry, Loma Linda, California, USA.

Correspondence to: Brian J. Goodacre, Loma Linda School of Dentistry, Graduate Prosthodontic Clinic, 11092 Anderson Street, Loma Linda, CA, 92350, USA. Email: bgoodacre@llu.edu

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might be encountered when using intraoral scanning to record the morphology of an edentulous mandible.

**Patient No. 1**

Five different digital impressions were made of the first patient’s edentulous maxilla using an intraoral scanner (Trios 3, 3Shape A/G). The first scan was made with no additives to the soft tissue (Fig 1a), the second scan used four radiopaque adhesive markers (Spee-D-Mar, PDC Healthcare) (Fig 1b) placed around the palate, the third scan used scanning spray (High Definition Scanning Spray, 3M) lightly sprayed on the soft tissue (Fig 1c), the fourth scan used a minimal amount of PIP (Mizzy, Keystone Industries) (Fig 1d), and the fifth scan used a maximal amount of PIP (Fig 1e). Each digital impression was exported as an STL file and sent to Global Dental Science for fabrication of a CAD/CAM milled denture base.

At the second appointment, each of the five denture bases was clinically evaluated for adaptation and retention. Clinically, no discernable difference was seen between the five denture bases. Therefore, the decision was made not to apply any additive to the tissue surface for the maxillary scans. There is very limited information with regard to the mandibular arch, so it was decided to apply a minimal amount of PIP to the mandibular crest.

The WTI was then fabricated based on the maxillary scan with no additives to the soft tissue, and the stability and estimated tooth positions were evaluated (Fig 2).

The retention and stability were surprisingly satisfactory given the estimation of border extensions obtained from the intraoral scan. Minor changes were made to the tooth positions, and an interocclusal record was made between the maxillary WTI and the mandibular natural teeth. The overall aesthetic outcome of the definitive maxillary complete denture is shown in Fig 3.

The completed denture was judged to be esthetically appropriate and exhibited good retention and stability. Instructions were provided to the patient regarding postplacement appointments and care.

**Patient No. 2**

At the initial appointment for the second patient, an evaluation was performed of the vestibular depth, frenal attachments, and border extensions of the edentulous arches. The clinical scanning procedure was performed using two people, one to scan the arch and the other to retract the lips, cheek, and tongue. Special care must be taken to retract the soft tissues to positions that simulate the border extensions of a complete denture while avoiding excess stretching. Retraction can be accomplished using a finger (Fig 4) or a surgical retractor (Fig 5), allowing visually appropriate border extensions during scanning. While the lips and cheeks were retracted, an intraoral scanner (Trios 3, 3Shape A/G) was used to record the crest of the maxillary edentulous ridge, then the palate, and finally the vestibule.
The intraoral scan of the mandible was expected to be more difficult, so PIP was applied to the crest of the ridge to potentially provide landmarks that would enhance the scanning. However, the PIP did not prove to be beneficial. The mandibular scanning was started at the crest of the ridge, including as much of the retromolar pad as possible, and then moved to the facial vestibule. Using an instrument—in this case an intraoral mirror—the tongue was displaced medially while the intraoral scanner recorded as much of the lingual vestibule as possible. It was not possible to record all the desired border extensions in the mandible due to the presence of movable mucosa extending close to the residual ridge crest, resulting in soft tissue movement during the scanning that halted the scanning process. Therefore, a decision was made to proceed with fabrication of WTIs based on the extent of the scanning that was possible and then make a traditional reline impression inside the mandibular WTI at the second appointment.

The desired tooth form and shade were selected, and the distance from the incisive papilla to the lip at rest was measured using the Massad Lip Ruler (Nobilium CMP Industries LLC). The incisive papilla-to-lip distance was used to determine the location of the incisal edge of the maxillary central incisors (Fig 6). This incisal edge position information, along with the STL file of both the maxilla and mandible, were sent to Global Dental Science for fabrication of a WTI. Based on the incisal edge position of the maxillary incisors, the location of the incisive papilla, and other anatomical landmarks, a WTI was fabricated that located the teeth based on anatomical average locations and provided a trial denture, which was then refined clinically.

The collected information and the digital impressions of the maxilla and mandible in a standard tessellation language (STL) file format were sent to Global Dental Science for fabrication of the maxillary and mandibular WTIs (Fig 7).

At the second appointment, the WTI trial dentures were placed in the mouth, and the adaptation, as well as the border extensions, was evaluated using PIP. The retention and stability of the maxillary trial denture was judged to be very good. Even the mandibular WTI fit the edentulous ridge well, but lacked ideal border extensions. Therefore, the mandibular WTI was modified using conventional border molding and impression techniques, as would
be performed during a reline impression (Fig 8). The esthetics and occlusal vertical dimension were evaluated, and refinements were made in the maxillary anterior tooth positions (Fig 9). A centric relation record was obtained, and the WTI, along with the interocclusal record, were sent back to Global Dental Science for fabrication of the definitive dentures (Fig 10). Using the records, the desired tooth arrangement was determined (Fig 11) and the prosthesis fabricated (Fig 12).

During the third appointment, the definitive dentures were placed in the mouth and the adaptation evaluated using PIP. Minor adjustments were made and the occlusion refined. The esthetic results were evaluated (Fig 13) and determined to be appropriate, as were the retention and stability.

**Discussion**

This technique determined that an intraoral scanner can be used to fabricate maxillary complete dentures. While it was not possible to accurately record all the borders of the mandibular denture, sufficient data were recorded to produce a stable trial denture base that was modified to the desired border extensions using a conventional reline impression technique. Further experimentation is needed to determine how this process can be accomplished solely with a digital impression of the mandibular arch.

Even though the mandibular arch was not successfully scanned in its entirety, the scanning was performed relatively quickly and did produce an accurate base for the trial denture. The subsequent border molding and reline impression were judged to require less clinical time than making a traditional impression in a custom tray, thereby having an advantage. On average, the maxillary scan required about 2 minutes while the mandibular scan required 5 minutes due to multiple attempts; the mandibular scan was not completely adequate in terms of border extensions.

The dentures for both patients demonstrated good retention and stability and only required minimal adjustments at the time of placement and during post-placement appointments. The authors were somewhat surprised and were satisfied with the positions of the maxillary anterior teeth based on the anatomical averages used with the Wagner EZ Guide process. At the second appointment, the esthetic tooth positions were evaluated and only required minor adjustments, after which an interocclusal record was made at the desired occlusal vertical dimension for fabrication of the definitive prostheses. The benefit of fabricating the denture over three appointments is the ability to evaluate and customize the tooth positions prior to definitive denture fabrication. As needed, the second appointment can also be used to record any deficient borders resulting from the scanning using a reline impression in the WTI.
While the use of intraoral scanning was not able to completely capture the mandibular denture borders, its use in the maxillary edentulous arch was judged to be rather straightforward. One challenge relates to digitally determining the depth of the posterior palatal seal in the area of the pterygomaxillary fissures and across the posterior area of the denture. These depths need to be palpated intraorally and the information sent so a seal can be established in the virtual cast for fabrication of the definitive dentures.

A potential benefit discovered during the scanning of the edentulous arches was the ability of an intraoral scanner to capture what could be described as a true mucostatic impression. Mucostatic impressions have been advocated in edentulous patients with hypermobile soft tissue. While there are many techniques proposed to eliminate forces applied to the tissue during the impression phase of treatment, they still produce some forces on mobile tissue. Therefore, one additional benefit to the use of an intraoral scanner is its ability to capture movable tissue at rest. Another benefit of the modern-day intraoral scanner is its ability to capture not only surface texture, but also color. This distinction allows the marking of the posterior extension of the maxillary denture base so as to be evident in the intraoral scan.

Prior to the start of the final master scan for the first patient, multiple materials were added to the surface of the mucosa to determine if they would improve the ability of the intraoral scanning. The use of PIP, scanning spray, and adhesive radiopaque markers placed around the palate were evaluated. There was no clinically discernable benefit found from these additives in conjunction with the specific intraoral scanner used (Trios 3, 3Shape A/G) when scanning the maxillary arches. Therefore, no additives were used during the scanning of the maxillary arches. While PIP was used for capturing the one mandibular scan due to expected difficulty, it is not known if that provided any benefit.

For the intraoral scanning of edentulous arches, as with any new clinical procedure, a learning curve is expected and more work needs to be performed by multiple clinicians; in particular, more experimentation needs to be performed in the mandible due to the increased difficulty from movement of the tongue and realigning newly captured images with the previous images. In addition, the size of the particular scanner head that was used, along with its somewhat square end, produced some patient discomfort when obtaining complete border extensions, and scans need to be captured using different scanners. Also, additional research is needed to compare conventional and digital impression accuracy with respect to varying ridge morphologies.

Conclusions
The two patient treatments in this report demonstrate that intraoral scanning can be used in conjunction with the Avadent WTI to effectively fabricate complete dentures in three appointments. The addition of the WTI allows both clinician and patient validation prior to definitive denture fabrication.

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References