This article provides proof of concept for the use of intraoral scanning technology to record hard and soft tissue morphology for the fabrication of a cast partial removable dental prosthesis. An open source intraoral scanner was used to scan the hard and soft tissues to create a stereolithographic file that was subsequently imported into a computer-aided design software program for the digital/virtual design of a partial removable dental prosthesis framework. Computer-aided design and computer-aided manufacturing technology was then used to fabricate a resin framework that was trial placed to evaluate accuracy and for conventional investing and casting with a cobalt-chromium alloy. The cast framework and definitive prosthesis were judged to be clinically accurate in fit, stability, and retention. (J Prosthet Dent 2014;112:444-448)

Computer-aided design and computer-aided manufacturing (CAD/CAM) technology has increased the treatment options available for clinicians. The use of this technology continues to increase in fixed prosthodontics, and has expanded in recent years to include both implant and complete denture prosthodontics. CAD/CAM technology can simplify treatment procedures and reduce time and appointments, but careful acquisition of data with precise execution of clinical procedures is essential to success.

Limited information is available regarding the application of digital technology and CAM software in the fabrication of partial removable dental prostheses (PRDPs) and PRDP frameworks. Williams et al published an early report on the application of CAD/CAM technology in the fabrication of PRDP frameworks. They described a technique in which a definitive cast was digitized with an optical scanning device and a 3-dimensional (3D) model was produced. With software, they designed and created a prototype of the PRDP framework. The digital information was used in a rapid prototyping (RP) machine to form a plastic pattern, which was subsequently invested, cast, and finished in the conventional manner. They noted that this concept could save time and increase efficiency in identifying survey lines. They reported casting defects when the RP pattern was cast and the significant increase in cost associated with the scanner, design software, and RP device.

Williams et al subsequently published a clinical report in which they verified the accuracy of a digitally fabricated PRDP framework by scanning a definitive cast made by using a conventional impression. A scanner (Comet 250; Steinbichler Optotechnik), normally used in high-precision engineering applications, was used to scan the cast. The resulting data were then exported to design software (FreeForm Software; SensAble Technologies) that was used to survey the digital cast, determine the appropriate tilt, and provide appropriate relief. The framework design was then planned, and the information was exported to RP software to create the framework from a printed cobalt-chromium alloy. A laser beam was used to weld the printable cobalt-chromium alloy powder layer by layer to create this metal framework. The authors reported that the composition of the alloy used for printing the framework differs slightly from that of conventional cobalt-chromium used for casting. They cautioned that toxicity studies were not available for the printed alloy and that the issue of toxicity should be addressed before commercial use of this product. Hence, the PRDP framework was only trial fitted to verify the accuracy of this technology, and a definitive prosthesis was not placed.

To date, no reports of direct intraoral scanning for the fabrication of PRDP frameworks are available. The purpose of this patient treatment report is to offer proof of concept and describe the process by which intraoral scanning of the maxillary arch was used in the fabrication of a PRDP framework.

CLINICAL REPORT

A 63-year-old partially edentulous white woman presented for treatment at Loma Linda University School of Dentistry requesting a new PRDP to replace her missing maxillary teeth (Fig. 1). After comprehensive evaluation, data collection, and discussion of treatment options, a PRDP was chosen as the most appropriate prosthetic option.

The Journal of Prosthetic Dentistry

Kattadiyil et al
treatment options, a treatment plan for the fabrication of a new maxillary PRDP was selected. The patient’s entire maxillary arch, including the hard and soft tissue morphology, was captured digitally with the open source intraoral scanner (Cadent iTero; Align Technology). Approximately 28 scans were used to capture the teeth and occlusion, with an additional 25 scans being used to enhance the capture of the rest seats, guiding surfaces, soft tissue, and maxillary palate. Another 28 scans were used to capture the mandibular dentition, for a total scan count of 81. Discounting initial test and trial scans to record soft tissue, the total time for scanning was approximately 17 minutes. The digital scan file was then sent to Cadent iTero with a laboratory work authorization form for processing and cast manufacturing. After image processing by Cadent iTero, a milled polyurethane maxillary cast (Fig. 2) was made along with the opposing mandibular cast. These casts and the processed digital information were sent to a commercial dental laboratory, where a designing system (SensAble System; SensAble Technologies Inc) was used to design and fabricate the framework. Appropriate relief and blockout were created on the virtual design cast with the SensAble software. The framework was designed (Fig. 3) based on the laboratory work authorization form and the images of the digital design received for approval. Once the design was approved, a resin pattern of the virtually designed PRDP framework was created with RP (3D printing) and then cast in a cobalt-chromium alloy (Wironium Plus; Bego) with the conventional lost wax casting technique. The resin pattern was sprued and invested (WiroFast; Bego). The invested resin pattern was placed in a gas burnout furnace (Miditherm 200 MP; Bego) and heated initially to 650°C for 30 minutes; the temperature was then raised to 1010°C. The investment was placed in an induction casting machine (Fornax T; Bego), and the alloy was cast at 1440°C. The cast metal framework was adjusted, finished, and polished in a conventional manner. The framework, the polyurethane maxillary cast (Fig. 4), a resin duplicate of the framework (optional), and the mandibular cast were received for trial placement and articulation.

The framework was judged to exhibit excellent fit when evaluated in the mouth (Fig. 5), and a comparison of disclosing contacts found matching contact areas between the mouth and the polyurethane plastic cast. A duplicate resin pattern, which had been requested as an option, was trial placed in the patient’s mouth (Fig. 6). Although this was not a required step, a trial placement of the framework provides an option to confirm fit before casting the wax pattern. Although not deemed necessary for this patient, the potential to modify the resin pattern while evaluating the fit and occlusal contacts before casting is an additional advantage of the resin pattern trial placement option. The limitations in
terms of stability of the resin pattern and the feasibility of making additive as well as subtractive adjustments is a consideration that is not addressed in this report, because this framework did not require modification.

After the trial placement of the metal framework, interocclusal records were made, the maxillary and mandibular polyurethane casts were articulated, and denture teeth were arranged in a conventional manner. After wax trial placement with denture teeth, processing was completed on the milled polyurethane cast. Because of concerns about chemical bonding between the cast and the heat polymerizing resin, a layer of tin foil (Fig. 7) was placed to facilitate separation. After processing, adjusting, finishing, and polishing, the definitive PRDP (Fig. 8) was placed and adjusted for comfort and function. The definitive maxillary PRDP revealed good adaptation to the soft tissue, which was confirmed with pressure indicating paste (Pressure Indicator Paste; Henry Schein). Patient response to the digitally fabricated PRDP was favorable. The patient was given routine instructions on the placement, removal, and maintenance of the new PRDP. No adjustments were required during the postplacement evaluations.

**DISCUSSION**

No published reports are available regarding the successful and accurate capture of soft tissue morphology with an intraoral dental scanner. Williams et al.17-10,13 published multiple clinical reports regarding the fabrication of a PRDP with CAD/CAM technology. However, they scanned dental casts made from conventional impressions with a tabletop optical scanner. This preliminary report provides proof of concept regarding the use of an intraoral scanner routinely used in fixed prosthodontics and orthodontics to accurately capture both hard and soft tissue images. However, the intraoral technique of capturing soft tissue morphology, although accurate, has disadvantages that may limit its application. The technique uses many scans that must be stitched together to capture the morphology of the soft tissue relevant to the design and fabrication of the PRDP. Also, the intraoral scanner does not capture appropriate extensions of movable tissue that would normally be captured in a conventional manner by border molding the impression material. Even so, the concept of capturing a digital impression and then using the data for CAD/CAM framework design and for printing the framework pattern in resin for conventional casting proved to be an effective alternative to conventional framework fabrication. The technique worked well in this Kennedy Class III clinical situation, in which capturing border molded extensions of the soft tissue was not as critical. In a distal extension base situation such as a Kennedy Class I or II, the inability to digitally record the physiologic extensions of the moveable mucosa could negatively affect the outcome. This limitation could be overcome by sectioning the polyurethane cast and making an altered cast impression.14 The placement of implants to serve as terminal abutments in Kennedy Class I and II situations has been used effectively to reduce rotational movement of the distal extension PRDP and significantly improve patient satisfaction.15 This might also eliminate the need to capture the distal extension soft tissues with border molding. Furthermore, scannable impression copings such as Scan body (Straumann)16 or similar code-incorporated implant components could serve to improve accuracy with digital impressions and need to be studied.

The use of a digital workflow in PRDP fabrication has some significant and potential benefits. Because the
scanner can add scans as needed, there are no concerns about a flawed impression, which could be a factor in a conventional technique. The scanner stitches images together in real time, allowing the clinician to identify and immediately address any deficient areas with additional scanning. Digital scanning can capture the tissues in a passive state, thereby developing a mucostatic impression that could be advantageous in certain situations. Communication between the dental laboratory and dental office can be improved through the use of screenshots, and designs can be approved and modified before the framework is fabricated. Finally, because the fabrication process is automated, it is easy to provide inexpensive pattern resin frameworks for trial placement. The cost of fabricating the digital framework was comparable with that of a traditionally fabricated framework. However, this does not include overhead costs related to initial hardware and software investments for commercial laboratories, which can be substantial. Additionally, an open source intraoral scanner is required, which is an expensive investment for the clinician.

Capturing soft tissue impressions digitally has other advantages. Patients who have a tendency to gag during impression procedures, as well as those with special needs or anxiety, may tolerate the intraoral scanning procedure better than a conventional impression. Given that the digital impression can be stitched together, it is not important to capture all details in one scan, making it easier to maintain moisture control in one area as opposed to trying to maintain moisture control in an entire arch. Similarly, recording small areas at a time in patients with active and forceful tongue musculature may be more accurate compared with making a bilaterally accurate impression. Patients who have allergies to impression materials could also benefit from this technology.

The authors believe that, in the future, the 3D printing of PRDP frameworks in resin or other suitable materials could be used for trial placement to confirm fit and design. This would allow easy confirmation of the accuracy of the digital impression. It would also allow the printed framework to be modified chairside (to improve design if needed) and would allow the modified framework to be used as the prototype for casting.

Although this clinical report supports intraoral scanning as an option for the fabrication of a PRDP framework in this tooth-supported clinical situation, more clinical reports and studies are required before the scope of the technology can be understood and definitive conclusions can be drawn.

**SUMMARY**

The clinical information required for the digital fabrication of PRDPs can be recorded by capturing intraoral hard and soft tissue morphology with an intraoral dental scanner that stitches together many individual scans. In this example, the resulting resin framework was judged to fit the digitally fabricated polyurethane cast as well as the mouth accurately. The definitive prosthesis was successfully placed in the mouth and is being used by the patient.

**REFERENCES**


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