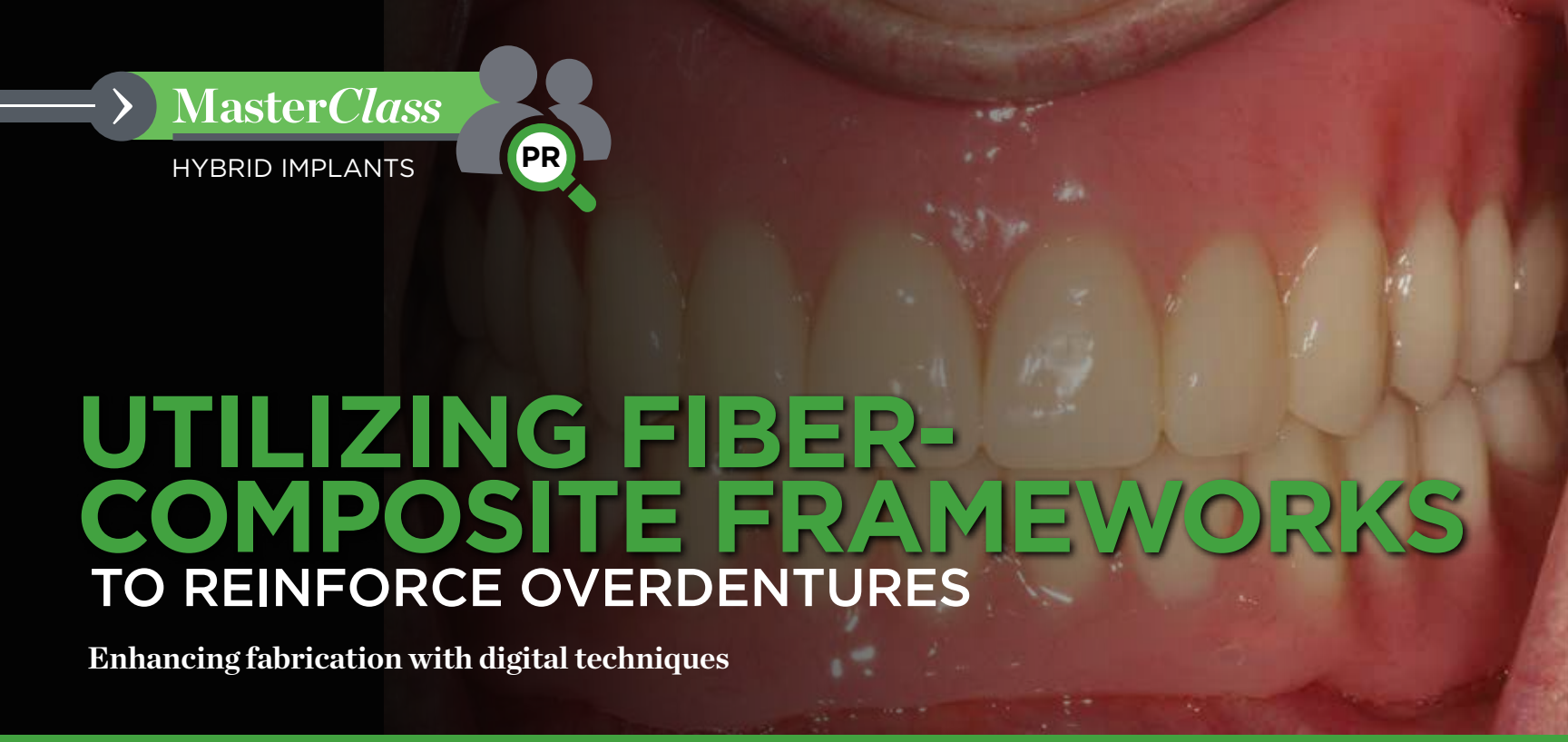

UTILIZING FIBER-COMPOSITE FRAMEWORKS TO REINFORCE OVERDENTURES

Enhancing fabrication with digital techniques

By Michael D. Scherer, DMD, MS

DESIGN AND FABRICATION OF implant overdenture restorations is a safe, predictable, and esthetic treatment modality. The design of implant overdenture prostheses is based upon decades of background and a thorough understanding of traditional complete denture construction.[1-3] The technical aspects of fabrication are based upon sound clinical guidance and factors related to patient satisfaction, long-term stability of the prosthesis, and simplicity.[4]

Patients interested in implant stabilization of mandibular complete prostheses have historically been treated with placement of two dental implants in the interforaminal region. Patients treated with implants in the interforaminal region have reported high degrees of satisfaction in long-term evaluation.[5] While the two-implant overdenture is often considered a very simple and straightforward procedure to complete, it can also be fraught with technical and clinical complications.[6] Evaluation of long-term studies shows that while incidence can vary, complications include: loss of retention, need for prosthesis adjustment, need for relining and rebase, clip or attachment fracture, overdenture fracture, screw loosening, and implant fracture.[7]

> Reinforcement of a denture base with the use of a metal framework has long been advocated to help mitigate and reduce the risk of fracture.

Prosthetic base fracture and acrylic resin fracture have been reported as a routine complication of implant overdentures.[8] Reinforcement of a denture base with the use of a metal framework has long been advocated to help mitigate and reduce the risk of fracture.[9] Historically, materials utilized for prosthetic reinforcement have included cobalt-chromium (CrCo), titanium, and individual fiber strands or sheets. While the use of a retention framework can contribute to prosthetic base strength, it can also potentially lead to increased forces and stress on the implant itself.[10-11] Metal-based materials tend to be much stiffer and more rigid than fiber and other types of polymer resins. Some authors have advocated the use of polymers over metal-based materials because the flexibility and modulus of elasticity is more like that of teeth and other intraoral structures.[12] Evidence has shown that use of polymethyl methacrylate (PMMA) and fiber-composite materials, in contrast to using metal-based frameworks, permits bonding of materials, increases the strength of the final prosthesis, and also minimizes the bulk. While the reinforcement of a prosthesis with a polymer may enhance the final prosthetic outcomes, use of polymer materials does increase the cost compared to metal-based frameworks. Since polymers cannot be cast, they do require a digital manufacturing method such as a CAD/CAM milling machine.

Digital techniques, such as intraoral scanning and CAD/CAM machining, are rapidly being embraced by clinicians and technicians alike. Edentulous intraoral scanning remains a challenge for many clinicians due to an initially more challenging learning curve associated with

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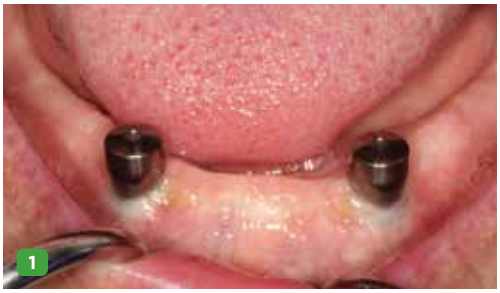
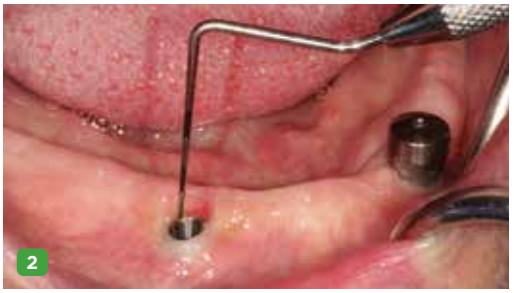
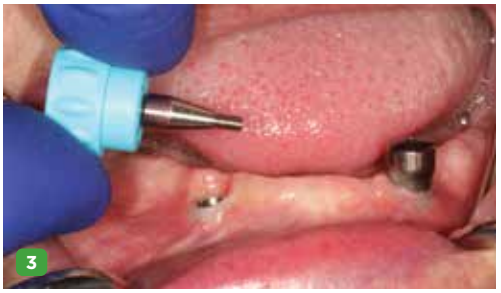
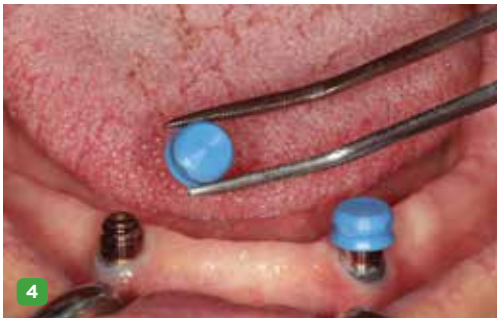








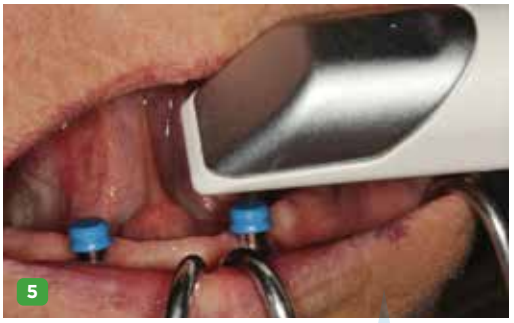


Fig. 1. Initial presentation of a patient with existing implants (Astra Tech Implant System EV, Dentsply Sirona). Fig. 2. Healing abutments were removed, and tissue depths recorded using a periodontal probe. Fig. 3. Definitive overdenture abutments (LOCATOR R-Tx, Zest Dental Solutions) were placed onto each implant and torqued according to the manufacturer's recommended torque values. Fig. 4. Scan housings (LOCATOR R-Tx Scan Body, Zest Dental Solutions) were placed onto each abutment. Fig. 5. An optical scan of the edentulous ridge and scan bodies was captured using an intraoral scanner (TRIOS 3, 3Shape). Fig. 6. A work order was created within a dental laboratory software (Dental System 2021, 3Shape) to fabricate a removable partial denture framework.

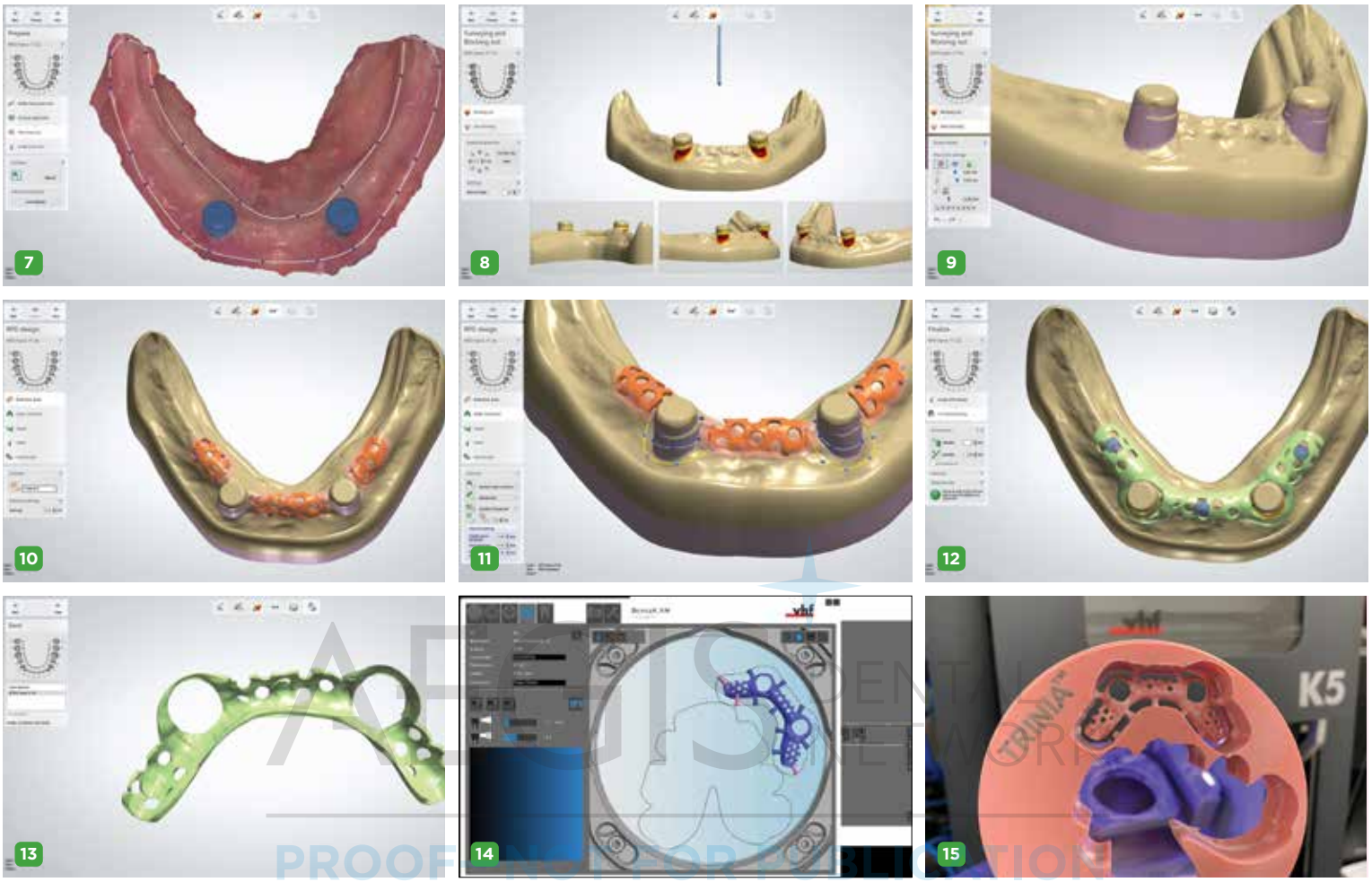


Fig. 7. The optical scan was imported and the borders refined using software algorithms. An outline was drawn to establish borders for the denture based upon clinically obtained physiological measurements. Fig. 8. The path of insertion of the framework was specified using a 3o blockout angle. Fig. 9. Virtual blockout was modified and added to the areas around the scan body. Fig. 10. Outline of the retention mesh was defined and set using a 2.5-mm wide hole parameter and 0.6-mm resin gap. Fig. 11. The major connector shape was drawn, and windows were provided to ensure encirclement of the framework around the abutments. Fig. 12. Tissue stops were added in three points, two on the molar and one in the incisor region to assist with acrylic resin processing. Fig. 13. Completed tissue appearance of the framework. The STL file of the framework and dental model were each exported from the design software. Fig. 14. The designed framework was imported into dental laboratory milling software (DentalCAM, vhf), and supports were placed on the facial and lingual aspects of the framework. Fig. 15. Framework milled using a fiber-reinforced composite resin (TRINIA®, Bicon Dental Implants) on a laboratory milling machine (K5, vhf).

scanning techniques, control of the soft tissues, and patient management. This article aims to review digital techniques related to intraoral scanning and fabrication of an implant overdenture prosthesis using stud-style abutments and a polymer-based framework to reinforce the prosthesis.

Case Report

A patient presented to the author's clinical practice with two implants and healing abutments placed between mental foramina on the mandibular arch (Figure 1). The patient indicated that she has been wearing complete dentures for approximately 20 years and had implants (Astra Tech Implant System EV, Dentsply Sirona) placed so she could enhance the retention and stability of her mandibular prosthesis.

The patient's existing prostheses were evaluated according to established evaluation criteria to ensure proper occlusal vertical dimension, centric occlusion, esthetics, phonetics, and stability as established by Sato et al.[13] Upon evaluation, it was determined that sufficient prosthetic space existed within the prosthesis; however, the patient wished for a new prosthesis to improve esthetics and strength. Her existing prosthesis had fractured several times and she wanted to minimize fracture in the future.

Initial Appointment: Abutment Placement and Optical Scan

The healing abutments were removed, and the peri-implant tissues were inspected to ensure health. Tissue measurements were made from the implant platform to the superior portion of the soft tissues using a periodontal probe (Figure 2). The tissue measurements aid in selecting the cuff height for the abutments; if the measurement is 3 mm, an abutment would then be ordered with a 3-mm cuff height, which places the retentive element of the abutment at the ideal position. The implants were irrigated using a sterile saline solution and abutments (LOCATOR R-Tx, Zest

Dental Solutions) were placed onto each implant using the corresponding height measurements (Figure 3). The abutments were torqued according to the manufacturer's recommended values.

The oral tissues were retracted with the aid of cheek retractors, and scan bodies for the overdenture abutments (LOCATOR R-Tx Scan Body, Zest Dental Solutions) were placed onto each implant (Figure 4). An optical scan of the edentulous ridge was captured using an intraoral scanner (TRIOS 3, 3Shape), ensuring capture of the complete dental arch, including scan bodies (Figure 5). The scan bodies were removed, and the patient was instructed to clean daily using a water-jet device and a toothbrush and paste to ensure long-term implant health.

Laboratory Phase: Framework Design

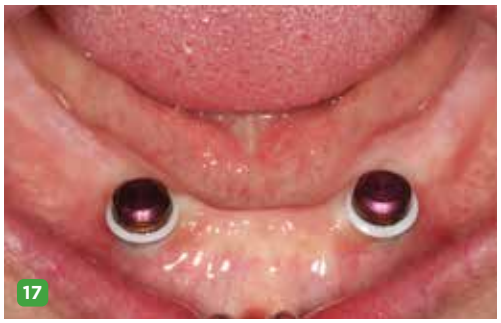
Using dental laboratory software (Dental System 2021, 3Shape), a virtual work order was created for the patient indicating a removable partial denture framework created using a digital impression scan (Figure 6). The optical scan files were imported into the software and minor refining functions were applied to smooth the edentulous borders. The optical scan was modified to adjust for over-capture of the borders and refined into the shape of a dental cast (Figure 7). The insertion direction of the prosthesis was set, and using an angle of 3o, virtual wax blockout was applied (Figure 8). Additional wax blockout was applied to the areas corresponding to the facial and lingual of the scan bodies on each implant abutment to ensure sufficient spacing around each for a passive fit (Figure 9).

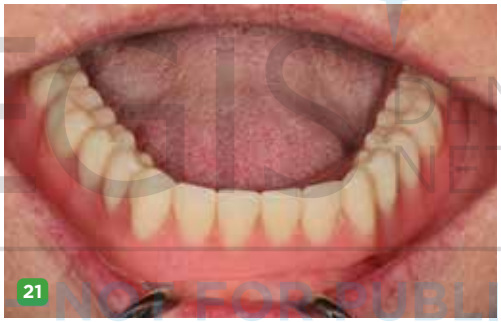
The retention mesh was outlined and designed using a standard 2.5-mm hole diameter and a 0.6-mm spacer between the model and framework in the area of the mesh (Figure 10). The retention mesh was applied to the areas in between the implants and approximately 10 mm distal to each abutment, keeping meshwork ideally within the keratinized tissue region and limiting the facial and lingual extent to within the future contours of the prosthesis.

The major connector shape was drawn in the software, connecting the areas of the retention mesh. A standard substructure thickness of 0.9 mm with a wax thickness of 0.3 mm was applied in the major connector settings. The outline was drawn around the facial and lingual aspects of the abutments to provide a strengthening mechanism, with windows placed around abutments to provide an encircling "loop-like" effect of the framework design (Figure 11). Emphasis was placed on ensuring the facial projection was not impinging upon the physiologic border of the proposed prosthesis. When using conventional CoCr frameworks, this facial projection can result in an unesthetic grey shadow within the prosthesis border and may be difficult to adjust. When using polymer-based frameworks, however, the technician can slightly over-extend in the design and then easily cut back after the milling process with an acrylic bur. Additionally, several fiber-composite polymers are manufactured in a pink shade that allows for use in tighter spaces where the framework will easily blend into the pink shade of the denture base resin.

Tissue stops were placed in a triangular position around the framework, in positions around the first molar and central incisors (Figure 12). The placement of 3-mm tissue stops results in three positive tissue contact areas to ensure the framework is seated on the cast during acrylic resin processing of the prosthesis. Furthermore, tissue stops assist the clinician in performing chairside adjustments and ensuring complete tissue adaptation of the prosthesis during delivery procedures.

The framework was completed and exported as an STL file from the design software (Figure 13). Additionally, the modified dental cast was exported





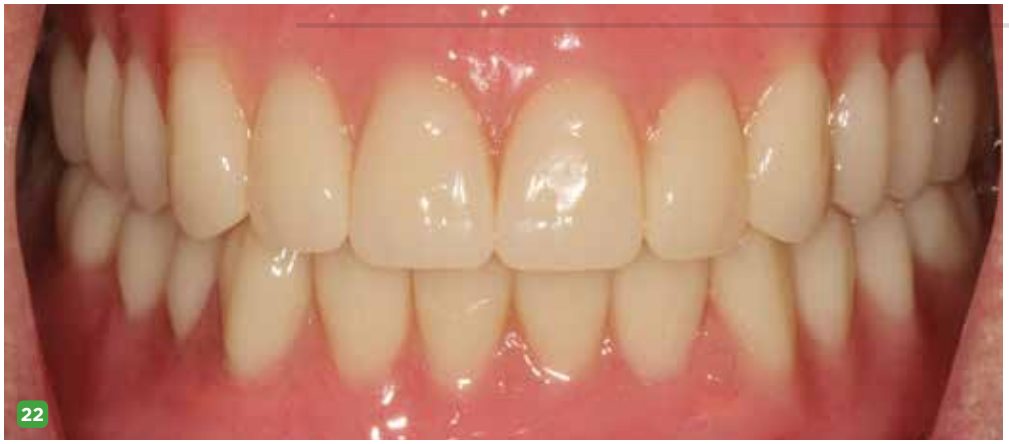


Fig. 16. The framework was air abraded and steam cleaned. Acrylic resin procedures were completed using conventional techniques on a duplicate of the 3D printed model. Fig. 17. Blockout spacers and housings (Denture Attachment Housings, Zest Dental Solutions) were applied to the top of the abutments. Fig. 18. The prosthesis was placed onto the edentulous ridge with the housings, and passive fit of the prosthesis was confirmed. Fig. 19. Composite resin (CHAIRSIDE Attachment Processing Material, Zest Dental Solutions) was placed onto each housing and into the intaglio of the prosthesis. The prosthesis was placed onto the edentulous ridge, ensuring light, passive forces. Fig. 20. After complete polymerization, the prosthesis was removed, and definitive inserts (Low Retention Limited Range LOCATOR R-Tx Inserts, Zest Dental Solutions) placed. Fig. 21. The prosthesis was inserted; complete adaptation and stability of the prosthesis were confirmed. Fig. 22. The patient was pleased with the final esthetic and functional result.

from the software and 3D printed using a commercially available 3D printer (NextDent 5100, 3D Systems) and a dental model resin (NextDent Model 2.0, 3D Systems).

The framework STL file was imported into laboratory milling software (DentalCAM, vhf) and placed within a virtual representation of a CAD/CAM disc. Supports in diameters of 1.7 to 2 mm were placed in strategic positions around the facial and lingual aspects of the framework (Figure 14). The disc was then loaded onto the milling machine (K5, vhf) to begin the milling procedure, which took approximately 1.5 to 2 hours. The framework was milled using a commercially available pink fiber-composite resin material (TRINIA®, Bicon Dental Implants) (Figure 15). Using an acrylic bur, the framework was carefully removed from the disc and lightly adjusted to remove any support pins. The framework was air abraded using 50-µm aluminum oxide (Aluminum Oxide White, Zest Dental Solutions) with a laboratory particle abrasion tool (MicroEtcher, Zest Dental Solutions) and steam cleaned. The final framework should have a smooth yet moderately rough, matte-like finish to aid in retention of PMMA acrylic denture base resin (Figure 16).

Clinical/Laboratory Phases: Wax Try-in and Processing

The patient returned for a second visit to record jaw relations. Baseplate wax was applied to the complete fiber-composite framework on the 3D printed dental model using standard 18-mm height measurements and 5-mm, 7-mm, and 10-mm widths in the areas corresponding to the anterior, premolar, and molar regions. The wax rim was adjusted intraorally using anatomical landmarks, phonetics, and centric occlusion measurements. An occlusal registration was made using a bite registration material (CHAIRSIDE Bite Registration Material, Zest Dental Solutions) and prosthetic teeth selection made using commercially available teeth (Mondial, Kulzer). The 3D printed model was placed onto an articulator and mounted against a 3D printed representation of the patient's maxillary arch using the records made previously. Prosthetic teeth were set according to anatomical landmarks and using the opposing dentition as a guide.

The patient returned for a prosthetic tooth try-in appointment and confirmed the esthetics, phonetics, comfort, and stability of the prosthesis. The 3D printed mandibular model was duplicated into dental stone (Microstone, Whip Mix) using

a hydrocolloid machine (Colloid Conditioner, Nobilium). The prosthetic tooth setup was placed onto the duplicated stone cast and flasked using conventional techniques. The wax was boiled out, framework placed onto the cast, and acrylic resin injected into the mold using a pressure injection technique and resin (Ivocap, Ivoclar Vivadent). After polymerization, the prosthesis was deflasked, adjusted, and polished.

Clinical Phase: Delivery

The patient returned for delivery of the definitive prosthesis. Blockout rings (Block-Out Spacers, Zest Dental Solutions) and denture housings (LOCATOR R-Tx Denture Attachment Housings, Zest Dental Solutions) were placed onto the abutments (Figure 17). The prosthesis was inspected and placed onto the edentulous ridge, and then centric/vertical dimensions and esthetics/phonetics were confirmed prior to definitive luting procedures (Figure 18). The prosthesis was confirmed to fit passively over the denture housings. When using scan bodies to assist in denture prosthetic procedures, they function both as a tool to improve optical scanning and as a spacer mechanism for within the processed prosthesis. Since the scan bodies are slightly larger than the housings, the prosthesis typically fits passively with few, if any, chairside adjustments.

The housings were air dried, and composite resin (CHAIRSIDE Attachment Processing Material, Zest Dental Solutions) placed onto each housing (Figure 19). The composite resin was also injected into the recesses on the intaglio of the prosthesis, filling up the recesses approximately half to two-thirds full. The prosthesis was seated and held in place using passive pressure; the patient was instructed to not bite down during the attachment processing procedures.

After complete polymerization, the prosthesis was removed and definitive retention inserts placed (LOCATOR R-Tx Low Retention Limited Range Insert, Zest Dental Solutions) (Figure 20). The prosthesis was placed onto the edentulous ridge and retention mechanism engaged to ensure complete adaptation of the prosthesis to the mandibular implants (Figure 21). The prosthesis was evaluated for stability using a two-finger technique by placing a finger on the molar region and another finger on the incisor region and rocking the prosthesis back and forth. The vertical dimension, centric occlusion, and esthetics were confirmed. The patient indicated that she was very comfortable biting and was very pleased with the final esthetic appearance of the restoration (Figure 22).

Closing Comments

While historically frameworks have been metal-based, this case shows that polymer frameworks can be utilized for implant overdenture cases to reinforce the prosthesis without sacrificing esthetics. Integrating the right combination of new technology and materials into the laboratory's workflow can greatly assist in providing the patient with a prosthesis that is durable, comfortable, and esthetic.

REFERENCES ONLINE
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