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DENTAL TECHNIQUE

A modified additive manufacturing injection molding technique for enhanced soft tissue management and cervical adaptation in anterior composite resin restorations

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ABSTRACT

This dental technique describes a modification of the additive manufacturing injection molding (AMIM) technique for restoring maxillary anterior teeth, specifically addressing challenges in soft tissue management, guide stability, and cervical adaptation. (J Prosthet Dent 2026;135:448-452)

Effective soft tissue management is paramount in dental procedures to ensure optimal visibility, access, and patient comfort. Retractors play a crucial role in retracting the lips and cheeks, facilitating various dental interventions such as restorative treatments, orthodontic procedures, and intraoral photography.[1] Traditional lip retractors, while functional, often present limitations in terms of patient comfort, adaptability to diverse oral anatomies, and prolonged use during extensive procedures.

Custom 3-dimensional (3D) printed tissue retraction devices for head and neck radiotherapy have been documented.[2] However, the authors are unaware of reports addressing custom soft tissue retraction as part of an injectable composite resin guide. In this technique, the additive manufacturing injection molding (AMIM) workflow was augmented by incorporating custom-designed lip retractors, and improved cervical fit into the 3D printed guide. This enhancement aimed to improve soft tissue management, occlusal stability, and minimize extrusion of material beyond the defined margins to maintain proper contour, thereby advancing the efficacy and patient comfort associated with the AMIM workflow.[3]

A 24-year-old woman with deterioration of her anterior composite resins and chromatic alteration on her maxillary lateral and central incisors received direct composite resin veneers on the 4 maxillary anterior teeth using a fully digital workflow. The definitive 3D printed flexible injection guide (IBT Flex Resin; Formlabs Inc) incorporated custom-designed lip retractor extensions, and features for enhanced cervical seal. These integrated components improved clinical handling, enhanced soft tissue displacement, provided occlusal stability, and reduced excess composite resin extruding beyond defined margins, leading to a predictable outcome.

TECHNIQUE

A patient sought esthetic enhancement of her smile, citing small maxillary lateral incisors, short crown length, and discoloration of existing composite resin restorations on the lateral incisors. Orthodontic treatment had been completed in 2013, but minor relapse

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Figure 1. Preoperative photograph.

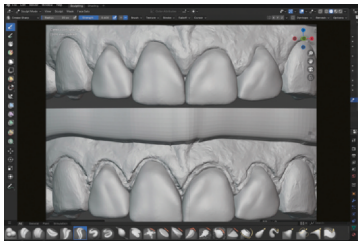

Figure 3. Creating circumferential groove around the cervical line of teeth in the Blender software program.

was present, creating an occlusal interference on her right lateral incisor. The risks of restoration fracture and occlusal imbalance without orthodontic correction were reviewed, but the patient declined additional orthodontic treatment. Her periodontal tissues were healthy (Fig. 1).

Following discussion of options, she elected direct composite resin veneers from the right to left maxillary lateral incisors using the AMIM. Although ideal smile design typically includes proportional restoration of the maxillary canines, she requested treatment limited to the central and lateral incisors. A restorative treatment plan, including maxillary canine restorations, was discussed using computer-aided design and computer-aided manufacturing (CAD-CAM); however, the patient declined treatment after being fully informed of the esthetic and functional implications. The final design reflected this patient-driven limitation.

1. Capture high-resolution extraoral photographs using a digital single-lens reflex (DSLR) camera (EOS 250D; Canon Inc).
2. Scan the maxillary and mandibular arches using an intraoral scanner (TRIOS 4; 3Shape A/S) to acquire high-resolution digital scans forming the basis for the subsequent digital design (Fig. 2).
3. Import photographs and scans into a dental design software program (Dental System 2021; 3Shape A/S) to digitally design optimal morphology for the maxillary right lateral incisor, right central incisor, left central incisor, and left lateral incisor, correcting contour and enhancing esthetics. As discoloration was not significant, the design focused on achieving morphology for a single-shade restoration. Then create 2 virtual casts. For cast 1 (Fig. 2B), include the definitive planned shape for the maxillary right central and left lateral incisors. For cast 2 (Fig. 2C), add the planned morphology of the maxillary right lateral and left central incisors.
4. For cervical groove modification, import standard tessellation language (STL) files from the intraoral scanner into a 3D sculpting program (Blender Version 4.4.3; Blender Foundation). Using the crease sculpting tool, create a circumferential groove around the cemento-enamel junction (CEJ) to improve the cervical seal and minimize excess composite resin extrusion (Fig. 3).
5. For the injection guide, design two 3D printable injection molding guides using a dental splint design software program (Dental System 2021; 3Shape A/S).
6. For guide 1, design from virtual cast 1 to guide the initial composite resin placement on 2 non-adjacent teeth, the maxillary right central incisor and maxillary left lateral incisor.
7. For guide 2, design from virtual cast 2. Design both guides to cover 1 mm of gingival tissue with a uniform 1.5 mm thickness. Preserve natural undercuts on unprepared teeth for optimal fit.
8. To add soft tissue retraction extensions, use the STL files of cheek retractors as reference[4,5] and add attachments to injection molding guide 2 using a CAD software program (Fusion 360, Version 2.0.20981; Autodesk Inc). Using the "Solid" toolbar, add Ø4×13 mm cylinders twice to the mucobuccal fold of the maxillary right lateral incisor and maxillary left central incisor to provide lip retraction. Add the cheek retractor STL file to the design to

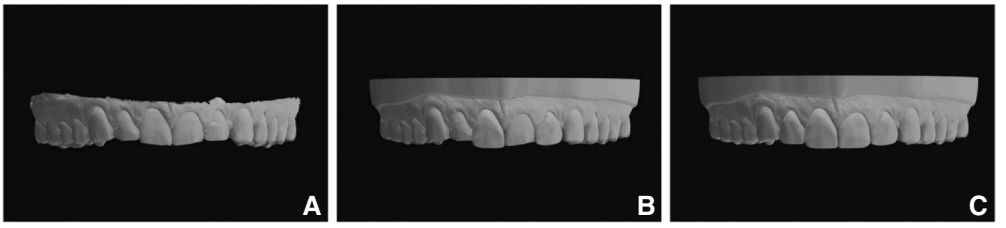

Figure 2. Virtual casts. A, Scanned teeth. B, Cast 1. C, Cast 2.

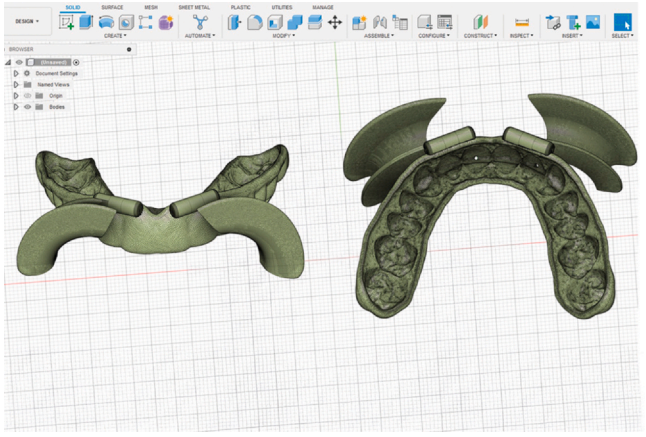

Figure 4. Adding soft tissue retraction extensions in Autodesk Fusion software program.

extend from the lateral aspect of each cylinder component. Add an angled 6×15-mm ramp to bilateral occlusal surfaces, spanning from the second premolar to the first molar to act as occlusal ramps (Fig. 4). Tessellate to generate the STL file for manufacturing.

9. To add injection channels, use the CAM software program (Photon Workshop, Version 2.1.29; Anycubic Technology Co Ltd) and add Ø1-mm injection channels to the incisal aspects of all teeth to be restored in both guides. Export final STL files and 3D print using a stereolithography 3D printer (Form 3B+; Formlabs Inc) with flexible translucent resin (IBT Flex Resin; Formlabs Inc) (Fig. 5). This flexible, translucent resin was chosen for its biocompatibility, optimal translucency for light polymerizing through the material, and flexibility, which is particularly advantageous in this no-preparation treatment for distortion-free seating and removal of the guide over existing tooth contours with undercuts.[6]
10. For the clinical preparation, use local anesthetic as needed; however, none was necessary for this patient. To improve micromechanical retention, use a fine flame-shaped diamond rotary instrument (8888.31 FG Fine Flame Diamond; Brasseler USA) to roughen the surface of existing composite resin. Clean teeth thoroughly with a fluoride-free pumice-based prophylaxis paste (Pumice Preppies; Whip Mix Corp).
11. To prepare the enamel surfaces for bonding, isolate using appropriate lip and cheek retractors (OptraGate; Ivoclar AG) and cotton rolls to maintain a dry field. No additional tooth preparation was required.
12. For injection guide 1 (maxillary right central incisor and maxillary left lateral incisor), isolate adjacent teeth with sterilized polytetrafluoroethylene (PTFE) tape (Fig. 6A), and etch facial and incisal enamel surfaces of the maxillary right central incisor and maxillary left lateral incisor with 37% phosphoric acid (Total Etch; Ivoclar AG) for 15 seconds, rinse, and gently air-dry. Medical grade PTFE tape is known to have high melting point and high melt viscosity, which permits autoclave sterilization without degradation.[7]
13. Apply universal adhesive (Scotchbond Universal Adhesive; Solventum Inc) to etched enamel per manufacturer's instructions. Air thin and light-polymerize for 20 seconds using a light-emitting diode (LED) polymerization light (Coltolux LED; Coltène Holding AG).
14. Immediately seat injection guide 1 accurately (Fig. 6B) and inject a low viscosity injectable composite resin (G-ænial Universal Injectable; GC America Inc) through the channels into the space defined for the maxillary right central incisor and maxillary left lateral incisor in the guide (Fig. 6C). Shade AO1 was selected for uniform color and opacity.
15. Tack-polymerize the composite resin by shining the polymerization light through the guide for 3 seconds per tooth (Fig. 6D), then carefully remove the guide (Fig. 6E).
16. Remove excess composite resin with a number 12 disposable scalpel blade (Henry Schein Inc) then light-polymerize each surface directly for 20 seconds per surface to finalize polymerization.
17. Perform initial finishing to establish shape and contours using composite resin finishing diamond rotary instruments (Peter Brasseler Series Finishing Diamonds; Brasseler USA).

Figure 5. Injection guide 2. A, Front view. B, Occlusal view. C, Intaglio view.

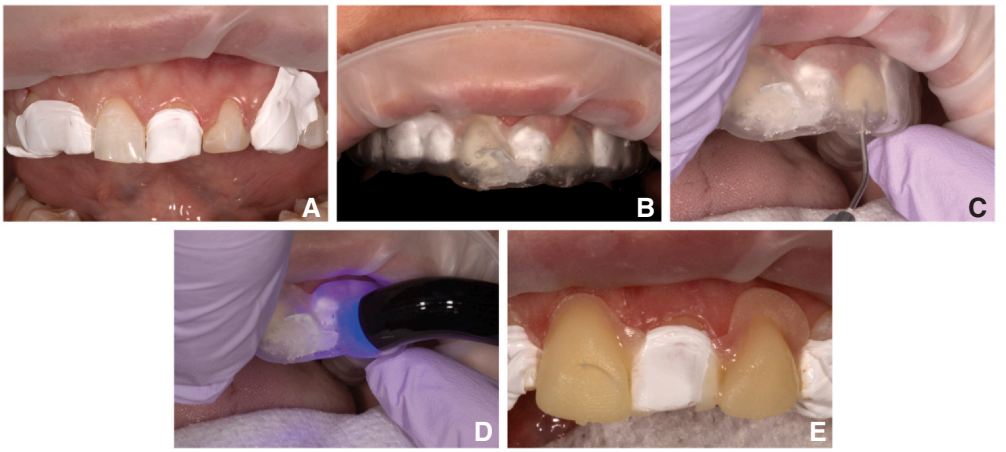

Figure 6. Applying injection guide 1. A, Isolated adjacent teeth with sterilized polytetrafluoroethylene (PTFE) tape. B, Injection guide placed. C, Injecting composite resin around maxillary left lateral incisor. D, Tack-polymerizing through injection guide. E, Immediately following tack-polymerizing.

Figure 7. Injection guide 2. A, Positioned on teeth. B, Injecting composite resin around maxillary right lateral incisor. C, Injecting composite resin around maxillary left central incisor.

18. For injection guide 2 (Fig. 7A), follow the same steps as for guide 1 before injecting composite resin to restore the right lateral incisor (Fig. 7B) and the left central incisor (Fig. 7C).
19. To finalize anatomical form and marginal adaptation, use fine flame-shaped diamond rotary instruments (Peter Brasseler Series Finishing Diamonds; Brasseler USA).
20. Polish restorations to a high-gloss surface using a polishing system (Sof-Lex Diamond Polishing System; Solventum Inc). The immediate postoperative results are shown from the anterior view and lateral view (Fig. 8).
21. Adjust occlusion in centric and excursive movements to ensure functional harmony. If the maxillary canines are not restored, assess for interferences from the opposing mandibular dentition. If present, selectively recontour the incisal edge of incisors to eliminate contact. Prioritize occlusal stability and restoration longevity while ensuring the result meets the patient's esthetic expectations (Fig. 9).
22. As part of postoperative care, a maxillary occlusal guard based on the final design of the new restoration was provided to promote restoration longevity.[8]

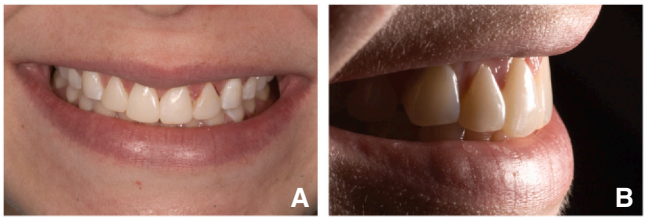

Figure 8. Immediate postoperative results. A, Anterior view. B, lateral view.

Figure 9. Postoperative view.

DISCUSSION

The AMIM technique was designed to save chairside time and provide predictable outcomes. The design and fabrication of the modified AMIM injection guide

presented challenges related to material properties and the current landscape of dental CAD software programs.

The flexible 3D printing resin (IBT Flex Resin; Formlabs Inc) was primarily chosen for its biocompatibility, translucency, and flexibility, which facilitated placement and removal without distorting the appliance or requiring significant tooth preparation to mitigate undercuts. However, its inherent flexibility is a limitation when used for components requiring stiffness, including the lip and cheek retractors.

This 3D printing resin has a tensile modulus of 8 MPa and a Shore A Hardness of 77 to 80 A,[6] confirming it is a very flexible material. Although conventional dental lip retractor design and measurements were used as a basis, the retraction achieved was less than optimal, requiring supplemental use of a lip and cheek retractor (OptraGate; Ivoclar AG) and cotton rolls for moisture control.

Future designs using flexible resins, such as IBT Flex, should optimize the geometry—such as by increasing thickness or incorporating reinforcing features—to achieve effective soft tissue retraction. This treatment illustrates the potential of a fully digital, additive manufacturing workflow for creating custom injection guides. The process required the integration of multiple software program—(Dental System 2021; 3Shape A/S, Blender; Blender Foundation, Fusion 360; Autodesk Inc, and Photon Workshop; Anycubic Technology Co Ltd)—to combine esthetic smiles design, precise cervical groove, and custom retractor extensions, functions which are not currently available in a single dental CAD software program. While the workflow was fragmented, it established a proof-of-concept for advanced digital appliance design and showcased how digital instruments can elevate traditional design boundaries to support highly customized restorative care.

SUMMARY

The AMIM technique presented aimed to enhance efficiency by integrating a custom-designed lip retractor directly into the 3D printed injection guide. A modification to the cervical aspect of the guide improved adaptation and minimized excess composite resin material extruding beyond the margins. These enhancements provided superior soft tissue management and maintain occlusal stability, streamlining the restorative procedure. Clinical research is recommended to establish definitive design protocols that optimize the materials used.

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