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Digital workflow for an esthetic rehabilitation using a facial and intraoral scanner and an additive manufactured silicone index: A dental technique

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ABSTRACT

The present article describes a digital workflow for planning an esthetic treatment using a facial and intraoral scanner, the dental and open source software design of a facially generated diagnostic waxing, and additive manufactured (AM) clear silicone indices. A virtual design was created to fabricate a unique 3-piece AM index composed of flexible, clear silicone at the labial and lingual aspects and a rigid clear custom tray. The 3 AM clear indices provided advantages compared with conventional procedures, including accurate reproduction of the digital diagnostic waxing, control of index thickness, various insertion paths of the silicone indices, flexibility of the indices, and online storage of the designs.

INTRODUCTION

An appropriate treatment plan from a diagnostic waxing is integral to successful esthetic treatment.[1-6] With the development and incorporation of intraoral scanners (IOSs), computer-aided design (CAD) software, and additive manufacturing (AM) technologies, a complete digital workflow for diagnostic treatment planning is available.[7,8] Furthermore, facial scanners in treatment planning allow for 3-dimensional (3D) visualization of the patient´s face.[9-11]

The relationship between the technology used by the IOS system and the accuracy of its acquisition procedure has been analyzed,[12-24] have factors that could impact IOS accuracy,[28] including the learning curve,[25,26] calibration,[27] scanning protocol,[28-30] surface characteristics,[31-34] mobile tissue,[35] reflective restorations, and the presence of saliva.[25,36,37]

Polymer AM technologies fabricate objects through a layer-by-layer building process.[38-41] Direct light processing (DLP) AM is similar to stereolithography (SLA).[40] In DLP, a vat of liquid

photopolymer is exposed to light from a projector under safelight conditions. The DLP projector displays the image of the 3D model on the liquid photopolymer.[41,42]

The primary function of AM silicone indices is translating the digital waxing to the patient´s mouth through a diagnostic trial restoration.[7,8] This article advances the AM silicone index design to facilitate its use for the fabrication of the diagnostic trial restoration in most clinical situations. Flexible silicone indices were designed as 2 pieces, labial and lingual, which were adapted into a clear rigid custom tray. A digital workflow using a facial and intraoral scanner and CAD and AM technology is described. The workflow facilitated the esthetic treatment of maxillary anterior teeth.

TECHNIQUE

A 22-year-old woman was referred by an orthodontist for closure of mesiodistal spaces between maxillary anterior teeth. Extraoral, intraoral, and radiographic evaluations revealed acceptable oral health. To analyze the esthetic restorative outcome, a virtual diagnostic waxing was completed using the following protocol:

1. During the first clinical appointment, digitize the patient´s face using a facial scanner (Bellus3D Face Camera Pro; Bellus3D™). Three facial scans are needed: reference, rest, and smile. First, place the forehead marker (ScanBodyFace; AFT Dental System) on the patient's forehead. For the reference scan, position the intraoral marker (ScanBodyMouth; AFT Dental System) in the patient´s mouth and stabilize using a polyvinyl siloxane impression material (Virtual putty and low viscosity regular setting; Ivoclar Vivadent AG). Make a facial scan with both markers in place following the manufacturer´s instructions (Fig. 1). For the rest scan,

remove the intraoral marker of the patient´s mouth and make a new facial scan of the patient at the rest position. For the smile scan, complete the third facial scan of the patient smiling.

2. At the same clinical appointment, make a digital scan of the patient´s dentition with an IOS (iTero Element; Cadent LDT) following the manufacturer´s recommendations. When the digital scan is completed, the IOS device creates a standard tessellation language (STL) file (STL_1).

3. Import the STL_1 file into dental CAD software (Exocad DentalCAD; Exocad GmbH). Superimpose the facial and intraoral scans (Fig.2). Complete a virtual diagnostic waxing of the teeth to be treated (Fig. 3) and export the file (STL_2).

For the present patient, the objective of the virtual additive diagnostic waxing was to close the mesiodistal spaces between the maxillary right canine and maxillary right lateral incisor and between the maxillary left canine and maxillary left lateral incisor in the most conservative manner. To create symmetrical maxillary lateral incisors with identical mesiodistal widths, the excess space between the right lateral incisor and the right canine was decreased by increasing the width of the canine. Even though esthetic limitations were encountered, the patient declined the option of additional orthodontic treatment and also declined a less conservative restorative approach.

4. Import the STL_2 file into open source CAD software (Blender, version 2.77a; Blender Foundation) with the plugin Open Dental CAD enabled. Design the silicone indices as follows:

A. Using the “Splints” tool on the menu, mark the splint outline on the lingual side of the teeth to obtain the lingual index. Determine a uniform index thickness of 2.5 mm (Fig. 4A). Select “Create” on the menu and the tool named “Cone” and create 3 indexations on the lingual index for location of the labial index (Fig. 4B).

B. Repeat step A for the fabrication of a 2.5-mm-thick labial index. Design the labial index covering the labial, incisal and inciso-lingual surfaces of the involved teeth such that the labial index will interlock with the lingual index (Fig. 4C).

C. Duplicate the initial maxillary cast and the 2-piece index created in the previous steps with a uniform thickness of 4 mm. Use the "difference" Boolean operation of the software to subtract the 4-mm duplicated index from the 2 indices obtained in steps A to B. This step results in the fabrication of a 2.5-mm-thick custom tray which covers the labial and lingual indices (Fig. 4D).

When the virtual design of the 3 indices is completed, 3 files are created: the labial (STL_B) and the lingual flexible silicone index (STL_L) designs and the rigid custom tray (STL_T).

5. Import the STL_B and STL_L files to a DLP 3D printer (RapidShape D30 II; RapidShape) to manufacture the flexible clear silicone indices with a 25-μm layer thickness of flexible photopolymer (Nexdent Ortho IBT; Nexdent), (Fig. 5A,B).Use the STL_T file with the same DLP 3D printer to manufacture the clear rigid custom tray with a 25-μm layer thickness of rigid photopolymer (Nexdent Ortho Clear; Nexdent) (Fig. 5C).

6. During the second clinical appointment, evaluate the 3D-printed indices and custom tray in the patient´s mouth (Fig. 6). For fabrication of the diagnostic trial restoration, use an autopolymerizing bis-acryl interim resin (Protemp Plus temporization material, A1 shade;3M ESPE). After polymerization, remove the custom tray and then the labial and lingual indices (Fig. 7).

After obtaining the patient's consent and understanding the limitations of the esthetic outcome, the maxillary anterior teeth were restored with direct composite resin restorations following the tooth shape and position indicated by the diagnostic trial restoration. The lingual AM silicone index was used to guide the placement of the direct restoration (Fig. 8).

DISCUSSION

The protocol presented involved a complete digital workflow, but since minimally invasive treatment was required, direct composite resin restorations were placed. However, if a ceramic veneer or crown was indicated, the procedure could have been completed digitally with a digital scan of the tooth preparation and a virtual waxing as reference for the restoration design.

The integration of different digital technologies has promoted the development of the concept of a 3D virtual patient.[9-11] However, the use of extraoral and intraoral scan bodies to superimpose facial scans with intraoral scans may improve alignment efficiency.

Dental CAD software is designed for the dental field and is generally more intuitive to dental professionals than open source software. Advantages of open source software include reduced cost, availability to any profession, and limitless application for virtual design.

Incorporation of the latest dental technologies into clinical practice is a crucial step for integrating the digital workflow in private practice and dental laboratories, but the effective use of these new technologies requires a significant learning curve.[25,26]

The improved design of the AM flexible silicone indices into 2 parts, labial and lingual, changes the path of insertion from vertical to horizontal. The virtual design of these indices allows for the easy positioning of both pieces together, and the customized rigid tray reduces possible deformation of the flexible silicone indices during handling. Furthermore, the lingual index was used to build up the direct composite resin restoration, allowing duplication of the size and shape of the digitally planned restoration. The clear material also allows for polymerization of composite resin material through the index.

As an alternative to the described technique, the STL file of the digital waxing can be used to manufacture the AM diagnostic casts from which a conventional silicone index can be made. However, this alternative may accumulate more distortion as a major number of steps are needed and there would be less control on the thicknesses and limits of the silicone indices compared with the present technique.

SUMMARY

The present article describes a complete digital workflow using a facial scanner, intraoral scanner, computer aided design (CAD) software, and additive manufacturing (AM) technologies to facilitate the esthetic treatment of maxillary anterior teeth. A virtual diagnostic waxing was designed with dental CAD software, which was used to fabricate AM labial and lingual silicone indices adapted into a custom tray using open source CAD software. This application of AM technologies allows for a more efficient procedure, requiring less time and cost compared with conventional procedures while maintaining reproducible results.

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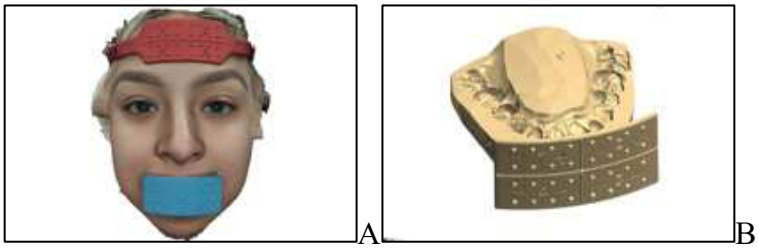
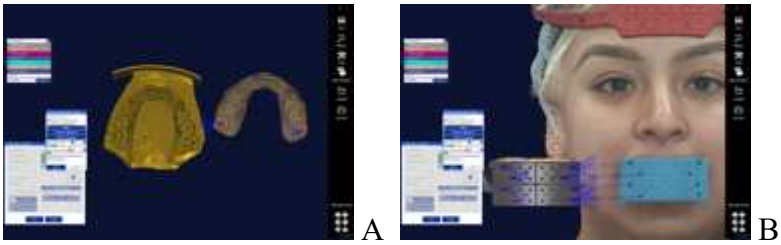
FIGURES

Figure 1. A, Facial reference scan of patient with forehead and intraoral marker positioned. B, Intraoral marker digitized with laboratory scanner.



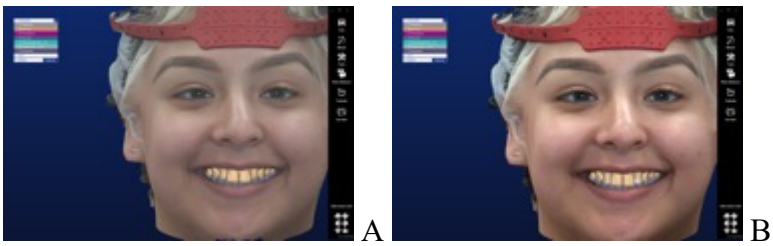
A B

Figure 2. Computer-aided design procedures completed to superimpose facial and intraoral scans. A, Superimposition of intraoral scan and intraoral marker. B, Superimpositions of facial scan and intraoral marker.



A B

Figure 3. A, Initial view of superimposed outcome. B, Diagnostic waxing of desired teeth on frontal view of smile facial scan.



A B

Figure 4. Digital design of silicone indices. A, Splint outline marked on lingual side of teeth to obtain lingual index. B, Three indexations created on lingual index to locate labial index. C, Labial index design involved coverage of labial, incisal, and inciso-lingual surfaces of involved teeth such that labial index would interlock with lingual index. D, Custom tray designed over labial and lingual indices.

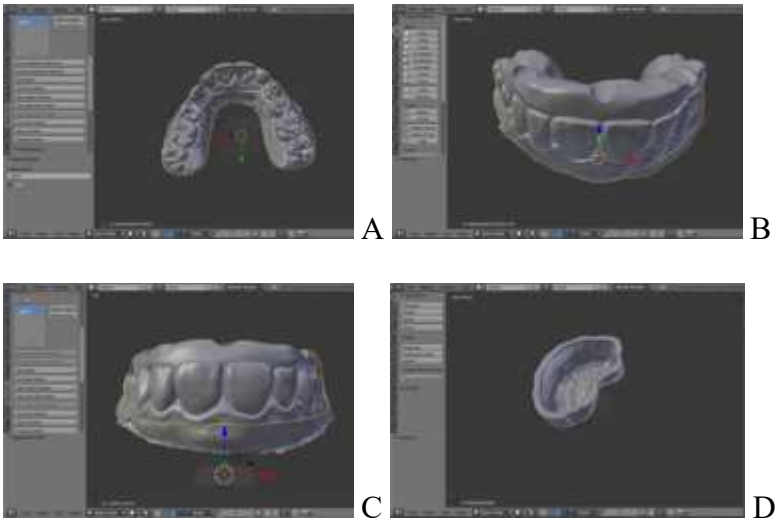


Figure 5. Additive manufactured silicone indices. A, Lingual flexible and clear silicone index. B, Labial flexible and clear silicone index. C, Rigid and clear custom tray.

Figure 6. Additive manufactured silicone indices intraorally. A, Lingual silicone index. B, Lingual and labial flexible clear AM indices with custom tray. C, Rigid AM custom tray positioned.

Figure 7. Trial restorations made with AM silicone indices. A, Lower third view of patient´s smile before treatment. B, Lower third view at smile position of trial restorations.

Figure 8. Direct composite restorations using lingual AM silicone index. A, Smile view, B, Periapical radiographs.