

DENTAL TECHNIQUE

Three-dimensional virtual representation by superimposing facial and intraoral digital scans with an additively manufactured intraoral scan body

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A facially driven diagnostic waxing is an integral part of successful esthetic prostheses.¹⁻⁴ The integration of digital technologies including facial digitizers, intraoral scanners (IOSs), and computer-aided design (CAD) software programs facilitate the patient's 3-dimensional (3D) virtual representation.⁵ Different techniques have been described to superimpose data from a patient's digital files.⁶⁻¹¹ A cone beam computed tomography (CBCT) scan eases the integration of facial and intraoral digital scans; however, when rehabilitating a patient without implant placement, a CBCT scan might not be indicated.^{6,12} A superimposition technique between facial and intraoral digital scans guided by an extraoral and intraoral scan bodies has been described.¹¹ However in that technique, 2 different scan bodies were needed, and the intraoral scan body was digitized extraorally by using a laboratory scanner.

The present article describes a technique to superimpose facial and intraoral scans guided by an innovative additively manufactured intraoral scan body¹³ by using a CAD software program. Furthermore, this technique includes the digitalization of the intraoral scan body positioned in the patient's mouth and eliminates the need for a laboratory scanner.

ABSTRACT

A technique to merge facial and intraoral digital scans guided by an additively manufactured intraoral scan body is described. The technique facilitates facially driven treatment planning of restorative procedures in situations where a cone beam computed tomography scan is not indicated. Furthermore, the intraoral scan body can be customized to the size of the patient's arch to improve patient comfort and simplify the digitalization procedures. (J Prosthet Dent 2020;■:■-■)

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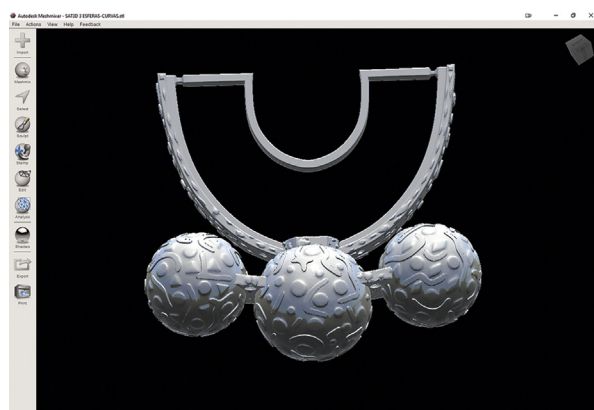
A patient's 3D virtual representation was completed by superimposing the facial and intraoral digital scans using a unique intraoral scan body (Fig. 1A). The digitalization and superimposition procedures were performed using the following protocol:

1. Import the virtual design of the intraoral scan body¹⁴ to the printer software (Anycubic i3; Anycubic). Position the device in the 3D build platform with 45-degree print orientation. Generate the corresponding attachment layer and the support structures necessary to ensure a successful printing process. Slice the standard tessellation language (STL) file of the device with a layer thickness of 100 μ m.
2. Select a vat-polymerization 3D printer (Photon 1; Anycubic) to additively manufacture the polymeric (Optiprint Mockup B1; Dentona) intraoral scan body. Calibrate the printer following the manufacturer's recommendations. Shake the resin bottle

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A



B

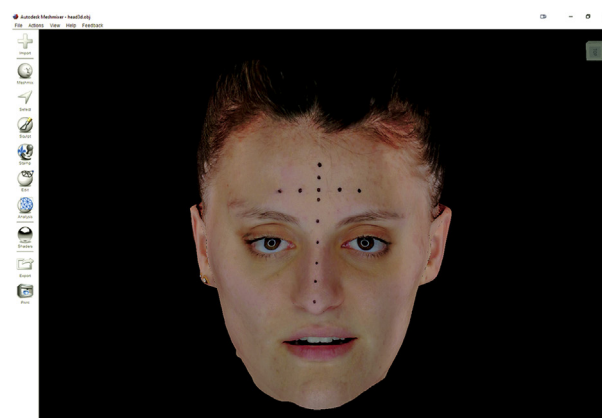


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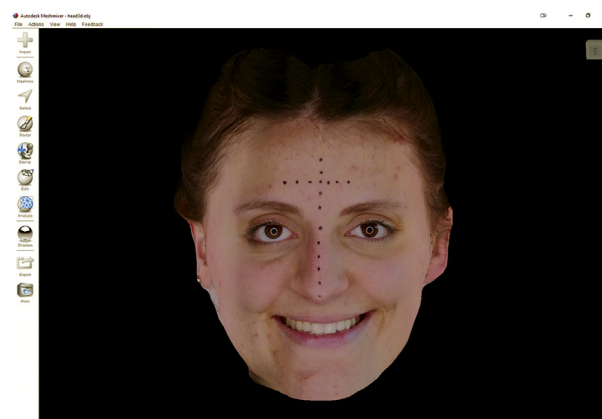
Figure 1. Additively manufactured intraoral scan body. A, Virtual design. B, Before removing supportive materials. C, After completing postprocessing procedures and placing black markings.

before using it for 5 minutes. Select the appropriate printing parameters for the selected resin material.

3. After printing the device, remove the scan body from the build platform and follow the post-processing procedures recommended by the manufacturer. Submerge the device in a container with 97% isopropyl alcohol for 3 minutes, followed by a second bath with clean isopropyl alcohol solvent for another 3 minutes. After, rinse the device with water and let it dry for 2 minutes. Place it inside



A

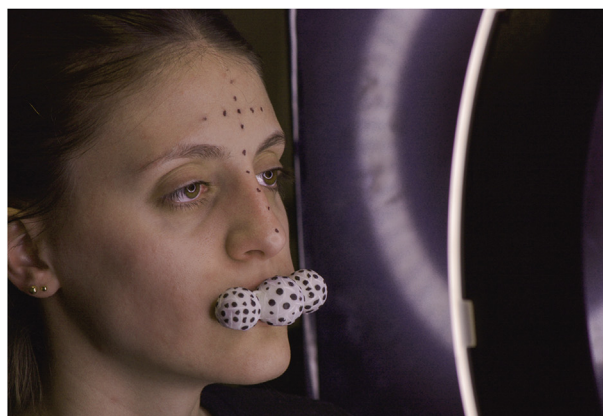


B

Figure 2. A, Rest facial scan. B, Smile facial scan.

a ultraviolet-polymerization machine (Otoflash G171; NK-Optik) for 10 minutes (Fig. 1B). Remove the supporting structures using a cutting device (Fig. 1C).

4. To facilitate posterior superimposition procedures, mark between 10 and 14 extraoral landmarks on the forehead and nose of the patient by using a black marker.
5. For facial digitizing procedures, seat the patient on an adjustable rotating chair, keeping 30 to 45 cm of distance to the facial scanner. Use a continuous ring light to obtain a uniform face illumination. First, ask the patient to sit upright adopting a natural head position and maintain a rest position. Capture the facial rest scan using a facial scanner (Bellus Face Pro; Bellus) connected to a tablet (Huawei MediaPad M3; Huawei) and controlled by a specific software (Face Camera App; Bellus3D). Second, instruct the patient to maintain a smile position and obtain a facial smile scan (Fig. 2). A geometry definition (OBJ) file per scan is exported.
6. Position the intraoral scan body¹³ in the patient's mouth using a self-polymerizing acrylic resin (Fas-tray LC Blue; Bosworth). Afterward, without removing the intraoral scan body from the patient's mouth, capture the facial reference scan (Fig. 3).



A



B

Figure 3. A, Additively manufactured intraoral scan body positioned. B, Facial reference scan

7. Without removing the intraoral scan body of the patient's mouth, ask the patient to lay down on the dental chair. Obtain a maxillary reference scan by using an IOS (TRIOS 4; 3Shape A/S) following the scanning protocol recommended by the manufacturer and under 1000-lux illumination.^{15,16} The maxillary reference scan should include the buccal surfaces of the intraoral soft tissues and dentition as well as the intaglio and buccal areas of the intraoral scan body (Fig. 4). Subsequently, recover the intraoral scan body from the patient's mouth. Then, complete the maxillary reference scan by scanning the entire buccal areas of the intraoral scan body by using the same IOS.
8. Record maxillary, mandibular, and interocclusal digital scans by using the same IOS following the manufacturer's recommended scanning protocol under the same ambient illumination conditions. Export the STL files.
9. Import the OBJs and STL files to a dental CAD software program (Plovidiv; Exocad). Superimpose the patient's digital information:
 - a. Merge the maxillary reference scan and the maxillary digital scans using the iterative closest

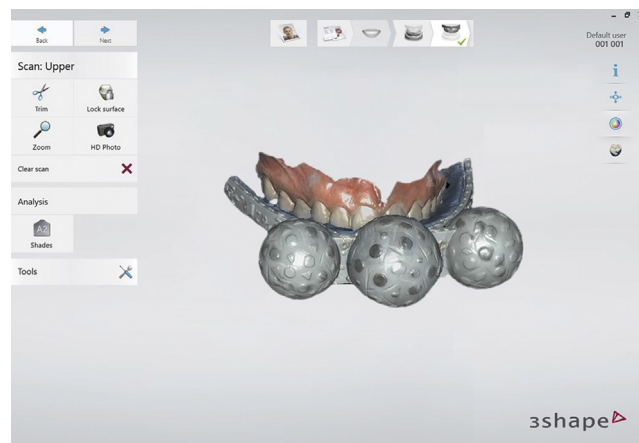
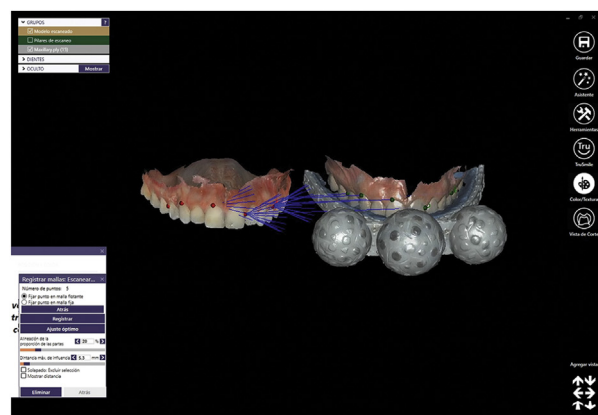
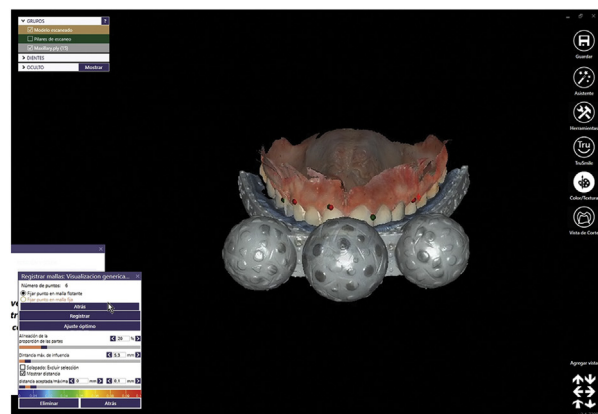


Figure 4. Maxillary reference intraoral digital scan.



A



B

Figure 5. Superimposition procedures between maxillary reference scan with maxillary intraoral digital scan. A, Iterative closest point technique using buccal surfaces of soft tissues and teeth used as common information. B, Completed merging procedures.

- point technique. Use the buccal surfaces of soft tissues and teeth as common information (Fig. 5).
- b. Superimpose the maxillary reference scan and the facial reference scan by using the iterative closest point technique. Use the intraoral scan

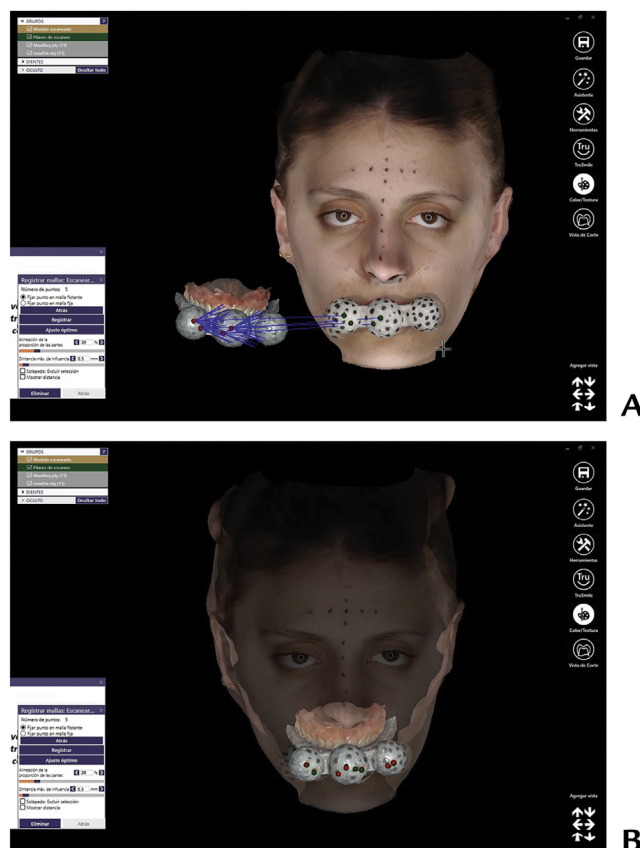


Figure 6. Merging procedures between maxillary reference scan and facial reference scan. A, Iterative closest point technique using intraoral scan body as common element in both meshes. B, Completed superimposition procedures.

body as a common element in both meshes (Fig. 6).

- c. Merge the reference facial scan and the facial smile scan using the iterative closest point technique. Use the black landmarks of the forehead and nose as common points in both files. Subsequently, superimpose the facial rest smile with the reference facial scan by using the same reference points (Fig. 7).
- d. When the superimposition procedures are completed, the patient's 3D virtual representation is obtained (Fig. 8).

DISCUSSION

The described technique allowed the patient's 3D virtual representation by merging the facial and intraoral digital scans guided by a unique intraoral scan body. The intraoral scan body was additively manufactured from a biocompatible dental resin. Merging procedures of facial and intraoral digital scans guided by extraoral and intraoral scan bodies have been previously described.¹¹

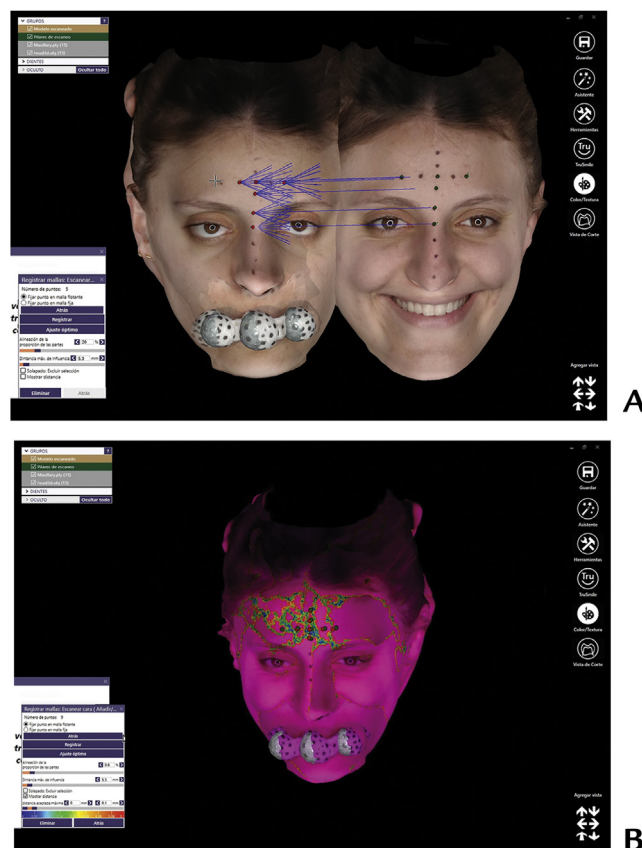


Figure 7. Merging procedures between facial reference scan and facial smile scan. A, Iterative closest point technique using black landmarks of forehead and nose as common points in both files. B, Completed superimposition procedures.

This technique included an intraoral scan body with a single dimension that was digitized with a laboratory scanner.¹¹ In the present technique, only one scan body was necessary, and the facial and IOS devices were the only digitizing elements required. Furthermore, the virtual design of the intraoral scan body can be modified for better adaptation to the maxillary arch shape and dimensions of each patient. In addition, the same manufacturing accuracy of the polymer printer to fabricate other dental devices is not required to fabricate such intraoral scan body. Therefore, a more accessible 3D printer can be selected.

The facial scanner selected contains 2 infrared laser structured-light projectors and 3 camera sensors.¹⁷ A black marker was used to locate extraoral landmarks, which eased the mark recognition on the software. The black mark is visualized on the program as a volumetric mark (Fig. 9), which helped the landmark location while performing the superimposition procedures. However, if another technology and resolution is used, this feature might not be achieved. Similarly, when manufacturing the intraoral scan body, the

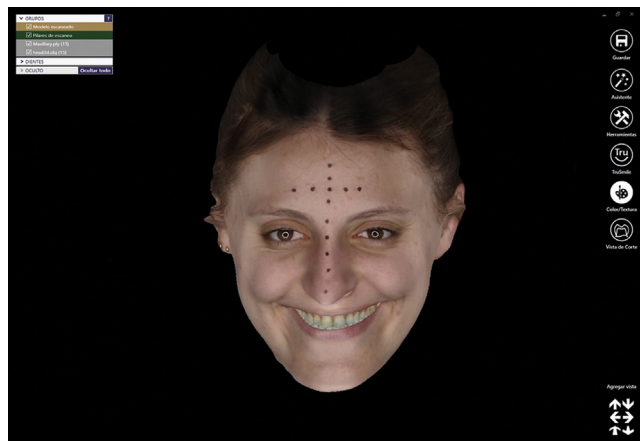


Figure 8. Patient's 3D virtual representation.

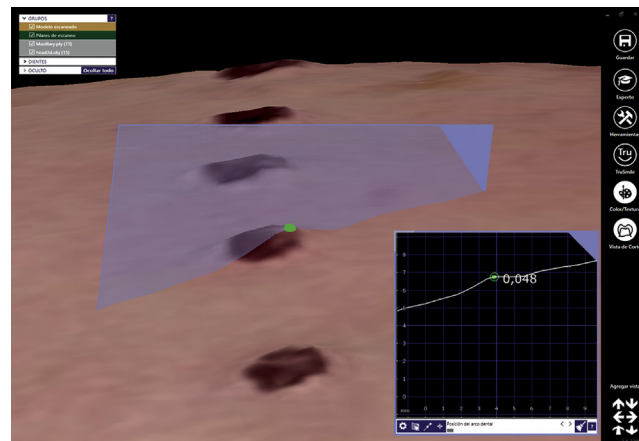


Figure 9. Black landmark visualization on computer-aided design software program.

whitest shade of the biocompatible material was selected to facilitate the contrast with the black marks added on its surface.

A learning curve is required to improve digitizing procedures and CAD technique. Studies are recommended to better analyze the behavior of the described intraoral scan body when using different facial scanner technologies, color, and materials. In addition, variations in clinical conditions such as completely or partially dentate patients should be evaluated.

SUMMARY

The present article describes a technique to merge facial and intraoral digital scans guided with an intraoral scan body by using a dental CAD software program. The technique facilitates the patient's 3D representation in situations where a CBCT scan is not required. It can also aid digital planning of restorative procedures. Furthermore, the intraoral scan body size can be customized to the patient's arch to improve patient's comfort and ease digitalization procedures.

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