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DENTAL TECHNIQUE

Calibrated splinting framework for complete arch intraoral implant digital scans manufactured by combining milled and additively manufacturing technologies: A dental technique

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ABSTRACT

Splinting frameworks are intended to increase the accuracy of complete arch intraoral digital implant scans. This article describes a technique that uses a calibrated splinting framework manufactured by combining milled and additively manufacturing technologies (IOSRing) for assisting with complete arch intraoral digital implant scanning. The splinting framework contains milled truncated cone-shape markers whose position in the metal framework is measured during the manufacturing process with a coordinate measurement machine. This framework splints the modified implant scan bodies and assists in the complete arch intraoral implant digital scanning. Computer-aided design procedures are then used to calculate the implant position on the virtual definitive implant cast by using the position of the calibrated markers as a reference. (J Prosthet Dent 2022;■:■-■)

Intraoral scanners (IOSs) provide an alternative to conventional impression methods,[1-4] but factors such as technology selection,[5-8] calibration,[9] ambient lighting conditions,[10-12] ambient temperature changes,[13] digital scan extension,[11,14] scanning pattern,[15,16] cutting-off and rescanning techniques,[17-19] presence of existing restorations,[20-23] and scanning surface characteristics[24-26] can decrease intraoral scanning accuracy. Furthermore, when capturing intraoral digital implant scans, additional factors should be considered, including implant position, depth, and angulation.[27-29]

Different techniques have been described to improve intraoral digital scans for complete arch implant-supported prostheses, including splinting the implant scan bodies and placing markers on the edentulous spaces between the implant scan bodies.[30-34] However, the technique that provides the most accurate values for complete arch intraoral implant digital scans remains uncertain.[30]

This article describes a technique that aims to increase the accuracy of complete arch intraoral implant digital scans by using a calibrated splinting framework manufactured by combining milled and additively manufacturing

Figure 1. Maxillary screw-retained implant-supported interim prosthesis and mandibular screw-retained metal-ceramic rehabilitation frontal view.

Conflicts of Interest: Mr Sergi Guirao has economical conflict of interest as Chief Visionally Officer of the company that has developed the present technique. The remaining authors did not have any conflict of interest, financial or personal, in any of the materials described in this study.

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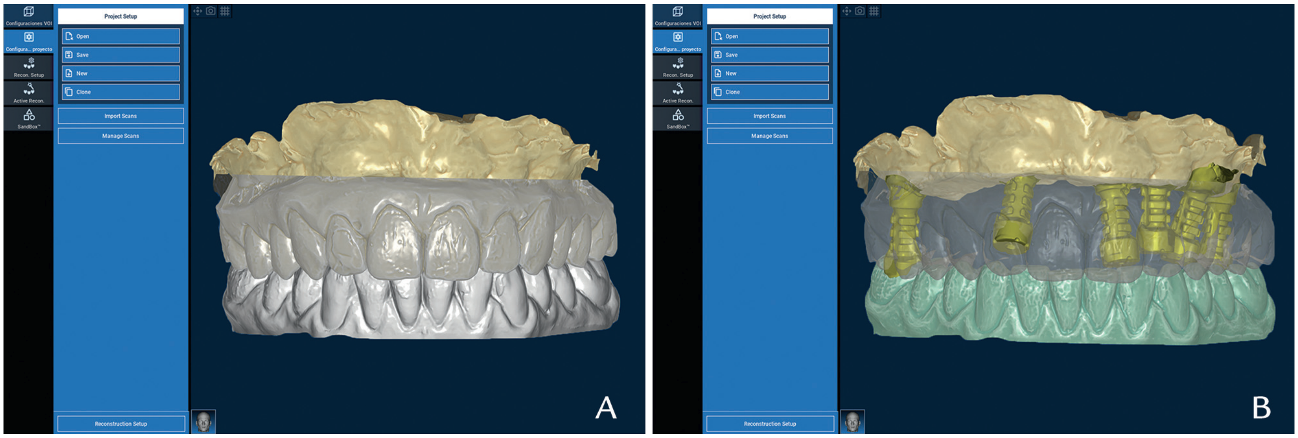

Figure 2. Initial intraoral digital scans. A, Intraoral digital scans of existing maxillary and mandibular prosthesis. B, Intraoral digital scan of maxillary arch with modified implant scan bodies positioned.

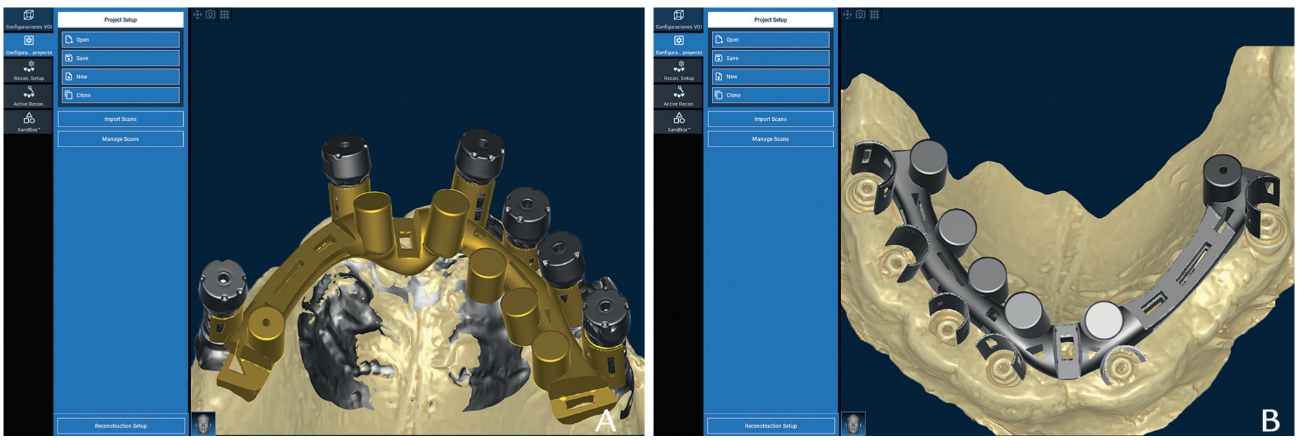

Figure 3. A, Virtual design of custom and calibrated milled and additively manufactured splinting framework over modified implant scan bodies. B, Splinting framework design.

technologies (IOSRing; IOSFix dental). The custom AM splinting metal framework contains milled truncated cone-shape markers. The position of these markers in the metal framework is measured during the manufacturing process with a coordinate measurement machine (CMM). This metal framework splints the implant scan bodies and assists with the complete arch intraoral implant digital scanning. Then, computer-aided design (CAD) procedures are used to calculate the implant position on the virtual definitive implant cast by using the previously measured position of the calibrated markers as a known reference.

TECHNIQUE

A patient receiving a maxillary complete arch screw-retained implant-supported prosthesis was selected to demonstrate the technique. The patient had 6 implants (Astra Tech Implant EV, 3.6S and 4.2S; Dentsply Sirona) in the maxillary arch with intermediate implant abutments (Multibase Abutment; Dentsply Sirona) and a maxillary screw-retained interim restoration (Fig. 1).

1. Obtain an intraoral digital scan of the existing maxillary and mandibular prosthesis by using an IOS (PrimeScan; Dentsply Sirona) under optimal ambient lighting conditions[10-12] according to the scanning protocol endorsed by the manufacturer. Subsequently acquire the maxillomandibular registration by using the same IOS (Fig. 2A). Ensure that the IOS device had been previously calibrated according to the manufacturer's protocol.[13]

Remove the maxillary screw-retained implant-supported interim prosthesis. Then, place a modified implant scan body (ScanTransfer Non-Engaging, IPD/AB-SR-11; IPD Dental Group) on each implant abutment tightened to 10 Ncm, as recommended by the manufacturer. Obtain a maxillary intraoral digital scan by using the same IOS according to the scanning protocol endorsed by the manufacturer (Fig. 2B). Export the standard tessellation language (STL_1) file and send the intraoral digital scans to the manufacturer to fabricate the custom calibrated milled and AM splinting framework (IOSRing; Fresdental Innovación y Manufacturas S.L.).

The initial intraoral digital scans are used by the manufacturer to design and fabricate the custom calibrated splinting metal framework (IOSRing, IOSFix Dental; Fresdental Innovacion y Manufacturas S.L.; IOSRing; Fresdental Innnovacio) (Fig. 3). The splinting framework is fabricated from a cobalt-chromium (Co-Cr) dental alloy (Cobalt Chromium Powder; Ador) by using a selective laser melting (SLM) printer (Metal Printer 1000; Trumpf) according to the manufacturer's recommendations. After fabrication, the housings of the screw-retained truncated cone-shape markers are prepared on the splinting metal framework by using a 5-axis milling machine (c250; Hermle) (Fig. 4). Additionally, the Co-Cr truncated cone-shape markers (Marker Ref. 2348; IPD Dental Group) are fabricated by using a torn milling machine. Subsequently, a milled truncated cone-shape marker is positioned on each corresponding housing on the AM splinting framework.

After the custom splinting AM framework manufacturing is complete, a CMM (Benchmark; Coord3) is used to measure the position of each milled marker.

2. During the following clinical appointment, place a modified implant scan body (ScanTransfer Non-Engaging, IPD/AB-SR-11, IPD Dental Group) on each implant abutment and tighten them to 10 Ncm according to the manufacturer's recommendations (Fig. 5A). Then, position the custom and calibrated framework and splint it with the implant scan bodies by using autopolymerizing acrylic resin material (Pattern Resin; GC America) (Fig. 5B). Next, obtain a definitive intraoral scan starting on the right-side lingual surface of the most distal implant and moving to the most distal implant on the left side. Continue scanning the occlusal surfaces from left to right and complete the scan by moving along the buccal surface to the most distal implant of the contralateral side, as recommended by the manufacturer (Fig. 5C). Export the definitive intraoral digital scan and send it to the manufacturer (IOSFix Dental; IOSFix Dental). Unscrew and remove the AM calibrated milled framework splinted to the modified implant scan bodies.

The CMM measurements obtained during the manufacturing procedures of the AM custom splinting framework are used to calculate the implant abutment positions by using the manufacturer's proprietary information (IOSRing; Fresdental Innovacion y Manufacturas S.L.).[35] The implant abutment positions captured in the definitive intraoral digital scan are corrected by using the known position of the cone-shape markers. Each marker is identified and defined by the point (center of the circumference in the coronal plane of the cone-shape marker) and its axis of rotation. This procedure is completed in the CMM analysis and intraoral digital scan files. The discrepancies between both are used to calculate the implant abutment position. As a result, a corrected definitive intraoral scan is provided in an STL file format.

Figure 4. A, Calibrated milled and additively manufactured splinting framework. B, Screw-retained milled markers.

3. Position an implant abutment analog (IPD/AB-AR-00; IPD Dental Group) on each corresponding implant scan body splinted to the AM calibrated milled splinting framework and tighten them to 10 Ncm. Subsequently, embed the implant abutment analogs in dental stone (IPD/AB-AR-00; IPD Dental Group) to obtain the definitive implant cast (Fig. 6).[36] This cast can be used during the fabrication of the maxillary framework for fit-verification purposes.

The corrected intraoral STL file is used to design and fabricate the definitive implant-supported prosthesis following the typical procedures by using a software program (DentalCAD, Galway v. 7662; exocad). First, the

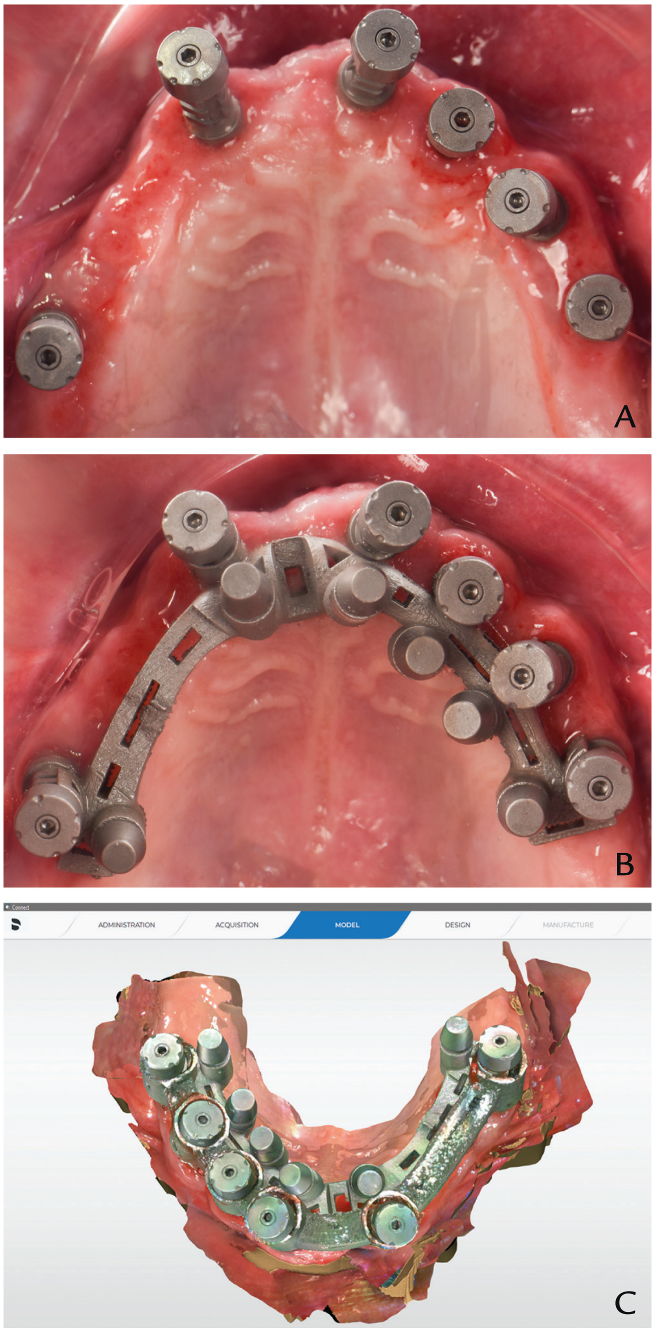

Figure 5. Definitive intraoral digital scan. A, Modified implant scan bodies positioned on implant abutments. B, Milled and additively manufactured splinting framework positioned over modified implant scan bodies. C, Definitive complete arch intraoral implant digital scan.

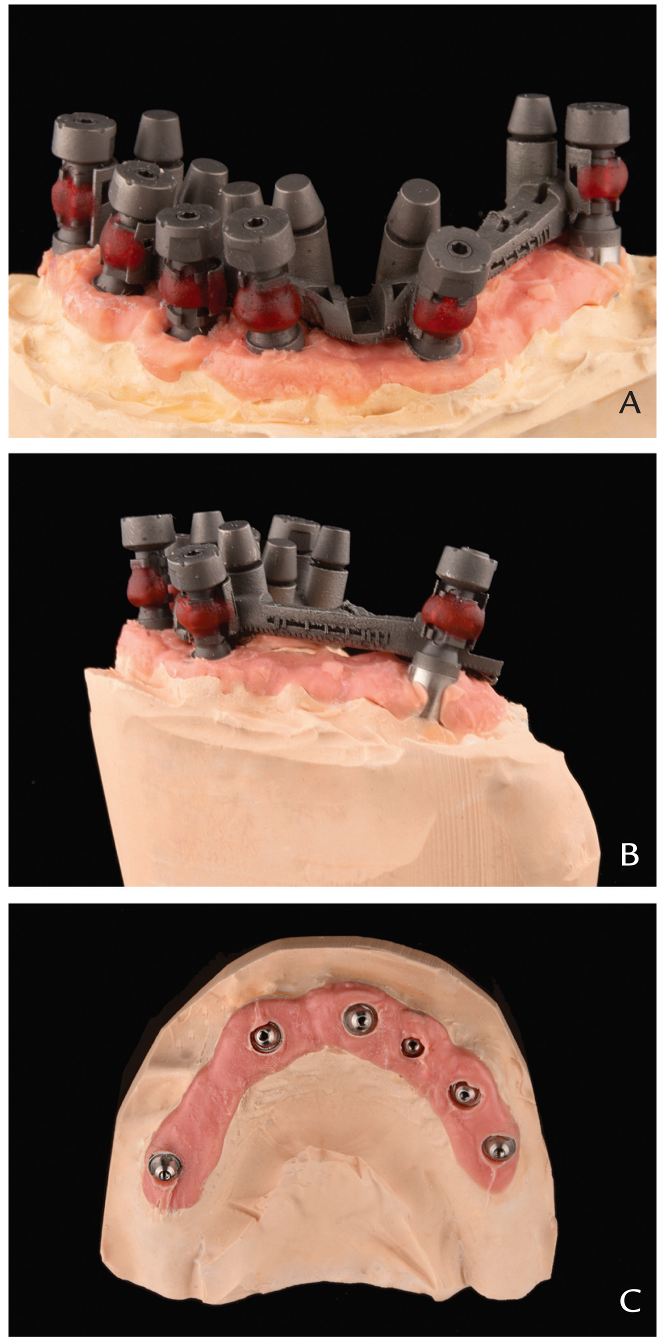

Figure 6. Definitive conventional implant cast fabricated for framework fit-verification purposes before framework evaluation appointment. A, Buccal view. B, Lateral view. C, Definitive implant cast.

virtual definitive implant cast is obtained by aligning each implant scan body of the intraoral digital scan with the corresponding implant scan body file of the library in the CAD program (Fig. 7). Then, the maxillary implant-supported titanium framework is designed by using the tooth position information provided on the initial intraoral digital scan of the maxillary screw-retained implant-supported prosthesis as a reference (Fig. 8).

The maxillary milled titanium implant-supported framework is placed intraorally, and the clinical assessment of the framework passivity is completed by using the Sheffield test with intraoral periapical radiographs (Fig. 9).[37] The titanium-acrylic resin implant-supported prosthesis is then finished and delivered by following conventional procedures (Fig. 10). For this patient, the implant abutment position discrepancy between the laboratory scan of the definitive stone implant cast and

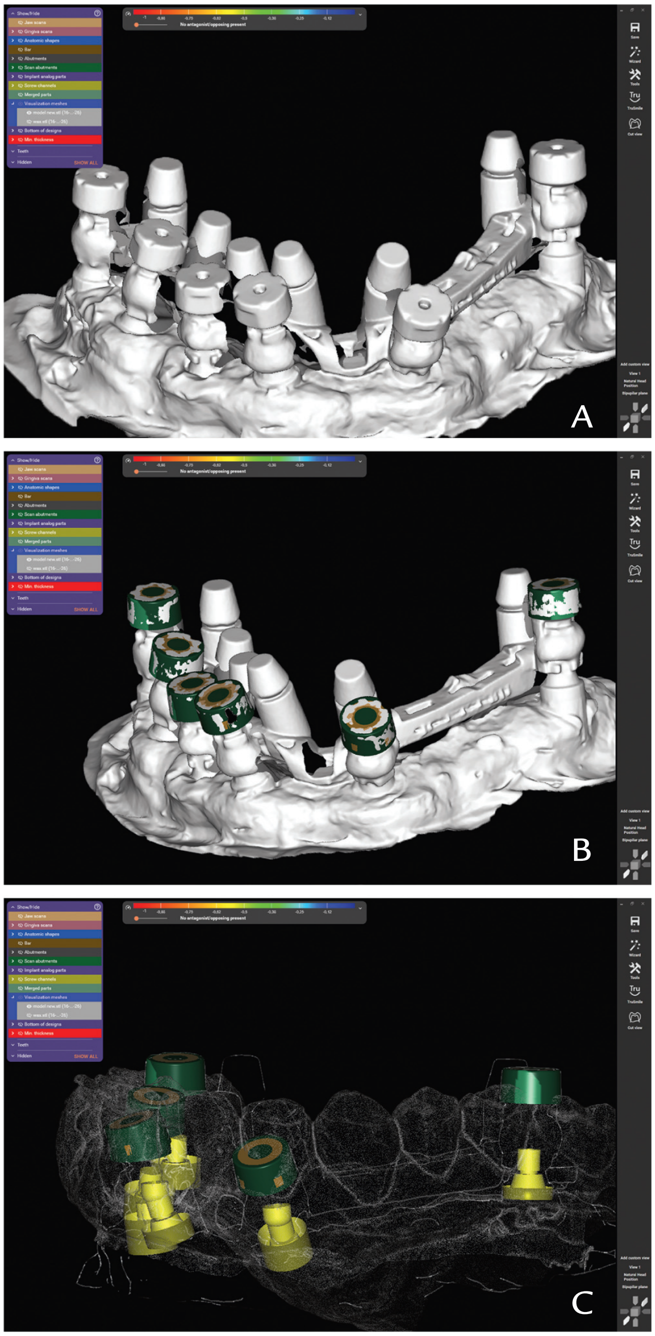

Figure 7. A, Imported modified intraoral implant digital scan. B, Alignment between modified implant scan bodies of intraoral digital scan and library of the CAD program. C, Implant abutment position on virtual definitive implant cast. CAD, computer-aided design.

the corrected definitive intraoral digital scan was compared. The implant abutment position discrepancy ranged from 6 to 25 μm (Fig. 11).

DISCUSSION

The described technique uses a calibrated framework manufactured by combining milled and additively manufacturing

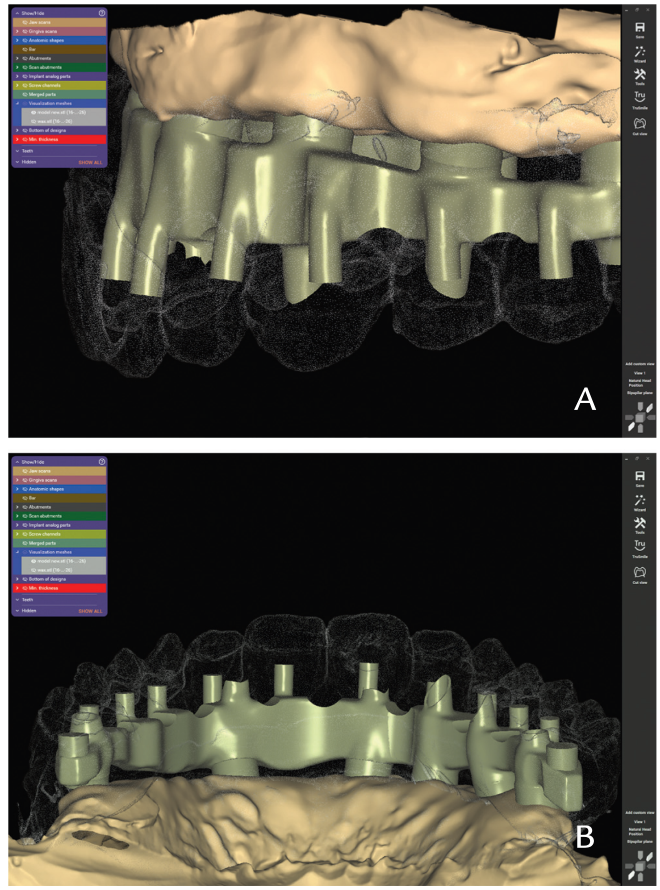

Figure 8. Definitive maxillary implant-supported framework design guided by the tooth position of the interim restoration. A, Lateral view. B, Lingual view.

technologies to increase the accuracy of complete arch intraoral implant scans. Although previous publications have described the use of auxiliary devices such as splinting frameworks or intraoral markers to improve the accuracy of complete arch scans by using IOSs,[30] this described technique provides a new method of reaching the same objective in which known positions and measures are used to correct intraoral scanning discrepancies. Nonetheless, studies are needed to measure the accuracy of the technique described.

The calibrated splinting framework used in this technique presents 2 main functions. First, the splinting framework is intended to facilitate the intraoral scanning procedure by providing a rigid structure between the modified implant scan bodies, which may minimize stitching errors. Second, the AM framework provides position information in the x-, y-, and z-axes of the milled markers, which was measured by using a CMM during the manufacturing process. These known measurements permit a calculation of the implant abutment position. This overall clinical procedure may provide a more predictable digital impression than nonsplinted digital implant scans. Studies are needed to assess the accuracy of the described technique.

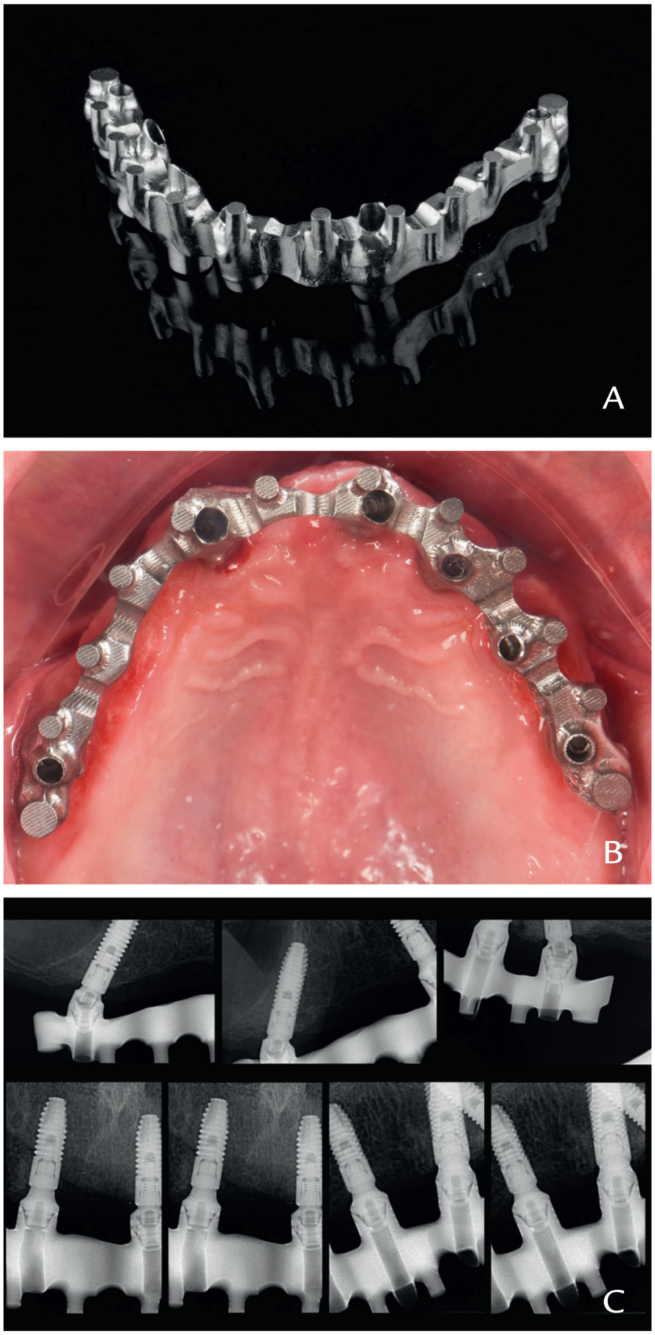

Figure 9. Maxillary implant-supported metal framework evaluation. A, Milled titanium implant-supported framework. B, Occlusal view of maxillary framework positioned intraorally. C, Radiographic assessment by using Sheffield test.

Figure 10. Definitive maxillary screw-retained metal-acrylic resin implant-supported prosthesis delivered.

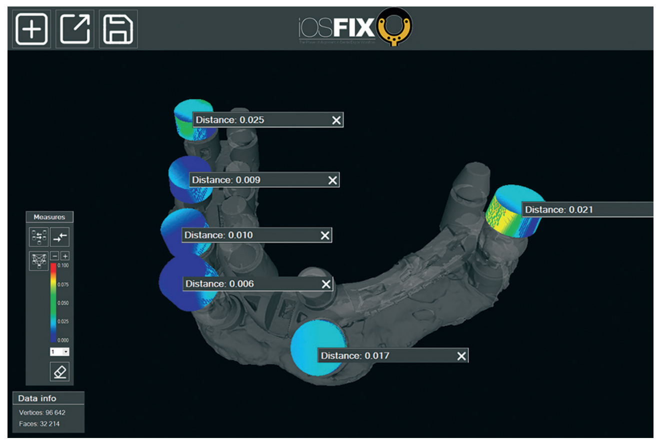

Figure 11. Implant abutment discrepancy between corrected intraoral digital scan and laboratory scan of definitive conventional implant cast.

SUMMARY

This article describes a complete arch intraoral digital scan technique by using a calibrated splinting framework manufactured by combining milled and additively manufacturing technologies. The splinting framework contains milled truncated cone-shape markers whose position in the metal framework is measured during the manufacturing process by using a coordinate measurement machine. This framework splints the modified implant scan bodies and assists with the complete arch intraoral implant digital scanning. Subsequently, CAD procedures are used to calculate the implant position by combining the known position of the calibrated markers and the definitive intraoral implant digital scan.

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