THE JOURNAL OF PROSTHETIC DENTISTRY

DENTAL TECHNIQUE

Guided implant scanning: A procedure for improving the accuracy of implant-supported complete-arch fixed dental prostheses

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ABSTRACT

This article describes a technique to improve the quality of digital intraoral scans for complete-arch prostheses by correcting the cumulative deviations that may arise with conventional digital methods. The approach involves an additional scan in which a reference-marked rigid splint of known dimensions is used to reduce the likelihood of such deviations. The scanned files are sectioned and best fit aligned to generate a more reliable definitive cast and consequently a better-fitting prosthesis. (J Prosthet Dent 2019;■:■-■)

Computer-aided design and computer-aided manufacturing (CAD-CAM) has been used for nearly all types of prostheses in recent years,[1,2] and digital intraoral scans are steadily replacing conventional impressions.[3,4] For implant-supported fixed dental prosthesis (FDPs), the impression materials most widely recommended are elastomers such as polyvinylsiloxane and polyether.[5,6] Despite their shortcomings,[7,8] however, suitable accuracy can be obtained when open trays and splinted transfer copings are used.[9-12] For implant-supported FDPs, a satisfactory passive fit is imperative to prevent technical and biological complications.[13,14]

Since the introduction of scannable impression copings in 2008, intraoral scanners are being used to make digital casts for implants.[15-17] Although some scanners feature extraoral devices especially designed to scan implant positions,[18,19] most are fitted with intraoral capture systems. Some of the drawbacks of the latter approach stem from the need for an intraoral wand small enough to scan the interarch space.[20] As the sensor has a concomitantly small range, a series of scans must be overlapped to reproduce large spans such as for complete arches. Minor errors can therefore occur in the image at each junction, altering the dimensions of the scan.[13,21,22] This issue is of such concern that different scanning strategies have been designed and assessed to determine which delivers the most accurate results.[23,24]

When scans are made for long spans or complete arches, the problem may be exacerbated when the scanner records normally moist gum or mucosa, which is mobile and provides fewer reference points than teeth.[25,26] The greater the distance from the starting point, the greater the discrepancies.[27] As a result, scanners are not generally accepted for making digital scans for implant-supported complete-arch FDPs.[28,29]

This article describes a procedure for enhancing intraoral scans and reducing the likelihood of dimensionally altered digital scans for complete-arch prostheses where great accuracy is required.

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Figure 1. Splint used in guided implant scanning.

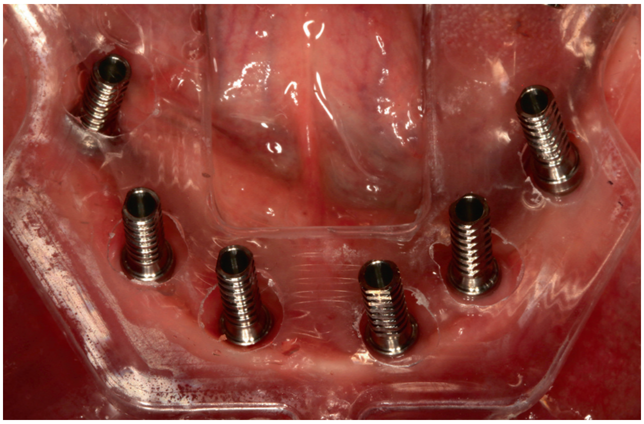

Figure 3. Holes on perforated transparent template matched to occlusal sides of abutments.

TECHNIQUE

This technique used a splint with the following characteristics: dimensions suitable for scanning patients' arches; made of a rigid material; readily perforated; and fitted with a series of reliefs and marks that serve as references for identifying and correcting possible deviations. Although the milled polymethylmethacrylate splint described here measured 70×60×5 mm (PMMA Block; Huge Dental Materials) (Fig. 1), the splints used may vary in design, material, and dimensions, providing they meet the characteristics specified. In particular, they must be made of a rigid material and carry clearly detectable markings that serve as a reference to ensure scanning accuracy.

1. Obtain a conventional intraoral scan cast with the scan bodies in place (cast A). Place the scan bodies on the transepithelial abutments (Scan abutment transepithelial; Avinent Implant System) and scan the arch conventionally by using the intraoral wand (TRIOS 3; 3 Shape A/S) to generate the original scan (cast A) (Fig. 2).

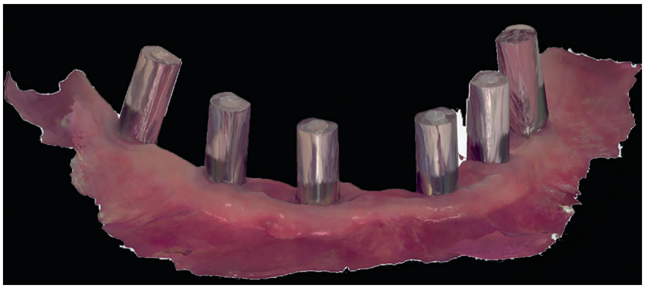

Figure 2. Conventional digital scan of cast A with scan bodies in place.

Figure 4. Guided implant scanning splint perforated in same locations as transparent template.

Figure 5. Titanium abutments embedded with autopolymerizing acrylic resin.

2. Secure titanium abutments to the GIS splint. With the titanium abutments for interim FDPs (Temporary abutment nonengaging; Avinent Implant System) on the transepithelial abutments, mark their occlusal side on a transparent template (020 Temp.Splint; Dentaflux) of size similar to that of the GIS splint. Perforate the template at the marks by using a rotary instrument (SMARTmatic S10; KaVo GmbH) and ensure that each perforation coincides with the occlusal sides of the abutments (Fig. 3).
3. Lay the transparent template over the GIS splint and repeat the aforementioned procedure: perforate

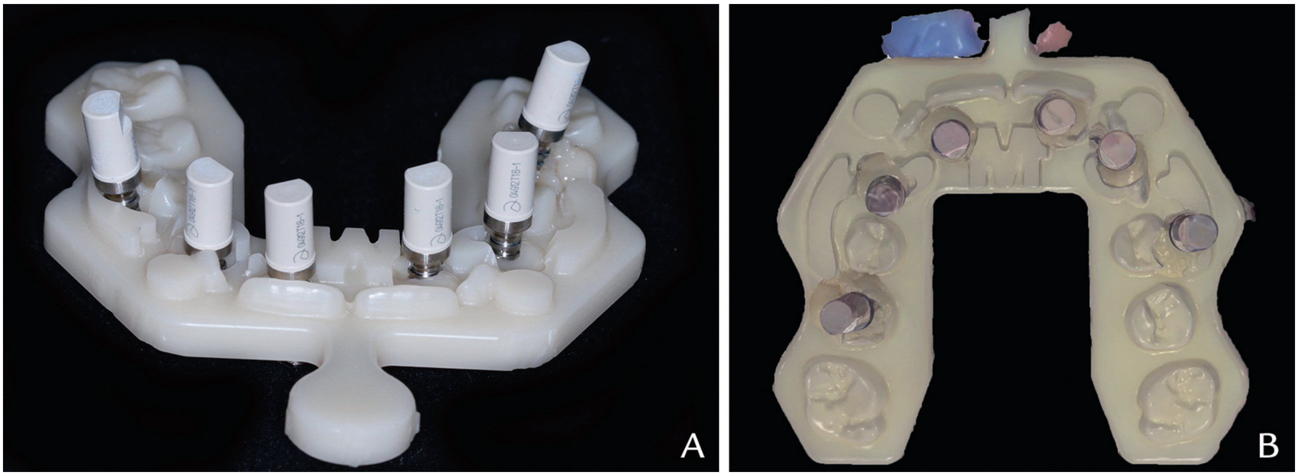

Figure 6. Implant analogs secured for scanning and intraoral scan image. A, Frontal view. B, Occlusal view.

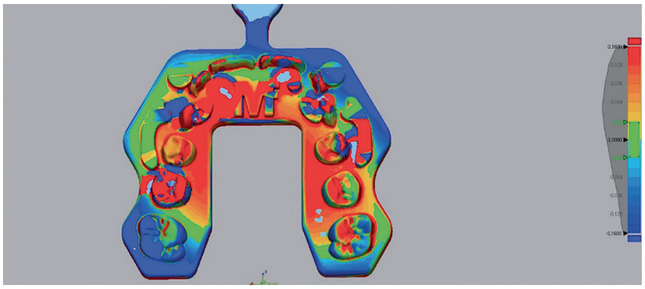

Figure 7. Cast B overlaid on the master guided implant scanning splint designed and color map of deviations.

the splint by using rotary instruments and ensure that each mark coincides with the occlusal side of the titanium abutment (Fig. 4). Secure the GIS splint to the titanium abutments with an auto-, photo-, or dual-polymerizing material (Structur 3; VOCO GmbH) (Fig. 5).

4. Scan the GIS splint with the embedded abutments and generate cast B.
5. Position the side of the splint with the reference markings downward, facing the implants, and screw the digital implant analogs (Transepithelial analog for digital model; Avinent implant system) to each embedded abutment. Scan the splint on the reference side, where the analogs are located. The resulting scan is cast B (GIS splint with digital implant analogs) (Fig. 6).
6. Align cast B with the master GIS splint designed and verify the deviations. Best fit model B (GIS splint with digital implant analog) to the master digital GIS splint designed (Geomagic Control X; 3D Systems) and verify the deviations (Meshmixer; Autodesk, Inc) (Fig. 7).
7. Divide the cast B file into sections and overlay each fragment on the master GIS splint designed to generate cast B1 (GIS splint with corrected implant position).

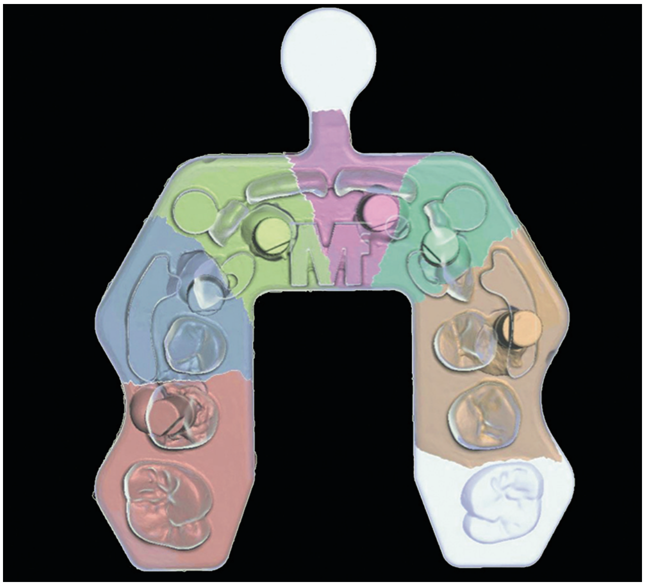

Figure 8. Division into sections of cast B and overlaid of fragments on master guided implant scanning splint.

8. Section cast B and lay each fragment over the master GIS splint designed to generate the cast B1 file (GIS with corrected implant position) (Fig. 8).

As, according to some authors, deviations of under 50 μm are acceptable,[30] if the distortions observed in step 4 are smaller than 50 μm, sectioning and overlaying may not be necessary. In this example, the ceiling was set at 30 μm to better illustrate the procedure.

9. Optionally, lay cast B1 over the master GIS splint for further verification that the procedure has yielded satisfactory results (Fig. 9).
10. Lay cast A over cast B1 and evaluate for deviations. Align cast A (conventional scan body) and B1 (GIS

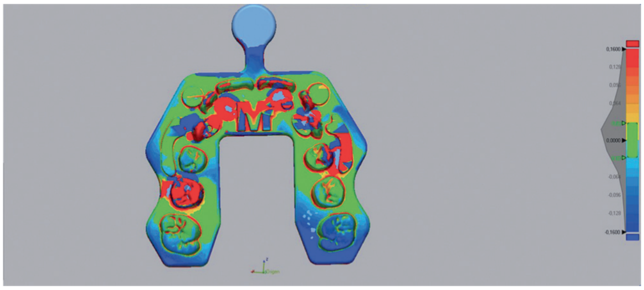

Figure 9. Color map of deviations in cast B1 laid over master guided implant scanning splint.

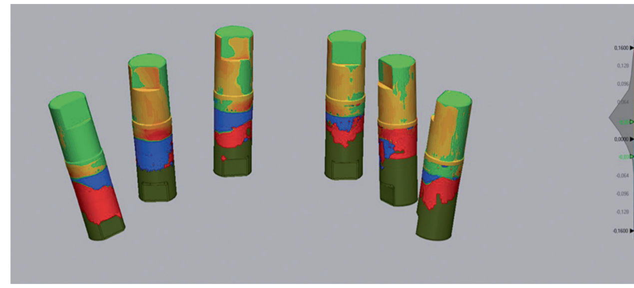

Figure 10. Color map showing differences in implant position between cast A (conventional scanning) and cast B1 (guided implant scanning splint with implant position corrected).

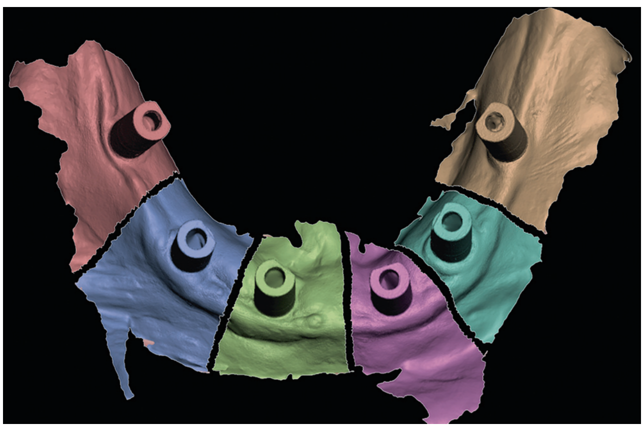

Figure 11. Cast C generated from (conventionally scanned) cast A after sectioning based on implant positions obtained with cast B1 (guided implant scanning splint with implant position corrected)

Figure 12. Comparison of cast A (conventional scan bodies) (*dark gray*) to cast C (with soft tissues and corrected implant position) (different colors, one per section).

splint with implant position corrected). The alignment is based on the location of the cast B1 implants (Fig. 10). Evaluate for deviations of over 50 μm between the 2 casts.

11. Divide cast A into fragments and lay each over cast B1 to obtain the third and last cast, cast C (with soft tissues plus corrected implant position). Divide cast A into sections and align them with cast B1. Although, as in step 7, this is only necessary for deviations >50 μm, in the example, it was performed on all the bodies to better illustrate the procedure. These divisions and alignments deliver cast C, which gives the corrected position of the implants and information on the soft tissues (Fig. 11). Optionally, compare (conventional) cast A to (definitive) cast C (Fig. 12). This step, which would not be necessary in clinical practice, is shown here to visualize the corrections made to the original model. Note that the implants closest to the mandibular right second molar starting position changed minimally, whereas greater repositioning was required in the ones farthest from that point.

DISCUSSION

This article describes a technique for improving the accuracy of digital intraoral scans with a specifically designed (GIS) splint and subsequent division and alignment of the splinted and unsplinted digital casts. It differs from the conventional method in that the splint is used to identify possible dimensional errors induced by conventional intraoral scanning. With this tool, such errors can be detected and virtually corrected as appropriate by dividing and aligning digital casts. The drawback to the approach relative to conventional scanning is that it calls for additional maneuvering, including preparation of a transparent template, as well as the GIS splint, splinting and embedding the titanium abutments in the splint, scanning the splint with the analogs connected to the scan bodies, and performing the digital operations described in the procedure.

The primary advantage of the procedure is that it improves the digital cast accuracy delivered by intraoral scanners in implant-supported complete-arch FDPs, one of the factors that presently limits the use of this technology. In essence, it minimizes the errors resulting from the narrow scans recorded by intraoral wands in these situations, ensuring the reliability of the scans. Although the approach also entails additional materials and more digital maneuvering, the extra costs, difficulty, and patient inconvenience involved are minor and offset by the resulting optimization of the passive fit so essential in this type of prosthesis.

SUMMARY

This technique is designed to generate digital files accurate enough for the preparation of complete-arch implant FDPs. It involves recording 2 intraoral scans, 1 conventionally and the other with scan bodies secured to a device with reference marks, the GIS splint. The marks contribute to greater scanning accuracy. Based on the file obtained with the splint, the original scan is fragmented, and the fragments are aligned on the new file to yield a more accurate third file. The primary advantage is that this file is appropriate for complete-arch implant FDPs, which can be made in a straightforward and reliable manner with essentially no inconvenience for the patient, beyond a second intraoral scan.

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https://doi.org/10.1016/j.prosdent.2019.09.022