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DENTAL TECHNIQUE

Improving the accuracy of complete arch implant intraoral digital scans by using horizontal scan bodies with occlusal geometry: A dental technique

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ABSTRACT

A technique to improve the accuracy of complete arch implant intraoral digital scans and to obtain more accurate virtual casts with them is described. First, 2 complete arch intraoral digital scans were obtained with an intraoral scanner: a multiunit abutment digital scan and an implant digital scan with reusable horizontal intraoral scan bodies (ISBs) placed on the implants. These were previously created by combining the conventional ISBs compatible with the patient's implants with extensional structures with occlusal geometry. Once the digital scans had been acquired, the position of the implants was obtained by superimposing a virtual design of the conventional ISB onto each horizontal ISB of the complete arch implant digital scan. Finally, the virtual cast was obtained by superimposing the complete arch multiunit abutment digital scan on the complete arch implant digital scan. (J Prosthet Dent 2025;133:57-61)

An accurate transfer of the position of implants from the patient's mouth to a virtual cast is essential for the passive fit of an implant-supported prosthesis made with a digital workflow.[1,2] In the direct digital workflow, this involves obtaining an accurate implant intraoral digital scan, with intraoral scan bodies (ISBs) screwed to the implants.[3] However, intraoral scanners (IOSs) have difficulties obtaining accurate digital scans of long edentulous spans.[4–12] This problem has been explained by the difficulty they have in accurately stitching together different images of movable soft tissues and smooth surfaces with poor geometric references in edentulous areas.[4–9] IOSs create digital scans by stitching together different images using best-fit alignment algorithms, which obtain the best results when the capture area is covered with geometric references and remains immobile.[13,14] Therefore, obtaining accurate complete arch implant intraoral digital scans is particularly challenging.[15,16]

The accuracy of complete arch implant digital scans has been reported to be improved by adding geometric references between the ISBs.[17–30] Various alternatives to adding geometric references between ISBs have been presented,[31–34] with the use of an auxiliary device to splint them being a common factor in many.[17–20,31,32,35–39] The major drawback of most of these auxiliary devices is that they need to be customized and so require a preliminary intraoral scan, which therefore necessitates an additional patient visit.[21,31,33,35,36,40]

This article describes a technique to improve the accuracy of complete arch implant intraoral digital scans without the need for custom auxiliary devices. The described technique uses horizontal ISBs with an extensional structure with occlusal geometry to cover interimplant edentulous spans with static geometric references. Reusable horizontal ISBs of different dimensions can be manufactured and used to cover different interimplant spans without the need for customization or additional appointments.

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TECHNIQUE

1. Create the virtual designs of the extensional structures of the horizontal ISBs in a reverse engineering software program (Geomagic Design X; 3D Systems Inc) (Fig. 1). Create extensional structures of varying lengths to cover different interimplant distances. Fill the extensional structures with posterior teeth, by using virtual designs of posterior teeth available in tooth libraries (use each of them only once). Take as a reference the virtual designs of the extensional structures of the horizontal ISBs used to describe this technique (Supplemental File, available online).
2. Complete the virtual designs of the horizontal ISBs by merging, in the reverse engineering software program, the virtual designs of the extensional structures with a virtual design of a conventional ISB compatible with the implants used (BTI Multi-IM; BTI Biotechnology Institute), available in implant libraries (Fig. 2). Ensure that the upper plane of the virtual design of the conventional ISB lies at a similar height to the teeth of the extensional structure.
3. Manufacture the horizontal ISBs in an opaque material that meets or exceeds established biocompatibility requirements (HP 3D HR PA12; HP Inc).[41,42]
4. Obtain a complete arch multiunit abutment digital scan with an IOS (TRIOS 3; 3Shape A/S) following the manufacturer's recommendations (Fig. 3).
5. Screw a horizontal ISB to each multiunit abutment and obtain a complete arch implant digital scan with the IOS, following the manufacturer's recommendations (Fig. 4). Select the dimension of each horizontal ISB according to the interimplant distance and position them in such a way that the gaps between the horizontal ISBs are minimal (Fig. 4A).

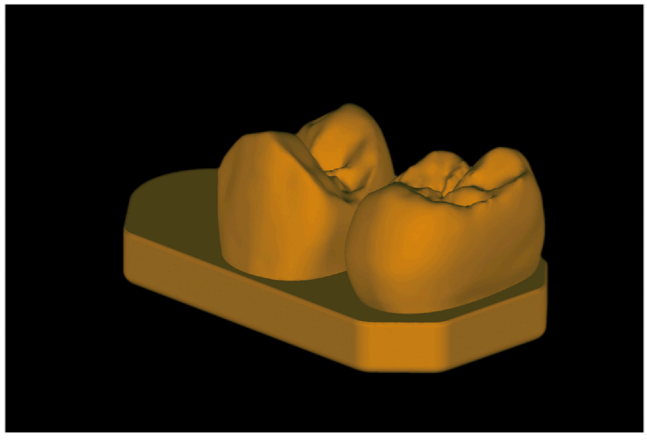

Figure 1. Virtual design of extensional structure of horizontal scan body.

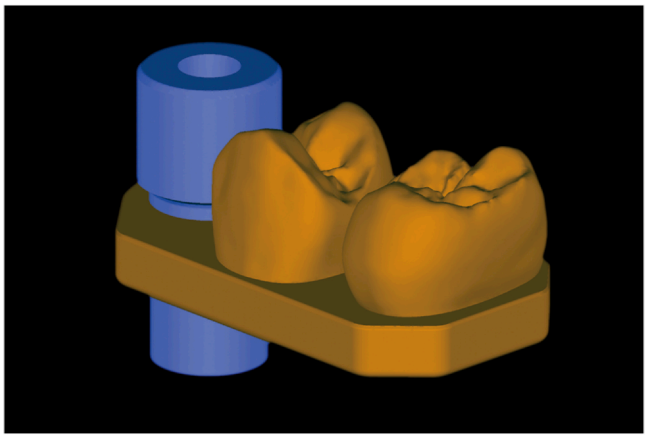

Figure 2. Virtual design of horizontal scan body obtained by merging virtual design of extensional structure (*orange*) with that of conventional scan body (*blue*).

6. In a dental computer-aided design (CAD) software program (exocad; exocad GmbH) superimpose the virtual design of the conventional ISB with each horizontal ISB of the complete arch implant digital scan to obtain the position of the implants (Fig. 5). Common regions of the ISBs should be superimposed by using a best-fit algorithm.
7. In the dental CAD software program, split the complete arch, multiunit abutment digital scan into as many parts as implants (Fig. 6A) and superimpose each of them with the complete arch implant digital scan (Fig. 6B). Common regions of the digital scans (corresponding to soft tissues) should be superimposed by using a best-fit algorithm.
8. Remove or hide the complete arch implant digital scan and stay with the virtual cast composed of the split complete arch multiunit abutment digital scan and the virtual designs of the conventional ISBs (Fig. 7).

DISCUSSION

A technique to improve the accuracy of complete arch implant intraoral digital scans and obtain with them more accurate virtual casts is described. To improve the accuracy of complete arch implant intraoral digital scans, this technique uses horizontal ISBs with occlusal geometry to cover interimplant edentulous spans with static geometric references that are more favorable for IOSs. Reusable horizontal ISBs of different dimensions can be manufactured and used to cover different interimplant spans, without the need for customization.

It has been reported that IOSs have difficulties in obtaining accurate digital scans of large edentulous spans,[4–12] because of the problems in accurately stitching together different images of mobile tissues and smooth surfaces with poor geometric references in edentulous areas.[4–9] The

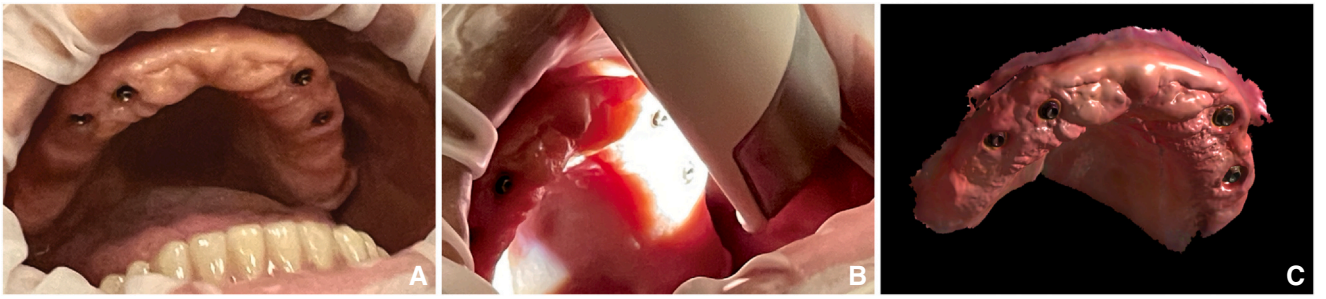

Figure 3. Acquisition of complete arch multi-unit abutment digital scan. A, Intraoral situation. B, Intraoral scan. C, Complete arch multiunit abutment digital scan.

Figure 4. Acquisition of complete arch implant digital scan. A, Intraoral situation. B, Intraoral scan. C, Complete arch implant digital scan.

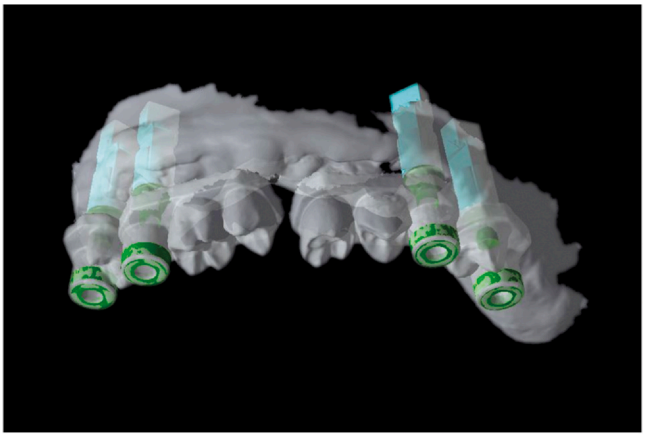

Figure 5. Superimposition of virtual designs of conventional scan bodies with horizontal scan bodies of complete arch implant digital scans.

accuracy of complete arch implant digital scans have been reported to be improved by adding geometric references between ISBs,[17–30] as almost all conventional ISBs are vertical and have no extensional structure to cover edentulous spans with static geometrical references.[3] Many of the reported alternatives for adding geometrical references between ISBs use splinting auxiliary devices,[17–20,31,32,35–39] most of which, unlike the horizontal ISBs used in this technique, need to be customized, therefore necessitating a preliminary digital scan and, therefore, an additional patient appointment.[21,31,33,35,36,40] To implement this technique, each clinic should acquire a set of reusable horizontal ISBs of different dimensions, compatible with the implants it is working with (steps 1 to 3 of the technique). Once acquired, those of the dimensions that best suit each patient can be used without the need for any further customization.

Limitations of horizontal ISBs include that the part corresponding to the conventional ISB (Fig. 2) should be manufactured as accurately as conventional ISBs. Accuracy is important because its virtual design is involved in the superimpositions (Fig. 5) and, therefore, manufacturing errors can lead to superimposition errors that negatively affect the accuracy of the resulting virtual model. In addition, its base seats on the abutment and, therefore, manufacturing errors can lead to incorrect seating that also negatively affect the accuracy of the resulting virtual model. Therefore, reusable horizontal ISBs should be designed and manufactured at a facility. The material used to manufacture them should be opaque and should meet or exceed the established biocompatibility requirements.[41,42] The material should exhibit negligible dimensional changes during usage and sterilization. In addition, if the seating of horizontal ISBs is to be evaluated with radiographs, the material used, at least to manufacture its base, should be radiopaque. Therefore, manufacturing the base of horizontal ISBs in a different material could be considered, as is often done with conventional ISBs.[3]

Virtual designs of the extensional structures with occlusal geometry of the horizontal ISBs used to describe this technique can be downloaded and used as templates by the dental community (Supplemental File,

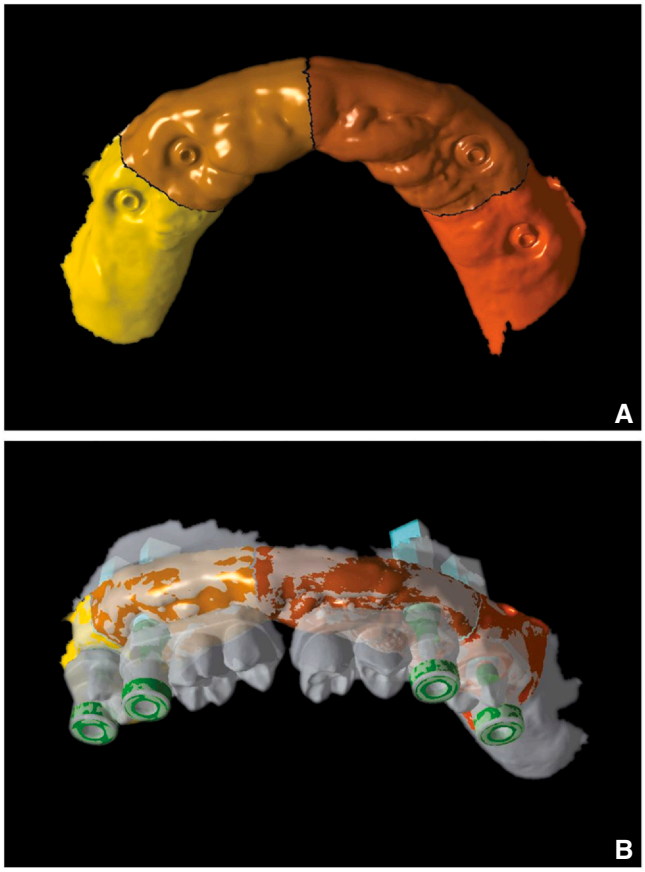

Figure 6. Splitting of complete arch multiunit abutment digital scan and superimposition of each part with complete arch implant digital scan. A, Splitting of complete arch multi-unit abutment digital scan. B, Superimposition of each part of complete arch multiunit abutment digital scan with complete arch implant digital scan.

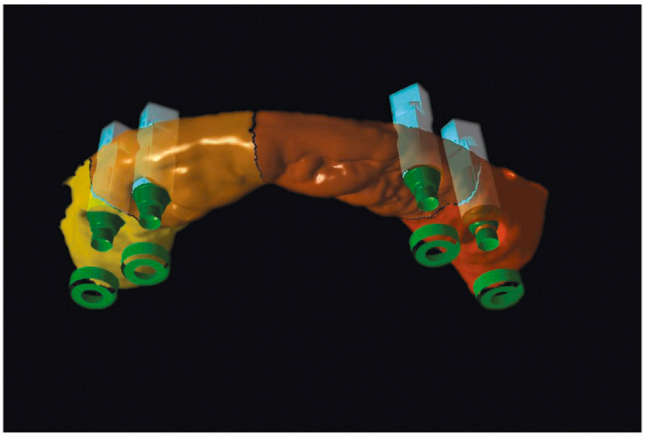

Figure 7. Resulting virtual cast.

available online). However, studies are needed to assess the accuracy of complete arch intraoral implant digital scans obtained with this technique, to optimize, if necessary, the design of horizontal ISBs.

SUMMARY

A technique to improve the accuracy of complete arch implant intraoral digital scans and to obtain with them more accurate virtual casts is presented. To improve the accuracy of complete arch implant intraoral digital scans, reusable horizontal ISBs with occlusal geometry were used. These ISBs were created by combining a conventional ISB compatible with the implants used and an extensional structure with occlusal geometry. Horizontal ISBs of different dimensions can be created to cover different interimplant distances without the need for customization.

PATIENT CONSENT

The illustrated patient signed an informed consent form. The procedure was approved by the university ethics committee (M10_2019_254) according to local and international ethical rules.

APPENDIX A. SUPPORTING INFORMATION

Supplemental data associated with this article can be found in the online version at doi:10.1016/j.prosdent.2024.01.026.

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