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DENTAL TECHNIQUE

Improving the accuracy of complete arch implant digital scans by using auxiliary clips for intraoral scan bodies: A dental technique

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ABSTRACT

A technique to improve the accuracy of complete arch implant intraoral digital scans and the accuracy of their virtual casts is described. Obtaining accurate complete arch implant intraoral digital scans with an intraoral scanner is challenging because of the smooth and movable tissues of edentulous areas. The described technique uses auxiliary clips attached to intraoral scan bodies to cover interimplant edentulous spans with immobile tooth-like geometric references that are more favorable for intraoral scanning. The technique is designed to be user friendly and compatible with any intraoral scanner. (J Prosthet Dent 2025;133:43-47)

In direct digital workflows for providing implant-supported prostheses, implant positions are transferred from the patient's mouth to a virtual cast by using an implant intraoral digital scan.[1] The digital scan should be accurate to ensure a passive fit of the prosthesis.[2–4] However, acquiring an accurate implant intraoral digital scan with an intraoral scanner (IOS) remains challenging.[4–7]

IOSs generate digital scans by stitching together several images using best-fit alignment algorithms.[8–15] These algorithms provide the best results when stitching together images of immobile areas with abundant geometric references. However, difficulties tend to occur in accurately stitching together images of the smooth and movable soft tissues in edentulous areas.[4,10–16] These image-stitching errors accumulate as the scanning span increases, thus making it challenging to obtain accurate complete arch implant intraoral digital scans.[17–19]

Adding geometric references between or around intraoral scan bodies (ISBs) has been reported to decrease image-stitching errors and thus improve the accuracy of the resulting complete arch implant intraoral digital scan.[4,20–31] Numerous methods have been developed to add geometric references between or around ISBs,[4,26–30,32] with the splinting of the ISBs being common to most.[26–29,31,33–35] Some methods use auxiliary devices that require customization with the aid of a preliminary intraoral digital scan and, therefore, require an additional patient visit.[29,30,35] Photogrammetry-based devices have also been developed to transfer implant positions more accurately from the patient's mouth to a virtual cast, but their acquisition can entail considerable cost for a dental clinic.[36–38]

This article describes a technique to improve the accuracy of complete arch implant intraoral digital scans by using auxiliary clips for ISBs to cover interimplant edentulous spans with immobile geometric references that are more favorable for IOSs. Once a dental clinic obtains a set of auxiliary clips of different dimensions for the ISBs used, those that best cover the individual patient's interimplant spans can be selected.

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TECHNIQUE

1. Create the virtual designs of the auxiliary clips in a reverse engineering software program (Geomagic Design X; 3D Systems Inc) based on the reference virtual design of the structure of the auxiliary clips (Fig. 1; Supplemental Files 1-3, available online). First, modify the reference virtual design to ensure a firm union between the created auxiliary clips and the ISBs used in the clinic (Tiny Universal Platform Multi-IM ISB; BTI Biotechnology Institute) by using the corresponding virtual design of the ISB available in implant libraries (note that auxiliary clips will be attached to ISBs apical to the scan region) (Fig. 1A). Then, by modifying the dimensions of the resulting virtual design, create a set of virtual designs of structures of different dimensions (Fig. 1B). Finally, fill the created virtual designs with posterior teeth by using the virtual designs of the posterior teeth available in tooth libraries (use each of them only once) (Fig. 1C). Note that the height of the teeth should be similar to the height of the scan region of the ISB and that the teeth should not hinder the scanning of that region of the ISB.
2. Manufacture the auxiliary clips in a biocompatible opaque material (HP 3D HR PA12; HP Inc).[39,40]
3. Attach an auxiliary clip to each ISB and screw them to the multiunit abutments according to the manufacturer's recommendations (Fig. 2). Select the auxiliary clips that best cover the patient's interimplant spans and position them in such a way that the gaps between them and the ISBs are minimal (Fig. 2). Ensure that the auxiliary clips are firmly attached to the ISBs.
4. Obtain a complete arch implant digital scan with an IOS (TRIOS 3; 3Shape A/S) by following the manufacturer's recommendations (Fig. 3).
5. Detach the auxiliary clips from the ISBs and obtain a conventional complete arch implant digital scan with the IOS by following the manufacturer's recommendations (Fig. 4).

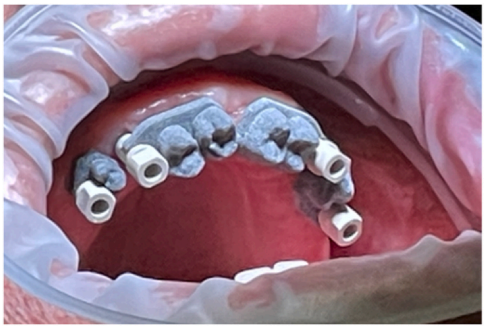

Figure 2. Auxiliary clips positioned in mouth.

6. In a dental computer-aided design (CAD) software program (exocad; exocad GmbH), superimpose a virtual design of the ISB with each ISB in the complete arch implant digital scan obtained in step 4 to obtain the position of the implants (Fig. 5). For that, common areas of the ISBs should be superimposed by using a best-fit algorithm.
7. In the dental CAD software program, split the conventional complete arch implant digital scan obtained in step 5 into as many parts as implants (Fig. 6A) and superimpose each of them with the corresponding area in the complete arch implant digital scan obtained in step 4 (Fig. 6B). For that, if the ISBs used provide orientation information, common areas of the ISBs should only be superimposed by using a best-fit algorithm. If not, common areas corresponding to the soft tissues should also be superimposed.
8. Remove or hide the complete arch implant digital scan obtained in step 4 and retain the virtual cast composed of the split complete arch implant digital scan obtained in step 5 and the virtual designs of the conventional ISBs (Fig. 7A). If necessary, remove the ISBs in the split complete arch implant digital scan (Fig. 7B).

DISCUSSION

The described technique aims to improve the accuracy of complete arch implant intraoral digital scans and provide

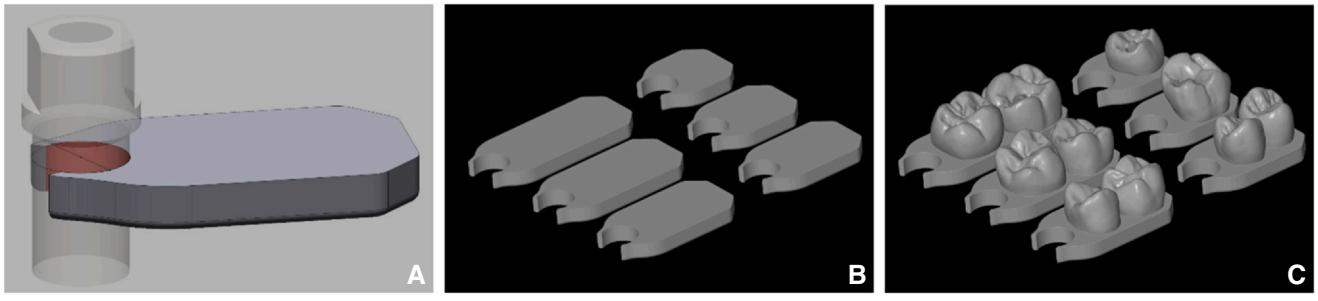

Figure 1. Creation of virtual designs of auxiliary clips for ISBs. A, Adaptation of reference virtual design of structure to used ISBs. B, Creation of virtual designs of structures of different sizes. C, Creation of virtual designs of auxiliary clips of different sizes. ISB, intraoral scan body.

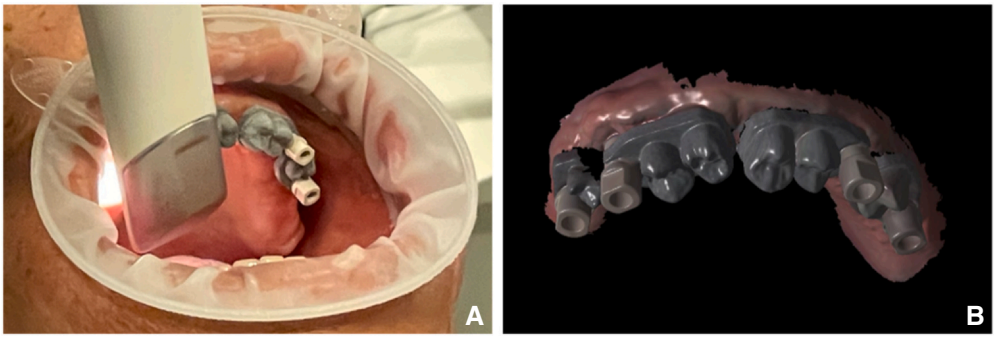

Figure 3. Acquisition of complete arch implant intraoral digital scan. A, Intraoral scan. B, Complete arch implant digital scan.

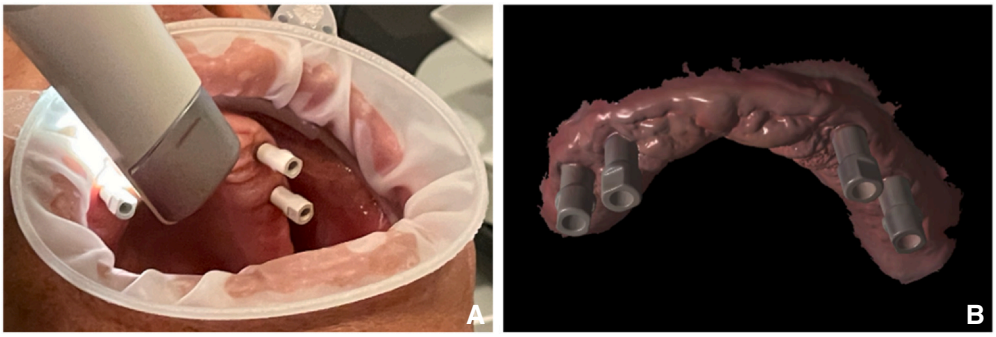

Figure 4. Acquisition of conventional complete arch implant intraoral digital scan. A, Intraoral scan. B, Conventional complete arch implant intraoral digital scan.

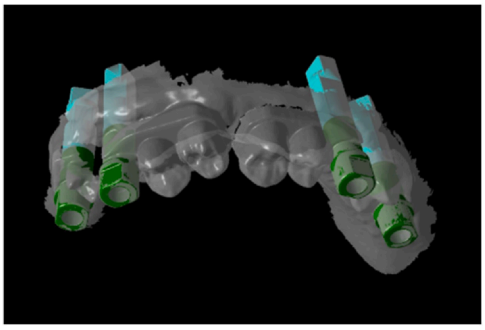

Figure 5. Superimposition of virtual designs of ISBs with ISBs of complete arch implant digital scan obtained in step 4. ISB, intraoral scan body.

more accurate virtual casts. Auxiliary clips for ISBs are used to cover smooth and movable tissues in edentulous areas with immobile geometric references that are more favorable for IOSs.

Obtaining accurate complete arch implant intraoral digital scans with IOSs has been reported to be challenging,[17–19] fundamentally because of the difficulties in accurately stitching together images of smooth and movable tissues in edentulous areas. Thus, accuracy has been reported to be improved by adding geometric references between or around the ISBs,[4,20–31] with different alternatives being proposed.[4,26–30,32] A distinctive characteristic of most alternatives is the splinting of the

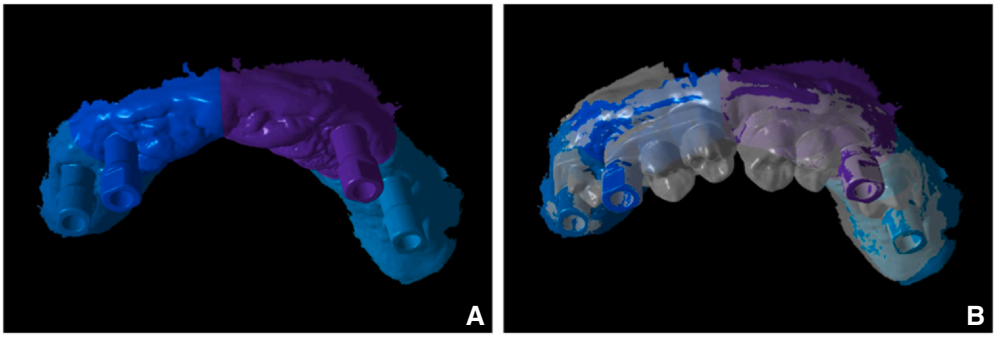

Figure 6. Splitting of conventional complete arch implant digital scan obtained in step 5 and superimposition of each part with complete arch implant digital scan obtained in step 4. A, Splitting of conventional complete arch implant digital scan obtained in step 5. B, Superimposition of each split part with complete arch implant digital scan obtained in step 4.

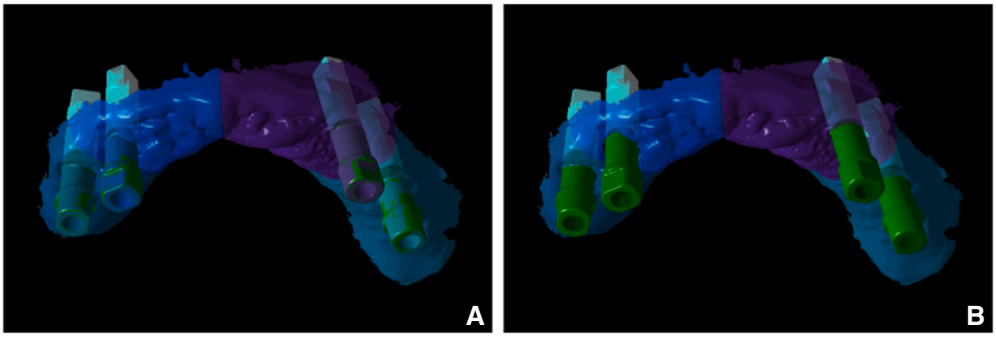

Figure 7. Obtained virtual casts. A, Virtual cast. B, Virtual cast with ISBs in split complete arch implant digital scan removed. ISB, intraoral scan body.

ISBs, typically by using auxiliary devices.[26–30,33–35] Several of these auxiliary devices, however, need to be customized,[29,30,35] requiring a previous digital scan and, therefore, an additional patient visit. The present technique, in contrast, only requires the clinic to acquire a set of auxiliary clips of different dimensions for the ISBs it uses. Once acquired, a combination of auxiliary clips that minimizes the gaps in the scanning path can be used with each patient without the need for any additional customization.

Recognizing the importance of seamless integration in existing clinical workflows, the technique is engineered to be user friendly and compatible with any IOS, allowing for straightforward adoption and implementation. The auxiliary clips are easily placed in the mouth, and obtaining a complete arch intraoral digital scan with them in place is comparable with obtaining a complete arch intraoral digital scan of a dentate patient. Auxiliary clips, in addition, are used only to add static geometric references between ISBs, so they do not need to be accurately fabricated, making them suitable for all dental clinics. The auxiliary clips could be manufactured with any additive manufacturing machine, as long as the material used is opaque and meets or exceeds the established biocompatibility conditions.[39,40] When designing the clips and selecting the manufacturing process, it should also be ensured that a firm attachment exists between the auxiliary clips and the ISBs to avoid movement of the auxiliary clips during the scanning process. However, excessive force should not be required to detach the auxiliary clip, to avoid patient discomfort or even displacement of the ISBs. Furthermore, if the auxiliary clips are intended to be reusable, the firm attachment should be maintained after multiple applications. Therefore, in that case the effects of use and sterilization cycles on the properties of the material should be considered.

The possibility of creating a library of auxiliary clips compatible with different ISBs on the market could be considered. However, studies are needed to assess the accuracy of complete arch intraoral implant digital scans obtained with this technique and to study the clip design that offers the tightest grip for different materials and fabrication methods.

SUMMARY

A technique for enhancing the accuracy of complete arch implant intraoral digital scans and more accurate virtual casts is presented. In this novel technique, auxiliary clips are attached to ISBs in order to cover edentulous spans with immobile geometric references that are favorable for intraoral scanning. To implement this technique, a clinic needs only to acquire a set of auxiliary clips of different dimensions for the ISBs it uses. Once acquired, the combination of auxiliary clips that best covers the patient's interimplant spans can be used without the need for further 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.2024.01.031.

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