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ORIGINAL ARTICLE

Additively manufactured devices with varying designs and sizes for acquiring initial intraoral implant scans

Sergi Guirao RDT[1] | **Ferran Llansana DDS**[2] | **Heather Button M Ed**[3] | **Burak Yilmaz DDS, PhD**[4,5,6] | **John C. Kois DMD, MSD**[3,7,8] | **Marta Revilla-León DDS, MSD, PhD**[3,7,9]

[1]University of Barcelona, iOSFIX, Aldosa, Spain

[2]Private practice, Palma, Spain

[3]Kois Center, Seattle, Washington, USA

[4]Department of Reconstructive Dentistry and Gerodontology, School of Dental Medicine, University of Bern, Bern, Switzerland

[5]Department of Restorative, Preventive and Pediatric Dentistry, School of Dental Medicine, University of Bern, Bern, Switzerland

[6]Division of Restorative and Prosthetic Dentistry, The Ohio State University, Columbus, Ohio, USA

[7]Department of Restorative Dentistry, University of Washington, Seattle, Washington, USA

[8]Private Practice, Seattle, Washington, USA

[9]Department of Prosthodontics, Tufts University, Boston, Massachusetts, USA

Correspondence
Ferran Llansana, DDS, Private Practice, Carrer Bisbe Massanet, 5. Palma de Mallorca, Illes Balears, 07005, Spain.
E-mail: ferran.llansana@hotmail.com

Abstract

Dental literature has reported greater intraoral scanning accuracy when implant scan bodies (ISBs) are connected compared with non-connected methods. Initial intraoral digital implant scans are required for the fabrication of a custom framework to connect implant scan bodies (IOSFix; IOSFix Dental). This calibrated metal framework is used to acquire definitive intraoral implant scans. However, the acquisition of initial intraoral implant scans can be challenging when ISBs are not connected. This article describes a step-by-step technique for connecting ISBs by using additively manufactured devices to acquire initial intraoral implant scans. This technique aims to facilitate the recording of initial intraoral implant scans, provide different device designs and sizes to connect ISBs, and reduce chairside time.

KEYWORDS
additive manufacturing, intraoral digital implant scans, prosthodontics, splinting implant scan bodies, 3D printing

Intraoral scanners (IOSs) are increasingly being implemented in dentistry. IOSs provide a digital alternative for manufacturing crowns and short-span implant-supported restorations.[1–4] However, the accuracy of complete-arch intraoral digital implant scans for complete-arch implant-supported rehabilitations is still controversial.[5–7] Different techniques have been described for the connection of implant scan bodies (ISBs), aiming to improve intraoral scanning accuracy.[8] Additionally, multiple influencing factors related to the operator skills and decisions, as well as the intraoral conditions of the patient can reduce intraoral scanning accuracy.[9,10] The understanding of these factors is fundamental for maximizing the efficiency and accuracy of intraoral digital implant scans.[9,10]

Different techniques have been previously described, which include the use of different materials such as dental floss, orthodontic wire, acrylic resin, bis-acryl composite resin, or implant-supported interim prostheses, to acquire definitive complete-arch intraoral digital implant scans.[8,11] However, these techniques can be time-consuming.[8] Additionally, when a calibrated custom metal framework (IOSFix; IOSFix Dental) is elected for recording definitive intraoral implant scans,[11] an initial intraoral implant scan is required to design and fabricate the calibrated and custom framework that will be used to connect the ISBs.[11] However, recording the initial scan without connecting the ISBs can be challenging, independently of the IOS

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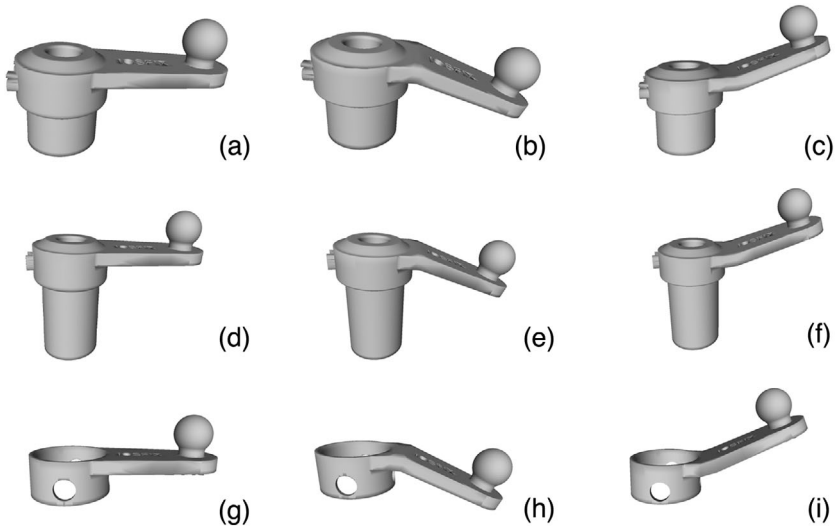

FIGURE 1 Connecting devices. (a), Screw-retained connecting device with 6.6 mm height and 0-degree inclination. (b), Screw-retained connecting device with 6.6 mm height and −25-degree inclination (c), Screw-retained connecting device with 6.6 mm height and 25-degree inclination. (d), Screw-retained connecting device with 10 mm height and 0-degree inclination. (e), Screw-retained connecting device with 10 mm height and −25-degree inclination. (f), Screw-retained connecting device with 10 mm height and 25-degree inclination. (g) Extension connecting device with 0-degree inclination. (h) Extension connecting device with −25-degree inclination. (i) Extension connecting device with 25-degree inclination.

technology and system used, especially in the mandible due to the presence of mobile tissues and lack of anatomical landmarks.[6,12,13]

This article describes a technique for connecting ISBs using additively manufactured devices to acquire an initial intraoral implant scan, which can be used to fabricate a calibrated custom metal framework (IOSFix; IOSFix Dental).[11] The calibrated metal framework would be used to acquire the definitive implant scan. The virtual designs of these devices can be additively manufactured by using a polymer 3D printer and a non-clear opaque biocompatible material, such as dental interim resin. Additionally, devices can vary in design and size, to simplify the connection to ISBs and reduce the chairside time, facilitating acquiring an initial intraoral implant scan.

TECHNIQUE

The virtual designs of connecting devices present different designs and sizes (Figure 1). There are two main designs: screw-retained (Figure 1a) and extension connecting device (Figure 1b). The screw-retained connecting device has 2 heights (6.6 and 10 mm) and 3 different angulations (0, 25, and −25 degrees) and can be tightened into the multiunit abutment (RP; Nobel Biocare) with a screw. Lastly, the extension connecting device is designed to facilitate the ISB connection, when the inter-implant distance is large, aiming to reduce the size of the edentulous area between implants.

1. Import the standard tessellation language (STL)[14] files of different connecting devices into the printer software program (PreForm; Formlabs). Select an opaque and biocompatible dental material (Temporary CB, A3; Formlabs) and position the virtual designs into the build platform. Define a 100 μm layer thickness and 0-degree print orientation and export the file to the printer (Form 3B+; Formlabs) (Figure 2).

After printing, remove the connecting devices from the build platform using a scraping tool (Print Removal Tool; Flashforge). Then, completely submerge the printed devices into a 99% isopropyl alcohol (IPA) bath (Form Wash; Formlabs) for 3 min. When finished, let the splinting devices dry on a paper towel for 30 min at room temperature. Lastly, complete the polymerization of the splinting devices in a specific polymerization unit (Form Cure; Formlabs) for 40 min at 60°C and remove the supportive material by using a cutting disk.

2. Place a screw-retained connecting device for implant abutments (Multiunit abutment, RP; Nobel Biocare) into each implant abutment and tighten the screw of an impression abutment with a screwdriver. The screw-retained connecting devices provide a rigid polymeric assembly between 2 implants, aiming to facilitate the digitizing procedure. The ball geometry of the screw-retained connecting devices should be oriented toward the occlusal surface. Select the connecting device that has the most favorable inclination (0, 25, and −25 degrees) to connect 2 implants. The 0-degree connecting piece has 0 degrees of inclination, the 25-degree connecting piece has 25 degrees of inclination towards the occlusal surface, and the −25-degree connecting piece has 25 degrees of inclination towards the apical surface.

When the distance between 2 implants is large, use the extension connecting device to ease the connection of the ISBs procedure. The connection device can be placed into the same implant abutment with a screw-retained connecting device. First place the connecting device, followed by the screw-retained connecting piece. The extension connecting device fits into the body of the screw-retained connecting piece. Similarly, the ball geometry of the extension connecting device should be oriented toward the occlusal surface. The extension connecting device can be stabilized by using a small amount of flowable composite resin material if needed.

FIGURE 2 Additively manufactured splinting devices. (a), Screw-retained devices. (b), Extension splinting devices.

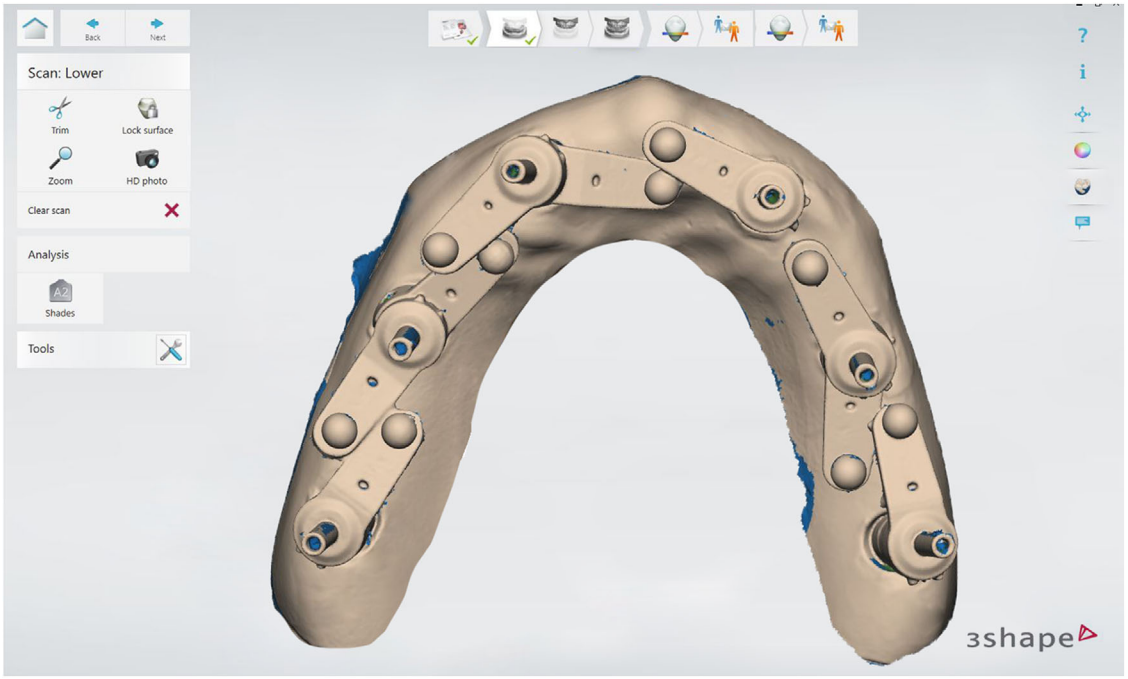

FIGURE 3 Initial intraoral digital implant scan.

The connecting devices should be in contact with each other, facilitating the rigid connection between 2 implants and the reduction of the bucco-lingual width of the connecting devices. The ball geometry also provides a stabilization point between the connecting devices and can be further stabilized by using a small amount of flowable composite resin material.

3. Obtain the initial intraoral digital scan using an IOS (Trios 4, wireless, v.21.2.0; 3Shape A/S) under optimal ambient lighting conditions following the recommended scanning pattern.[15,16] Ensure that the IOS has been previously calibrated by following the calibration[17] protocol recommended by the manufacturer (Figure 3).

The initial intraoral digital implant scan would be used to design and manufacture a calibrated custom splinting device (IOSFix; IOSFix Dental) for recording the definitive intraoral digital implant scan by using an IOS, following the technique previously described by Llansana et al.[11]

DISCUSSION

Acquiring complete-arch intraoral digital scans using IOSs can be challenging independently of the IOS technology and system selected, especially in the mandibular arch.[6,12,13] This

article describes a step-by-step technique for connecting ISBs to acquire an initial intraoral digital implant scan, which can be used for the fabrication of different custom devices, such as a calibrated custom device (IOSFix; IOSFix Dental)[11] to facilitate definitive intraoral digital implant scans. The main advantage of this technique is that it enables the use of varying designs of splinting devices to facilitate the connecting technique, ease the intraoral digitizing procedure, and reduce the time for chairside procedures.

The intraoral ISB connection can be a challenging and time-consuming clinical procedure depending on the implant positions and inter-implant distances.[8] Similar ISB connecting devices have been reported in the dental literature;[8,18] however, these ISB connecting devices were fabricated in metal[8] or polypropylene materials.[18] The present technique employs a vat-polymerized interim dental material, which can be easily accessed by dental professionals.

The connecting device designs used in this technique can be manufactured using a polymer printer and an opaque and biocompatible dental material such as interim dental resin. The selection of a clear biocompatible material is not recommended, as scanning a translucent material may be difficult.[19] These printed connecting devices can be stored in dental practice, having them prepared for clinical intervention. Although in this technique the printing accuracy is not as important as other dental printed devices, it is recommended to follow the printing and post-polymerization recommendations of the material and printer manufacturer, aiming to maximize the outcome of the printed connecting devices.[20] As an alternative, a metal printer can be used to fabricate metal connecting devices. Printed metal connecting devices could be reused, after proper sterilization, providing an advantage when compared with polymer connecting devices.

A previous dental technique described a patient-custom calibrated framework acquiring definitive complete-arch intraoral implant scans.[11] The printed metal connecting device has screw-retained milled cones, which are palpated by using a coordinate measuring machine (CMM). Therefore, the position and angulation of the cones in the framework are known and used to calculate the implant position captured in the intraoral digital implant scan and obtain the virtual definitive implant cast.[11] The CMM analysis is performed by the manufacturer of the calibrated framework (IOSFix; IOSFix Dental), not by the clinician or dental technician. Additionally, the framework's manufacturer calculates the distortion of the ISB positions of the definitive intraoral implant scan, having as a reference the known positions of the screw-retained milled cones into the custom metal framework.[11] Afterwards, the corrected definitive intraoral implant scan is provided to the dental technician for the design and fabrication of the prostheses, following the conventional computer-aided design and computer-aided manufacturing (CAD-CAM) procedures.[11]

The accuracy of the initial intraoral digital implant scans is not a critical element of the present technique, as the main purpose of the initial intraoral scan is the fabrication of the calibrated custom framework. This connecting framework is then used to record the definitive implant scan. The described technique aims to facilitate the acquisition of the initial complete-arch intraoral digital implant scan.

The described technique has several limitations. Currently, the ISB connecting devices are compatible with a limited number of implant connections and implant abutments;[14] however, the library extension of the ISB connecting devices will increase over time. The connecting devices manufactured with interim dental material may be indicated for single use, which represents an additional cost.

SUMMARY

This article describes a technique for connecting implant scan bodies by using additively manufactured splinting devices to acquire the initial intraoral digital implant scan, which can be used to fabricate a calibrated metal framework (IOSFix; IOSFix Dental) for the acquisition of definitive intraoral digital implant scan. The connecting devices have varying designs and sizes aiming to facilitate the clinical procedure and reduce chairside time. Additionally, dental professionals can use the virtual designs of connecting devices to additively manufacture multiple devices by using a polymer 3D printer and a dental biocompatible material.

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CONFLICT OF INTEREST STATEMENT

Mr Sergi Guirao has an economic conflict of interest as Chief Visionary Officer of the company that 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.

ORCID

Ferran Llansana DDS https://orcid.org/0000-0002-5375-061X

Marta Revilla-León DDS, MSD, PhD https://orcid.org/0000-0003-2854-1135

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