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A fully digital approach for implant fixed complete dentures: a case report

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ABSTRACT

Intraoral scanner has been widely used for implant impression in partially edentulous cases, however, it's accuracy in full-arch implant impression is still questionable. This clinical report presents a technique to check the accuracy of IOS for complete-arch implant restorations using an implant index cast (The Glossary of Prosthodontic Terms 9th Edition) and a three-dimensional

(3D) printed cast. A clinical case of immediate loading on a maxillary edentulous patient illustrates the application of an implant index cast in implant fixed complete dentures (IFCDs). The implant index cast was fabricated based on the immediate interim prosthesis and provides an effective control of the fit of scanned files and printed models. Therefore, this approach allows a more predictable and accurate fit of the final prosthesis.

CLINICAL SIGNIFICANCE

In this paper we present a technique to check the accuracy of the final prosthesis without the need for a conventional impression and final cast in a digital workflow. This proposed approach is demonstrated through a case report of a maxillary edentulous patient restored with an immediate loaded IFCDs.

INTRODUCTION

The increased access and use of digital technology in dentistry have improved the predictability of clinical implant treatment and related laboratory procedures. These technologies are especially valuable for implant fixed complete dentures (IFCDs) treatments. Digital approaches provide various advantages including accurate implant placement using computer-assisted implant surgery (CAIS), and fabrication of restorations by milling or 3D printing. Interim prostheses play a key role in the immediate implant loading protocol by providing instantaneous esthetics and function. Moreover, characteristics like occlusal vertical dimension (OVD), tooth shape and position are often replicated and can be improved in the final restoration.[1]

Despite the obvious advantages of intraoral scanning (IOS),[2] it is essential to investigate whether intraoral scans are clinically reliable in terms of accuracy. Accuracy is essential for the proper fit of a fixed prosthesis and it could be defined as a combination of trueness and precision. Trueness is described as the ability to capture the real entity of a measure and precision is defined as the ability to catch the same measure with subsequent samplings.[3,4,5]

Numerous studies have compared the accuracy of different intraoral scanners with conventional implant impression for IFCDs.[5-13] A limitation of this comparison is that a live patient cannot be scanned to obtain a reference dataset using a high precision laboratory scanner.

In implant dentistry passive fit of an implant-supported fixed prosthesis is critical to treatment success, especially in cases of immediate implant placement and loading.[14] Misfit of an implant prosthesis due to an inaccurate impression may induce both mechanical and biologic complications.[15] To date, it is still uncertain the predictability of fully digital protocols, using intra-oral scanners, to transfer implant position for screw-retained restorations in IFCDs. Capturing implant position to the final restoration, in this scenario, usually involves sophisticated hardware and software.[1,16] In this approach we minimize the risk of changing the vertical dimension and possible esthetic complications.

CLINICAL REPORT

A 72-year old man with failing maxillary dentition presented seeking for rehabilitation of teeth with dental implants. After clinical examination and assessment of Cone Beam Computed Tomography (CBCT) and IOS Trios 3 scan (3Shape Dental Desktop v1.6.4.1; 3Shape), treatment options were discussed (Fig. 1A-C). Most of the maxillary teeth were considered not restorable due to the severity and extension of the decays. After a discussion with the patient on varied treatment options, the plan of a full-arch extraction followed by immediate implant placement and immediate implant loading were determiend. A virtual extraction model was created using CAD/CAM software (3Shape Dental Systems 2020, 3Shape). A digital wax-up was made taking reference from remaining teeth, midline and occlusal plane using intraoral scans and intra- and extraoral photographs. A prosthetic-driven digital implant plan was performed using an implant planning software (BlueSky Plan4; BlueSky Bio) and surgical templates were designed (Fig. 2A). Three templates were designed (Fig 2B-D): a tooth supported template for drill fixation pin bed, a pin-supported guide for implant bed preparation, and a teeth color template that can be converted into an interim restoration. The surgical guides were fabricated by 3D-printing (Form2, FormLabs) using a biocompatible resin (Dental LT; FormLabs), while the interim restoration was 3D-printed using a denture tooth resin (Denture teeth A2, FormLabs). Four Implants (GM Helix, Neodent, Straumann) were placed and prosthetic abutments with 2.5mm transmucosal height were installed (GM Exact Mini Angled Conical Abutment 17°, Neodent, Straumann).

Using the same fixation pins, the interim prosthesis was stabilized intra-orally, and was connected to the abutment cylinders using a pink flowable resin (CHAIRSIDE®, Zest Dental Solutions). After final set, the interim prosthesis was removed from the mouth (Fig. 3A). For this technique, implant analogs were then attached to the interim prosthesis before finishing and connected to each other with metal bars and red acrylic resin (Pattern Resin, GC Corp.). A gingival mask silicone (Soft Tissue Moulage Gingival Replication Material, Kerr Dental) was poured out on the intaglio surface of the interim prosthesis and a laboratory putty polyvinyl siloxane (PVS) (Extrude VPS Impression Material, Kerr Dental) was used to fabricate the base of the implant index cast (Fig. 3B). Alternatively, a fast setting die stone could be used. Making the implant index cast on the day of surgery provides a physical model that can be used for repair of the interim prosthesis if technical complications (e.g., fracture) happen during the healing period. After soft tissue healing, a new intraoral scan was made to capture the soft tissue contour. Then, the interim prosthesis was scanned on the implant index cast with the IOS Trios 3 to facilitate alignment with the software. After suturing, the interim prosthesis was delivered, and occlusal adjustment was performed (Fig. 3C). A new CBCT was taken with the interim prosthesis in position (Fig. 3D) for evaluation of final implant positioning.

After four months of osseointegration and soft-tissue healing, an intraoral scan was taken of the interim prosthesis in occlusion (Fig. 4A). This file was duplicated and the existing restoration in this file was deleted. This file contained the maxilla arch and the lower arch, and it maintained the occlusal vertical dimension (OVD) of the patient. The interim prosthesis was then removed from the mouth and the soft tissue was scanned to capture the abutment profile (Fig. 4B). The implant index cast scanned with interim prosthesis was then aligned with intraoral scan files (Fig. 4C). Abutments with scan bodies were also scanned on the implant index cast using a desktop scanner (D2000, 3Shape) to allow the fabrication of final restoration and production of a digital model for 3D printing (Fig. 4D). Alternatively, the implant index cast could have be scanned with Trios IO scanner. All images can be superimposed by the dental lab and information of the interim prosthesis can be used as virtual wax-up for the final prosthesis maintaining the patient established OVD. All these procedures could be done without the need of a conventional intraoral PVS impression and bite registration to increase accuracy of final restoration occlusion.

An implant indexing device using impression copings with pattern acrylic resin was fabricated on the implant index cast (Fig. 5A). Abutment analogs were positioned on the 3D printed model with gingiva cutback and cemented in position using an implant indexing device as reference (Fig. 5B). Digital models with and without cut back were generated (Fig. 6A-D) for soft tissue material and they were 3D-printed with occlusal supporting pods (Fig. 6C-D). These casts were fabricated to represent the healed soft tissue to allow layering of pink porcelain. A PVS mask was made on 3D printed model without gingiva cutback (Fig. 6C). Analogs were kept in position to maintain space and mucosa was made using pink PVS on the 3d printed cast with gingival cutback (Fig. 6C and 6D). At this time, the implant indexing device should present a passive fit on the 3D printed model. In this case we noted during the design of the final prosthesis a possible error in the midline and because of that a prototype try-in was milled in PMMA (Ivoclar Vivadent Inc.) to verify and adjust possible errors in the midline (Fig. 7A-D). After confirming midline final prosthesis was designed and the 3D printed master cast was used for try-in of a milled restoration and pink porcelain addition. The prosthesis was designed on 3Shape Dental Systems, milled in Full contour zirconia ArgenZ HT+ (Argen Corp.) and finalized on the printed model with layered pink porcelain before try-in in the mouth (Fig. 8A-D). The first implant index cast fabricated during implant placement was the master model for implant position because it was fabricated based on the accurate implant position using the interim restoration as an implant indexing device. Additional casts based on intraoral scans were done to reflect healed gingival tissue but aligned to the original model based on the interim prosthesis to allow fabrication of final restoration. This technique avoids the need for conventional final impression and subsequent bite registration.

DISCUSSION

The present case report demonstrates a technique to improve the accuracy of the digital workflow through the combined use of an index cast that provides validation of obtained digital files. The technique used here intends to address a key determinant of clinical IFCD success, passive fit. Accuracy of the impression and master cast is critical to the fabrication of a well-fitting prosthesis that avoids mechanical and biological complications. Current protocol includes a conventional impression that after pouring the master cast the lab then scans the cast. Because of that now it is necessary to fabricate record bases or any other type of device to capture the proper occlusion and mount in the articulator. Mounting can lead to errors in occlusion that could require extensive adjustments. Our proposed approach eliminates the need for conventional impression and conventional mounting in the articulator. The implant index cast permits to have a physical model that can be used at any time to verify passive fit of the final restoration and confirm that the scans were done properly. If the clinician does not have an intraoral scanner that is accurate enough, that same implant index cast can be scanned with scan bodies using a desktop scanner and files can be aligned with the soft tissue and occlusion scan of the interim prosthesis.

IOS systems have been advocated to facilitate impression making procedures by reducing working time and improving patient comfort.[17] However, the scanning of a completely edentulous arch is still challenging through limitations such as presence of mobile mucosa,[18] light reflection, [19] inter-implant distance, and scanning protocol.[20] Moreover, the absence of anatomic landmarks such as teeth represents a difficulty for the registration and superimposition of images recorded by intraoral scanner.[21] In this approach, an implant index cast made using the immediate interim prosthesis can be scanned with a desktop scanner avoiding the limitation of using IOS and conventional final impression fabrication.

In-vitro studies have tested intraoral scans for multiple implants in the edentulous jaw reporting an overall questionable accuracy.[10,22–24] However, studies also describe little discrepancies, within a clinical acceptable range, for intraoral scans of straight and/or tilted implants in edentulous casts.[6,9,12,25] Continuing, a recent clinical study evaluating the 3D accuracy of full-arch digital implant scans in 16 patients concluded that despite the mean deviation of 162 ± 77µm, a complete digital workflow in the fabrication of maxillary IFCDs may be clinically feasible.[8] With conflicting data regarding the accuracy of complete-arch scans, it is logical to assume that development of straight-forward methods to clinically test the accuracy of IOS in such clinical situations are needed. Alternatively, the implant index cast with and without the scan bodies (Fig. 4C and 4D) can be scanned in an IOS. However, the fit of the prosthesis has to be carefully evaluated on the implant index cast.

The authors present a technique that can be useful to reduce the clinical and laboratory steps in manufacturing a framework and/or final restoration. To date, many different methods have been used to test the accuracy of IOS in complete-arch impressions. Most of them used complex software restricted to a research scenario where clinical application on daily basis would be difficult and costly.[8,10] Advantages of the presented procedure includes substantial elimination of multiple clinical visits to evaluate prosthesis fitting, thus reducing chair time and treatment costs. The implant index cast offers the clinician and the dental laboratory the opportunity to validate a 3D printed cast generated from the digital file and check passivity of the prosthesis prototype. To the authors' knowledge, there is no clinical trial measuring the accuracy of fit of prostheses generated with a complete digital workflow and this is necessary to validate this promising technique.

It is not advisable to perform occlusal adjustment using the 3D printed models in the technique here reported. Minimal deviations in the apical-coronal direction when placing the analogs can generate substantial differences in the occlusal contacts. Therefore, this model is ideal to help the technician when layering pink porcelain. Moreover, limitations of this workflow, including the extrapolation of laboratory work into the clinical field, should be done with caution since its evidence is limited to this case report. Also, this procedure demands a certain degree of operator experience for both analogue and digital workflows to obtain clinically satisfactory outcomes.

SUMMARY

This case report describes a technique that uses an implant index cast in which the dentist is able to validate the scanning of complete edentulous arch with an intraoral scanner before fabrication of an implant fixed complete dentures (IFCDs). The implant index has the advantage of producing an additional interim prosthesis in times of need.

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FIGURE CAPTIONS

Figure 1A: Initial intraoral labial view. 1B: Panoramic view of CBCT showing failing maxillary dentition. 1C: CBCT image of the planned implant position.

Figure 2A: Four implants were virtually planned following prosthetically-driven implant positions based on intraoral scan and intra and extraoral photography. 2B: 3d printed interim prosthesis fabricated for intraoral pick-up. 2C: Surgical guide for implant placement in position after teeth extractions were performed.

Figure 3A: Interim prosthesis after intraoral pick-up of abutment temporary cylinders. 3B: Implant index cast fabricated from the interim prosthesis. The abutment analogs were connected with metal bars and resin pattern acrylic to prevent rotation and distortions. 3C: Interim prosthesis finished in the mouth. 3D: CBCT taken after implants healing (4 months) (compare implant position with Figure 1C).

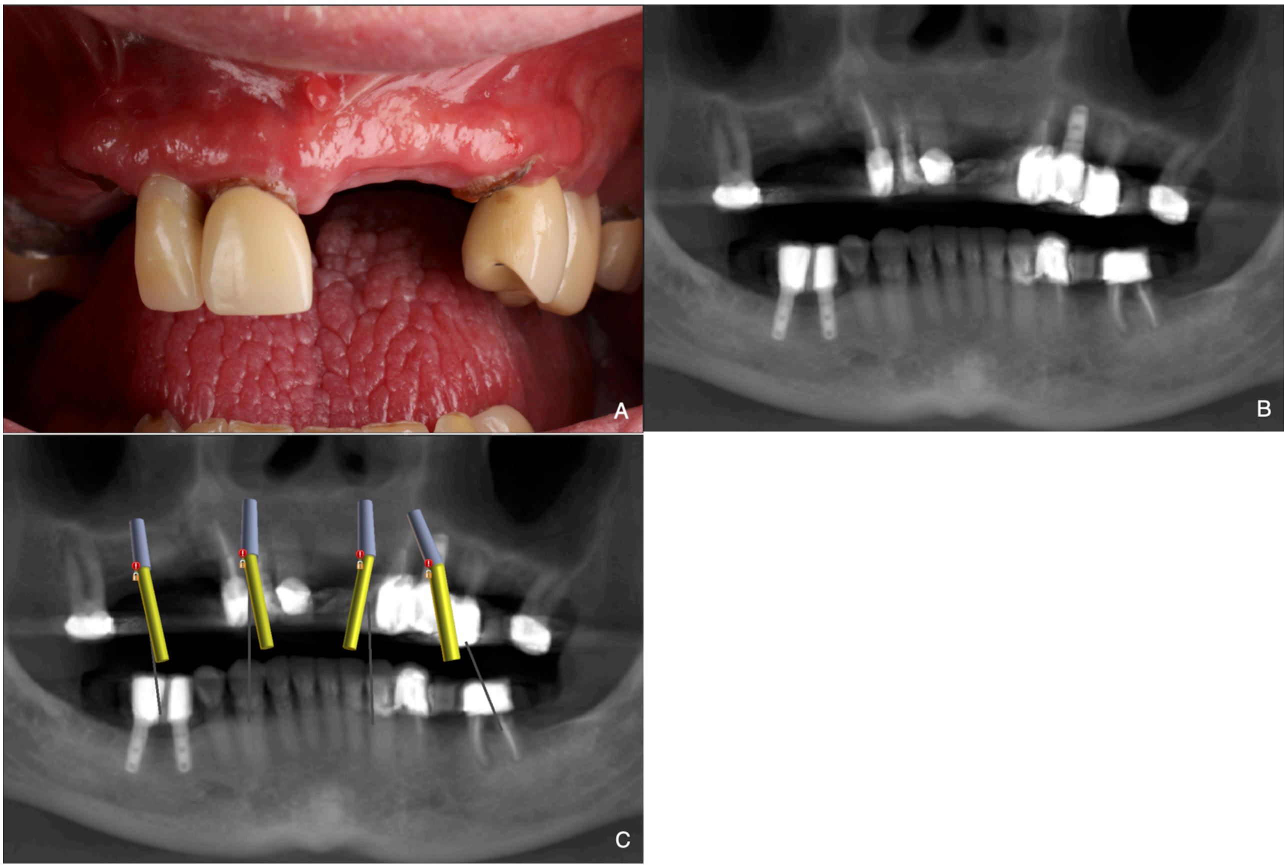
Figure 4A: View of intraoral scan of interim prosthesis in occlusion. 4B: Interim prosthesis is removed and mucosa is scanned to maintain occlusal vertical dimension (OVD). 4C: Alignment of digital files from maxilla and implant index cast using the interim prosthesis scanned on the implant index cast. 4D: Implant index cast, maxillary edentulous ridge with abutment and files with scanbodies positioned on the implant index cast were aligned to allow fabrication of final prosthesis and digital model for 3d printing.

Figure 5A: Implant indexing device fabricated on implant index cast. 5B: Analogs were positioned on 3D printed model with gingiva cutback and cemented in position using implant indexing device as reference.

Figure 6A: Digital models were generated without cut back and. 6B: with cutback for soft tissue material. 6C: PVS mask made on 3d printed model without gingiva cutback. Analogs kept in position to maintain space. 6D: soft tissue made using pink PVS on the 3d printed model with gingival cutback.

Figure 7A and B: Intraoral scan with temporary aligned and used to design try-in prototype. 7C and 7D: Try-in prototype milled in PMMA and tried in patients mouth correcting midline.

Figure 8A and B: Final prosthesis designed based on milled prototype on articulated cast for pink porcelain build up. 8C and D: Final prosthesis in the patient’s mouth.



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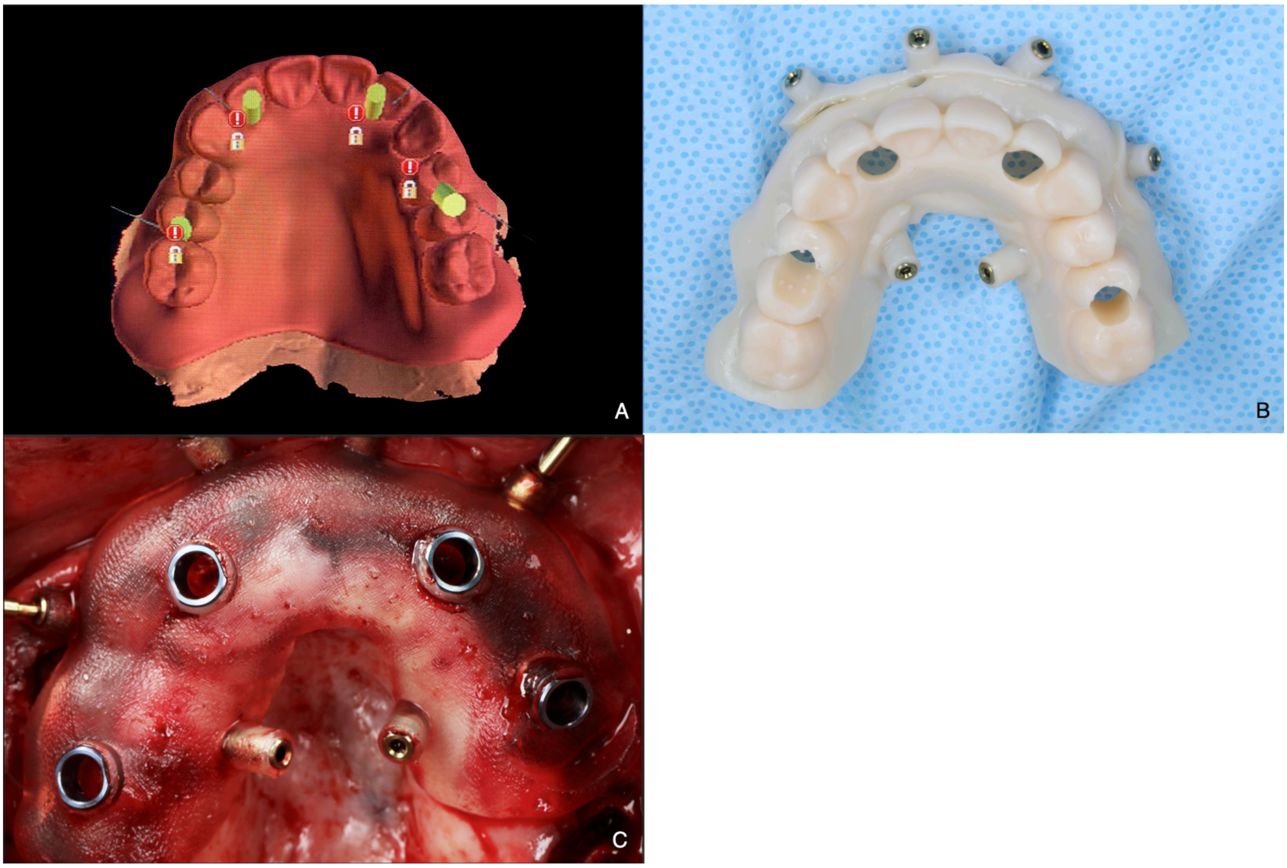

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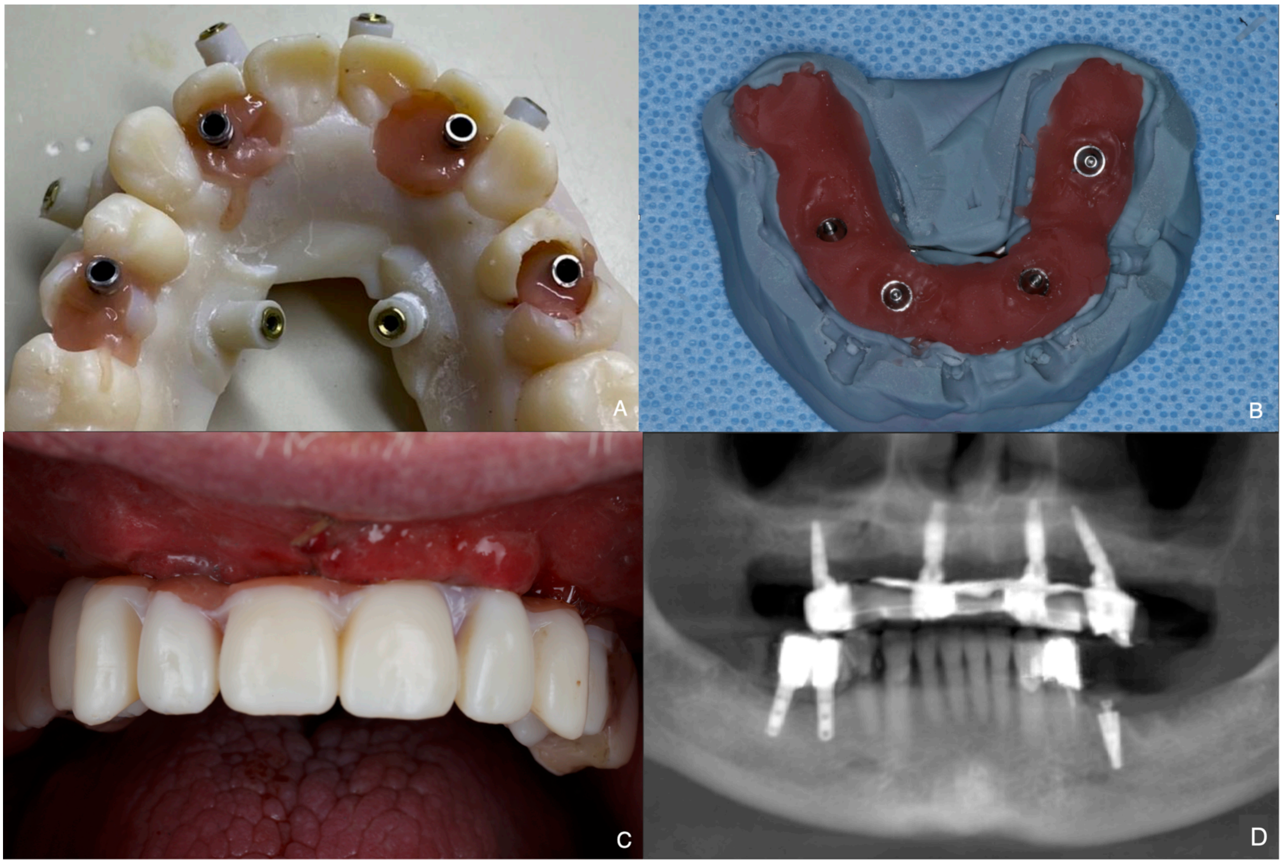

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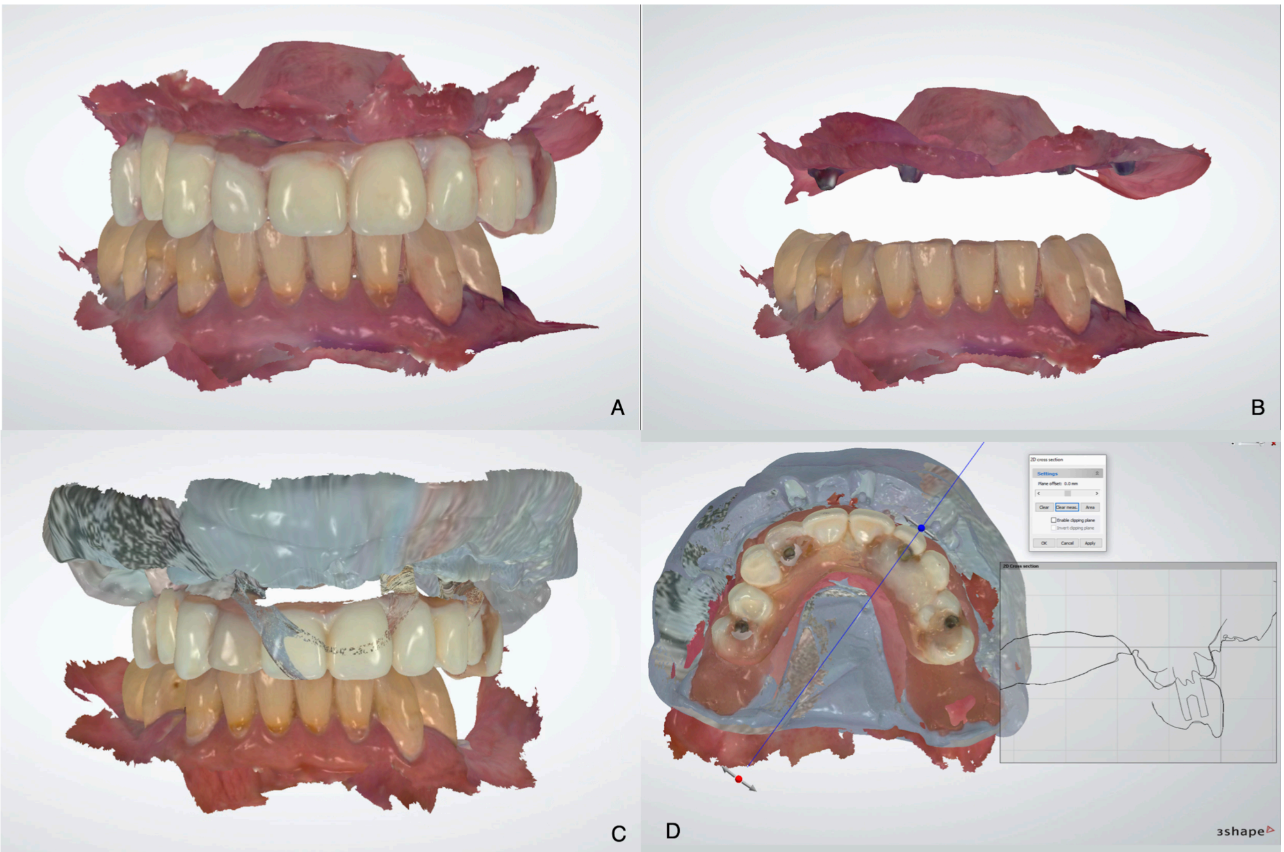

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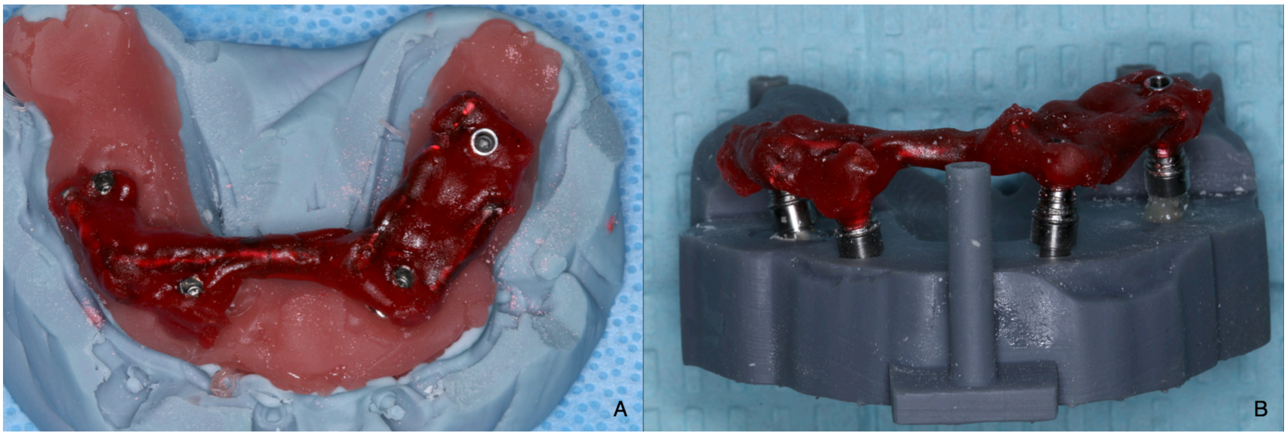

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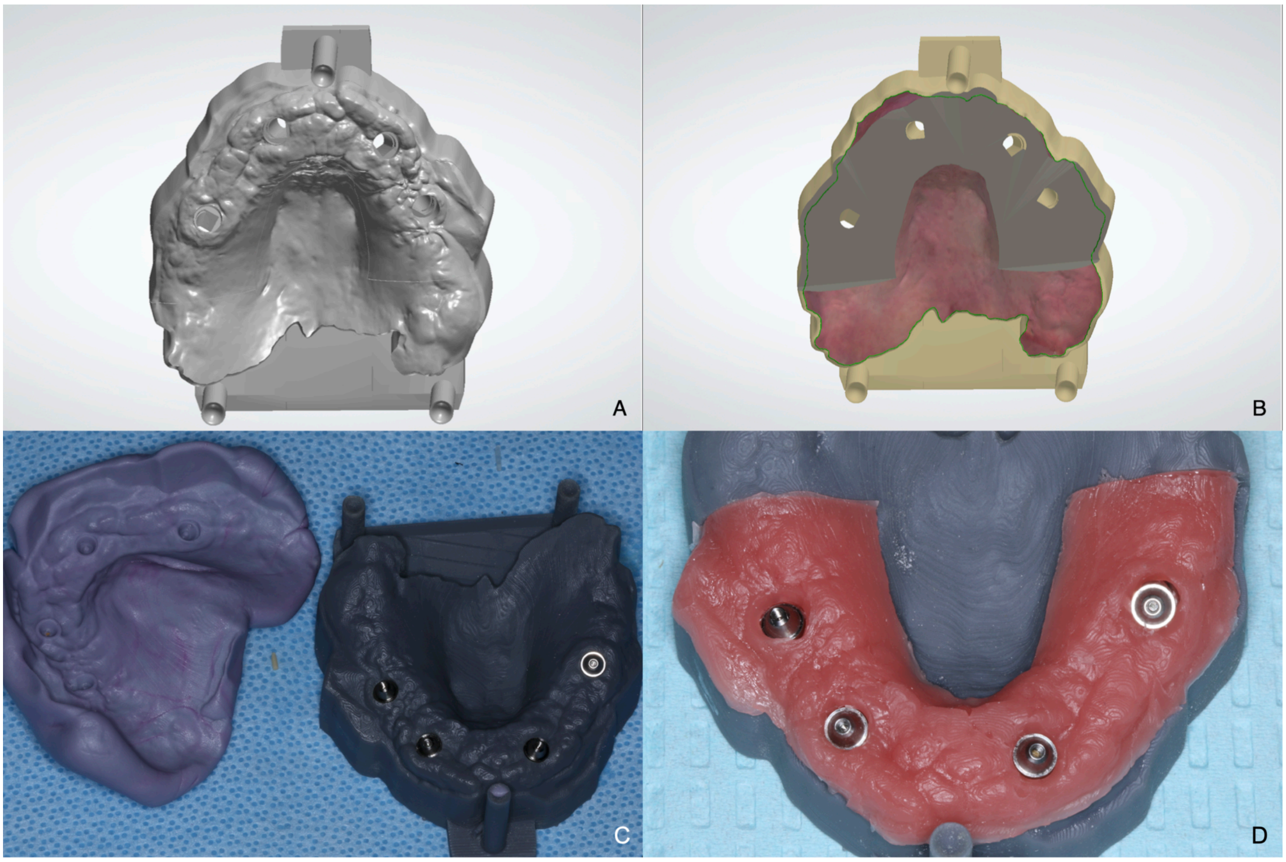

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A fully digital approach for implant fixed complete dentures: a case report

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