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DENTAL TECHNIQUE

# Using postoperative CBCT to enhance preoperative planning integration in complete arch implant rehabilitation

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## ABSTRACT

In biorestoratively driven implant treatment planning, the initial prosthetic design is determined before implant placement. However, in patients with a terminal dentition, the loss of vertical dimension after tooth extraction and the absence of reference teeth complicate the alignment of the prosthetic design with the postextraction clinical situation, as well as precise occlusal registration and optimal tooth positioning. This article introduces a novel workflow that employs an additional cone beam computed tomography (CBCT) scan after implant placement to enhance data alignment, prosthetic rehabilitation, and occlusal registration for complete arch immediate loading of dental implants. By integrating preoperative and postoperative CBCT scans and utilizing stable bony landmarks as reference structures, this method effectively transfers preoperative planning into the postoperative intraoral environment. Unlike removable appliances or fiduciary markers, which are prone to misalignment, this technique ensures accurate prosthesis insertion with minimal adjustments, is adaptable to various workflows, including freehand implant placement, and provides a reliable and versatile solution to optimizing the outcomes of implant-supported prostheses. (J Prosthet Dent xxxx;xxx:xxx-xxx)

Bio-restorative implant planning has been considered pivotal in achieving a healthy supracrestal tissue complex and successful implant-supported prostheses.[1] The preoperative assessment of both esthetic and functional factors establishes the foundation for defining prosthetic treatment objectives.[2] In patients with a terminal dentition, the existing teeth serve as critical reference points for preoperative treatment planning, facilitating the evaluation of essential parameters such as the occlusal plane orientation, incisal edge position, vertical dimension of occlusion (VDO), and maxillomandibular relationship.[3] Digital technologies now facilitate implant-prosthetic planning by registering the maxillomandibular relationship and creating a virtual patient where the initial situation, prosthetic design, and biological information obtained from intraoral scans and radiological information can be combined to enable. comprehensive treatment planning.[3] The integration of digital workflows –intraoral scanning, static occlusal registration, maxilla-mandibular registration, and computer-aided design and computer-aided manufacturing (CAD-CAM) - has been reported to simplify procedures, improve patient communication and comfort, and enhance treatment outcomes by optimizing the accuracy of implant positioning.[4–8]

The acquisition of volumetric digital imaging data and registration techniques provides comprehensive information on hard and soft tissues.[9,10] Within the digital workflow, the preoperative treatment goals are transferred to the clinical situation using stable anatomic landmarks such as remaining teeth.

In patients with a terminal dentition, correlating the preoperative plan with the postoperative situation—-after tooth extraction and implant placement—can be challenging because of the absence of reliable landmarks. In such patients, soft tissue landmarks may offer a solution for data registration.[11,12] Distinctive and stable

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soft tissue features such as the rugae in the maxillary arch can be used as reference points. However, when soft tissue anatomy changes because of flap elevation during surgery or when stable areas are lacking, as in the mandibular arches, registration accuracy may be compromised unless additional surgical fiduciary markers are used.[13] These markers can result in discrepancies between the prosthetic components and the initial planning, potentially requiring significant intraoral adjustments, such as in the maxillomandibular relationship, particularly the occlusion, and in the esthetic parameters.

This technique article introduces a novel clinical workflow using preoperative and postoperative cone beam computed tomography (CBCT) scans for data alignment in patients with a terminal dentition. Preoperative prosthetic planning is registered with a postoperative CBCT using bony anatomic landmarks. Using the implant structures in the postoperative CBCT, a postoperative intraoral scan capturing the implant locations and the soft tissue information is matched with the remaining data sets. This workflow enables the seamless transfer of the preoperative digital prosthetic design to the postsurgical clinical situation, facilitating the fabrication of implant-supported prostheses based on the preoperative plan. While the example used in this article illustrates the fabrication of an interim prosthesis, the described technique using postoperative CBCT is intended for general occlusal registration and is applicable to both interim and definitive restorations.

## TECHNIQUE

1. Make a digital scan of the patient's terminal dentition using an intraoral scanner (TRIOS 5; 3Shape A/S), including a buccal scan captured at the intended vertical dimension of occlusion (VDO) of the definitive rehabilitation.
2. Design an idealized digital diagnostic tooth arrangement using a CAD software program (DentalCAD 3.0 Galway; exocad GmbH), incorporating facial esthetics, occlusion, bone anatomy, and soft tissue contours. Use this design as the reference for the intended prosthetic restoration and VDO (Fig. 1).
3. Make a CBCT scan (Veraviewepocs 3D R100; J. MORITA Mfg Corp) of the maxilla and mandible with the teeth slightly apart. Ensure the teeth are out of occlusion to reduce scatter and to enable accurate registration of the digital scans. Do not use this scan for occlusal or prosthetic references.
4. Import the intraoral scans and diagnostic tooth arrangement into an implant planning software program (coDiagnostiX; Dental Wings GmbH). Align each jaw individually to the CBCT using the digital scans as the reference for positioning (Fig. 2). Virtually plan implant positions based on the diagnostic tooth arrangement and anatomic landmarks.
5. Proceed with implant placement surgery in either a freehand approach, or use static or dynamic guided protocols to facilitate implant placement and any required bone modification (Fig. 3).
6. Immediately after implant placement, make intraoral scans of the maxillary and mandibular arches. Ensure that the scans capture the edentulous soft tissues and the protective caps placed on the multiunit abutments (Screw Retained Abutment; Institut Straumann AG) (Fig. 4A, B). Make a postoperative CBCT scan and register it to the intraoral scans using the protective caps as common reference points (Fig. 4C, D).
7. Export the registered datasets for each arch separately.
8. Align the postoperative CBCT and IOS data with the preoperative scans and the diagnostic tooth arrangement using the anatomic bony landmarks, including the zygomatic process, floor of the nose, pterygoid plates, mandibular border, mental foramen, and coronoid process (Fig. 5). At this stage, the jaws are not yet in the preoperatively planned occlusion or VDO because the CBCT based alignment reflects the postoperative jaw position.
9. Register the postoperative intraoral scans and the diagnostic tooth arrangement to the original


**Figure 1.** Digital diagnostic tooth arrangement based on preoperative intraoral scan and extraoral photographs.

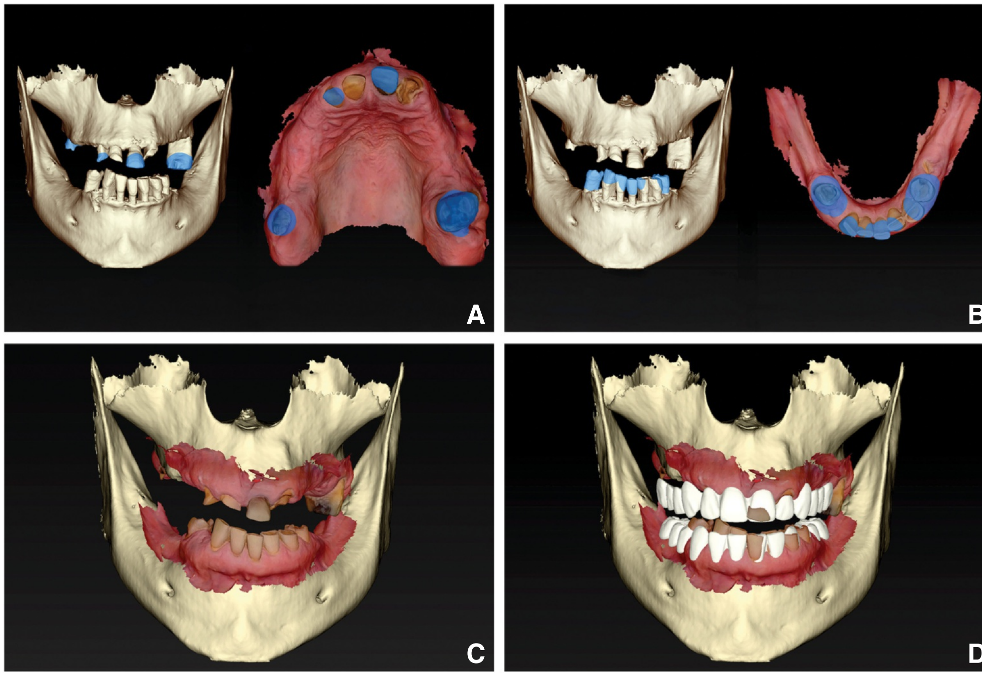


**Figure 2.** Registering preoperative maxillary and mandibular intraoral scans to cone beam computed tomography (CBCT) using teeth as common references. Note that CBCT made with teeth separated out of occlusion.

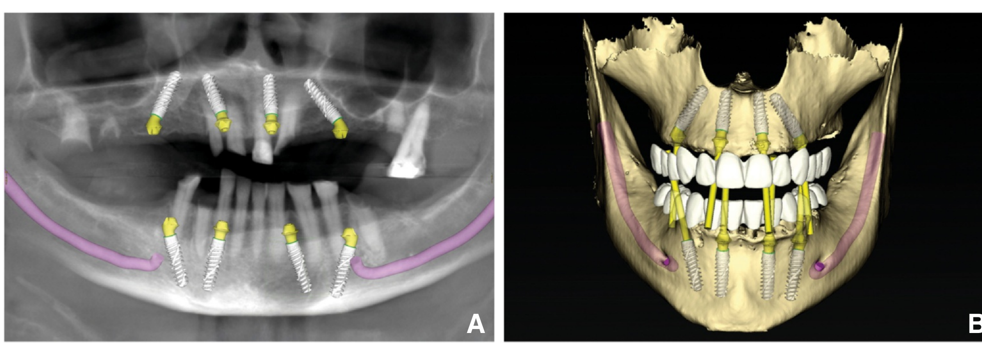


**Figure 3.** Implant planning for static computer-assisted implant surgery (sCAIS) using implant planning software program.

preoperative occlusal registration. This restores the original jaw relationship and occlusal position and allows prosthetic planning to proceed based on the initially prescribed VDO (Fig. 6).

10. Use a photogrammetry system (iCam4D; Imetric 4D Imaging Sàrl) to make a digital record of the implant positions. Register the implant positions to the soft tissue scans using the protective caps as common references. Alternatively, make intraoral scans with scan bodies or use a definitive cast from a conventional impression and register them in the same manner (Fig. 7).
11. Design the prosthesis using the registered implant positions and the preoperative digital tooth arrangement as a guide (Fig. 8A). Fabricate and deliver the prosthesis within 24 hours. Verify the fit, occlusion, and midline alignment using radiographs and a modified Sheffield test to confirm passive seating (Fig. 8B, C).

## DISCUSSION

The technique presented facilitates the effective transfer of preoperative information to the postoperative intraoral environment. This method leverages both preoperative and postoperative CBCT scans for accurate registration using bony landmarks. By relying on stable radiographic bony landmarks, such as the zygomatic bones, floor of the nose, pterygoid plates, inferior border of the mandible, mental foramina, mandibular ramus, and coronoid process, the described method enables the accurate transfer of the preoperatively defined prosthetic position into the post operative dataset. By maintaining

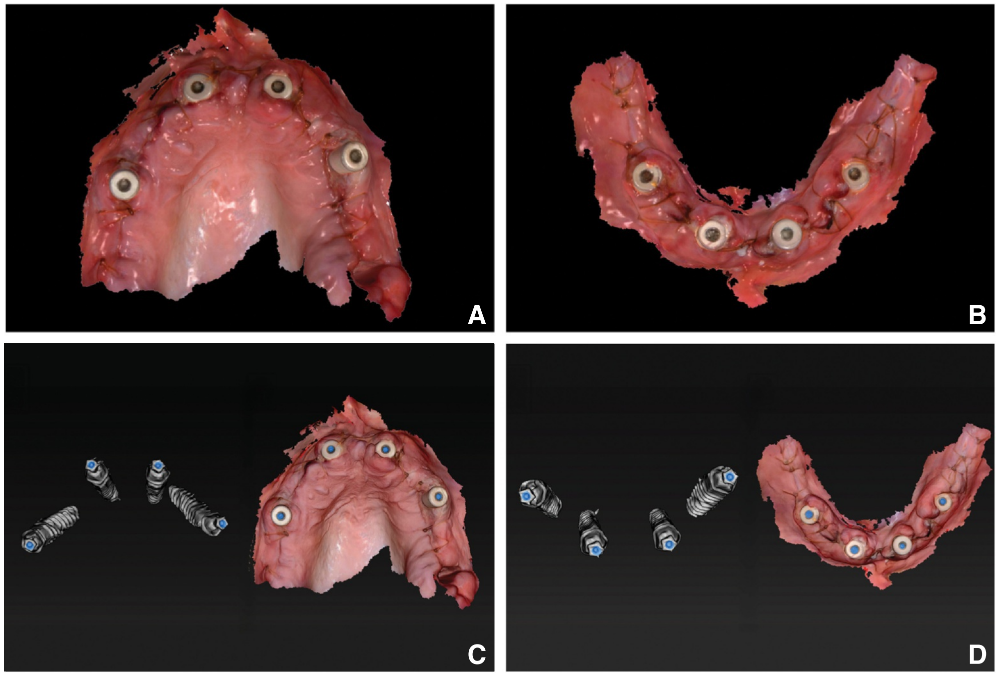


**Figure 4.** Postoperative intraoral scans of soft tissues and implant protective caps. A, Maxilla. B, Mandible. C, D, Registration of maxillary and mandibular soft tissue scan with postoperative CBCT scan using prosthetic screws within implant protective caps as common references. CBCT, cone beam computed tomography.

the occlusion and vertical relationship of the jaws from the preoperative to the postoperative phase, this method minimizes the risk of misalignment after implant placement. As a result, mandibular and maxillary prostheses can be inserted with minimal need for occlusal adjustments. Moreover, the technique can be integrated with various workflows and implant placement protocols, including freehand implant placement.

Alternatively, a removable appliance, such as a denture, may be used for intraoral pickup and reline after implant placement, and the conventional interocclusal record then digitally scanned; however, such appliances often exhibit reduced fit after surgical interventions because of soft tissue alterations.[14,15] Therefore, their use postsurgically may not yield accurate results. Additionally, after the extraction of all teeth, the habitual occlusion is lost, compromising the patient's ability to correctly position the jaw; this, in turn, diminishes feedback regarding the accurate positioning of removable appliances.

Another method involves the use of fiduciary markers such as surgical screws or pins secured in the palate, retromolar area or buccal vestibule.[13] However, this approach carries the risk that these appliances may move during treatment, and, in some patients, limited available space may prevent their effective application.

Although this example demonstrates the design and delivery of an interim restoration, the described protocol

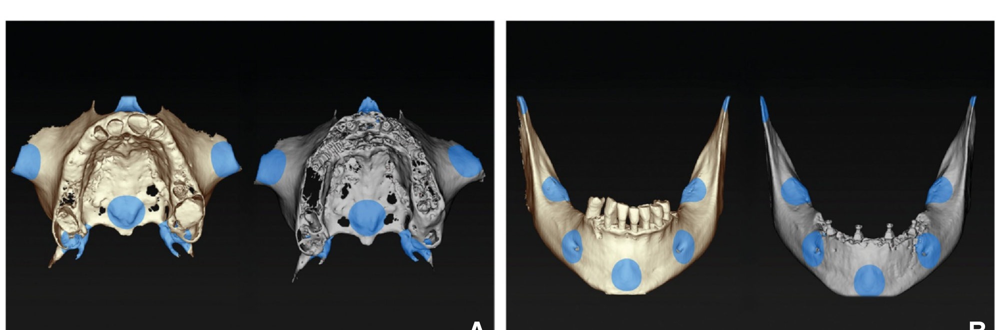


**Figure 5.** Individual registrations. A, B, Maxillary and mandibular jaws from preoperative CBCT with postoperative CBCT using anatomic landmarks, including zygomatic processes, anterior nasal spine, floor of the nose, pterygoid plates, inferior border of mandible, mental foramina, and coronoid processes. CBCT, cone beam computed tomography.

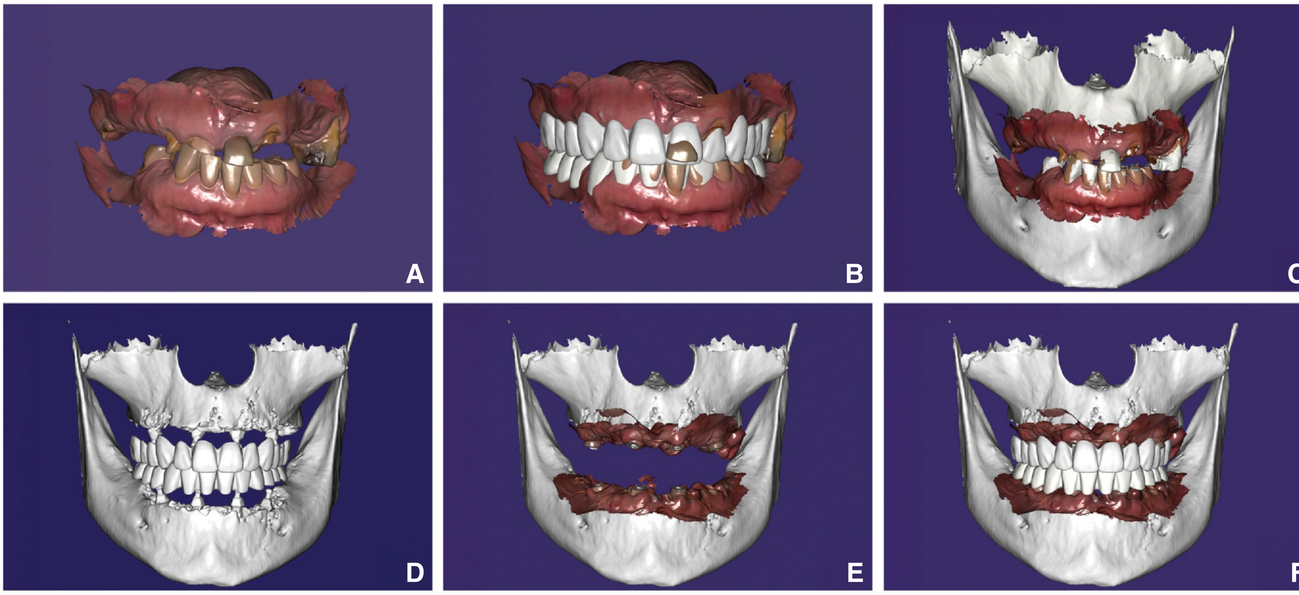

Figure 6. Alignment of all preoperative and postoperative maxillary and mandibular scans. A, To original occlusal registration from preoperative intraoral scan. B, To digital diagnostic tooth arrangement. C, Preoperative segmentations of maxillary and mandibular jaws individually aligned into occlusion. D, Postoperative CBCT scan brought into same occlusion. E, Registration of postoperative intraoral scans. F, Complete dataset. CBCT, cone beam computed tomography.

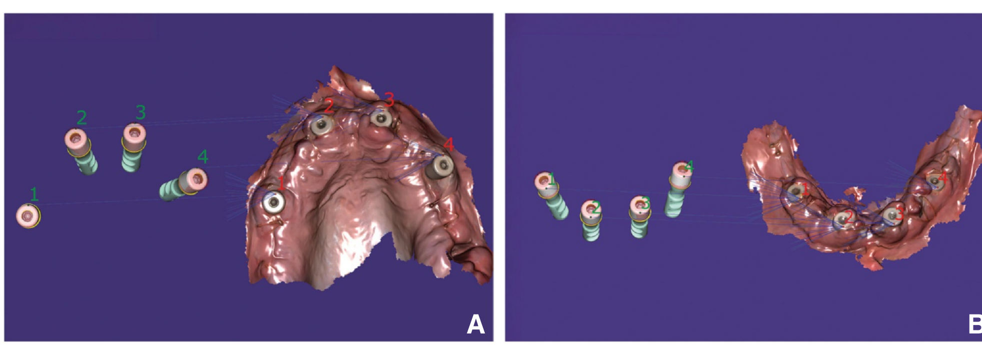

Figure 7. Registration of implant-abutment positions from photogrammetry, intraoral scans, or conventional impressions to soft tissue scan using protective caps as references. A, Maxilla. B, Mandible.

is equally applicable when indications are present for immediate loading with a definitive restoration. In such situations, a prototype or evaluation phase is strongly recommended to verify the occlusal relationship and ensure accuracy before fabricating the definitive prosthesis. Despite offering highly accurate registration of the preoperative prosthetic plan, the technique has certain limitations. It requires an additional CBCT scan after

Figure 8. A, Computer-aided design of interim prosthesis using postoperative implant positions and preoperative waxing. B, C, Insertion of interim prosthesis.

implant placement, which extends the working time. The new CBCT needs to be registered with the preoperative prosthesis design, final adjustments to the prosthesis based on the actual implant positions need to be performed, and the modified interim prosthesis needs to be fabricated. This process can lead to increased waiting times for the patient on the day of delivery. Furthermore, the additional CBCT scan results in increased radiation exposure, a factor that must be carefully considered in the overall treatment plan.[16,17] However, the postoperative CBCT may provide valuable benefits such as the radiographic verification of implant positions relative to anatomic structures, thereby justifying its use independently of the specific technique discussed.

## SUMMARY

A workflow using preoperative and postoperative CBCT scans to improve complete arch implant rehabilitation is introduced. By aligning prosthetic planning with surgical outcomes via bony landmarks, enhancing accuracy, minimizing adjustments, supporting immediate prosthesis insertion, and offering a highly accurate, adaptable, alternative to conventional methods using removable appliances or fiduciary markers.

## PATIENT CONSENT

Written informed consent for inclusion of photographs and screenshots was obtained from the patient.

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