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Opportunistic Use of a Pre-existing CBCT Dataset for Fabrication of an Immediate Mandibular Removable Partial Provisional Prosthesis: A Clinical Technique

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Abstract

Immediate removable partial provisional prostheses are commonly fabricated from conventional impressions, intraoral scans, or diagnostic casts; however, medically time-sensitive patients may be unable to attend multiple appointments for impression making, occlusal registration, laboratory design, and prosthesis delivery. This clinical technique describes the opportunistic use of a pre-existing cone beam computed tomography dataset to fabricate an immediate mandibular removable partial provisional prosthesis for a patient requiring rapid elimination of odontogenic infectious foci before planned hip replacement surgery. A CBCT scan originally obtained for implant planning was exported in DICOM format and imported into 3D Slicer. Threshold-based segmentation was performed using case-specific gray-value limits selected to reduce metallic interference and include the gingival soft-tissue contour as far as possible. Median smoothing and the Scissors tool were used to refine and separate the maxillary and mandibular segmentations, which were exported as STL files. The STL meshes were imported into Exocad PartialCAD Rijeka 3.1, where mesh trimming, mesh closure, surface smoothing, manual articulation, artificial tooth arrangement, and denture-base design were performed. The mandibular model, provisional denture base, and prosthetic teeth were printed separately.

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The printed teeth were bonded to the denture base, and a flexible acrylic retentive extension was incorporated. On the surgical day, teeth 43 and 44 and the residual root of 46 were removed, the infected sites were curetted, and the prefabricated prosthesis was inserted after chairside soft relining and occlusal adjustment. This workflow enabled fabrication and delivery of an immediate mandibular removable partial provisional prosthesis without an additional preoperative impression appointment. The technique may be useful in selected medically time-sensitive patients, but it should be considered an adjunctive workflow rather than a replacement for conventional impression or intraoral scanning protocols when those are feasible.

Keywords

CBCT; DICOM; STL; Removable partial denture; Immediate provisional prosthesis; Digital dentistry; Additive manufacturing; Dental technique.

Introduction

Immediate removable partial provisional prostheses are frequently required after extraction of teeth with poor prognosis, especially when tooth loss may compromise function, appearance, or patient comfort during healing. Conventional fabrication usually involves impression making or intraoral scanning, occlusal registration, laboratory procedures, and delivery after extraction. In medically time-sensitive situations, however, reducing the number of appointments may be clinically advantageous.

The evolution of digital dentistry has facilitated the development of fully digital workflows for removable prosthodontics. Kanazawa et al [1]. described an early trial of a computer-aided design and computer-aided manufacturing (CAD-CAM) system for fabricating complete dentures, utilizing a five-axis milling machine and 3D imaging to reproduce the denture base and artificial teeth. Since then, intraoral scanning and CAD-CAM technologies have been successfully applied to the fabrication of immediate prostheses. For example, a fully digital workflow for an immediate complete denture has been described, utilizing an intraoral scanner to capture the dentition before extraction, followed by digital tooth removal and prosthesis design [2]. Furthermore, CAD-CAM systems are increasingly being used to design and manufacture removable partial dentures, offering improved accuracy and efficiency compared to conventional methods [3].

Cone beam computed tomography (CBCT) has become an essential diagnostic tool in dentistry, particularly for implant planning, three-dimensional anatomical assessment, and digital treatment planning [4]. Charette et al [5]. described a digital workflow in which CBCT imaging was used as the primary diagnostic tool for virtual planning, computer-guided surgery, and CAD-CAM fabrication of interim removable and fixed prostheses. In their report, diagnostic impressions and casts were not required in the proposed workflow, although careful patient selection and clinical verification remained essential.

More recently, techniques have been developed to superimpose and merge various digital datasets to enhance surgical and prosthetic planning. Carosi et al [6]. described a method to merge an intraoral optical scan of the edentulous maxilla with a CBCT scan using a modified radiographic template, thereby combining soft tissue topography with underlying bone architecture. Similarly, Abdelaziz and Elshikh⁷

reported the digital design of a hybrid bone- and tooth-supported surgical guide, demonstrating the feasibility of merging segmented CBCT bone data with intraoral scan data of the remaining teeth and soft tissues. These advancements highlight the growing capacity to utilize CBCT data beyond traditional osseous evaluation, extending into the realm of prosthetic and surgical guide design.

The present article describes a modified and opportunistic clinical workflow. A CBCT scan that had been acquired before the urgent prosthetic need was reused as the primary anatomical dataset for fabrication of an immediate mandibular removable partial provisional prosthesis. Unlike an ideal prosthetic CBCT protocol, the scan had not been obtained in maximum intercuspation and was not originally intended for denture fabrication. Therefore, the technique required digital compensation, artificial articulation, chairside soft relining, and clinical occlusal adjustment at delivery.

Clinical situation

A 52-year-old female patient initially attended Unique Dental, Dublin, Ireland, on 27 March 2025 for assessment of implant placement in the mandibular right posterior region, involving sites 44 and 46. A CBCT scan was obtained for implant planning. The scan was acquired with standard head positioning; however, it was not recorded in maximum intercuspation because the patient was biting on the positioning device during image acquisition.

The patient did not return immediately because of professional commitments requiring travel between Ireland and England. In early June 2025, she sustained a hockey-related accident in England and was subsequently diagnosed with the need for right hip replacement surgery. Because the planned orthopaedic procedure required management of potential odontogenic infectious foci, the dental treatment plan was modified.

Tooth 44 remained indicated for extraction. Tooth 43 had initially been considered for endodontic retreatment; however, because of the extent of periapical infection and the limited time available to confirm lesion regression before orthopaedic surgery, extraction was selected as the more predictable approach for rapid elimination of the infectious focus. A residual root in the 46 region was also planned for removal.

The clinical objective was to fabricate an immediate mandibular removable partial provisional prosthesis before the surgical appointment, using the previously acquired CBCT dataset. This would allow the patient to attend for extraction, debridement, immediate prosthesis insertion, and continuation of medical care without an additional impression appointment.

Technique

1. Export the pre-existing CBCT scan in DICOM format and import the dataset into an open-source medical image computing platform (3D Slicer version 5.10.0; Brigham and Women's Hospital).⁸ Open the Segment Editor module and create a new empty segmentation. Select the CBCT volume as the source volume to allow the dataset to be segmented and visualized in sagittal, coronal, and axial views.

2. Perform threshold-based segmentation. In this case, the upper threshold was adjusted to 2942.59. This case-specific gray-value limit was selected by progressively modifying the threshold until the metallic component of the patient's fixed prosthesis was no longer visible, thereby reducing the influence of the metallic framework on the generated surface. The lower threshold was adjusted to 126.20, aiming to include the gingival and mucosal surface with minimal inclusion of irrelevant soft-tissue structures and artifacts (Figure 1-3).

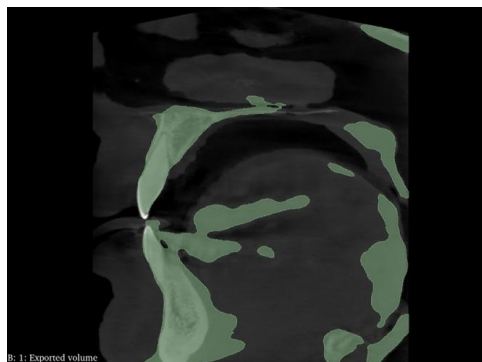


Figure 1: Sagittal view from 3D Slicer showing the relationship among dental structures, alveolar bone, and soft-tissue contour during CBCT segmentation.



Figure 2: Coronal view from 3D Slicer used to evaluate mandibular anatomy and tissue-volume relationships before STL export.

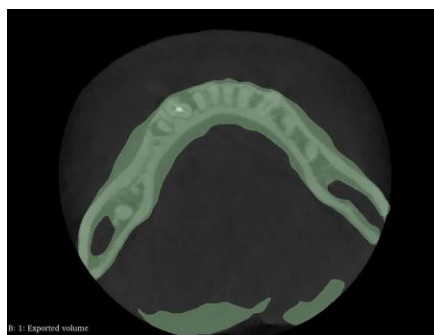


Figure 3: Axial view from 3D Slicer used to refine the segmentation and assess the relationship among teeth, bone, and gingival soft tissue.

3. Apply the threshold effect to the complete volume. These threshold values are specific to this CBCT dataset and should not be interpreted as standardized Hounsfield-unit values. This distinction is important because gray values in CBCT are not directly standardized as Hounsfield units, and teeth, restorations, scanner settings, field of view, voxel size, and artifacts can influence threshold-based segmentation and resulting surface geometry [9,10]
4. Apply the Smoothing effect after thresholding. Select the Median smoothing method with a smoothing value of 3 mm, corresponding to a $19 \times 19 \times 19$ voxel kernel in this dataset. The objective is to reduce surface irregularities and improve the usability of the generated mesh for subsequent CAD processing.
5. Use the Scissors tool to remove the maxillary arch from the segmentation. In this case, the separation was facilitated by the fact that the CBCT scan had not been acquired in maximum intercuspation and the arches were separated by the positioning device. Export the isolated mandibular segmentation as a standard tessellation language (STL) file.
6. Repeat the process to isolate the maxillary arch. Remove the mandibular structures and export the remaining maxillary segmentation as a separate STL file.
7. Send the maxillary and mandibular STL files to the dental laboratory. Import the files into a dental CAD software program (PartialCAD Rijeka 3.1; exocad GmbH).
8. Perform initial mesh trimming to remove residual areas that are not relevant for prosthesis design. Close the meshes because CBCT-derived STL conversion may produce open surfaces that interfere with CAD processing. Apply additional surface smoothing to improve the usability of the digital models.
9. Manually articulate the maxillary and mandibular arches in the CAD software. Because no intraoral scan or occlusal registration was available, approximate the occlusal relationship as closely as possible to the expected clinical relationship, with the understanding that chairside occlusal adjustment will be required at insertion (Figure 4,5).

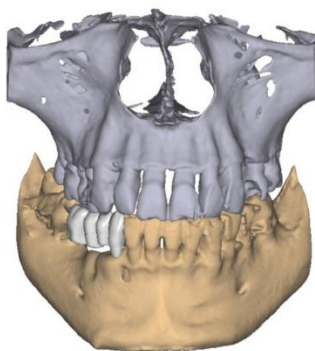


Figure 4: Frontal view of the CBCT-derived maxillary and mandibular STL meshes imported into Exocad PartialCAD after mesh trimming, closure, and smoothing.

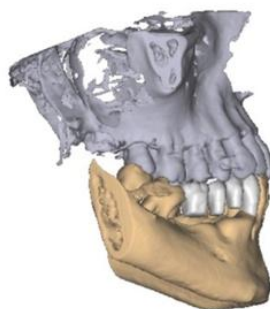


Figure 5: Right lateral view of the manually articulated maxillary and mandibular arches in Exocad PartialCAD before denture-base design.

10. Use the partial denture workflow in the CAD software to design the immediate mandibular removable partial provisional prosthesis. Plan the artificial teeth and the denture base as separate components. This allows the prosthetic teeth to be printed in tooth-colored resin and the base to be printed in pink denture-base resin.
11. Design the prosthetic tooth anatomy, tooth position, base extension, gingival contour, and relationship to the opposing arch. Use the processed mandibular STL to print a working model, which will assist in finishing, verification, and adaptation of the flexible acrylic retentive extension. Complete the final digital design of the artificial teeth and denture base (Figure 6,7).

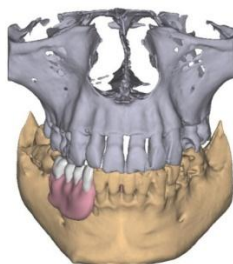


Figure 6: Frontal view of the digital removable partial provisional prosthesis after artificial tooth arrangement and denture-base design.

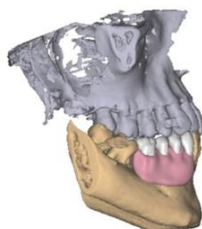


Figure 7: Right lateral view of the digital prosthesis design showing tooth position, denture-base extension, and relationship to the opposing arch.



Figure 8: Preoperative right lateral intraoral view of the mandibular arch before extraction of teeth 43 and 44 and removal of the residual root in the 46 region.

12. Print the mandibular working model generated from the processed STL file, the pink denture base, and the tooth-colored prosthetic teeth.
13. Bond the printed prosthetic teeth to the denture base. Incorporate a flexible acrylic retentive extension into the prosthesis to improve positioning and retention. Finish and polish the prosthesis before the surgical appointment (Figure 9,10).



Figure 9: Occlusal view of the completed immediate mandibular removable partial provisional prosthesis before clinical insertion.



Figure 10: Right lateral view of the completed provisional prosthesis after printing, finishing, bonding of the prosthetic teeth to the denture base, and incorporation of the flexible acrylic retentive extension.

14. On the day of surgery, extract teeth 43 and 44 and remove the residual root of 46. Perform extensive curettage of the infected sites associated with teeth 43 and 44. Suture the surgical sites.
15. Insert the prefabricated mandibular removable partial provisional prosthesis immediately after the surgical procedure. Apply a chairside resilient soft relining material to improve adaptation over the fresh extraction sites. Perform occlusal adjustment intraorally, particularly because the

occlusion had been manually approximated in the software without a true clinical occlusal record. Deliver the prosthesis and provide postoperative instructions (Figure 11,12).



Figure 11: Occlusal intraoral view of the immediate mandibular removable partial provisional prosthesis after extraction, curettage, suturing, soft relining, and chairside adjustment.



Figure 12: Right lateral intraoral view of the prosthesis inserted after immediate postoperative adjustment.

Discussion

This clinical technique demonstrates the opportunistic use of a previously acquired CBCT dataset to fabricate an immediate mandibular removable partial provisional prosthesis in a medically time-sensitive patient. The principal advantage of the workflow was not that CBCT derived surfaces are superior to conventional impressions or intraoral scans, but that an existing DICOM dataset allowed prosthesis fabrication without an additional preoperative impression appointment.

The workflow was conceptually based on the digital protocol described by Charette et al., in which DICOM data from CBCT imaging were used for segmentation, soft-tissue outline identification, virtual diagnostic cast reconstruction, virtual tooth arrangement, prosthesis design, and CAD-CAM fabrication [5]. In that report, the CBCT was acquired in the desired maxillomandibular relationship, and the authors emphasized that stable occlusal vertical dimension and maxillomandibular relationship are important prerequisites. They also stated that, if a stable relationship cannot be achieved, a record base and occlusal rim with interocclusal record may be used during CBCT acquisition [5].

The present case differed in several important ways. First, the CBCT scan had not been acquired for prosthetic fabrication, but for implant planning. Second, the patient was not in maximum intercuspation during acquisition because she was biting on the positioning device. Third, no intraoral scan, diagnostic impression, or clinical occlusal record was available before laboratory design. Consequently, the maxillary and mandibular arches had to be manually articulated in the CAD software, and the prosthesis required chairside occlusal adjustment at insertion.

Another limitation was the use of CBCT-derived soft-tissue surfaces. CBCT has limited soft tissue contrast, and metallic restorations may produce artifacts and scatter [11]. Charette et al. acknowledged that the accuracy of the intaglio surface of CBCT-derived interim removable prostheses and its adaptation to intraoral soft tissues requires further validation, and they used interim soft liner to facilitate adaptation and insertion [5]. The present technique followed the same principle: the prosthesis was not delivered as a definitive intaglio fit but was clinically adapted with a resilient relining material at the time of insertion.

The threshold values used in this case were intentionally described as case-specific CBCT gray values rather than Hounsfield units. This is essential because CBCT gray values are influenced by acquisition parameters, artifacts, field of view, voxel size, scanner type, teeth, and dental restorations. Wagendorf et al. reported that standard CT-derived gray values do not apply directly to threshold-based segmentation in CBCT and that teeth influence gray values and segmentation results [10]. This limitation is particularly relevant in partially edentulous patients with existing restorations.

Despite these limitations, the clinical outcome at insertion was acceptable for the intended purpose: immediate provisional replacement after extraction and debridement, while reducing the need for an additional appointment. Only limited clinical adjustments were required, principally related to occlusion and intaglio adaptation. The technique should therefore be considered a contingency workflow for selected cases rather than a routine replacement for conventional protocols. In routine circumstances, an intraoral scan or conventional impression, antagonist record, and clinical occlusal registration would remain preferable. However, in selected medically time sensitive patients, especially when a CBCT dataset already exists and an additional appointment is impractical, this workflow may provide a clinically useful provisional solution.

Summary and Conclusion

A pre-existing CBCT dataset was used opportunistically to fabricate an immediate mandibular removable partial provisional prosthesis for a patient requiring rapid elimination of odontogenic infectious foci before planned hip replacement surgery. The DICOM file was segmented, exported as STL files, refined and articulated in CAD software, and used to design a printed provisional prosthesis. The prosthesis was delivered immediately after extraction, curettage, suturing, soft relining, and occlusal adjustment.

This technique reduced the need for an additional preoperative impression appointment. However, because CBCT-derived soft-tissue surfaces and manually approximated occlusion are less predictable than conventional or intraoral scan-based records, chairside verification, soft relining, and occlusal adjustment remain essential.

Declarations

Patient consent Written informed consent was obtained from the patient for treatment and for publication of anonymized clinical information, CBCT/radiographic images, digital workflow screenshots, and intraoral photographs.

Conflict of interest statement

The authors declare no conflicts of interest related to this clinical report.

Funding statement

No external funding was received for this clinical report.

Data availability statement

Clinical photographs, CBCT-derived screenshots, STL files, and supporting digital workflow documentation are available from the corresponding author upon reasonable request, subject to patient confidentiality, written consent, and applicable data protection regulations.

Author contributions

Bruno Viana Reis was responsible for conceptualization, diagnosis, clinical assessment, treatment planning, interpretation of the pre-existing CBCT dataset, development of the CBCT-derived clinical workflow, DICOM import and segmentation workflow in 3D Slicer, clinical decision-making, surgical extraction of teeth 43 and 44 and removal of the residual root in the 46 region, curettage of the infected sites, suturing, prosthesis insertion, chairside soft relining, occlusal adjustment, postoperative planning, clinical documentation, manuscript drafting, and final manuscript review. Felipe Marconi dos Santos Dutra was responsible for the laboratory and CAD/CAM workflow, including importation of the CBCT-derived STL files into Exocad PartialCAD Rijeka 3.1, mesh trimming, mesh closure, surface smoothing, manual articulation of the arches, artificial tooth arrangement, denture-base design, preparation of the files for additive manufacturing, printing of the mandibular model, denture base, and prosthetic teeth, bonding of the printed teeth to the denture base, incorporation of the flexible acrylic retentive extension, prosthesis finishing, technical documentation, manuscript review, and approval of the final manuscript. Both authors reviewed and approved the final version of the manuscript.

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