Use of a CAD-CAM Surgical Template to Improve Accuracy for Simultaneous Implant Removal, New Implant Placement, and Bone Graft

A running title: Dual-Purpose Implant Surgical Template

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Abstract

A fractured implant is considered a catastrophic failure that leads to the loss of implant and the prosthesis. Available methods of implant removal include the reverse screw technique, use of trephines, or osteotomies around the implant. In case of a fractured implant, the access hole for the reverse screw technique is impossible, leading to the need for an osteotomy. When the apical part of the fractured implant is embedded in bone, finding the piece may lead to a more ample osteotomy and significant bone loss, complicating future implant placement. This technique presented utilized a CAD-CAM surgical template that was designed with the purpose of improving accuracy in finding the fractured part with minimal osteotomy, allowing for simultaneous placement of a new implant in the same site, with additional bone graft, utilizing the same template.

Keywords: Surgical template, 3D printed, broken implant, fractured implant

Multiple factors can affect the success of dental implants, including poor implant planning, implant design, 3D positioning, biomechanics, and clinician factors. According to the available
dental literature, six reasons have been identified as contributing to dental implant failure: surgical complications, implant loss, bone loss, peri-implant soft tissue complications, mechanical complications, and esthetic/phonetics complications. One of the mechanical complications is the occurrence of dental implant fracture. Implant fractures do not take place as often as abutment screws or dental prosthesis fractures, and the incidence of implant fracture is low (0.2 to 1.0 %). Numerous factors could contribute to the fracture of the implant, which is considered a catastrophic failure as it will lead to implant loss and prosthesis loss in addition to the emotional implications for the patient. It can lead to the need for extensive bone removal, soft tissue scars, bone graft, and a staged placement of a new implant. Three explanations have been identified as possible causes of dental implant fracture: implant design, physiological, and biomechanical factors. One retrospective clinical study concluded that a combination of improper implant occlusion and bruxism during the first year of functional loading could contribute to implant body fracture. The potential overload that arises from parafunctional habits can be increased on the implants. Duration, the magnitude of the load, and frequency are factors related to the mechanical complications contributing to the implant fracture. The removal of an osseointegrated implant requires careful and conservative approaches, especially if a replacement is indicated. The available methods of removing osseointegrated implants require osteotomies around the osseointegrated apical part of the implant using devices such as Piezosurgery, high-speed burs, and trephines. Also, the use of explantation methods, such as the “high-bur forceps technique”, and the “neo-bur-elevator-forceps technique”, have been reported in the literature. Possible perforation of the bone or the need for a two-surgery procedure is considered a limitation to some of the techniques mentioned. However, the application and success of the accessible three-dimensional (3D) surgical planning software sided with cone beam computerized tomography images reshaped to
3D models would help to maximize the efficiency of delivering applicable clinical data. This available technology allows representation of the patient data in an entirely virtual environment. A 3D surgical template designed based on a cone beam computed tomography (CBCT) and optical scanning can help locate a fractured implant, allowing its removal with minimal osteotomy, and guide a new implant placement and bone graft at the same time.

In the case described, a printed dual-purpose surgical template was designed to improve the accuracy on finding the apical part of the fractured dental implant, minimize osteotomy to remove it, and guide a simultaneous placement of a new implant, with bone graft using a substitute.

**Technique**

1. Make an intraoral scan (Trios 3; 3Shape A/S) and export it in the standard tessellation language (STL) file format.

2. Import the STL files and Digital Imaging and Communication in Medicine (DICOM) files from a CBCT scan into an implant planning software program (coDiagnostiX; Institut Straumann AG).

3. Locate the fractured implant fragment at the cross-section, panoramic, and axial views in the implant planning software program (coDiagnostiX; Institut Straumann AG) (Fig 1 A-C).
4. Create the segmentations of maxilla and implant fragments and complete a virtual
diagnostic wax up (Fig 2 A-C). Complete the implant planning and design of a tooth-
supported surgical template for implant placement.

5. Export the surgical template, segmented implant fragment, and maxillary intraoral scan into
an open-source CAD software (Meshmixer v3.5; Autodesk Inc). Under “Meshmix” tab, select
a cube shape from the primitive parts. Use the transform tool to adjust the size and position
of the cube and create a strut connecting the guide to the region where the implant fragment
is located. (Fig 3A).

6. Create another cube shape and transform it to an adequate size allowing access to the
implant fragment. After position and size adjustments, perform the “Boolean Difference”
function to create the implant fragment access window on the strut, and connect the strut to
the surgical template using the combine tool (Fig 3B and 3C).

7. Print the surgical template using a 3D printer (P30; Institut Straumann AG) (Fig 4).

8. Seat the dual-purpose surgical template to confirm the implant fragment's location after the
flap elevation (Fig 5).

9. Use the Piezosurgery (Piezosurgery Inc., a mectron company, USA) to remove the bone
under the guidance of access window on the surgical template (Fig 6).

10. Place a new implant following the same surgical template (Fig 7A, and 7B).

Discussion

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The benefit of this technique includes identifying the location of the implant fragment virtually and designing a dual-purpose surgical template based on that information. The variety of the virtual tools in the implant planning and open-source CAD software programs provide customization of the dual-purpose surgical template based on the implant fragment location and surgical planning of a new implant position. Therefore, it minimizes the quantity of bone removal to retrieve the implant fragment compared to conventional methods.4,5 The rationale behind using the buccal window to expose the bone and remove the implant fragment instead of approaching it occlusally is to preserve available bone for new implant placement. This also helps prevent fracture of the buccal bone by using alternative available methods.5 A limitation of this technique is the radiographic scatter from the implant fragment. To overcome this, the size of the windows was increased as it provided a safe distance. This safe distance aided in removing the implant fragment freely with no obstruction. The technique was advantageous in eliminating the need for a second surgery to place the implant.

Summary

The presented 3D printed dual-purpose surgical template was designed in implant planning and open-source CAD software programs based on digital diagnostic information. It facilitated locating and retrieving implant fragment with minimal bone removal and immediately placing a new implant with the same surgical template.
References


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Legends to Figures

Figure 1. CBCT Images. (A) Axial view; (B) Cross-sectional view; (C) Panoramic view.

Figure 2. (A) Segmented maxilla; (B) Segmented implant fragment; (C) Virtual diagnostic wax-up.
Figure 3. (A) A strut was designed; (B) Positioning of the access window; (C) Access window and segmented implant fragment.

Figure 4. 3D printed maxilla and dual-purpose surgical template.
Figure 5. Dual-purpose surgical template in situ.
Figure 6. (A, B) Pezosurgery was used to remove the bone and uncover implant fragments following the access window on the surgical template; (C) Implant fragment removal.
Figure 7. Immediately place a new dental implant.