ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2023; 9(1): 183-187

www.oraljournal.com
Received: 18-11-2022
Accepted: 23-12-2022

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3D-printed-tooth for socket and soft tissue preservation in the aesthetic zone: Clinical protocol and case report

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DOI: https://doi.org/10.22271/oral.2023.v9.i1c.1681

Abstract
Background: Since 1965, Dental Implantology and rehabilitation have evolved significantly, changing the paradigms in oral rehabilitation, from single-tooth replacement to complex maxillofacial reconstructions secondary to trauma or pathologic entities.
Methods: The main goal of this article is throughout the preoperative, surgical and restorative phase, trace the path to copy the technique and get similar results in coincident patients. A brand new protocol step by step is written and detailed from previous techniques with the aid of CAD-CAM Technologies.
Clinical Results: Soft tissue management on provisional with critical and subcritical emergence maintenance and select the most accurate healing abutment. The technique must be used precisely to achieve similar outcomes.
Conclusions: Dental Implants play an essential role in oral rehabilitation. We must update and analyze treatments, co-working hand-by-hand with digital technologies. Further prospective randomized clinical studies are required to objectively measure this technique's clinical outcomes, which we are expecting to publish in the future.

Keywords: Implantolgy, guided-surgery, CAD/CAM 3D-tooth, oral surgery

Introduction
Since 1965, Dental Implantology and rehabilitation have evolved significantly, changing the paradigms in oral rehabilitation, from single tooth replacement to complex maxillofacial reconstructions secondary to trauma or pathologic entities. Many authors have exposed different techniques that lead to the same outcome: consistent successful dental implant treatment [1].
Single dental implant placement and rehabilitation in the aesthetic zone is an extremely challenging scenario. This picture is even more complicated in cases where the tooth has periapical/periodontal defects. Patient age, clinical status, and expectations should be evaluated and discussed before executing any treatment [4]. Successful outcomes depend on a well-organized treatment sequence and protocols [2, 3, 5, 6].
Nowadays, it is well-known that Cone Beam Computed Tomography (CBCT) combined with CAD/CAM technologies facilitates the workflow for a precise diagnosis, planning, and treatment execution.
Surgical guides allow the surgeon to execute a proper surgical treatment, decreasing the likelihood of buccal plate fenestration or perforation of the anterior maxilla, composed of complex and unique anatomic contours.
Moreover, the survival rate of implants in infected-fresh-drilled-sockets has been studied (90.8% - 98.2%). The challenge comes with replication and long-term stability of the soft tissue contours after removing the teeth, most of the time requiring thoughtful and precise manoeuvres [2, 6, 8-12].
Many authors had developed new techniques to improve peri-implant soft tissue aesthetic contour, such as Dr. Gamborena, with the "Slim Concept" for soft tissue and bone augmentation in early surgical stages, and Anssari *et al*. with "Root Analogue Implant designed based on CBCT and CAD/CAM technology [9]."

The goal of a healing abutment is to create a biological sealing around the implant connection and oral cavity and restore the correct cervical tooth anatomy. With the introduction of custom healing abutments, tissue reconditioning, and periodontal plastic procedures, we can recreate the gingival aesthetic contours [7].

We developed a technique to recreate the preoperative soft tissue contours with the aid of CAD-CAM technologies. This technique allows us to highlight two of the main four phases of Implantology: 1) Soft tissue management on provisional with critical and subcritical emergence maintenance and 2) select the most accurate healing abutment [13-18].

Materials and Methods

Case report

A 28-year-old female, ASA I, came to IMPLANTXP with a chief complaint "I have a bump in the gum of my upper right tooth." Two years ago, she suffered facial trauma with a subluxation of tooth 1.1 (FDI numbering system) requiring RCT and coronal restoration. Eighteen months later, she developed an asymptomatic apical buccal parulis associated with the affected tooth. Intraoral examination showed a restored tooth #1.1 with an apical fistula without active drainage. Radiographic examination revealed tooth 1.1 with RCT and defective filling. An apical radiolucency extending from the mesial mid-radicular surface of tooth 1.1 to the apex of the root and associated external root resorption was identified. (Fig.1).

Fig 1: Clinical view for a hopeless tooth #1.1(FDI Numbering system)

A CBCT was taken on 20/12/20 in Planmeca Pro Max® in (Helsinki, Finland) at ø5.0x5.0cm, 90kV, mA10.0 in 15.26secs.

Tooth FDI #1.1 with RCT and coronal restoration with an apical hypodense lesion, evidencing internal and external root resorption and buccal plate erosion. (Fig.2)

Fig 2: (CBCT examination with axial measurements).

After a comprehensive evaluation, the main goal is to determine the more predictive and appropriate treatment.

a) Prosthetic.

a) Occlusion
b) Immediate, early ordelayed loading.
c) Type of restoration
- Provisional
- Definitive

a) Crown materials.
b) Color, hue, chroma, and value.

b) Surgically

a) Bone
- Type of bone defect.
- Bone quality.
- Bone quantity.
- Bone graft.

b) Soft tissue
- Biotype.
- Soft tissue defect.
- Mucogingival defects.
- Soft-tissue grafts.

c) Implant
- Depth, angulation, and position.
- Adjacent anatomic structures and dentition.
- Type and size.
- Implant stability.

Evaluating these parameters in order allows us to:

1. Determine the most precise path to preserve every healthy hard and soft tissue.
2. Achieve function, aesthetics, and zero compromises of implant osseointegration.

Regardless CBCT reveals a hopeless tooth with a considerable bone defect, an acceptable bone is present for dental implant placement.

3D Printed Tooth Protocol

Step 1: Maxillo-mandibular arch impressions are taken with Speedex Putty Soft® (Old Towns, Switzerland) [20]

Step 2: Type IV stone models are obtained (Smart Rock®. Guadalajara, Mexico),

Step 3: Stone models are scanned with 3Shape d700 table scanner® and converted into STL files [21].

Step 4: STL files and CBCT are transferred to Planmeca Roomexis® Software and merged. The tooth to be extracted is segmented and separated as a different object in the software. Once this is completed, digital extraction is performed. (Fig. 3)

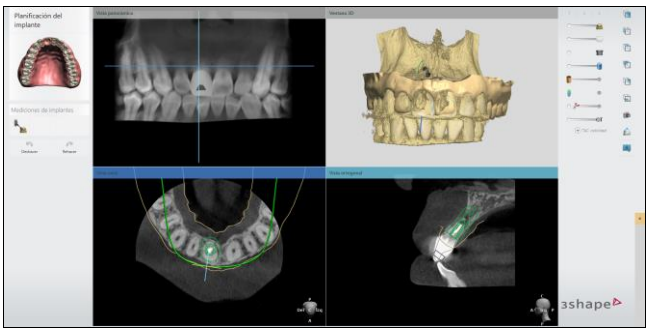


Fig 3: Virtual planning of the case.

Step 5: The segmented tooth is exported and edited in Meshmixer® (Autodesk, San Rafael, CA. USA), exporting

errors corrected, avoiding alterations in the emergency profile.

Step 6: Edited and the exported tooth is printed in our 3-D printer IBEE® Uniz with SLA/LCD technology (San Diego, Ca. USA) with black composite ANYCUBIC® (Shenzehn, China) the post-impression process consists of:

- Cleaning with Isopropyl alcohol for five minutes.
- Light curing with Ultraviolet 40W chamber for twenty minutes for any remains of porosity. (Fig. 4).

Fig 4: Post-processing of the print and segmentation of 3D tooth.

Step 7: The 3D printed tooth is covered by a layer of Vaseline as a barrier for the plaster and secured in the silicone impression.

The stone model is then removed from the impression. Afterward, the 3D printed tooth is removed from the stone model, leaving the socket intact and replicated. (Fig.5.).

Fig 5: Stone Model with printed tooth.

Step 8: Implant Studio 3Shape® (Copenhauer, Dinamarca) used to plan the surgery and design a surgical guide for implant placement.

Step 9: Surgical guide in-house printed with 3D printer Moonray-SprintRay® (Los Angeles, California) with DLP technology.

Surgical phase

After completing every preoperative aspect, an Atraumatic Dental Extraction is performed.

Step 1: Crown segmentation with surgical burr and handpiece (failed crown).

Sindesmotomy and elevation are performed with aid of periotomes. Dental extraction was achieved with forceps A #65 TBS Inox® (USA), avoiding injury to the periodontal structure.

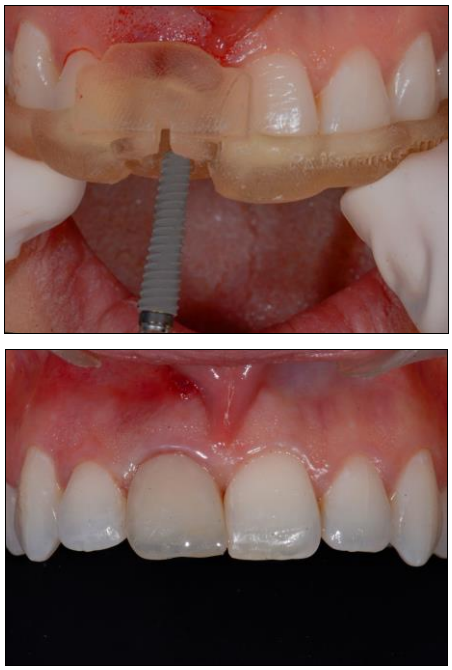
The apical lesion is enucleated and curettage. The socket is irrigated, and the remaining debris is removed. The socket was a type I according to Elian *et al*. Classification [19]. (Fig. 6).

Fig 6: Frontal view. Observe the maintenance of the contour of the soft tissue socket after extraction.

With a previously surgical implant guide printed and sterilized, guided implant placement was done with Kit One Guide® 800rpm drilled for a ø3.5mm x 15mm at HIOSSEN Implant®. (Asia) 35N. X-Ray evidenced adequate implant placement. Since the buccal plate was eroded, a xenograft was required to avert soft tissue dehiscence and effectively osseointegration.

A Hybrid Cement-Screw-Retained provisional was made with rapid simplex powder surrounding the abutment. It is worth mentioning that said temporary was an exact copy of the emergence profile.

The provisional is wrenched at 20N with zero contact occlusion, and the access hole was filled with composite. (Figs 7-8).



Figs 7-8: Immediate Guided Implant Placement, the emergence profile duplicated in the immediate provisional.

A postoperative photo and X-ray were taken to observe and compare the outcomes. Drugs prescriptions were given to the patient, and 2-week Follow-up was scheduled.

Follow-ups

No complications were present during the healing period. A healthy soft tissue healing with stable cervical marginal levels was observed. Complete resolution of buccal fistula followed with minimal soft tissue erythema.

A 1.5-month follow-up showed proper healing, but the parulis scar was still visible on the gingiva. A X-ray = with evident bone formation.

After 3months, the patient is asymptomatic-excellent soft tissue healing. Complete osteointegration was confirmed clinically and radiographically.

Restorative phase

The provisional is removed, and the gingival tissue is evaluated. Critical and subcritical zones without any pathological signs and excellent soft tissue healing. It is worth mentioning that said profile is an exact copy of the tooth extracted.

In the meantime, a single indirect custom implant impression was taken to duplicate the emergence profile the provisional created [24-27]. This prevents any collapse of the soft tissue

during the impression. (Fig. 9).

Fig 9: Single direct custom implant Impression.

An Open Tray Implant-Impression was performed. The protocol for shade matching was based on The Exact Shade-Taking- Photographic by Edward McLaren [28]. (Fig. 10).

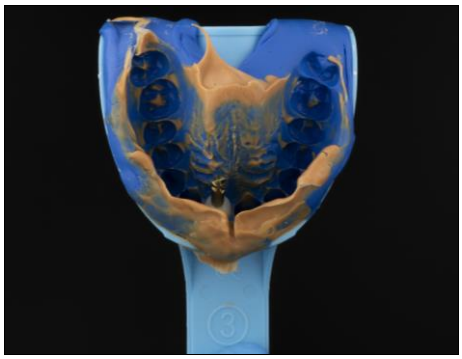


Fig 10: Open Tray Implant Impression).

The preparation line width and depth were carefully exanimated and sent to our technician. A layered zirconia technique is done, replicating the contralateral central incisor.
The build-up of the crown was made following the Skeleton Buildup Technique of Edward McLaren and CAD/CAM using the 3Shape Software® (Copenhauer, Dinamarca)**.** [29] The final shade was Color M03 Vita 3D Master.
A Cement-Retained-Crown with a T-Base, implant Abutment was used. The zirconia abutment was wrenched at 35N, and the crown cemented to the abutment with light and dual-curing permanent cementum for aesthetic restorations. Cements remnants were removed by thorough rinsing of the tissue with saline and chlorhexidine.
The final view shows a biological sealing surrounding the restoration and deeply respected every structure around the aesthetic crown. Any soft tissue abnormalities were excluded. (Fig. 11).

Fig 11: Final view of the final Cement-retained Zirconia restoration.

Figure format
Fig.1. Clinical view for a hopeless tooth #1.1(FDI Numbering system)
Fig.2 (CBCT examination with axial measurements).
Fig.3 Virtual planning of the case.
Fig.4 Post-processing of the print and segmentation of 3D tooth.
Fig.5 Stone Model with printed tooth.
Fig.6 Frontal view. Observe the maintenance of the contour of the soft tissue socket after extraction.
Figs.7-8 Immediate Guided Implant Placement, the emergence profile duplicated in the immediate provisional.
Fig. 9 Single direct custom implant Impression.
Fig.10 Open Tray Implant Impression).
Fig.11 Final view of the final Cement-retained Zirconia restoration.

Discussion and Conclusion
Dental Implants play an essential role in oral rehabilitation. We must update and analyze treatments, co-working hand-by-hand with digital technologies. This scopes our vision to improve the quality of the treatments, reduce non-biological process and makes feasible the approach to every Dentist [7].
Preservation of the gingival contour subsequently to dental extraction in the aesthetic zone is undoubtedly a relevant topic. This 3D Tooth Protocol highlights the path to replicate a legit copy of the tooth anatomy. Each case has its own challenges, and that is why this technique is called: "Customized Treatment" [9].
Therefore, if the final restoration does not modify the gingival contour, the changes will be extremely minimized [2, 10, 11, 21].
Further prospective randomized clinical studies are required to objectively measure this technique's clinical outcomes, which we are expecting to publish in the future.

Acknowledgments
We declare any conflict of interest related to the work.

Conflict of Interest
Not available

Financial Support
Not available

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How to Cite This Article
Garza LRS, Ruiz OAP, Ramírez LRS, Reyes ORS de los. 3D-printed-tooth for socket and soft tissue preservation in the aesthetic zone: Clinical protocol and case report. International Journal of Applied Dental Sciences. 2023;9(1):183-187.