Immediate Implant Placement of a Single Central Incisor Using a CAD/CAM Crown-Root Form Technique: Provisional to Final Restoration

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ABSTRACT

Objective: Preserving soft and hard tissues after extraction and implant placement is crucial for anterior esthetics. This technique will show how the information gathered from a cone-beam computed tomography (CBCT) scan of the maxillary left central incisor and an intra-oral digital impression can be merged to fabricate a CAD/CAM crown-root matrix to be used as an immediate provisional restoration that mimics the natural anatomy.

Clinical Considerations: Due to trauma, a left central incisor appeared to be fractured and was scheduled for extraction and implant placement. The crown-root configuration captured by the CBCT scan was merged with the digital files from an intra-oral digital impression. A CAD/CAM crown-root matrix was fabricated. Because the matrix shell was fabricated with the exact anatomy of the natural tooth, it replicated the position and three dimensional anatomy of the soft and hard tissue. It was connected to the implant with a customized provisional abutment. A digital impression of a coded healing abutment was made to fabricate the final implant abutment and final restoration. Throughout the treatment time and 36 months after completion, the thickness of tissue, emergence profile, and adjacent papilla was analyzed by clinical evaluation and photography and seemed to be maintained.

Conclusion: The use of a pre-operative intra-oral digital scan of the clinical crown-root architecture and the CBCT scan of the bone/root anatomy, can be used together to fabricate a CAD/CAM crown-root form provisional matrix. This digital design helps in the preservation of the 3D tissue topography, as well as the final restoration.

CLINICAL SIGNIFICANCE

The preservation of soft and hard tissue after extraction and implant placement has always been paramount for ideal anterior implant esthetics. Using the information from digital files from CBCT scans and intra-oral scans may help the clinician identify critical anatomical features that can be replicated in the provisional and final CAD/CAM restoration.

(J Esthet Restor Dent 29:13–21, 2017)

INTRODUCTION

Immediate implant placement after extraction in the aesthetic zone has been shown to have a beneficial response due to preservation of the soft tissue and bony architecture[1–5] particularly when using a customized immediate provisional.[6–13] This case report will demonstrate how a pre-operative intra-oral digital scan of the clinical crown anatomy/gingival architecture and the cone-beam computed tomography

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This paper was presented at the 36th Annual AAED Meeting August 2-5, 2011 The Ritz-Carlton, San Juan, PR.

 DOI 10.1111/jerd.12265

FIGURE 1. Radiograph of maxillary left central incisor after trauma, before extraction.

(CBCT) scan of the bone/root anatomy were used to fabricate a CAD/CAM crown-root form provisional matrix from the information gathered from these digital files. Replicating the original natural tooth anatomy and form helps retain the soft tissue gingival architecture and mid-facial tissues following extraction.[14,15]

A 37-year-old female, non-smoker presented with pain and mobility on a non-vital maxillary left central incisor that had been traumatized in an accident. It was previously restored eleven years prior with an unknown post and core material and an all-ceramic crown. Radiographs of the anterior teeth were taken and the decision was made to extract the tooth (Figure 1). Prior to extraction, a clinical aesthetic tissue analysis and bone analysis of the tooth to be extracted was performed by probing around the tooth, inter-proximally and also between the adjacent teeth. Pre-operative intra-oral digital impressions of the maxilla, from right first pre-molar to left first pre-molar, the opposing arch and the maximum inter-cuspation (MI) of both arches were made with a color captured infrared digital scanner (Trios, 3-Shape North America, Warren NJ) and a pink esthetic score based on Furhausers' data that evaluates peri-implant soft tissues around single-tooth implants.[16] The CBCT scan of the maxillary arch revealed that the labial plate was still intact and that an implant could be placed immediately after extraction.[17,18] Digital planning software (BlueSky Plan, IL) was used to analyze the placement and position of the desired implant and clarifying "Dicom" segmentation software (Mimics; Materialise Plymouth, MI) was used by the lab to accurately define root contour. In addition, the anatomy of the crown-root form and adjacent gingival architecture were analyzed from the "Stl" file captured by the intra-oral scan. These files would be used to plan the contour of the crown-root provisional matrix restoration. Views in the cross-section sagittal plane of the natural crown-root were analyzed. The axial plane and the lateral plane were also analyzed at the CEJ level of the crown and below, onto the root of the central incisor at 1 mm, 2 mm, 3 mm, and 4 mm.[19–21]

DIGITAL DESIGN TECHNIQUE

A software program was used to import the clarified "dicom" and "stl" file images (BlueSky-Bio, IL, USA). The digital designer (ROE Dental Lab, Cleveland, OH, USA) then used a "point section-correlation" technique in the digital software program that allows the merging of these files (3-shape, North America, Warren NJ; Figure 2). This technique allows the two different digital files, one from the intra-oral scan and one from the CBCT scan to be merged together into a single screen view allowing the digital design technician to view the osseous architecture, root anatomy, intra-oral tooth and gingival architecture in one merged file. By viewing these files simultaneously, the clinician can now plan the design of the immediate implant crown-root form provisional matrix. In addition, the clinician can plan the implant placement insertion direction as it relates to the provisional matrix (Figure 3).[22–26] After the design approval of the provisional restoration by the restorative dentist, the digital designer can fabricate a crown-root form provisional matrix of the exact anatomy of the crown and root using a digital milling machine (Imes-Icore 450i 5 axis mill, Stoneham, MA, USA) and a CAD/CAM block of poly

 DOI 10.1111/jerd.12265

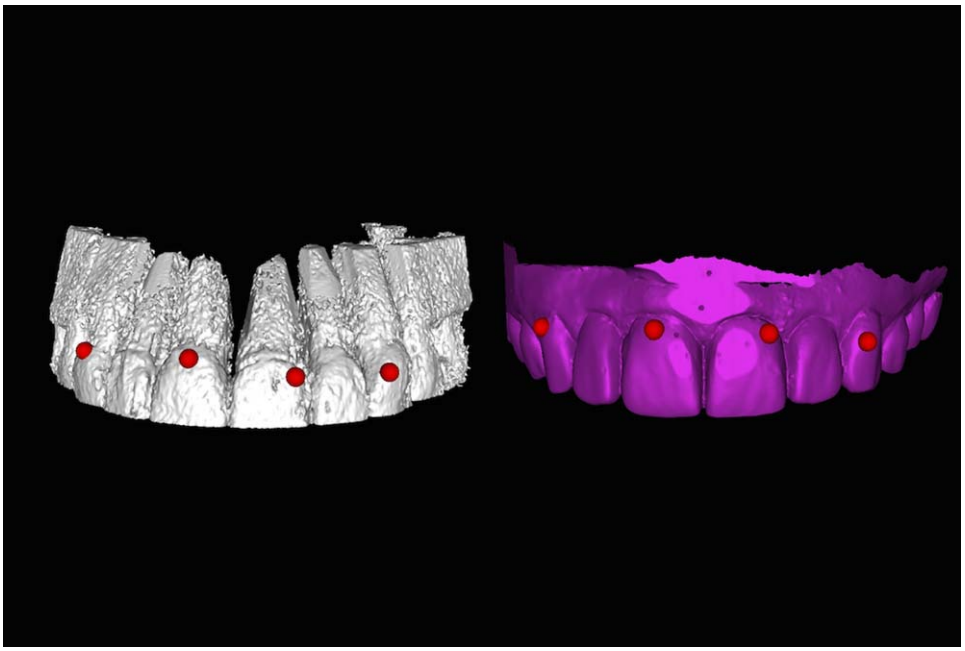

FIGURE 2. Screen view of "Dicom" file and "Stl" file using point section correlation technique which will merge the two files.

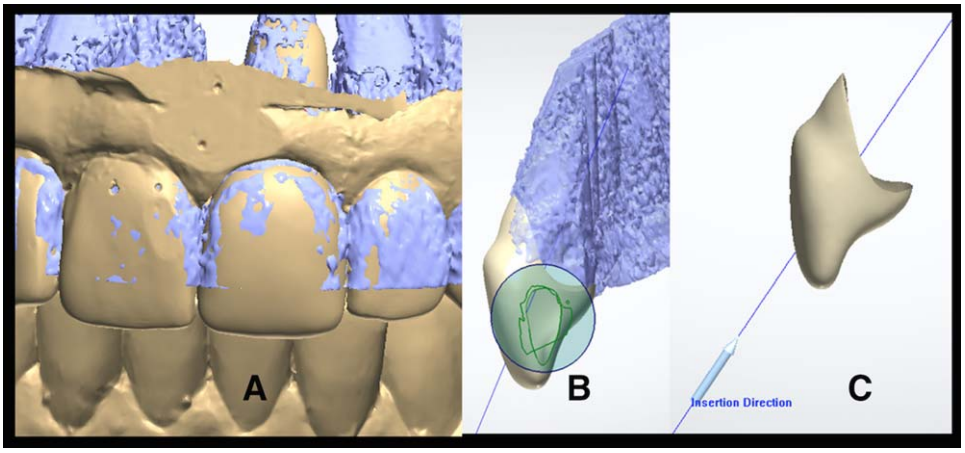

FIGURE 3. A, Screen view of the CBCT "dicom" and intra-oral scan "stl" merged files. B, Lateral view isolated crown-root from provisional matrix. C, Isolated provisional matrix, replicating crown-root anatomy 4 mm below CEJ and digital plan of implant insertion direction axis.

methyl methacrylate material (Premio-temp, Multilayer PMMA, Primotec USA; Norwalk, CONN) for the single central incisor in the requested shade (Figure 4).

After a flap-less extraction of the central incisor, an endosseous tapered implant 4.0 mm × 13 mm (Certain Osseotite, Biomet 3I, Palm Beach Gardens, FL) was placed in the lingual aspect of the socket. At placement, primary stability was achieved to 50 Ncm of torque at placement. A provisional abutment made from polyether methyl ketone "PEEK" material (Pre-formance Post, Biomet 3I, FL) was placed, and a radiograph was taken (Figure 5). The abutment was then customized to receive the digitally fabricated provisional matrix, replicating both the root and coronal form of the extracted tooth. A lingual access hole was made in the prefabricated provisional matrix to insure a passive fit with no obstruction in any position. Auto polymerizing composite

 DOI 10.1111/jerd.12265

FIGURE 4. Milled polymethyl metharcrylate (PMMA) crown-root provisional matrix.

FIGURE 6. Crown-root form provisional matrix placed over provisional abutment with plastic insert, blocking access hole.

resin (Luxa-temp, DMG Englewood, NJ) was then used to "spot attach" the provisional to the pre-fabricated abutment. A plastic brush tip was placed into the screw access chamber to prevent the provisional material from intruding into the access and blocking it (Figure 6).

After the initial set of the composite material, the screw-retained provisional was removed and remaining void areas were filled in with light-cure flowable composite (Luxa-flow, DMG Englewood, NJ, USA) (Figure 7). The provisional was polished and

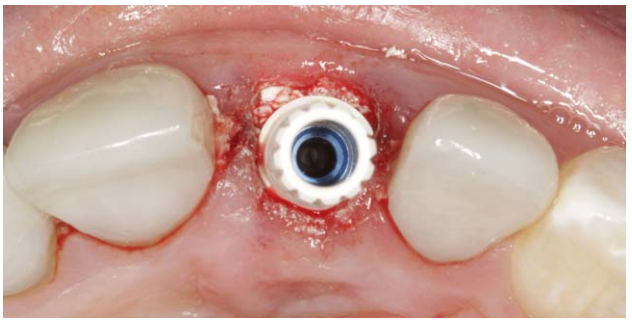

FIGURE 5. Screw retained pre-fabricated provisional abutment.

FIGURE 7. Addition of light-cure flowable composite to provisional matrix-abutment unit.

finished with fine diamonds and fine rubber wheels. After polishing, the screw-retained provisional was inserted and torqued to 20 Ncm. No occlusal contacts were present in maximal inter-cuspation position (MIP) or in any mandibular excursive movements. The access hole was sealed with Teflon tape and the light-cured flowable composite (Luxa-flow DMG, Englewood, NJ, USA). Final radiographs and photos were made before the patient was dismissed. The patient was seen 48 hours, 3 weeks, 3 months, and 4 months for evaluation of the healing (Figure 8).

CAD/CAM FINAL RESTORATION

After 4 months, the provisional restoration was removed and evaluated for soft tissue preservation

 DOI 10.1111/jerd.12265

FIGURE 8. Provisional in place for 48 hours after extraction.

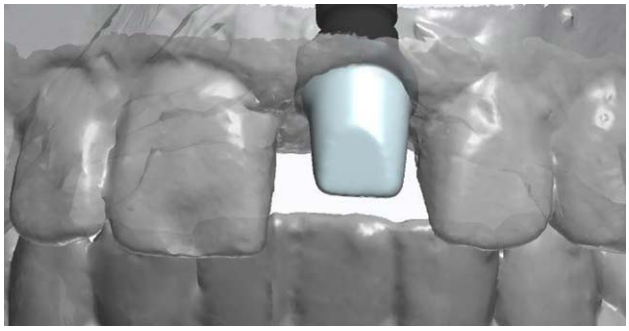

FIGURE 10. CAD–CAM design of final abutments (3 shape software).

FIGURE 9. Removal of provisional 3 months after extraction and implant placement.

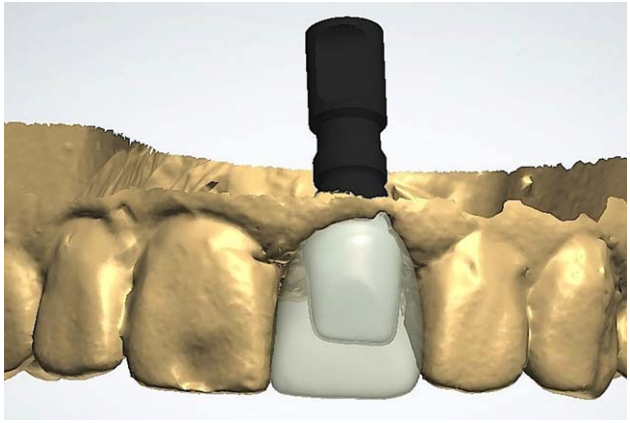

FIGURE 11. Utilizing emergence profile formula, biotype and radiograph for ideal analysis, the final design of CAD–CAM abutment and final crown was made.

(Figure 9). At that visit, a coded healing abutment (Encode, Biomet 3I, Palm Beach Gardens, FL) was placed.[27–30] An intra-oral digital scan of the coded healing abutment was made with the color captured infrared digital scanner (Trios 3-Shape, North America, Warren NJ, USA). Both arches were scanned and the occlusal registration MIP position was recorded. These files, along with intra-oral photographs showing gingival dimensional profiles, color and biotype, were sent via a secure internet wireless network directly to the same laboratory. All the data from the original scans, as well as the new data of the intra-oral final impression scan, were merged to develop the individual customized form of the final CAD/CAM abutment and restoration (Figures 10 and 11). The photographs of the tissue biotype and gingival dimensional levels were also utilized for additional customization. Radiographs of the inter-proximal bone in relation to the implant placement were assessed. In addition, a formula was utilized for predicting the degree of gingival displacement around the digital abutment.[31] This formula can assist the clinician in predicting the relative final position of the gingival collar, as well as the underlying three-

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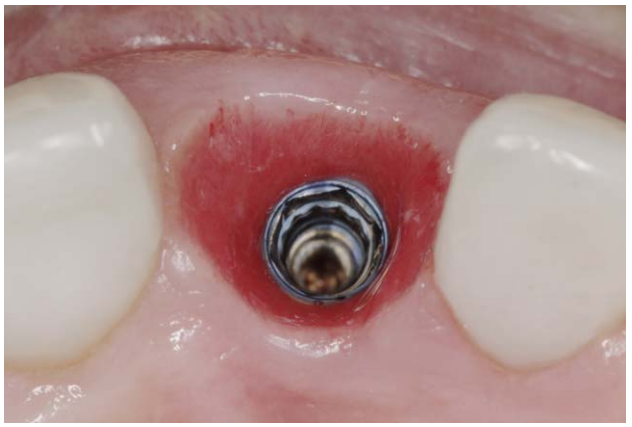

FIGURE 12. Pink tissue of emergence profile 5 month post-op, after removal of tooth-root form provisional showing preservation of mid-buccal facial tissue.

FIGURE 14. Final abutment torqued to 35 Ncm.

dimensional root form of the abutment, which is crucial in maintaining the peri-implant soft tissue aesthetics (Figure 12).

A zirconia with titanium base abutment was custom milled to the ideal tissue form and a pink hue stain on the abutment collar was added to mimic underlying gingival colors.[32,33]

The cement line was specifically CAD/CAM designed to circumferentially be 0.3 mm below the free gingival margins. The individual abutment was torqued to 35 Ncm (Figures 13 and 14).

A CAD/CAM lithium disilicate all ceramic crown was milled to replicate the form of the original coronal portion

FIGURE 13. Zirconia with titanium base final abutment with pink stain hue.

FIGURE 15. Radiograph of final abutment and restoration.

of the natural tooth and after occlusal adjustment, was custom stained and glazed, and cemented with a provisional radio-opaque zinc oxide-based cement

DOI 10.1111/jerd.12265

FIGURE 16. Six month post-operative photo of final CAD–CAM lithium disilicate crown.

(Temrex, Temrex Corp, Freeport, NY, USA). The possibility of leaving residual cement was vastly reduced by a properly designed emergence profile and the definitive positioning of the abutment/crown interface close to the free gingival margin.[19] A radiograph was taken to insure no cement was below tissue level before dismissing the patient (Figure 15). Final Photos were taken 6 months, 12 months, and 36 months after placement for observation (Figures 16 and 17).

DISCUSSION

In previous publications some provisionals were screw retained and others were cement retained.[5,13,14] This may or may not be a factor in the final restoration but during initial healing the one piece screw-retained provisional may play a pivotal role in optimal tissue healing and preservation. Currently available CAD/CAM software allows the clinician to evaluate the existing bony architecture and anatomical dimensions of the tooth before extraction, and then fabricate an ideal provisional matrix that duplicates the natural anatomy.[34–37] This critical sub-gingival restorative abutment interface is a separate and defined aspect to the supra-gingival esthetics and functional aspects of the coronal aspect of the restoration. All the original data acquired is used by the laboratory in conjunction with the gingival displacement formula in designing the optimal submergence and emergence profiles of the abutment relative to the gingival collar and separate

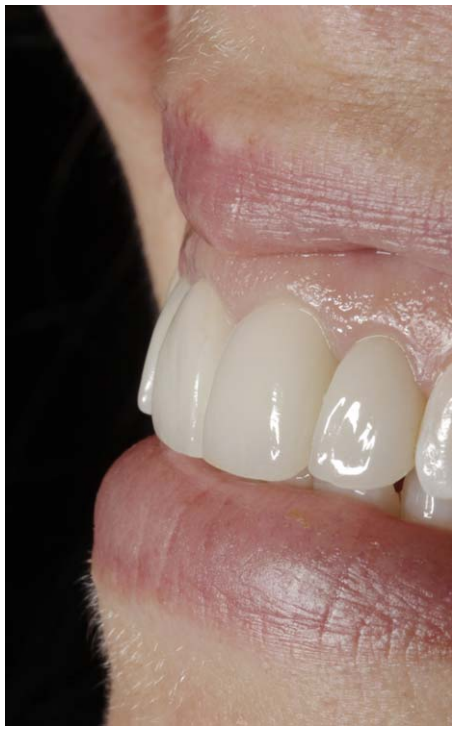

FIGURE 17. Lateral view of final restoration.

crown. This technique is an expeditious way to rapidly and predictably allow the tissues and emergence profile to be replaced with a crown-root form provisional restoration that has been digitally copied from its original form and maintain the mid-facial buccal tissue.

CONCLUSION

Digital CAD/CAM technology allows accurate and rapid fabrication of the provisional restoration, the abutment and the final restoration utilizing information on the crown-root anatomic structures generated prior to the tooth extraction and immediate placement of the implant. Preservation and replication of the natural emergence profile demonstrated with this technique has the ability to maintain a healthy gingival architecture and the mid-facial buccal tissues.

DISCLOSURE AND ACKNOWLEDGEMENTS

The corresponding author is a consultant for the following companies: Trios, 3 Shape software and

 DOI 10.1111/jerd.12265

Zimmer/Biomet Implant company. The authors would like to thank BJ Kowalski, Roe Dental laboratories for his innovative digital knowledge and contribution to this article. Also we would like to thank Dr Mark Stein, Oral-Maxillofacial Surgeon for his skills in implantology.

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 DOI 10.1111/jerd.12265