Preservation of Soft Tissue Contours Using Computer-Aided Design/Computer-Assisted Manufacturing Healing Abutment with Guided Surgery in the Esthetic Area: Case Report

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This case report describes a digital workflow for a computer-aided design/computer–assisted manufacturing (CAD/CAM) healing abutment used in immediate implant placement in the esthetic zone. The design of the healing abutment was based on the existing tooth anatomy in order to provide anatomical support to the gingival tissues and to preserve the gingival contours of the natural tooth. This approach enhances the esthetic outcome of the definitive implant restoration. The surgical procedure including the guided bone regeneration is simplified, postoperative morbidity is reduced, and excessive occlusal loading during healing is limited. Int J Oral Maxillofac Implants 2020;35:e15–e20. doi: 10.11607/jomi.7668

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Implant-supported restorations have become a well-established treatment for the replacement of missing teeth.[1,2] However, such a treatment continues to be a challenging endeavor, particularly in the esthetic zone.[1,3,4] In order to optimize the esthetic outcome of an implant-supported restoration, the use a provisional crown to contour the emergence profile is recommended.[4] Different techniques for the use of provisional crowns and multiple loading protocols exist and are well documented in the literature.[1,2,5–9] Loading protocols for dental implants include: conventional loading, where implants are allowed to heal for a period greater than 2 months after implant placement; early loading, where implants are restored between 1 week and 2 months after implant placement; and immediate loading, where implants are restored within 1 week of implant placement.[5,7,10]

It is well known that following a tooth extraction, significant dimensional alterations in the ridge and soft tissue contours occur within the first 3 to 6 months. It has been suggested that immediate implant placement in conjunction with immediate loading of dental implants (type 1A[7]) may limit changes in the soft tissue architecture and ridge resorption.[2,6] This is most effective when graft material is placed into the socket around the implant in a flapless approach and the provisional restoration is utilized to provide support to the soft tissue as well as containment of the graft material.[11] In addition, providing an immediate implant restoration eliminates the need for a removable transitional prosthesis, which provides additional psychosocial benefits to the patient, particularly in the esthetic zone.[2,5,8] Despite these advantages, type 1A cases (immediate implant placement and loading) are sensitive, and this approach requires strict adherence to a specific set of criteria.[2,5,7,10] These include the achievement of primary stability, minimizing occlusal loading, and appropriate patient selection.[2,5] The reduced bone-to-implant contact may result in higher levels of strain and unfavorable outcomes.[10] Alternatively, the provisional restoration can be delivered at a later stage for a delayed loading protocol. Although

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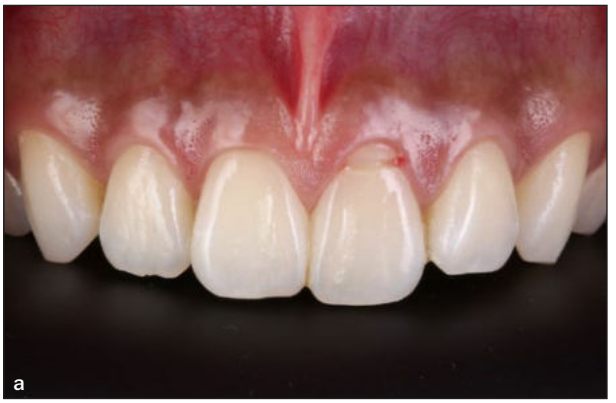

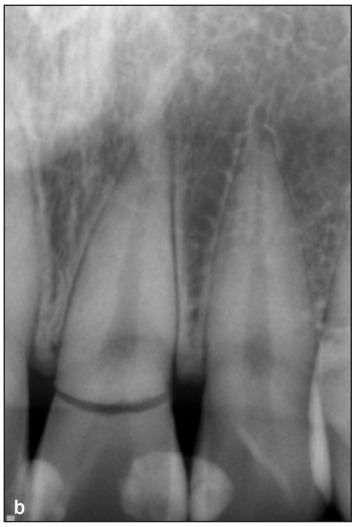

Fig 1 *(a)* Clinical appearance of maxillary left central incisor at initial presentation. *(b)* Preoperative periapical radiograph.

the risk of premature loading is reduced and the gingival tissues have time to heal, delayed loading protocols may require multiple appointments in order to perform a stage-two surgery, to fabricate and deliver a provisional crown, and to modify the crown contours in order to establish the correct position of the gingival margin and the required emergence profile.[4,6,10]

The use of customized healing abutments has been previously reported, particularly with implants in the non-esthetic zone.[12–15] Customized healing abutments allow for the immediate shaping of the gingival contours, can eliminate the need for a stage-two surgery, and reduce the risk of premature loading.[13–15] When combined with immediate implant placement, customized healing abutments can be fabricated to match the contours of the natural tooth in order to preserve the existing gingival architecture.[12,14] They can also protect the extraction site and retain the graft material isolated from the oral environment.[12,14]

This case report describes a digital workflow for the design and fabrication of a computer-aided design/computer-assisted manufacturing (CAD/CAM) healing abutment used with immediate implant placement in the esthetic zone (type 1C according to Gallucci et al).[7] It will focus on how the design of the healing abutment was based on the existing tooth anatomy in order to provide support to the gingival tissues and to preserve the gingiva contours of the natural tooth, which can ultimately produce a high esthetic outcome with the definitive implant restoration while reducing the risk of implant overloading during healing.

CASE PRESENTATION

An adult male patient presented with a fractured maxillary left central incisor due to trauma (Fig 1a). The tooth was fractured at the cervical area of the clinical crown and in the mid-root area (Fig 1b). After clinical and radiographic examination, the tooth was deemed not restorable and was extracted. An implant-supported restoration was the treatment planned for the patient.

Implant Planning, Surgical Template, and CAD/CAM Abutment Fabrication

A maxillary cone beam computed tomography (CBCT) scan (Kodak 9000 Extraoral Imaging System, Carestream Health) was performed, and the images were stored as Digital Imaging and Communications in Medicine (DICOM) files. The DICOM files of the CBCT scan were imported to implant planning software (CodiagnostiX, Dental Wings). The bones and the teeth were isolated; scattering and radiographic artifacts were removed from the three-dimensional (3D) rendering of the CBCT scan using the segmentation tool (Fig 2a). This allows for clear identification of anatomical landmarks.

Direct digital diagnostic scan of the maxillary arch was made using an intraoral scanner (TRIOS 3 Pod, 3Shape) and saved as a Standard Tessellation Language (STL) file (Fig 2b). The STL file was imported into CAD/CAM software (Straumann CARES Visual, Institut Straumann). The esthetics of the maxillary left central incisor, incisal edge position, and the gingival margin level were assessed for use as implant positioning parameters.

At this point, a connection was created between the planning software and the CAD/CAM software (Synergy, Dental Wings). This connection permits the transfer of the digital scan to the planning software, which can then be registered onto the CBCT scan using the dentition as common reference points (Fig 3a). An implant (Bone Level Tapered RC 4.1 × 12 mm, Institut Straumann) was virtually planned in the position of the maxillary left central incisor based on the desired prosthetic, esthetic,

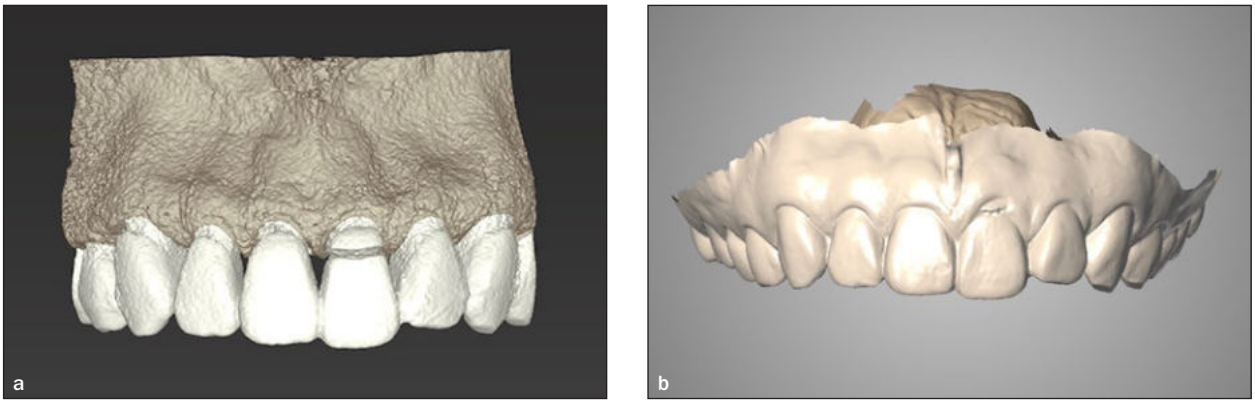

Fig 2 *(a)* 3D rendering of CBCT scan after segmentation of maxilla and teeth. *(b)* Intraoral scan.

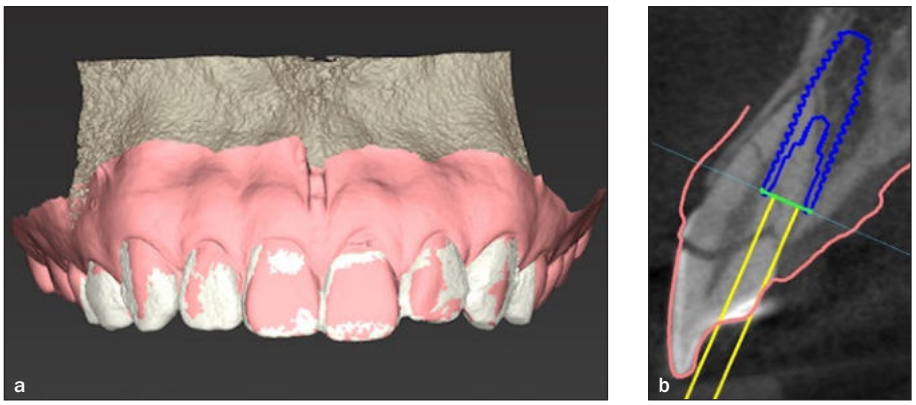

Fig 3 *(a)* Intraoral scan registered onto CBCT scan. *(b)* Virtual implant planning.

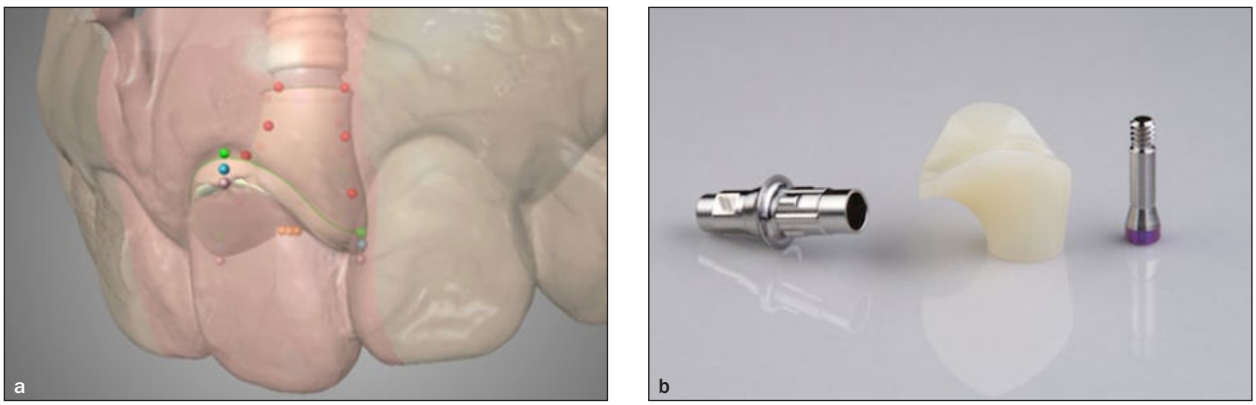

Fig 4 *(a)* Virtual design of customized healing abutment conforming with contours of the tooth. *(b)* Customized healing abutment core prior to cementation to the stock titanium abutment.

and anatomical considerations. The implant was placed so that the emergence profile of the existing tooth can be maintained, while providing the appropriate angulation to fabricate a screw-retained restoration (Fig 3b).

Once the implant position was finalized, the digital connection allowed for the transfer of the proposed implant position from the planning software to the CAD/CAM software. On the CAD/CAM software, the customized healing abutment can be designed and fabricated based on the type and dimensions of the planned implant. With the shape and contour of the maxillary left central incisor present, the customized healing abutment was designed to conform with and maintain the existing gingival architecture (Fig 4a).

The final design was digitally transferred to a milling center, which fabricated the customized healing abutment out of poly(methyl methacrylate) (PMMA) resin (Polycon, Institut Straumann) by subtractive milling. The milled PMMA portion of the customized healing abutment was then bonded to a stock titanium

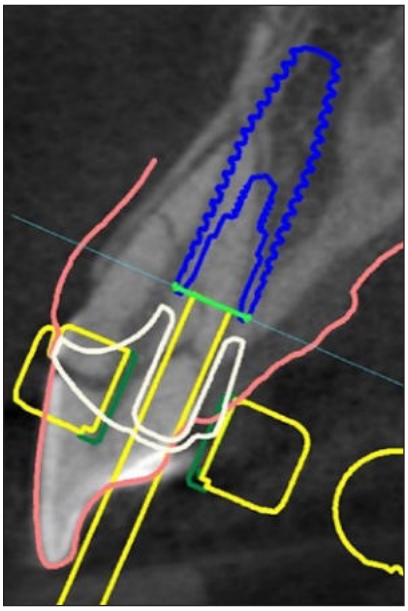

Fig 5 All components of digital workflow aligned: virtual implant planning *(blue)*, customized healing abutment *(white)*, guiding sleeve *(green)*, and surgical template *(yellow)*.

abutment (RC Variobase, Institut Straumann) using a resin-based luting agent (Variolink, Ivoclar Vivadent) (Fig 4b).

A surgical template was designed on the planning software with engraved rotational markers to ensure that the implant was accurately positioned to receive the prefabricated customized healing abutment, including the rotation of the implant-abutment connection. The surgical template was fabricated using a 3D printer (Form 2, Formlabs) (Fig 5).

Surgical Phase

The procedure was done under local anesthesia; lidocaine 2% with epinephrine 1:100,000 was administered through labial and palatal infiltration. The fractured clinical crown was gently removed using forceps. The root was sectioned, followed by the use of periotomes to sever the periodontal ligaments. The root fragments were then removed with forceps preserving the mesial and distal papillae, as well as the gingival margin (Fig 6a). The socket was debrided using a curette to ensure that no remnant ligaments or granulation tissues were left behind. The surgical template was seated in the patient's mouth; adequate seating was confirmed visually through the designed inspection windows (Fig 6b).

The osteotomy was prepared based on the digital planning and according to the guided drilling protocol. An alignment pin was placed into the osteotomy to allow for packing of the bone graft material (RegenerOss Allograft, Zimmer Biomet Dental) into the socket. The pin was then removed, and the implant was placed in a guided fashion (Fig 6c) achieving primary stability, with the depth and rotation of the implant determined by the surgical template. The CAD/CAM prefabricated healing abutment was screwed onto the implant (Figs 6d and 6e), sealing the socket and supporting the gingival architecture. The patient was issued a removable clear tooth-supported vacuum-formed mouth guard with a pontic tooth, which was fabricated for esthetic purposes and did not have any contact with the healing abutment.

Follow-up was performed at 1 week and 6 weeks after implantation, during which the patient did not report any significant issues or complaints. Clinical examination showed a normal healing process with no signs of infection.

Restorative Phase

After the 8-week mark, a digital intraoral scan was performed using the same scanner used for the diagnostic scans. A scan body (CARES RC Mono Scanbody, Institut Straumann) was attached to the implant while performing the intraoral scan. A CAD/CAM zirconia crown was designed based on the emergence profile created by the customized healing abutment and fabricated by subtractive milling. A labial cutback was incorporated in the design to allow for subsequent porcelain layering of the labial surface of the crown. The crown was bonded to a titanium abutment (RC Variobase, Institut Straumann) using a resin-based luting agent (Variolink, Ivoclar Vivadent). Upon delivery, the contact points, seating of the crown, and the occlusion were adjusted as needed. The screw was torqued to 35 Ncm, and the screw channel was covered with polytetrafluoroethylene (PTFE) tape and composite resin material (Vit-l-escence, Ultradent Products) (Figs 7a to 7c). Follow-up was performed at 3 months followed by annual recall.

DISCUSSION

Although desirable, immediate implant placement with immediate loading (type 1A) has demonstrated significant variability in the treatment outcomes.[7] A systematic review by Gallucci et al found the success and survival of type 1A placement and loading to range from 87% to 100%.[7] Such variability is not seen with delayed loading of immediately placed implants (type 1C), resulting in higher success and survival rates ranging from 91.3% to 100%.[7] The loading protocol for immediately placed implants can have a direct impact on the outcome of the treatment; therefore, strict adherence to case selection criteria is necessary to ensure efficacy of therapy.[7]

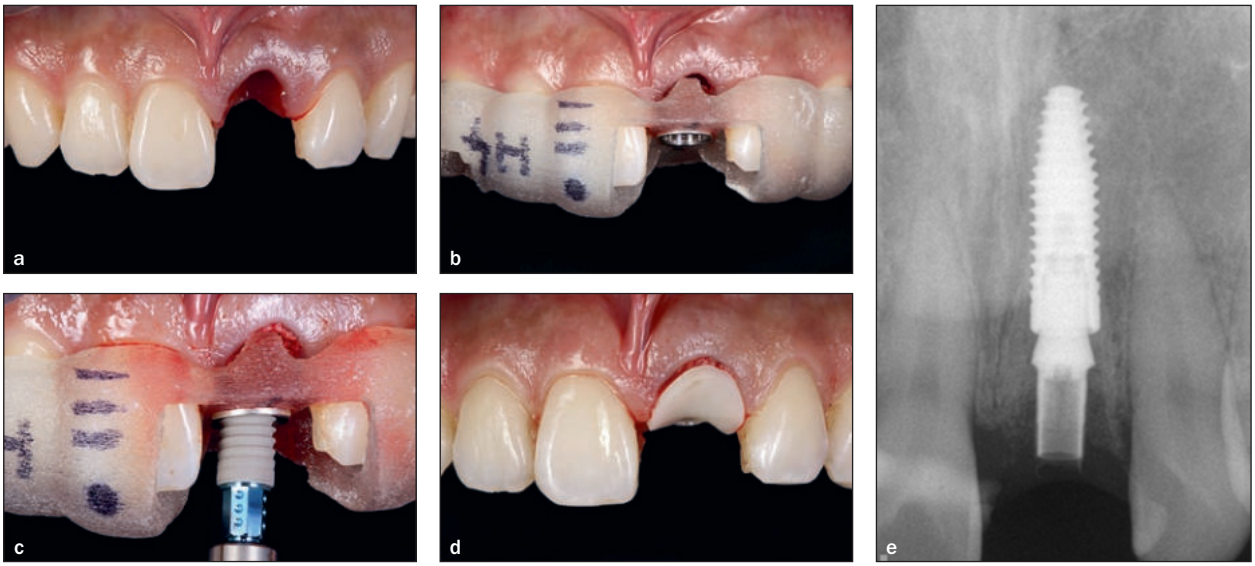

Fig 6 *(a)* Postextraction. *(b)* Surgical template seated. *(c)* Guided implant placement. *(d)* Customized healing abutment seated. *(e)* Postoperative periapical radiograph with seated customized healing abutment.

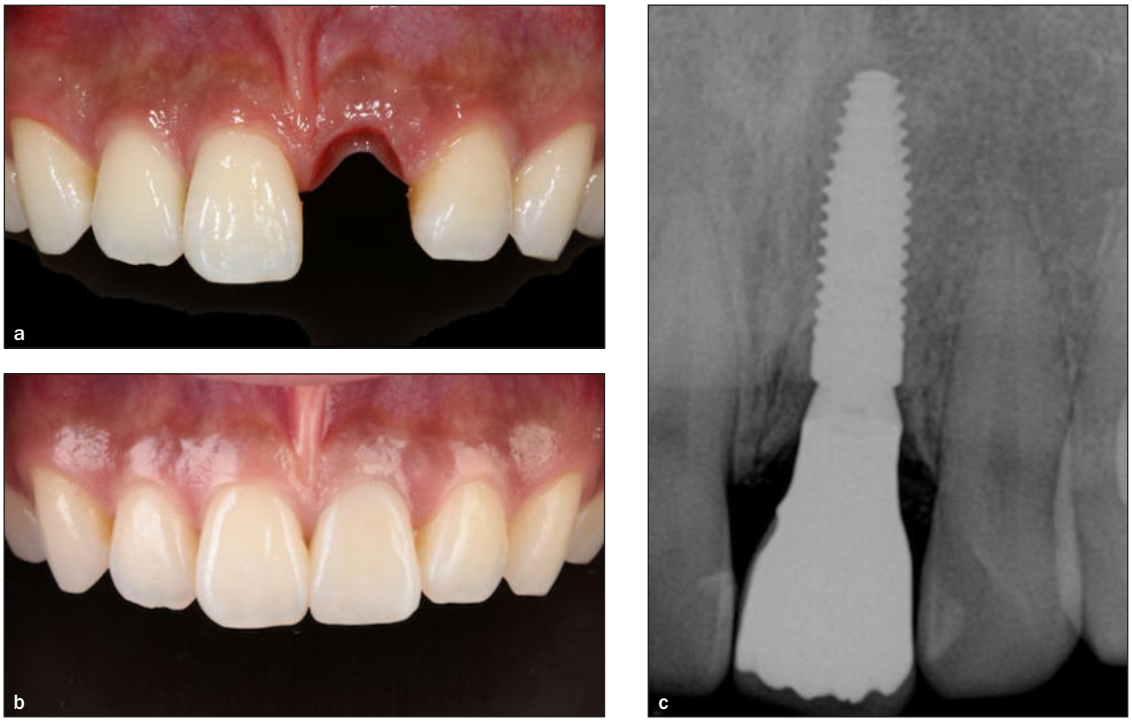

Fig 7 *(a)* Soft tissue contours prior to delivery of definitive restoration. *(b)* Definitive restoration. *(c)* Periapical radiograph of definitive restoration.

Customized healing abutments provide significant advantages throughout the implant treatment process. With type 1C placement and loading protocol, the use of customized healing abutments permits a more conservative surgical approach. Open flaps, releasing incisions, and stage-two surgeries are not needed, which limits the disruption of the soft tissues, preserves the architecture, and reduces the healing time.[13–15] Furthermore, the circular profile of prefabricated healing abutments cannot adequately support the soft tissues during the healing phase. This issue can be overcome with a well-adapted customized healing abutment.[13] When bone grafting is necessary, customized healing abutments can contain the grafting material and protect the extraction/implant site, preventing any unwanted soft tissue growth.[14] The risk

of premature loading during the healing phase is also reduced.[13,14] The introduction of the desired emergence profile during the healing phase, with the use of customized healing abutments, allows for the development of a gingival architecture that can passively adapt to the definitive restoration.[13,15]

A majority of the reports on customized healing abutments advocate their use in posterior areas due to the associated esthetic concerns.[12–15] However, this concern is limited to the healing period, and can potentially ensure a more esthetically predictable final outcome with less chair time needed to condition the soft tissues.[4] Alternative approaches such as removable prostheses, Essex retainers with an acrylic tooth, resin-retained fixed partial dentures, or orthodontic brackets with an attached pontic can be used to provide satisfactory provisionalization during the healing period.[3]

Replicating the contours of the existing tooth as described in this report may further reduce the amount of disruption and changes to soft tissues, as the soft tissue architecture and contours are preserved with little manipulation required during the procedure. Otherwise, if the tooth to be replaced is missing or extensively damaged with no record made of its shape and contours, the contralateral tooth can be used with the "Digitally Flip Technique" to shape the customized healing abutment as previously described by Joda et al.[4]

Conventionally, customized healing abutments are fabricated using a composite resin or acrylic materials, which can be time-consuming and may potentially compromise the normal healing process.[12,14] CAD/CAM systems have been frequently used in prosthodontics and implant dentistry.[13,15] Customized healing abutments fabricated using CAD/CAM technology have been described with both immediate and delayed implant placement protocols.[4,13–15] This technology allows the operator to more precisely control the dimensions and contours of the abutment, particularly when replicating an existing tooth.[14] The ability to link the CAD/CAM software with the implant planning software and the CBCT scan permits the fabrication of the customized healing abutment in accordance with the virtual planning, which can be precisely transferred to the patient's mouth with the use of a surgical template.[13,14]

This report described a protocol for immediate implant placement and prosthetically guided healing with a customized healing abutment in the esthetic zone where the criteria for immediate loading could not be met. Although the indications for such a procedure might be reduced, the combination of CAD/CAM technology with virtual implant planning for the fabrication of a customized healing abutment with an anatomical emergence profile provides an efficient and predictable way to preserve the esthetics of the soft tissues. The surgical procedure including the guided bone regeneration is simplified, postoperative morbidity is reduced, and excessive occlusal loading during healing is limited. Initial outcomes with this protocol are promising; however, additional research and clinical trials might be needed to validate the approach.

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