Guided protocol for indirect fabrication of a custom provisional restoration prior to immediate implant surgery in the esthetic zone

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Running title: Guided indirect provisional restoration

One Sentence Summary: The described guided protocol for indirect fabrication of a custom provisional crown prior to immediate implant surgery may simplify treatment, minimize chair time, and enhance patient satisfaction.

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Abstract

Introduction: Delivery of a high quality provisional restoration at a maxillary anterior immediate implant site enhances patient-centered outcomes and promotes development of favorable hard and soft tissue architecture. The purpose of this report is to present a protocol relying upon compatible guided surgery and laboratory systems for fabrication of a custom provisional crown prior to immediate implant surgery in the esthetic zone.

Case Presentation: A female patient, aged 33 years, presented to the Army Postgraduate Dental School, Fort Gordon, Georgia, with an unfavorable prognosis for tooth #9. The patient elected extraction with immediate implant placement. Prior to the surgery, we utilized a cone-beam computed tomography volume, stone models, implant planning software, and an implant indexing system to fabricate a custom provisional crown. Following extraction of tooth #9 and immediate implant placement, the provisional crown exhibited excellent fit and finish, requiring virtually no chairside adjustment. We noted minimal change in baseline mucosal contours throughout the healing phase.

Conclusion: The clinical/restorative protocol described in this report assured accurate three-dimensional implant positioning and permitted indirect fabrication of a high quality custom provisional crown in advance of surgery. The laboratory workflow—which dental technicians/auxiliaries can master—has the potential to shorten surgery, enhance treatment outcomes, and increase patient satisfaction.

Key Words: Dental implants, cone-beam computed tomography, clinical protocols, treatment outcome, patient satisfaction, esthetics

Background

Immediate implant placement with immediate provisionalization (IIPP) is an established treatment for replacement of a single maxillary anterior tooth.[1-8] Reported advantages of IIPP include preservation of favorable mucosal/osseous architecture, enhanced esthetics, and high patient satisfaction.[1,4-6,8] Because some IIPP protocols do not involve flap reflection,[1,4-6,8] the periosteum and supraperiosteal plexus remain intact, avoiding insult to the blood supply of the alveolus.[1,5] Whether IIPP preserves crestal peri-implant bone levels relative to a staged approach remains undetermined,[9] although some evidence supports maintenance of favorable osseous architecture at sites receiving grafts in peri-implant gap defects.[1,5-8] Risk of advanced mucosal recession is a concern when providing IIPP.[10] However, patient-, site-, and procedure-related factors associated with successful IIPP treatment have been clarified over the last two decades (Table 1).[1,4-8,10,11]

In implantology, clinicians have applied computer-aided design/computer-aided manufacturing (CAD/CAM) technology to facilitate treatment and enhance outcomes. Implant surgeons commonly use CAD/CAM to produce surgical templates that improve accuracy in implant positioning.[1] CAD/CAM-generated and conventional implant abutments, crowns, and frameworks exhibit comparable clinical performance.[12,13] Because cone-beam computed tomography (CBCT) scanners, milling and printing capabilities, implant planning software, and digital workflows are constantly evolving, numerous CAD/CAM protocol variations appear in the literature.[12-15] Our purpose is to present a guided CAD/CAM protocol (Table 2) for indirect fabrication of a custom provisional restoration prior to immediate implant placement.

Clinical Presentation

On July 13, 2021, a systemically healthy female, aged 33 years, presented to the Army Postgraduate Dental School requesting evaluation of tooth #9. The patient reported that the existing crown was loose and fractured. A private dentist had placed a post in the canal and recemented the crown on an emergency basis. On evaluation, probing depths were 1-3 mm generally, and bleeding was virtually absent. Tooth #9 exhibited insufficient tooth structure for proper crown fabrication, and radiographically, the post in the canal space demonstrated poor fit (Figs. 1 and 2). After discussing treatment options, the patient elected extraction of tooth #9 with IIPP. The informed consent process included verbal and written components.

Case Management

After the evaluation appointment, and prior to surgery, we fabricated a custom provisional crown for the planned immediate implant (Fig. 3). Our method relied upon an implant indexing system[‡] and the corresponding guided surgery kit.[§] The template used to position the lab mount and implant analog was subsequently transferred to the patient for guided implant placement.

On the day of surgery, we extracted tooth #9, preserving baseline bone and mucosal architecture to the extent possible. Our surgical template guided the initial 2-mm twist drill, the shaping drills, and implant placement (Fig. 4). Aligning the slots incorporated within the implant carrier and the surgical template (Figs. 5 and 6) ensured timing agreement between the implant and the provisional abutment/crown. Prior to delivering the milled ceramic provisional restoration, we placed a particulate freeze-dried bone allograft[¶] (FDBA) in the

peri-implant gap defect and in the space between the crown and the facial keratinized mucosa (Fig. 7). The provisional crown exhibited excellent fit and finish, requiring almost no chairside adjustment (Figs. 8 and 9). The patient avoided brushing the provisional crown for one week and utilized chlorhexidine rinses twice daily until normal oral hygiene measures resumed. We encouraged frequent warm, gentle saline rinses.

Clinical Outcomes

The patient reported high satisfaction with immediate esthetics, and early healing was uneventful (Fig. 10). At three months, interproximal radiographic bone levels appeared stable, and no clinical signs of inflammation were present (Fig. 11). We delivered the definitive implant supported crown at postoperative month seven (Figs. 12 and 13).

Discussion

Our purpose was to present a guided workflow for indirect fabrication of a custom provisional crown in advance of immediate implant placement. From a surgical standpoint, we utilized the dual-zone therapeutic concept published by Chu and colleagues.[6] Essential elements of this technique include minimally traumatic extraction, placement of a bone biomaterial in the peri-implant gap defect, and a screw-retained provisional restoration to provide a prosthetic socket seal.[6]

Numerous chairside and indirect methods are available for establishing a provisional restoration at an immediate implant site. The method we present offers several clinical and patient-oriented advantages. The benefit of achieving a nearly finished provisional restoration before tooth extraction is obvious. For an experienced clinician, tooth extraction, guided implant placement, and delivery of the custom provisional crown may

require considerably less than one hour. Moreover, clinicians and auxiliaries efficiently and routinely acquire the essential data requirements for this protocol—a CBCT volume and alginate impressions—in the course of a typical evaluation appointment. Beyond simplifying and shorting the surgery, provisional crowns produced using this protocol may exhibit superior clinical performance. Unlike ceramics and prepolymerized acrylic surfaces, conventionally cured acrylic materials develop microporosities that increase surface roughness.[14,15] In contrast, the milled ceramic crown we delivered was smooth, cleansable, esthetic, and pleasing to the patient.

Favorable baseline gingival phenotype and architecture contributed to the efficiency of the described protocol. We easily duplicated the existing harmonious soft tissue contours in the stone model used to design the provisional crown. Then, using a computer-aided milling system,[#] we matched the critical contours in the restoration with the baseline form of the marginal gingiva. Subcritical contours in the provisional restoration were presumptive; however, the soft tissue moulage provided a reasonable template for subcritical contour design.

The planned implant in this case emerged through the incisal edge of the provisional crown. This position/angulation optimized use of palatal bone for implant anchorage, avoided trauma to the facial cortical plate, allowed a 2-mm peri-implant gap for FDBA placement, and facilitated fabrication of a provisional restoration with favorable contours. The final restoration incorporated an angled channel to conceal the screw access.

Summary

Why is this case new information?	• This report provides a stepwise workflow guiding indirect fabrication of a custom provisional crown prior to immediate implant placement.
What are the keys to successful management of this case?	• The described technique requires compatible laboratory and guided surgery systems to assure that the restoration accounts for the three-dimensional position and timing of the implant.
What are the primary limitations to success in this case?	• Dental technicians/auxiliaries can master this protocol and independently produce high quality provisional implant restorations under supervision, potentially enhancing practice efficiency. However, practitioners should provide adequate staff training to optimize reliability and quality.

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[‡]Navigator Laboratory Kit for Certain Tapered Implants, Zimmer Biomet, Warsaw, IN

[§]Certain Tapered Navigator System, Zimmer Biomet

[‖]e.max, Ivoclar Vivadent, Schaan, Liechtenstein

[¶]LifeNet Oragraft, Virginia Beach, VA

[#]CEREC, Densply Sirona, York, PA

CRediT author statement

Dr. Sarah M. Vargas: Conceptualization, writing – original draft preparation. Manuscript approval. Conceived of writing an article on this topic. Performed literature search. Performed and documented surgical treatment. Wrote case description and other portions of the original draft.

Dr. Walter G. Dimalanta: Writing – original draft preparation, writing – review & editing, manuscript approval. Performed and documented the restorative treatment and laboratory protocol. Wrote portions of the original draft. Critically edited the manuscript.

Dr. Thomas M. Johnson: Writing – original draft preparation, writing – review & editing, supervision, manuscript approval. Supervised surgical treatment. Wrote portions of the original draft. Critically edited the manuscript.

References

1. Kan JY, Rungcharassaeng K, Deflorian M, Weinstein T, Wang HL, Testori T. Immediate implant placement and provisionalization of maxillary anterior single implants. *Periodontol 2000* 2018;77:197-212.

2. Barone A, Rispoli L, Vozza I, Quaranta A, Covani U. Immediate restoration of single implants placed immediately after tooth extraction. *J Periodontol* 2006:77;1914–1920.

3. De Rouck T, Collys K, Cosyn J. Immediate single tooth implants in the anterior maxilla: a 1-year case cohort study on hard and soft tissue response. *J Clin Periodontol* 2008:35;649–657.

4. Cheng AW, Berridge JP, McGary RT, Erley KJ, Johnson TM. The extraction socket management continuum: a hierarchical approach to dental implant site development. *Clin Advances Periodontics* 2019;9:91-104.

5. Tarnow DP, Chu SJ, Salama MA, et al. Flapless postextraction socket implant placement in the esthetic zone: part 1. The effect of bone grafting and/or provisional restoration on facial-palatal ridge dimensional change – a retrospective cohort study. *Int J Periodontics Restorative Dent* 2014:34;323–331.

6. Chu SJ, Salama MA, Salama H, et al. The dual-zone therapeutic concept of managing immediate implant placement and provisional restoration in anterior extraction sockets. *Compend Contin Educ Dent* 2012;33:524-532.

7. Kuchler U, Chappuis V, Gruber R, Lang NP, Salvi GE. Immediate implant placement with simultaneous guided bone regeneration in the esthetic zone: 10-year clinical and radiographic outcomes. *Clin Oral Implants Res* 2016;27:253-257.

8. Arora H, Khzam N, Roberts D, Bruce WL, Ivanovski S. Immediate implant placement and restoration in the anterior maxilla: Tissue dimensional changes after 2-5 year follow up. *Clin Implant Dent Rel Res* 2017;19:694-702.

9. Covani U, Bortolaia C, Barone A, Sbordone L. Bucco-lingual crestal bone changes after immediate and delayed implant placement. *J Periodontol* 2004;75:1605-1612.

10. Cosyn J, Hooghe N, De Bruyn H. A systematic review on the frequency of advanced recession following single immediate implant treatment. *J Clin Periodontol* 2012;39:582-589.

11. Grunder U, Gracis S, Capelli M. Influence of the 3-D bone-to-implant relationship on esthetics. *Int J Periodontics Restorative Dent* 2005;25:113-119.

12. Papaspyridakos P, Chen YW, Gonzalez-Gusmao I, Att W. Complete digital workflow in prosthesis prototype fabrication for complete-arch implant rehabilitation: a technique. *J Prosthet Dent* 2019;122:189-192.

13. Kapos T, Evans C. CAD/CAM technology for implant abutments, crowns, and superstructures. *Int J Oral Maxillofac Implants* 2014;29:117-136.

14. Mota EG, Smidt LN, Fracasso LM, Burnett Jr LH, Spohr AM. The effect of milling and postmilling procedures on the surface roughness of CAD/CAM materials. *J Esthet Restor Dent* 2017;29:450-458.

15. Gantz L, Fauxpoint G, Arntz Y, Pelletier H, Etienne O. In vitro comparison of the surface roughness of polymethyl methacrylate and bis-acrylic resins for interim restorations before and after polishing. *J Prosthet Dent* 2021;125:833.e1-833.e10.

Figures

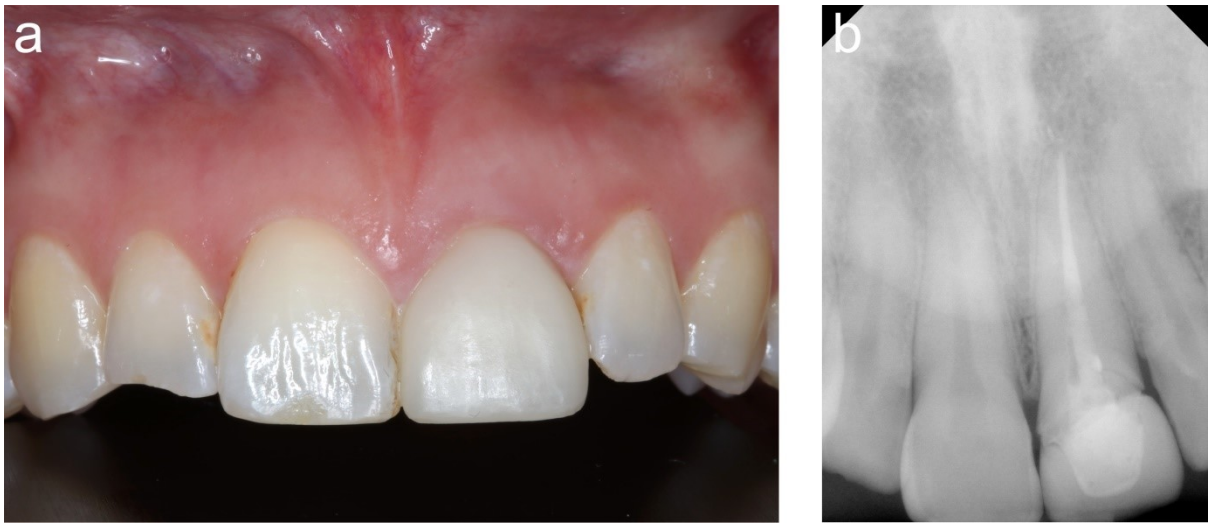

FIGURE 1 Baseline clinical and radiographic appearance. 1a Tooth #9 presented with a provisional crown exhibiting open margins. The facial gingiva displayed slight marginal erythema and edema. 1b A poorly fitting post was present within the canal space.

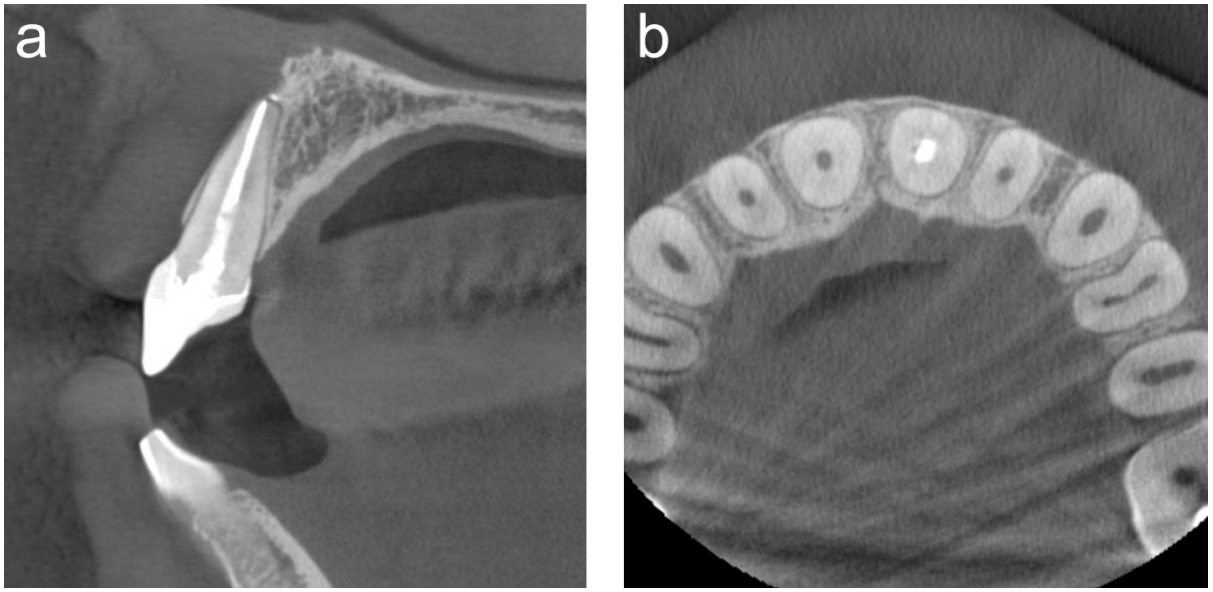

FIGURE 2 Baseline cone-beam computed tomography volume. 2a Parasagittal view through tooth #9. 2b Axial view.

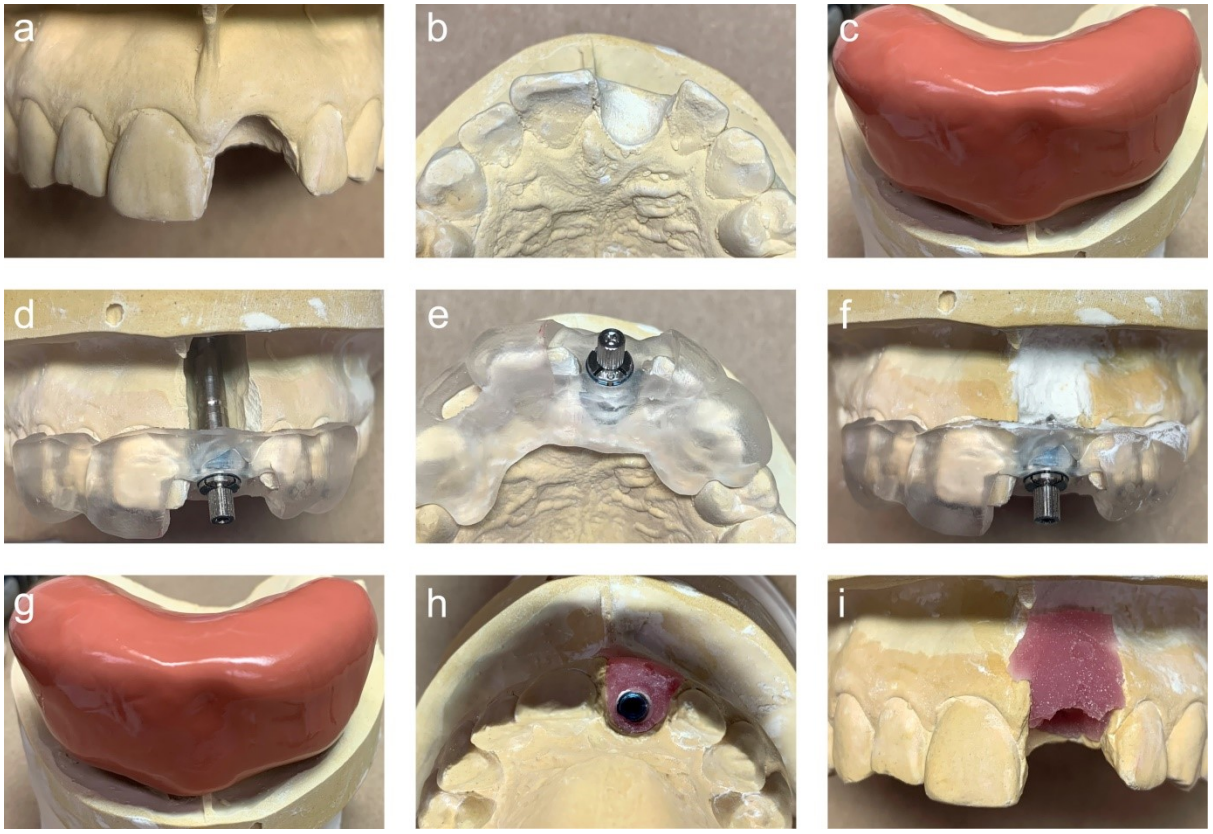

FIGURE 3 Guided laboratory workflow for indirect fabrication of a custom provisional crown in advance of maxillary anterior immediate implant surgery. 3a, 3b We subtracted the crown of tooth #9 from the stone model to approximate ideal soft tissue contours. 3c A putty matrix recorded the planned soft tissue morphology. 3d, 3e We created space for an implant analog in the stone model. Then, we applied the CAD/CAM-generated surgical template to the model and secured the lab mount, transferring the precise position and timing of the planned immediate implant to the analog. 3f Snap stone stabilized the implant analog within the model. 3g After replacing the putty matrix on the model, we injected polyvinyl siloxane to transfer the planned mucosal contours. 3h, 3i Implant analog and soft tissue moulage incorporated into the stone model.

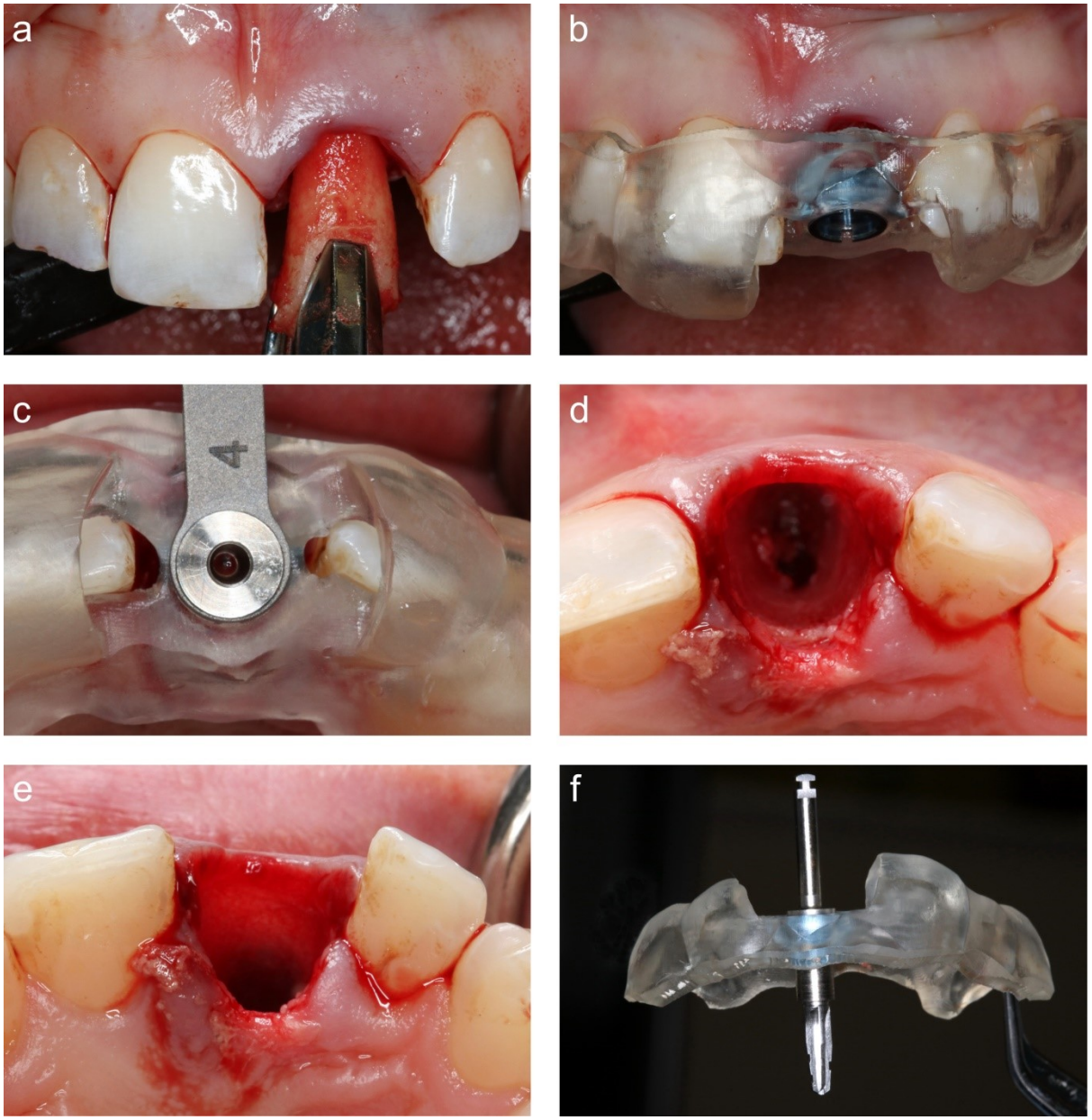

FIGURE 4 Surgical procedure. 4a We extracted tooth #9 with minimal trauma, preserving baseline architecture of the alveolus and mucosa. 4b The surgical template, which we used to guide indirect fabrication of the provisional crown, now guided the implant surgery. 4c We used a 2-mm twist drill positioning handle to guide the initial osteotomy. 4d Initial osteotomy in the planned implant position. 4e Appearance of the intact facial cortex and the favorable facial mucosal architecture. 4f Extraoral view of the surgical template demonstrating limitation of the shaping drill depth.

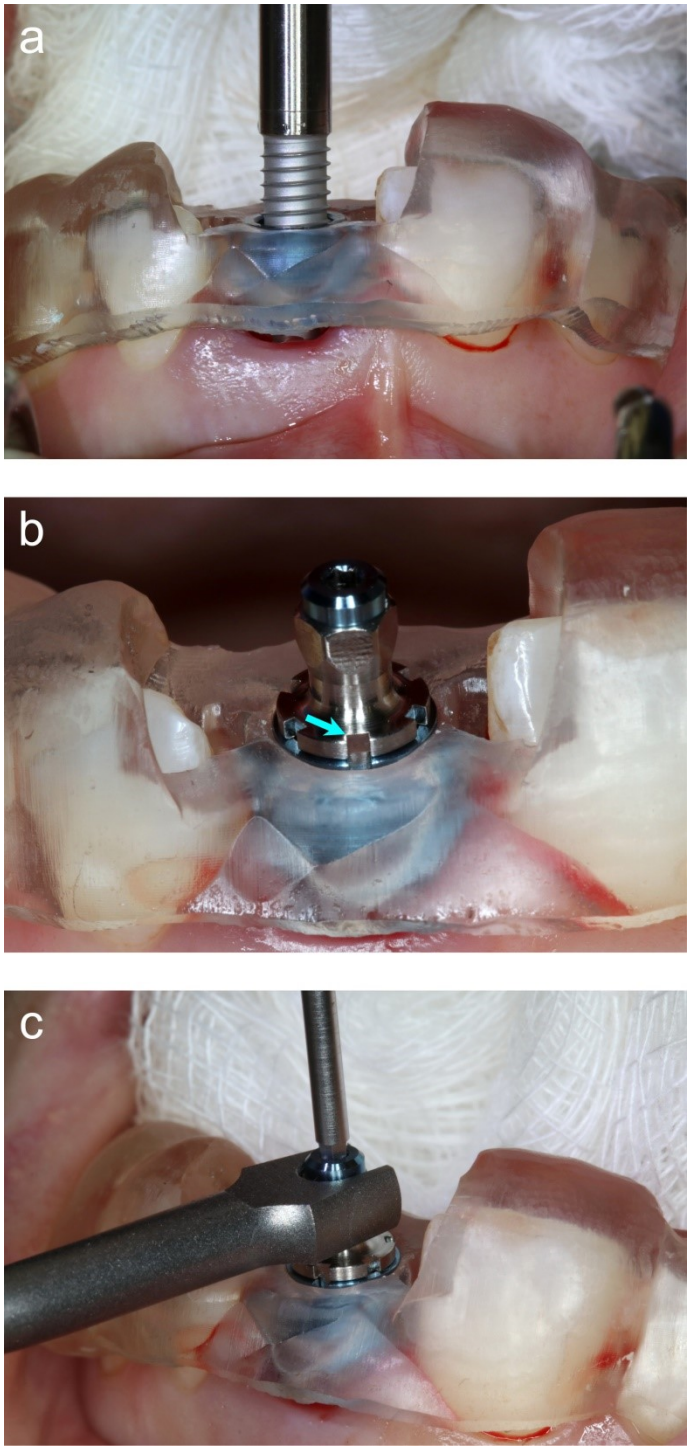

FIGURE 5 Guided implant installation. 5a The surgical template dictated the three-dimensional position of the implant. 5b Alignment of slots in the implant mount and the surgical template sleeve (arrow) assured timing agreement between the immediate implant and the custom provisional crown. Insertion torque measured ≈ 45 Ncm. 5c During removal of the implant mount, we used a wrench to avoid rotation of the implant.

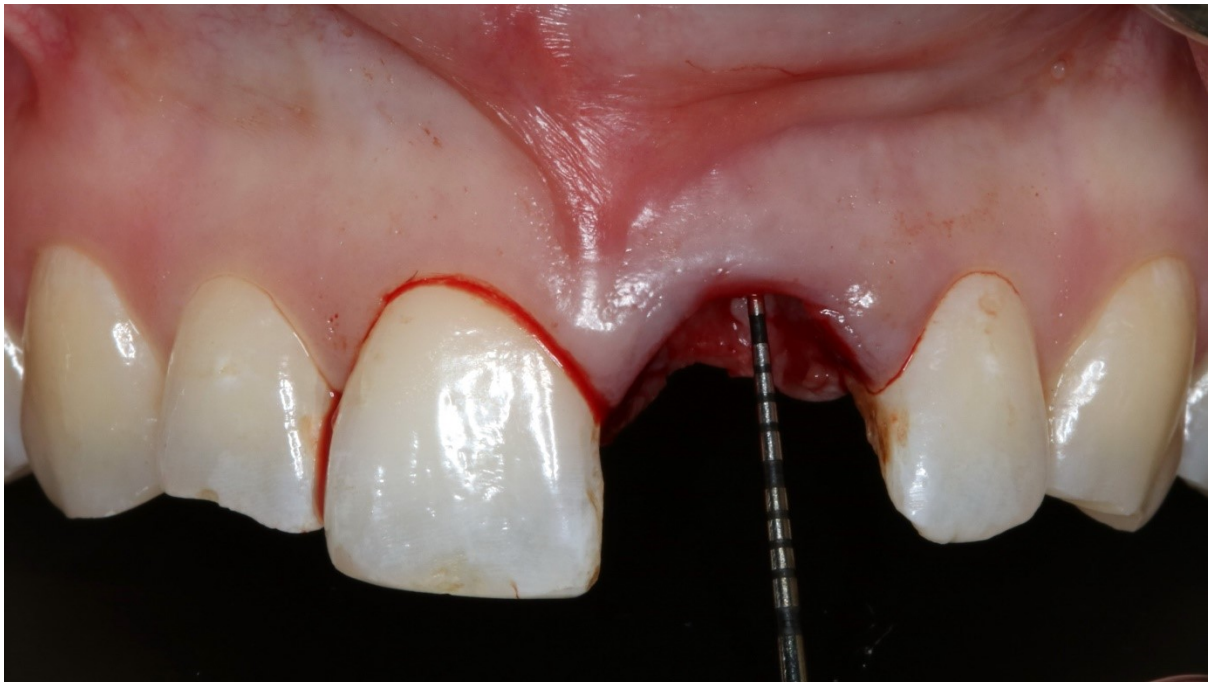

FIGURE 6 As planned, the implant platform was 3 mm apical to the harmonious mucosal zenith. **{"Before" figure for the first page, left side.}**

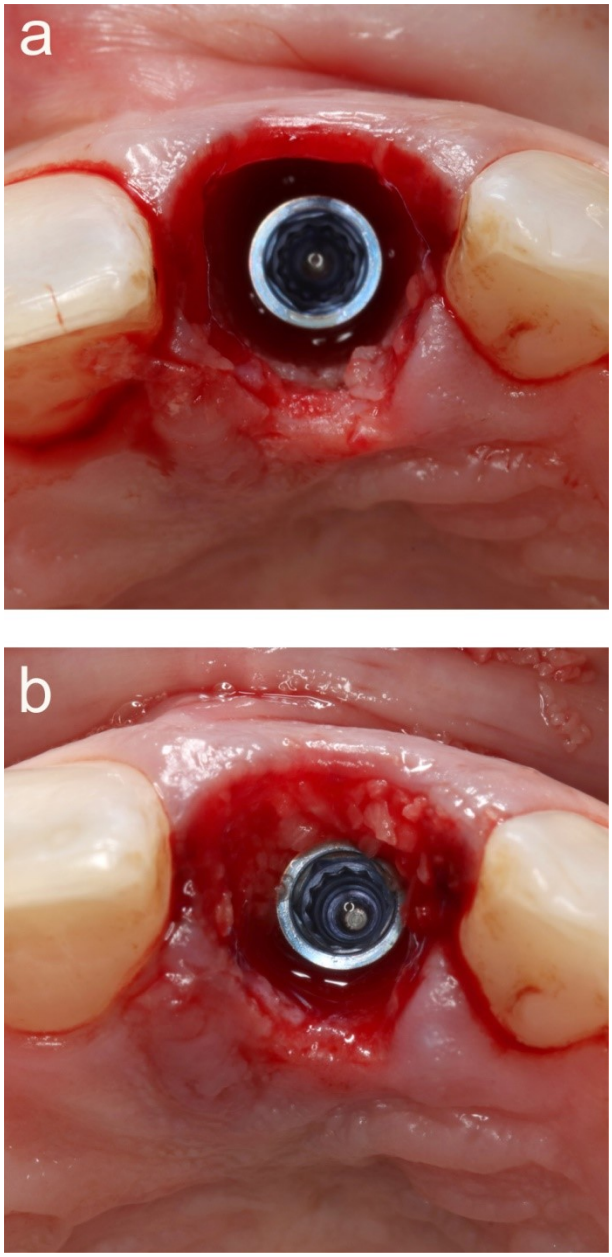

FIGURE 7 Immediate implant stabilized. 7a Occlusal view of the implant stabilized within the extraction socket, tooth #9 position. The implant emerged through the incisal edge of the planned restoration. This position permitted a favorable 2-mm peri-implant gap and did not obligate excessive facial contours in the restoration. In the definitive restoration, we planned to conceal the screw access using an angled channel. 7b A particulate freeze-dried bone allograft applied within the peri-implant gap defect and along the deep aspect of the facial mucosa.

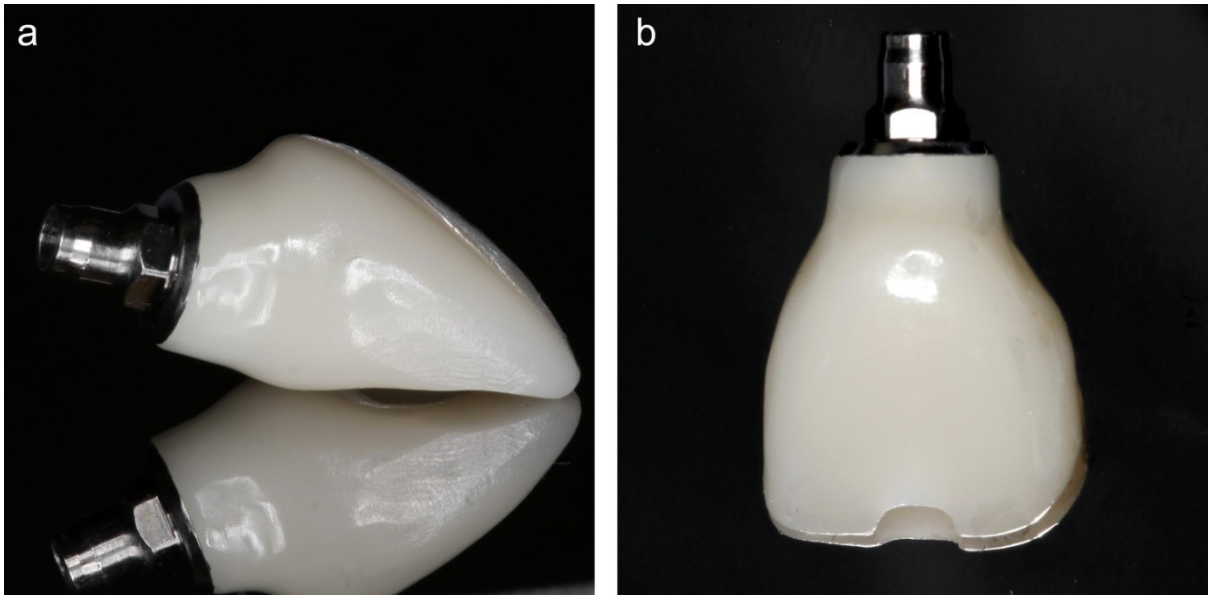

FIGURE 8 Custom provisional crown fabricated prior to tooth extraction. 8a Mesial aspect. 8b Facial aspect.

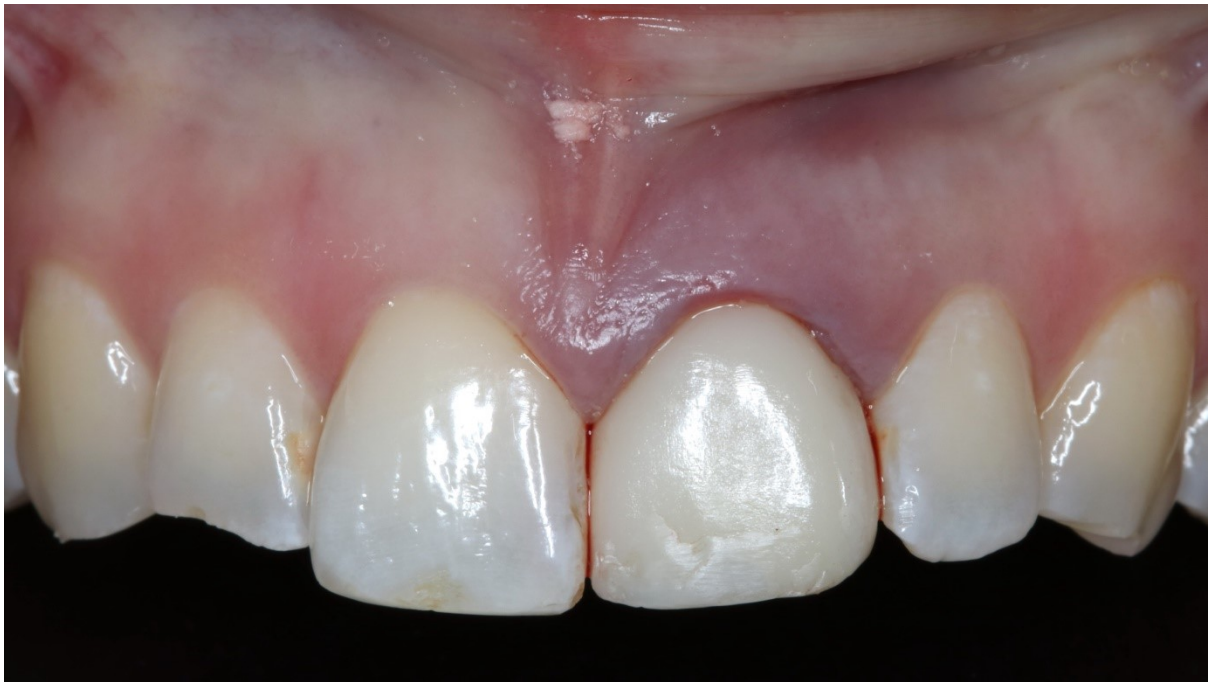

FIGURE 9 Custom provisional crown delivered. The provisional restoration required minimal chairside adjustment. Having the provisional crown prepared in advance shortened treatment time and enhanced the patient experience. Postoperatively, the patient received amoxicillin (500 mg) three times daily for one week as well as ibuprofen (800 mg) and acetaminophen (500 mg) three times daily, as needed for analgesia, with hydrocodone/acetaminophen (5/325 mg) reserved for breakthrough pain.

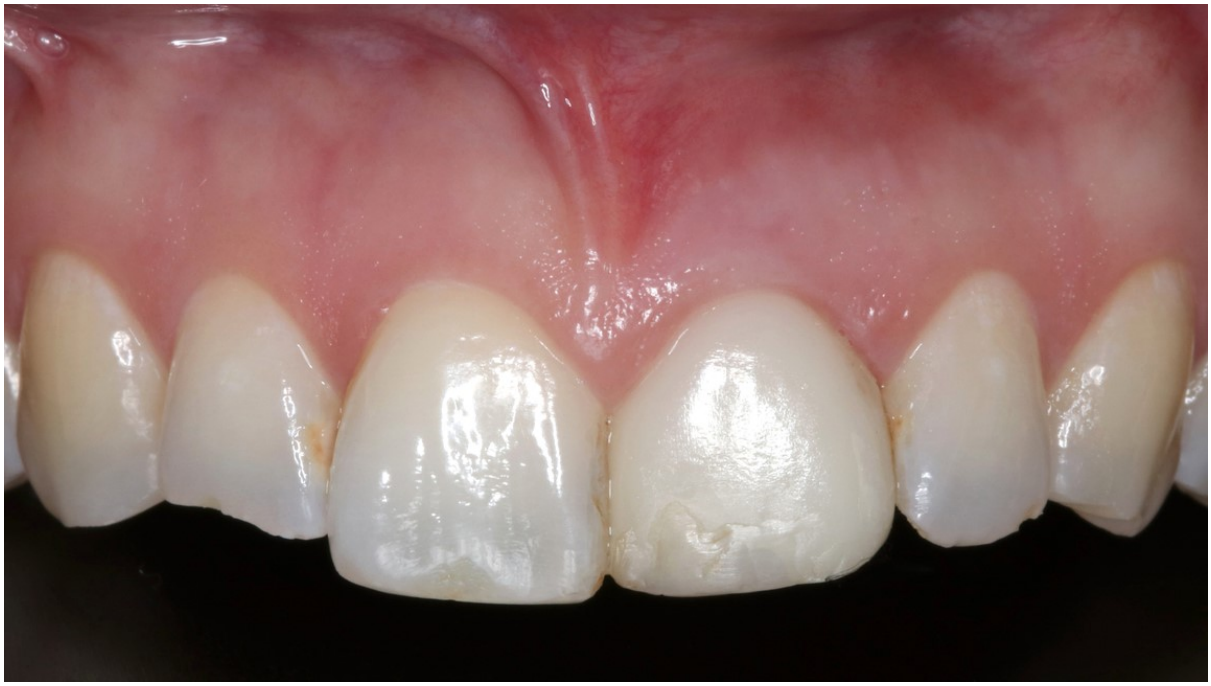

FIGURE 10 Appearance of the site at postoperative week one.

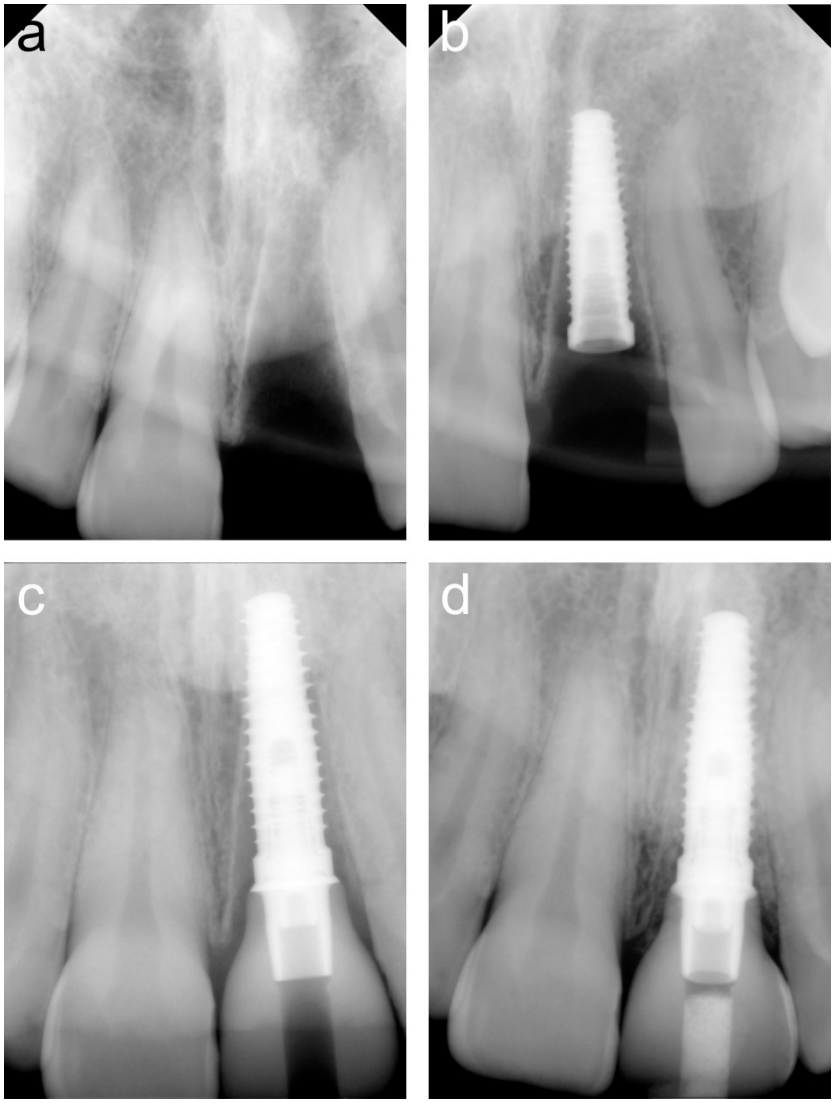

FIGURE 11 Radiographic appearance. 13a Extraction socket. 13b Immediate implant stabilized. 13c Custom provisional crown delivered. 13d Postoperative month three.

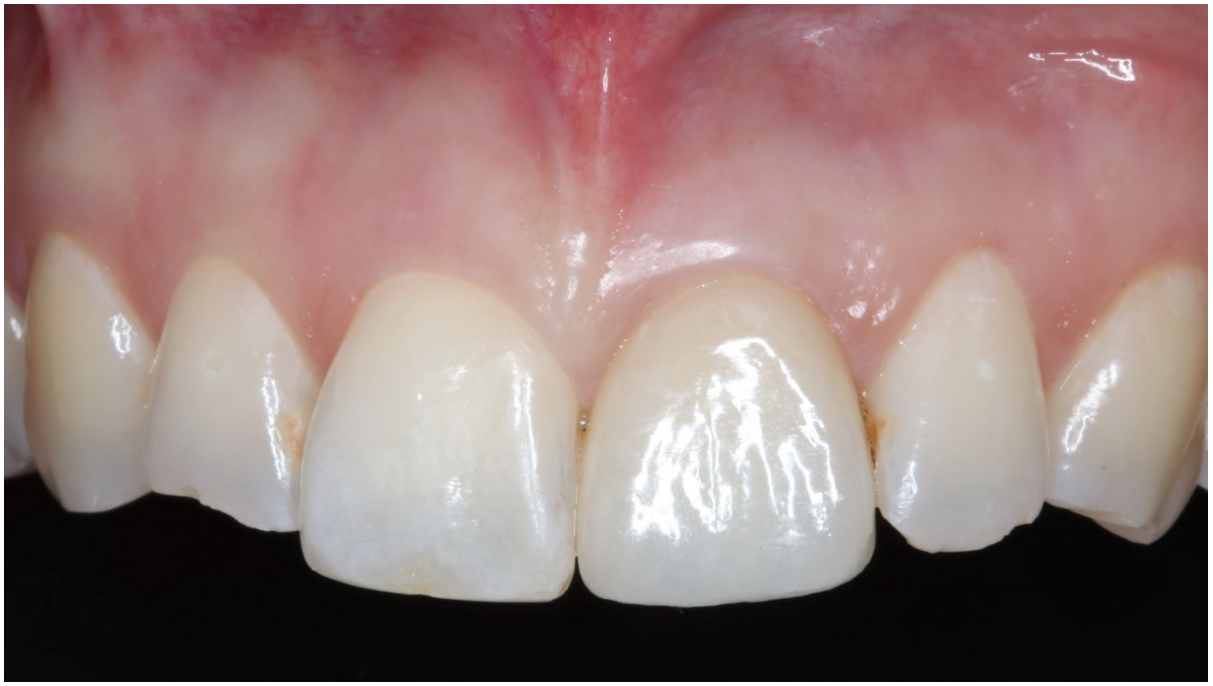

FIGURE 12 Definitive implant supported crown delivered at postoperative month seven.

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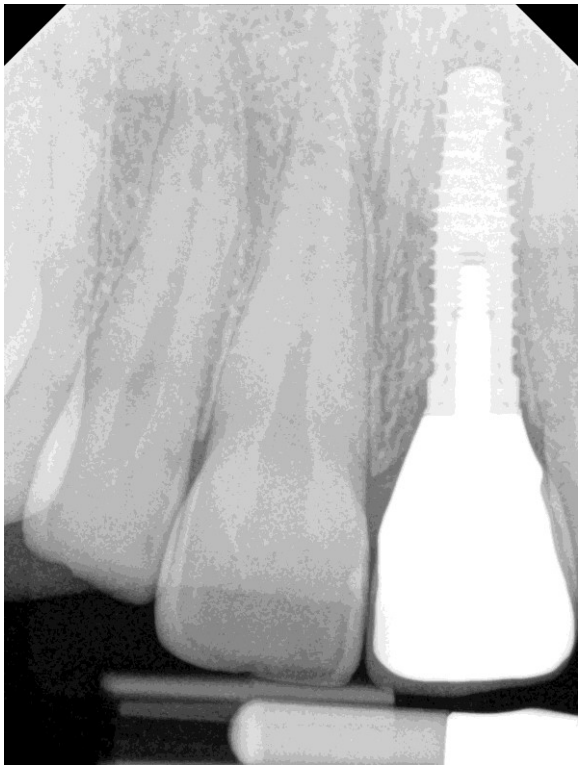

FIGURE 13 Periapical radiograph at crown delivery (postoperative month seven).

Table 1. Factors influencing clinical and patient-centered outcomes at maxillary anterior immediate implant sites

Factor	Comments
Intact extraction socket walls following tooth extraction	Presence of a facial bone deficiency at a maxillary anterior extraction socket compromises predictability of immediate implant surgery.[1,4] In such a case, the alveolus does not fully delineate and protect the area where bone regeneration is crucial—the zone immediately facial to the implant surface. Thus, depending upon defect severity and configuration, facial bone deficiency reduces or eliminates clot stability, regenerative space, and cellular resources needed for bone formation and osseointegration.[1,4]
Flapless surgery	Tooth extraction unavoidably disrupts the microvasculature supplying the alveolar bone from the periodontal ligament side. Flap reflection enhances the insult by traumatizing also the periosteum and supraperiosteal plexus.[1,5] Normal healing at a maxillary anterior immediate implant site is characterized bone fill within the socket and resorption of the facial cortex outer surface.[1] Some evidence suggests that—relative to protocols involving flap reflection—flapless implant immediate surgery may preserve crestal bone.[1,5,6,8]
Three-dimensional implant position	Labiopalatal dimension: The immediate implant should emerge at or slightly palatal to the incisal edge of the planned restoration.[1,2,4-6,8] Inappropriate implant positioning toward the facial direction increases the likelihood of cortical bone resorption and advanced mucosal recession.[1,10,11] An excessively palatal implant position compels overcontouring of the implant restoration, diminishing cleansability.[1,11] Apicocoronal dimension: When the implant platform is overly shallow, the vertical distance from the mucosal margin to the platform is insufficient to permit development of harmonious restorative contours.[1,11] In such cases, the emergence angle between the abutment and the platform can approximate 90 degrees. In the opposite extreme, when platform depth is excessive, the funnel-shaped physiologic bone remodeling that accompanies transmucosal abutment installation extends further apically.[11] The site is then at risk for unfavorable probing depths, chronic inflammation, progressive bone loss, and biologic complications.[11] Mesiodistal dimension: Provision of at least 1.5 mm (preferably 2 mm) between an implant and an adjacent tooth and at least 3 mm between adjacent implants promotes proper restorative relationships and enhances peri-implant tissue health/stability.[1,11]
Placement of a bone graft, derivative, or substitute in the peri-implant gap defect	Limited evidence suggests that placement of a bone graft or bone biomaterial within the peri-implant gap defect may mitigate untoward horizontal and vertical changes in alveolar dimensions.[1,5,6,8] Additionally, this approach may be

	protective against advanced mucosal recession.[1,4,10]
Dimensions of keratinized peri-implant mucosa	Thin periodontal phenotype is a predictor of mucosal recession at IIPP sites.[1,4-6,10] After IIPP site healing, keratinized peri-implant mucosa should measure at least 2 mm in width and thickness.[4]
Insertion torque and control of occlusal forces	Primary stability and lack of implant micromovement are prerequisites for successful osseointegration.[4,6] Clinicians have applied immediate loading protocols to IIPP;[1] however many providers elect to place the provisional restoration in infraocclusion at maximum intercuspation and in excursive movements of the mandible.[4,6] Practitioners should monitor the occlusal load at IIPP sites throughout the healing phase.
Use of a high quality provisional restoration	At IIPP sites, application of a high quality provisional restoration with excellent fit and finish is critical. Immediate postoperative esthetics and ability to resume normal activities are principal concerns for many patients.[4,6] In addition, the provisional restoration seals the socket, protects implanted biomaterials, and aids in the development/maintenance of favorable soft tissue contours.[1-6,8,10]

IIPP = immediate implant placement with immediate provisionalization

Table 2. Guided protocol for indirect fabrication of a custom provisional crown in advance of immediate implant placement in the esthetic zone

Step	Description
1	Acquire essential data elements at the evaluation appointment. The practitioner performs a thorough assessment of the patient and the potential immediate implant site. Typically, this evaluation will involve a cone-beam computed tomography (CBCT) scan and alginate impressions. A diagnostic CBCT volume and accurate stone models are necessary inputs for the described provisionalization protocol.
2	Use planning software to place a virtual immediate implant in the ideal position. This step typically involves performing an optical scan of the stone model to create a .stl file, then importing both the .stl file and the CBCT Digital Imaging and Communications in Medicine (DICOM) files into the implant planning system.
3	Establish a surgical template for the immediate implant procedure. The template and the laboratory system used to generate the custom provisional restoration must be compatible.
4	On the stone model, subtract the crown of the tooth planned for extraction. This step establishes the critical and subcritical contour requirements in the provisional restoration design.
5	Establish a putty matrix of the planned soft tissue levels on the stone model.
6	Remove stone to create space for the implant analog.
7	Attach the lab mount and implant analog to the surgical template.
8	Apply the surgical template to the stone model.
9	Stabilize the implant analog within the stone model using dental stone.
10	Remove the lab mount and surgical template.
11	Drill an injection port in the putty matrix and apply the matrix to the stone model.
12	Inject polyvinyl siloxane in the injection port to establish the soft tissue moulage.
13	Trim the soft tissue moulage to idealize the emergence profile.
14	Attach the implant scan body corresponding to the selected Ti-base to the implant analog.
15	Use optical scanner to scan the stone model, opposing model, and models in maximum intercuspation, producing an stl file for each scan.
16	Import the stl files into dental CAD software and design implant-supported crown.
17	Utilize CAD software tools to remove all static and dynamic occlusal contacts.
18	Mill the designed crown in PMMA or ceramic with a five-axis or three-axis mill.
19	Lute the crown and Ti-base.
20	Deliver the custom provisional implant-supported crown upon insertion of the guided immediate implant.

CAD = computer-aided design

PMMA = polymethyl methacrylate