

Prefabricating Implant-supported Interim Prosthesis from CBCT Scans: a Case Report of Digital Immediate Implant Restoration

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This clinical report describes the immediate implant placement and restoration for a 47-year-old woman with a protruded and loose maxillary right central incisor. The treatment included minimally invasive extraction, flapless immediate implant placement using a fully guided surgical template, and immediate implant-supported provisionalisation. The interim anatomical prosthesis was fabricated in advance based on preoperative CBCT scans, and the digital technique made it possible to integrate data precisely from different sources. After 6 months of provisionalisation, satisfactory gingival aesthetic and functional improvements were achieved, followed by a definitive screw-retained zirconia restoration. Thus, application of a complete digital workflow could reduce chairside time and create an optimal emergence profile that matches the residual bone architecture of the extraction sites with minimal interference.

Key words: aesthetic restoration, anterior teeth, digital dentistry, flapless surgery, immediate implant

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After tooth extraction, alveolar bone resorption is inevitable and presents many challenges for implant restoration, especially in the aesthetic zone^{1,2}. Immediate implant placement combined with immediate restoration is a preferred treatment option to preserve peri-implant bone and soft tissues which significantly shortens the treatment period, reduces the number of surgical procedures and improves aesthetics quickly³⁻⁶. A previous

study recommended the synergistic application of flapless surgery and immediate implant restoration to further reduce the collapse of the peri-implant bone and soft tissue⁷. As such, a straightforward and noninvasive method of designing an implant-supported anatomical interim prosthesis from CBCT scans was required.

This clinical report presents a complete digital workflow of flapless and immediate implant restoration, including diagnosis and the design and fabrication of the implant-supported prosthesis.

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Case report

Patient profile

The patient first presented to the Department of Prosthodontics, School and Hospital of Stomatology, Wuhan University, Wuhan, China, when she was 47 years old, with the chief complaints of tooth loosening and an unaesthetic smile. She was eager to achieve a better aesthetic and functional outcome with implant restoration. The facial examination showed that the protruded max-

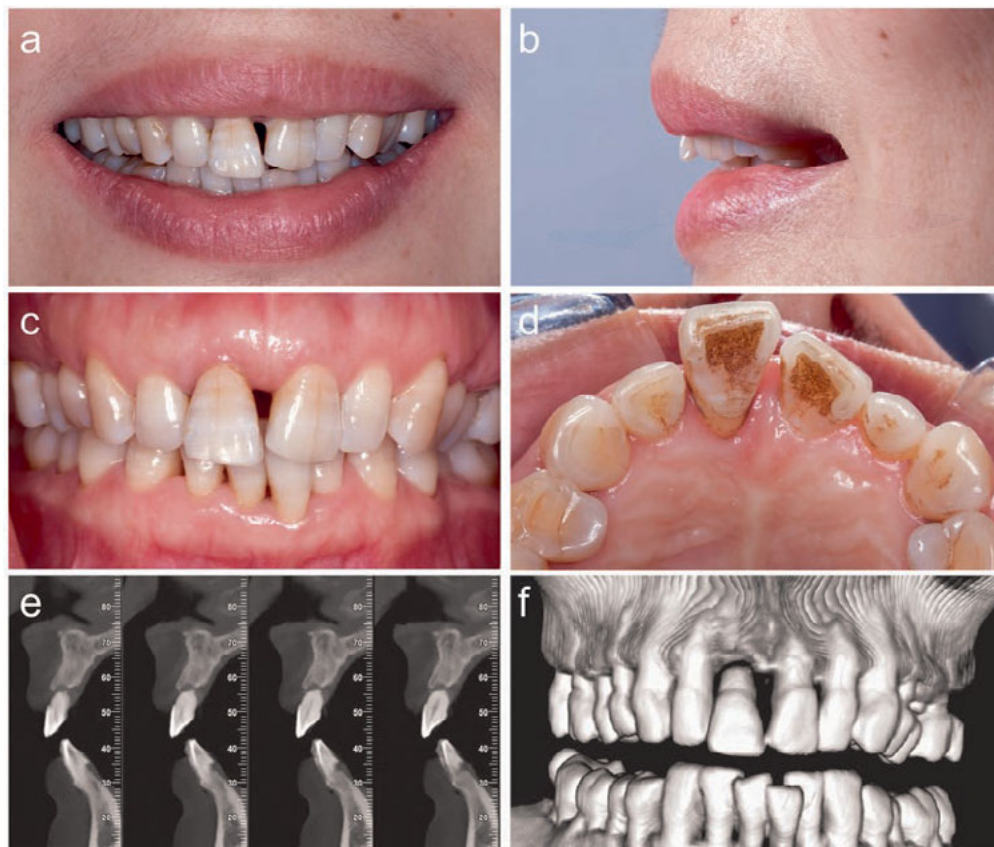


Fig 1 Pretreatment clinical examination. **(a)** Frontal smile view. **(b)** Profile smile view. **(c)** Anterior view of dentition. **(d)** Maxillary arch view. **(e and f)** CBCT slice and reconstituted images.

illary right incisor produced a disharmonious lip–tooth relationship, excessive tooth visibility at rest and black triangles during her maximum smile (Figs 1a and b). An intraoral examination identified Class 3 mobility of the right central incisor according to Miller’s classification (Figs 1c and d). A CBCT evaluation further confirmed obvious resorption in the root apical zone of the maxillary right central incisor and separate from the alveolar ridge, and no inflammation was seen (Figs 1e and f). It was determined that the occlusal relationship was stable and there was sufficient restorative space.

Treatment plan

After the preoperative clinical and radiographic examination, treatment alternatives and costs were discussed. A comprehensive, detailed treatment plan was proposed, which comprised minimally invasive extraction of the maxillary right central incisor, insertion of the implant in an optimal 3D position, followed by appropriate provisionalisation, and delivery of the definitive restorations after 6 months of peri-implant tissue stability. The patient was informed of the clinical plan and informed consent was obtained prior to treatment.

Design of the surgical template and interim prosthesis

The CBCT scans generated digital imaging and communications in medicine (DICOM) files, while a 3D desktop lab scanner (iSCAN-I; Shining 3D, Hangzhou, China) was used to produce standard tessellation language (STL) files from the patient’s dentition. The DICOM and STL files were merged in planning software (3Shape Implant Studio; 3Shape, Copenhagen, Denmark) to design the fully guided surgical template for implant placement (Figs 2a to c). We segmented the tooth data from the preoperative CBCT scans to design the implant-supported interim anatomical prosthesis (Fig 2d). Specifically, the emergence profile of the prosthesis was designed based on the tooth to be extracted, while the crown contour was designed with reference to the contralateral natural tooth.

It is noteworthy that, compared with the extracted tooth, the subcritical contour of the customised temporary abutment was reduced to leave enough space for the soft tissue (Figs 3a and b). The design software was also used to map the bone density around the entire circumference of the planned implant, which indicated that ideal primary stability could be achieved (Fig 3c)⁸. All the design data were sent to the dental laboratory

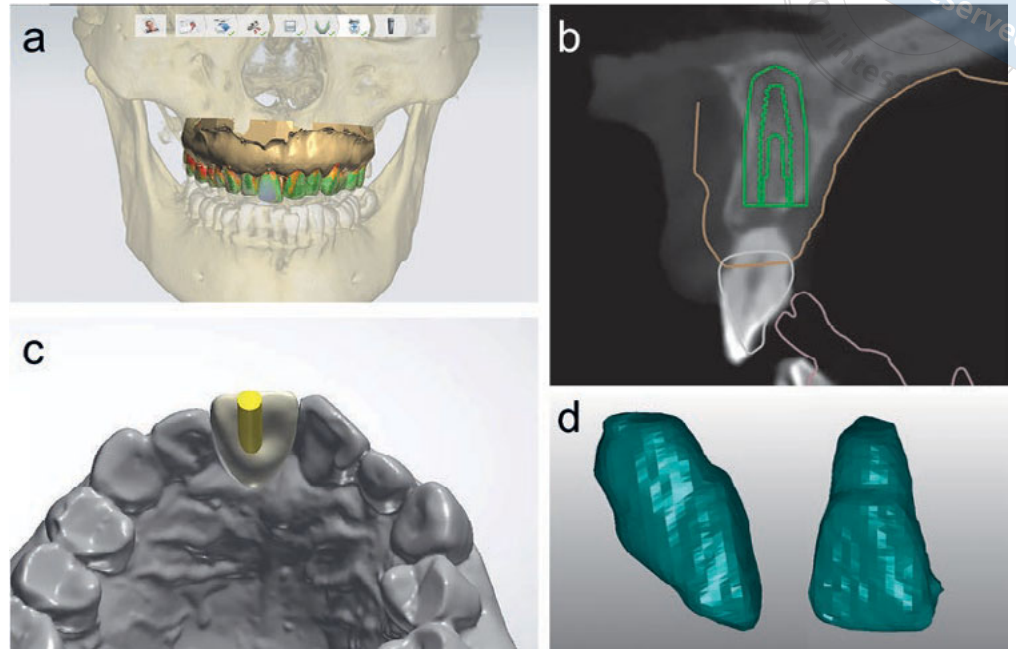


Fig 2 Design of surgical template and interim prosthesis. **(a)** Fusion of the CBCT scans and digital impression. **(b and c)** Implant placed in the optimal 3D position. **(d)** Exported tooth STL file.

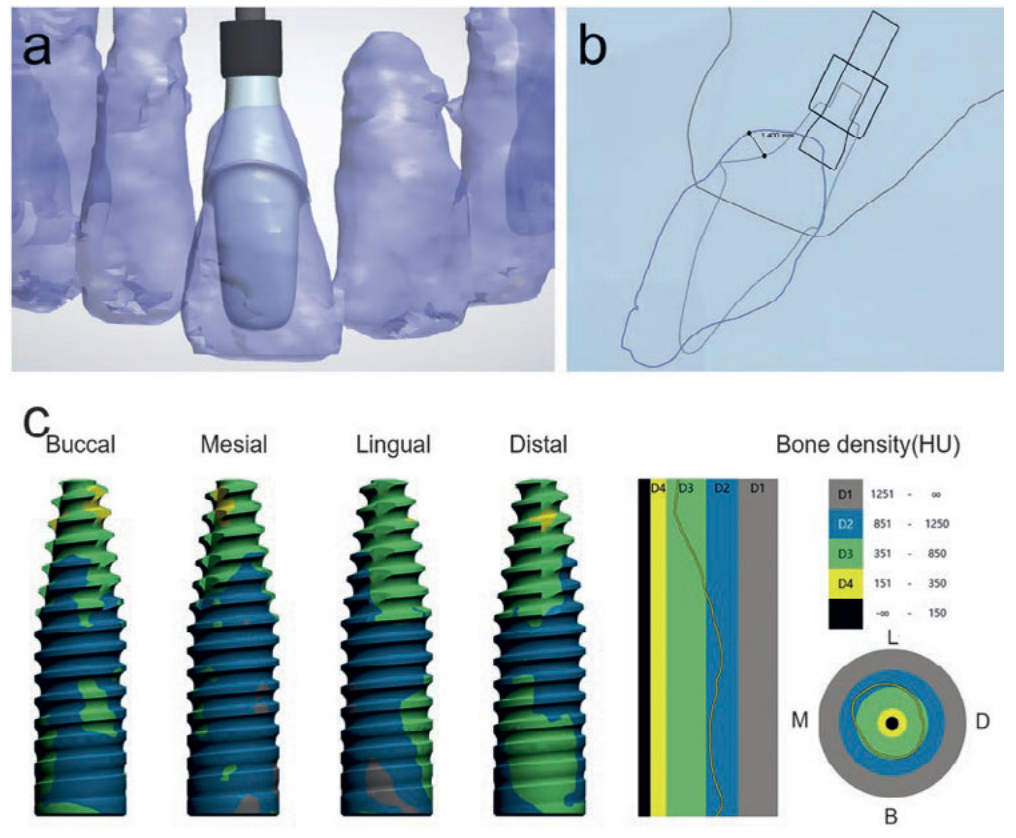


Fig 3 **(a)** Design of the temporary abutment. **(b)** The diameter of the temporary abutment was reduced on the buccal side. **(c)** Bone map around the planned implant.

for fabrication and 3D printing and the surgical template (Fig 4a) and interim prosthesis were produced. The interim prosthesis was composed of a CAD/CAM-customised titanium temporary abutment and an acrylic

resin crown (Figs 4b and c) and they were cemented extraorally to form an integrated structure before use.

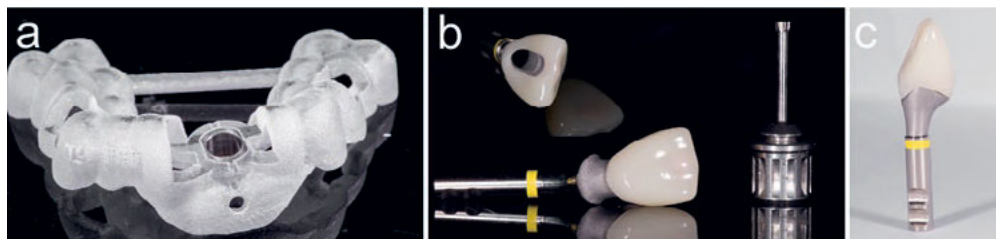


Fig 4 (a) Prefabricated surgical template. (b and c) Interim prosthesis.

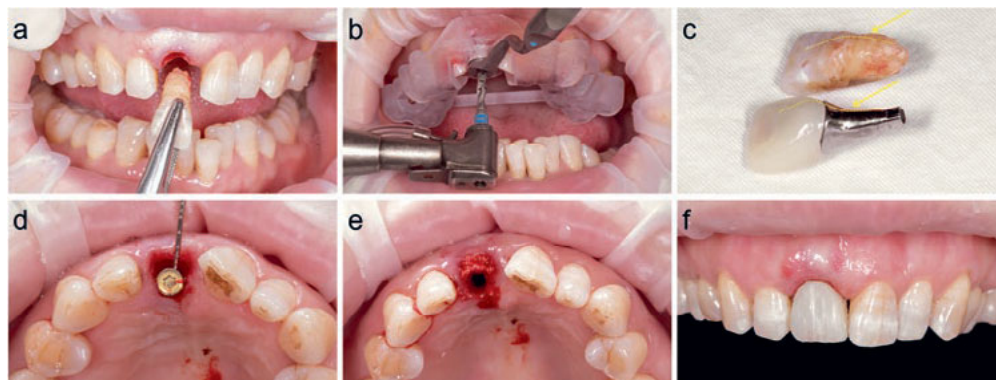


Fig 5 Surgical procedures. (a) Minimally invasive tooth extraction. (b) Fully guided implant placement. (c) Comparison of the extracted tooth and the temporary prosthesis. (d) Implant placement in a prosthetically guided position. (e) Bone augmentation. (f) Temporary restoration.

Treatment steps

Minimally invasive extraction of the maxillary right central incisor was performed under local anaesthesia, followed by socket cleaning (Fig 5a). Implant placement procedures were performed step by step according to the digital planning surgical template (Fig 5b). The self-tapping conically shaped implant (Straumann Bone Level Tapered, Basel, Switzerland) was inserted, and the primary stability reached over 35 Ncm, which allowed for immediate provisionalisation⁹. After trying-in of the interim prosthesis and confirming it matched with the actual extraction site, a healing abutment (3.6*5.0 mm) was screwed into the position to avoid the bone graft material entering the implant screw hole during the following bone augmentation procedure (Fig 5d). Guided bone regeneration (GBR) was performed using bone substitutes (Bio-Oss; Geistlich Pharma, Wolhusen, Switzerland) (Fig 5e). Finally, the implant-supported interim prosthesis was placed without occlusal contact, and this treatment can close the implant cavity to stabilise the underlying bone graft substitute and support the soft tissue contour. The screw hole was closed with Teflon and composite resin (Fig 5f).

After 6 months of provisionalisation, clinical and radiographic examination verified that the patient had preserved the contour and volume of the peri-implant bone and soft tissues, achieved gingival aesthetics and stabilised the gingival margin (Fig 6). Then, the customised impression coping was fabricated and

definitive impressions were made with a polyether impression material (Impregum Penta Soft, 3M, St Paul, MN, USA) and a 3D printed customised open tray. It is notable that the labial appearance of the definitive prosthesis was designed according to the shape, contours and characteristics of the left central incisor, as well as the acrylic resin interim crowns (Fig 7). The screw-retained zirconia restoration was completed and tried-in to evaluate the aesthetic performance, occlusion and phonetics clinically. The patient was very satisfied with the final treatment outcome. The pink and white aesthetic scores were 8 and 9, respectively, according to the maxillary anterior single-tooth implants aesthetic index¹⁰. She was instructed to perform adequate oral hygiene. After two years of treatment, she has maintained good oral hygiene and the hard and soft tissues have remained stable.

Preoperative design and actual placement of the implant body

The data from the preoperative and postoperative CT scans were analysed using planning software. After superimposing the preoperative CBCT images on the postoperative CBCT images, 3D positional deviations, distances and angulations between the preoperative designed position and the actual placement of the implant body were measured (Fig 8).



Fig 6 After 6 months of provisional restoration. **(a)** Anterior view. **(b)** Gingival emergence profile. **(c)** Periapical radiograph.

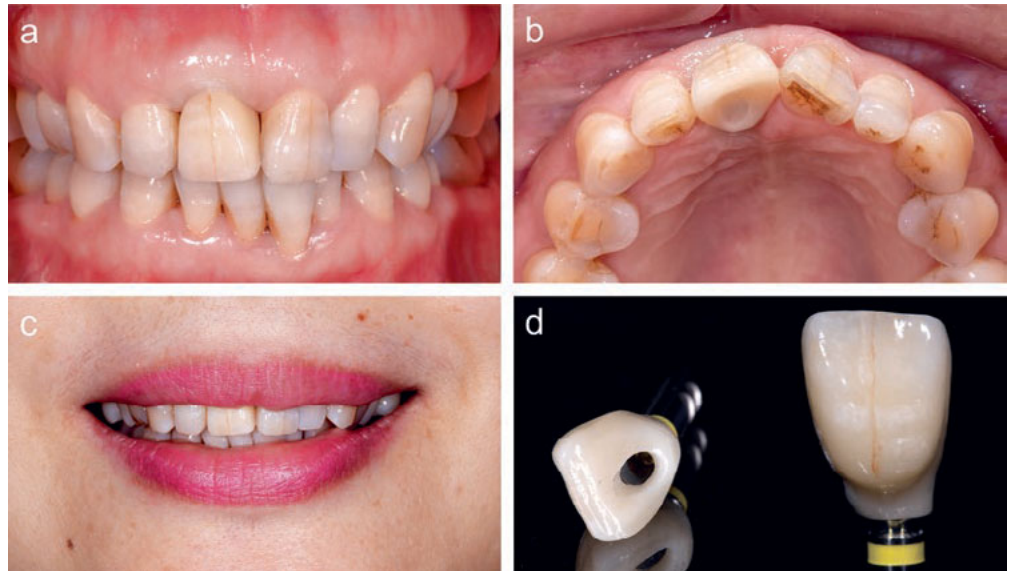


Fig 7 Posttreatment clinical examination. **(a)** Anterior view of the dentition. **(b)** Maxillary arch view. **(c)** Frontal smile view. **(d)** Definitive screw-retained zirconia prosthesis.

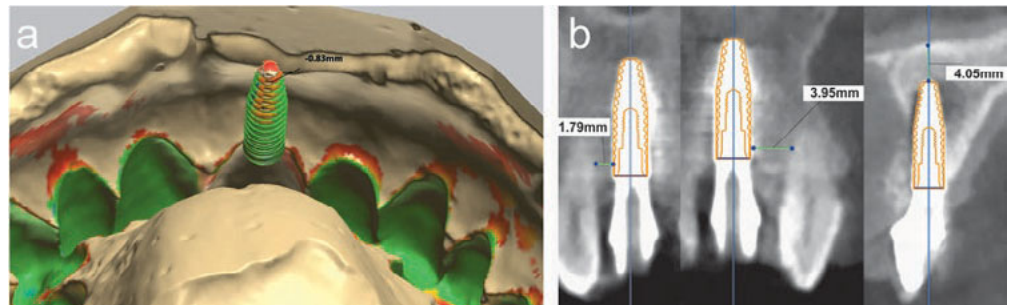


Fig 8 **(a)** Assessment of implant placement deviation. **(b)** Postoperative CBCT examination.

Discussion

According to the simplified extraction socket classification proposed by Elian et al¹¹, the extraction socket in the present study was Type I; that is, both the facial soft tissue and the buccal bone plate were at normal levels in relation to the cemento-enamel junction. As such, the implant was placed simultaneously to tooth extraction, and immediate insertion of an interim prosthesis into the fresh extraction socket was an appropriate choice to guide wound healing and counter the physiological process of tissue resorption in this case.

Traditionally, for immediate provisionalisation, the temporary abutment is hand-tightened onto the implant, and composite resin was used directly to build up the

buccal/lingual contour of the interim crown, then the mesial/distal contour and emergence profile were layered carefully extraorally. After repeated grinding, trimming and polishing, the immediate restoration can be obtained¹². However, this method relies heavily on the dental practitioner’s composite building skills, and the steps require a considerable amount of chairside time. Furthermore, there is a risk of contaminating the surgical wound during this procedure. In the present study, to overcome these problems and achieve more desirable aesthetic results, we applied a straightforward method to design an interim anatomical prosthesis based on preoperative CBCT scans. Use of the appropriate software distinguished the different components of the 3D

images developed by CBCT scans, making it possible to record the subgingival anatomy of the tooth to be extracted and the crown contour of the contralateral natural tooth at the same time¹³. The customised design of critical and subcritical contour is beneficial to achieve a better emergence profile for the definitive restoration¹⁴.

The six critical steps in this paper for minimally invasive immediate implant placement and restoration were, in consecutive order:

1. Surgical template design and interim prosthesis preparation;
2. Minimally invasive tooth extraction;
3. Fully guided flapless immediate implant placement;
4. Guided bone regeneration;
5. Implant-supported provisionalisation;
6. Delivery of the screw-retained definitive restoration.

Immediate implant placement protocols in the aesthetic region require thorough treatment planning and step-by-step execution. Traditional implant surgery involves flap reflection to prepare the site for fixture positioning. In this case, the surgery began with a minimally invasive tooth extraction without damaging the buccal bone wall. Flapless surgery could reduce surgical discomfort, minimise aesthetic damage and preserve the contour and volume of the peri-implant tissues¹⁵. However, flapless surgery with digital immediate implant placement is highly technique sensitive and requires a skilled clinician. There are some ways to help beginners in implantology reduce errors. First, beginners should ensure complete seating of the surgical guide and master the correct use of the guide cassette. Second, complete osteotomy depth but under-drilling for primary stability is necessary in most immediate placement cases. Third, it is important to fill the jumping gap with slow-resorbable biomaterial to prevent bone resorption after tooth extraction. Last but not least, soft tissue augmentation is recommended for patients with a thin gingival biotype.

With the aid of digital techniques, accuracy analysis of implant placement was performed in the present case. The 3D deviation in the entry section and tip section and the maximum angle shift of the implant body was 0.85 mm, 0.83 mm and 1.2 degrees (Fig 8), respectively, which was substantially less than reported in previous studies¹⁶. It could be observed that there was sufficient distance between the implant body and adjacent teeth. Based on the experience in the present case, we suggest that a fully digital workflow could represent a very attractive method to increase the accuracy of implant placement and provisional restoration.

Conclusion

This clinical report presented a complete digital workflow for immediate and flapless implant placement, and a novel strategy for prefabricating an implant-supported interim prosthesis from CBCT scans was developed. This approach reduced time and created an optimal emergence profile that matched the residual bone architecture of the extraction sites with minimal interference.

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Conflicts of interest

The authors declare no conflicts of interest related to this study.

Author contribution

Dr Hong Ye YANG diagnosed and treated the patient and checked the manuscript; Dr Aihemaiti MUHETAER created the treatment plan, collected the data and drafted the manuscript; Dr Ya Ke WANG treated the patient and checked and revised the manuscript; Dr Cui HUANG created the treatment plan and revised the manuscript. All authors approved the final manuscript.

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References

1. Araújo MG, Lindhe J. Dimensional ridge alterations following tooth extraction. An experimental study in the dog. *J Clin Periodontol* 2005;32:212–218.
2. Araújo MG, Lindhe J. Ridge alterations following tooth extraction with and without flap elevation: An experimental study in the dog. *Clin Oral Implants Res* 2009;20:545–549.
3. Blanco J, Carral C, Argibay O, Liñares A. Implant placement in fresh extraction sockets. *Periodontol* 2000 2019;79:151–167.
4. Araújo MG, Silva CO, Souza AB, Sukekava F. Socket healing with and without immediate implant placement. *Periodontol* 2000 2019;79:168–177.
5. Oh KC, Jeon C, Park JM, Shim JS. Digital workflow to provide an immediate interim restoration after single-implant placement by using a surgical guide and a matrix-positioning device. *J Prosthet Dent* 2019;121:17–21.
6. Gamborena I, Sasaki Y, Blatz MB. Predictable immediate implant placement and restoration in the esthetic zone. *J Esthet Restor Dent* 2021;33:158–172.

7. Noelken R, Moergel M, Kunkel M, Wagner W. Immediate and flapless implant insertion and provisionalization using autogenous bone grafts in the esthetic zone: 5-year results. *Clin Oral Implants Res* 2018;29:320–327.
8. Turkyilmaz I, Tözüm TF, Tumer C. Bone density assessments of oral implant sites using computerized tomography. *J Oral Rehabil* 2007;34:267–272.
9. de Carvalho BC, de Carvalho EM, Consani RL. Flapless single-tooth immediate implant placement. *Int J Oral Maxillofac Implants* 2013;28:783–789.
10. Belser UC, Grütter L, Vailati F, Bornstein MM, Weber HP, Buser D. Outcome evaluation of early placed maxillary anterior single-tooth implants using objective esthetic criteria: A cross-sectional, retrospective study in 45 patients with a 2- to 4-year follow-up using pink and white esthetic scores. *J Periodontol* 2009;80:140–151.
11. Elian N, Chi SC, Froum S, Smith RB, Tarnow DP. A simplified socket classification and repair technique. *Pract Proced Aesthet Dent* 2007;19:99–104.
12. Siadat H, Alikhasi M, Beyabanaki E. Interim prosthesis options for dental implants. *J Prosthodont* 2017;26:331–338.
13. Polara G, Pistone F, Giorgio Alfredo S. Digital immediate tooth restoration: Fabricating acrylic resin interim crowns from CBCT scans for immediate implant-supported prostheses: A case series. *J Prosthet Dent* 2022;127:578–584.
14. Su H, Gonzalez-Martin O, Weisgold A, Lee E. Considerations of implant abutment and crown contour: Critical contour and subcritical contour. *Int J Periodontics Restorative Dent* 2010;30:335–343.
15. Dietrich T, Schmid I, Locher M, Addison O. Extraction force and its determinants for minimally invasive vertical tooth extraction. *J Mech Behav Biomed Mater* 2020;105:103711.
16. Chen Z, Li J, Sinjab K, Mendonca G, Yu H, Wang HL. Accuracy of flapless immediate implant placement in anterior maxilla using computer-assisted versus freehand surgery: A cadaver study. *Clin Oral Implants Res* 2018;29:1186–1194.