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DENTAL TECHNIQUE

A digital technique for fabricating an interim implant-supported fixed prosthesis immediately after implant placement in patients with complete edentulism

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ABSTRACT

The conversion of a denture into an interim implant-supported, screw-retained restoration has become the standard method for immediate interim restoration in patients with complete edentulism. The most critical steps of the denture conversion process are the creation of appropriate denture access holes to prevent displacement of the denture by the interim cylinders and removal of the denture flanges to facilitate both good esthetics and accessibility for oral hygiene after the denture is connected to the interim cylinders. This article presents a digital technique for designing and fabricating an interim implant-supported, fixed prosthesis for edentulous patients. The interim prosthesis has cylinder access holes that are digitally prefabricated and a denture flange part that is designed to be easily sectioned. This technique facilitates more straightforward and efficient immediate restoration for edentulous patients after implant placement. (J Prosthet Dent 2019;121:26-31)

The use of immediate interim implant-supported fixed restorations has been a popular treatment approach for edentulous individuals after implant placement.[1-3] Although several techniques for immediate interim restoration have been proposed,[1,2] the conversion of a denture into an interim implant-supported, screw-retained restoration has become the standard method for edentulous patients.[3] The technique involves the placement of interim cylinders onto the implants and modification of the patient's existing denture.[4] One of the most critical steps in the denture conversion process is the creation of appropriate denture access holes to prevent displacement of the denture by the interim cylinders.[3,5] The access holes made in the denture should allow the denture to be placed passively into the proper position in the mouth without being disturbed by interference from the abutments and cylinders.[3,5] When access holes are made in the wrong position, the denture cannot be placed over the interim cylinders unless a large part of the denture is removed.[6] Another critical step of the denture conversion process is the removal of denture flanges and the palatal denture base material to allow for both good esthetics and accessibility for oral hygiene. This preparation process requires time and skill. Therefore, the process is subject to human error and inaccuracies and is time-consuming.[6] This report presents a digital technique for fabricating an interim implant-supported restoration for edentulous patients in a rapid, accurate, and comfortable manner. As both the planning and restorative procedures are entirely digitally driven, the process is highly accurate, thereby substantially reducing patient chair time.

TECHNIQUE

The following steps are followed for fabricating a complete-arch, fixed, implant-supported interim restoration:

1. To implement a prosthetically driven implant plan, obtain intraoral scan data and cone beam computed tomography (CBCT) data. Before obtaining the digital data from the edentulous ridge, inject flowable composite resin (CharmFil Flow; Dentkist Inc)

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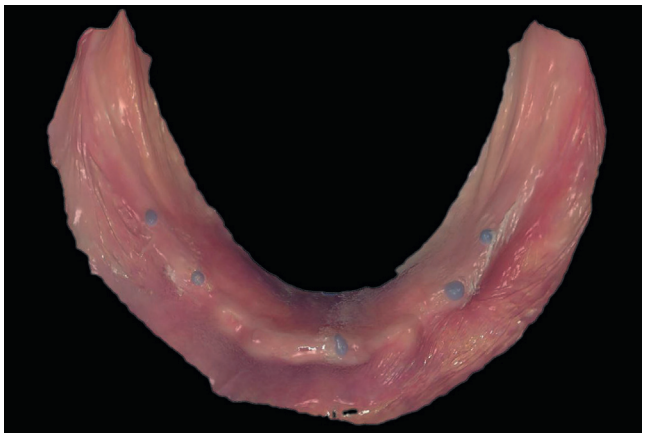

Figure 1. Scan of edentulous mandible from intraoral scanner (TRIOS).

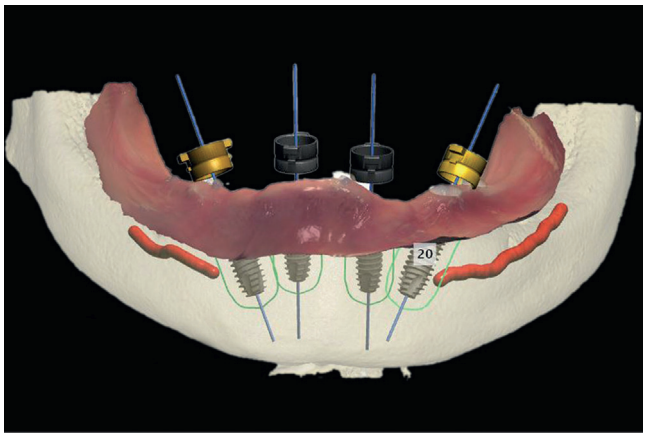

Figure 2. Virtual implant planning.

with a diameter of 1 or 2 mm in a half-sphere shape at more than 3 different sites on the attached gingiva for use as markers to superimpose the intraoral scan and CBCT data. Then, light polymerize the injected resin. After polymerization, apply adhesive (Histoacryl; B. Braun, Aesculap AG) to the resin markers to secure them in place. After the adhesive has dried, obtain CBCT scans of the maxilla and mandible. When the scans are completed, obtain digital scans of the edentulous ridge and opposing teeth using an intraoral scanner (TRIOS 3; 3Shape A/S) (Fig. 1).

2. Virtually superimpose the intraoral scan and CBCT images by matching the resin markers present in both the images using virtual implant planning software (Implant Studio; 3Shape A/S).
3. Implement a prosthetically driven implant plan in the superimposed virtual model using virtual implant planning software (Implant Studio; 3Shape A/S) (Fig. 2).
4. Once the implant plan is completed, design a surgical template from the same data and software (Fig. 3). Print the template using a 3-dimensional (3D) printer (PROBO; DIO Implant Co).
5. Design an interim restoration aligned with the corresponding occluding surfaces by using the denture planning software (Dental System; 3Shape A/S) (Fig. 4A). The program allows occlusal adjustment via the virtual articulator. More accurate denture teeth can be prepared by simulation of the mastication function using the virtual articulator (Fig. 4B). The interim restoration has 2 parts: a fixed prosthesis and a denture flange. The fixed prosthesis is designed to have the cylinder access holes, considering the planned implant positions (Fig. 4C, 4D). The holes allow enough space for the cylinders to pass through the restoration. In addition, the fixed prosthesis part has a design that is in

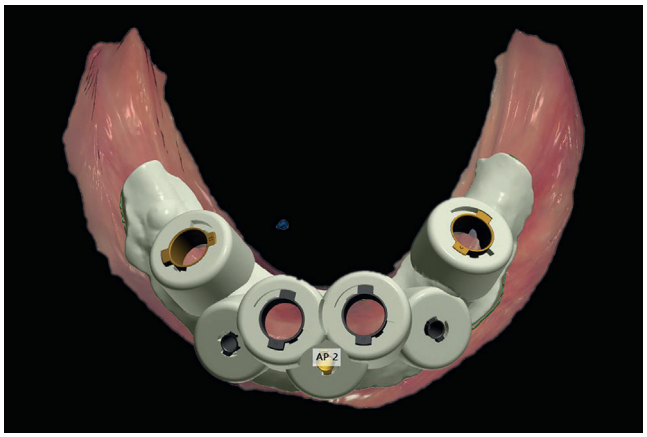

Figure 3. Designed guide to place four dental implants.

accordance with the definitive restoration, in terms of esthetics, occlusion, ideal emergence profile, and accessibility for oral hygiene. The denture flange part is designed as a complete denture for repositioning the fixed prosthesis in the mouth, which is then easily cut off from the fixed prosthesis. The interim restoration has no denture flange in the labial aspect. Once the restoration design is complete, print it using a commercial printable resin (DIOnavi C&B; DIO Implant Co) in a 3D printer (Probe; DIO Implant Co). After printing the interim restoration (Fig. 5A), apply tissue-colored composite resin (Gradia; GC America) onto the gingival area of the prosthesis with subsequent light polymerization to simulate gingival tissue (Fig. 5B, C).

6. After placing implants with the surgical template in the patient's mouth, connect the abutments to the implants (Fig 6A). Then, connect the interim restoration to the interim cylinders that are seated onto the abutments by adding acrylic resin (Duo-Link; Bisco Dental) around the cylinders with a syringe (Fig 6B).

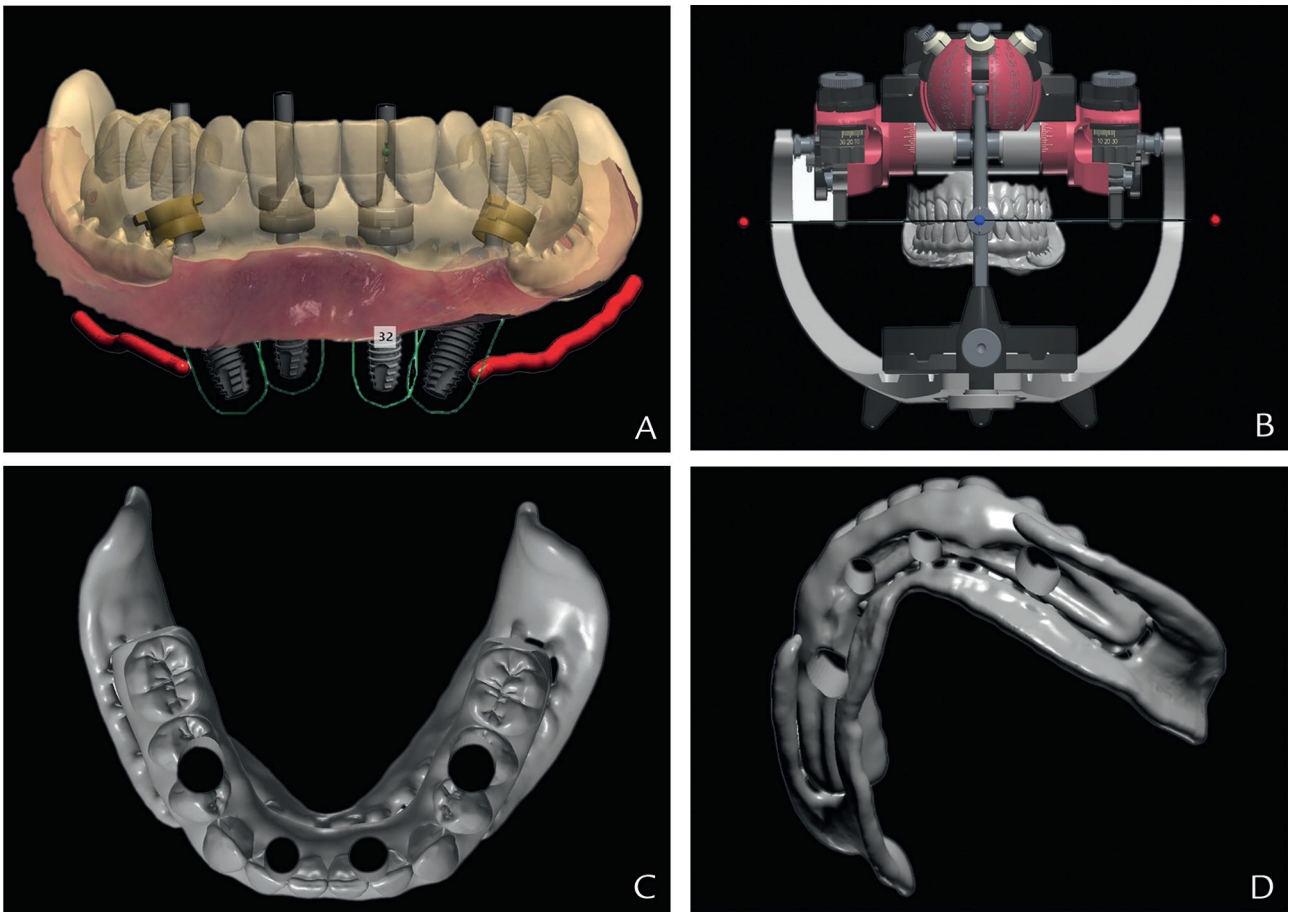

Figure 4. Designed interim restoration. A, Facial view. B, Occlusal adjustment on virtual articulator. C, Occlusal view. D, Intaglio view.

7. When the resin has polymerized, remove the interim restoration from the mouth and the denture flange part with either an acrylic resin trimming bur or a diamond disk (Fig. 7A).
8. Attach the fixed prosthesis part to the implant abutments in the mouth with interim cylinders fastened by screws (Fig. 7B).
9. Evaluate the occlusion and make occlusal adjustments when necessary.

DISCUSSION

The purpose of this article was to describe a digital technique for fabricating an interim implant-supported restoration for edentulous patients. The key factor in the technique is that an interim restoration is produced by combining an intraoral scanner, CBCT, computer-aided design and computer-aided manufacturing (CAD-CAM), and 3D printing. First, the interim restoration is digitally designed using digital data acquired from the patient's mouth with an intraoral scanner and CBCT, after which the restoration is printed using a 3D printer. The fabrication of the restoration is based on the benefits of the digital workflow, that is, the prediction of the type, length, size, and position of the implants, abutments, and cylinders that are used for the patient, which in turn leads to the addition of cylinder access holes in the design of the interim restoration.[7,8] The main advantage of the technique is that it enables clinicians to obtain a prefabricated interim-fixed prosthesis before implant placement, simulating the design of the definitive prosthesis. The fixed prosthesis has a denture flange part that can be easily cut off after connecting the interim restoration to the interim cylinders. The denture flange part is used to reposition the fixed prosthesis part in the mouth while maintaining the vertical dimension and occlusal relationship. This technique allows the prosthetic procedures at the time of implant placement to be accomplished in a rapid manner, as the time required to connect the interim restoration to the interim cylinders and remove the denture flanges and palatal denture base material is significantly reduced by this digital workflow.

Computer-guided implant surgery has been validated as an efficient and reliable technique since its introduction in the early 2000s.[9-12] Computer-guided implant surgery is defined by the use of a surgical template that

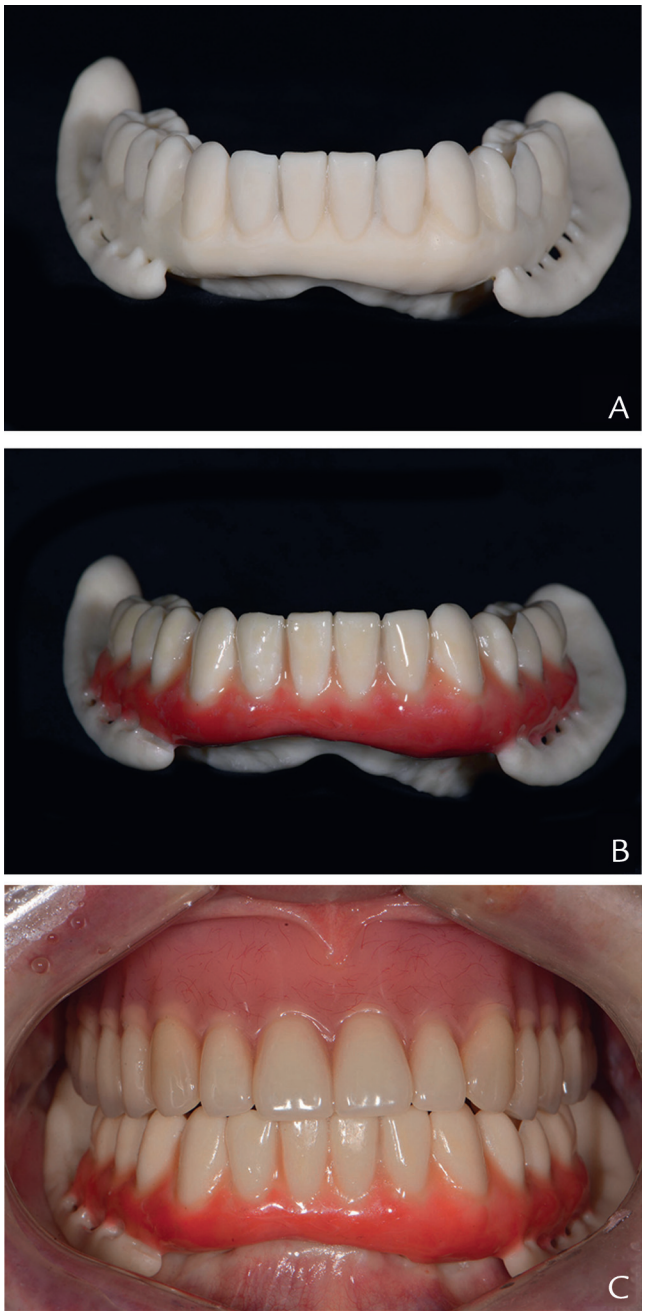

Figure 5. A, Interim restoration fabricated using 3D printer. B, Interim restoration with tissue-colored composite resin on gingival area. C, Interim restoration in mouth.

reproduces a virtual implant surgical plan from computed tomographic data.[13-15] The benefit of this approach is a more predicable implant placement with a surgical template fabricated using CAD-CAM based on a prosthetically driven treatment planning process in a virtual implant planning software.[16] The accuracy of the interim restoration for cylinder access holes is directly related to the accuracy of the surgical template. The higher the deviation of implant placement, the bigger the holes and the longer the time required to convert the denture. When the implants are placed according to the implant planning, the denture can be placed over the interim cylinders in the patient's mouth without expanding the holes in the denture.

Restoration in patients with complete edentulism has been associated with a high incidence of fracture of fixed implant-supported interim prostheses fabricated through a denture conversion process, especially during the healing phase.[10,11] One of the main reasons for such fractures is the lack of strength of the denture after the conversion process, especially when a large part of the denture is removed to make the cylinder access holes. The repaired denture usually loses about 40% to 60% of its strength.[17] Keerthi et al[18] suggested the use of a CAD-CAM interim prosthesis milled from a polymethyl methacrylate (PMMA) block because the superior mechanical properties of a PMMA block can reduce the incidence of mechanical complications associated with the use of the interim prosthesis. However, they used a conventional diagnostic waxing to design the interim prosthesis. The technique presented in this article uses a digital approach to design the interim prosthesis. In addition, it allows the fabrication of a monolithic denture, in which the denture teeth are printed as part of the denture; a monolithic denture has a lower risk of fracture than a bonded denture, in which the denture teeth are bonded into the denture base.

The technique presented offers the advantage of allowing the use of the denture if the implants are not stable enough to support the fixed prosthesis after implant placement. The denture can be relined chairside. An additional advantage of the digital workflow is that when a new denture is required, the prefabricated denture can be used as a custom tray for border molding and for obtaining the definitive impression. The digital images of the denture base obtained by scanning the definitive impression can be used to fabricate a new denture. Therefore, the fabrication of new dentures is simplified, as the digital workflow allows dentists to acquire the necessary data easily.

CAD-CAM technology has been recently applied to the fabrication of dentures.[19-22] Until recently, laboratory scanners were used for the digitalization process in edentulous jaws. The information needed for a CAD-CAM restoration in edentulous jaws was previously acquired extraorally using an impression or a cast. This technique has the same deficiencies as conventional impression and cast making. There is also concern over the possibility of scanning inaccuracies with a laboratory scanner.[23,24] To avoid the errors associated with the conventional CAD-CAM production workflow, it would be more practical to perform digitalization directly in the patient's mouth using intraoral scanners. Therefore, this technical report describes the CAD-CAM fabrication of dentures based on direct digital scans of edentulous jaws made with intraoral scanners.

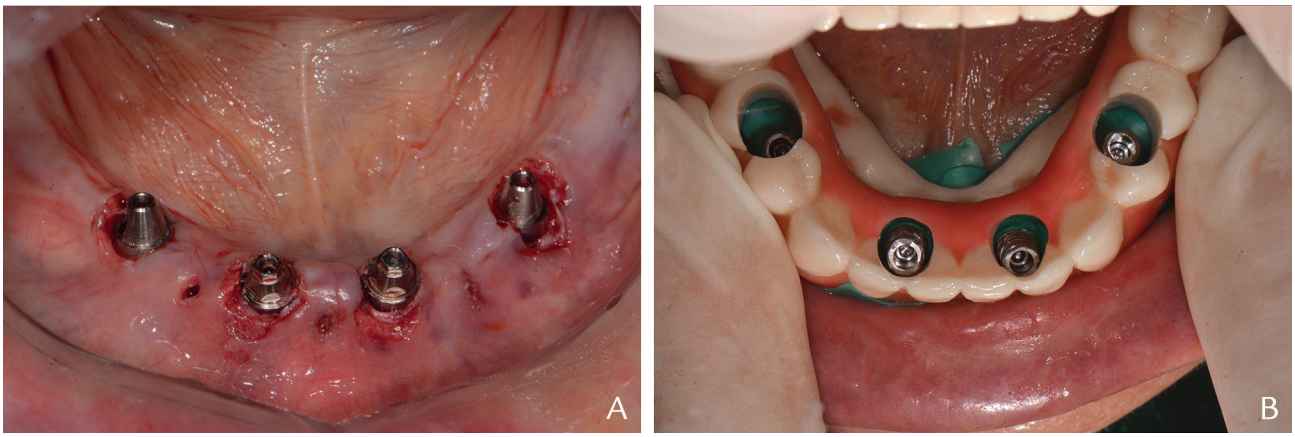

Figure 6. A, Abutments in place. B, Evaluation of interim restoration over interim cylinders. Rubber dam placed beneath interim cylinders to cover and protect underlying soft tissue.

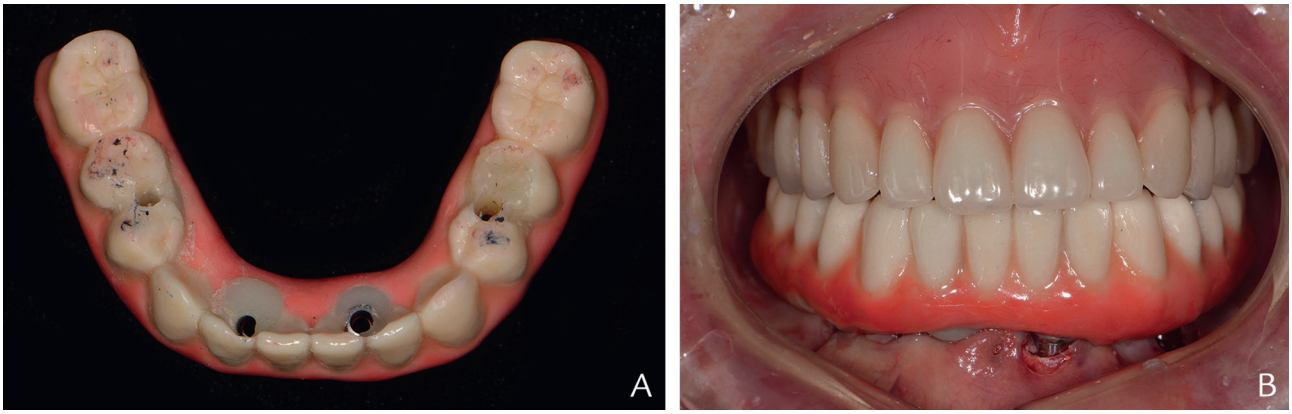

Figure 7. A, Interim prosthesis after sectioning denture flange part. B, Interim prosthesis in mouth.

Although the digital workflow presented in this article has many benefits, there may also be some technical challenges. During surgery, improper seating of the surgical guide can lead to misalignment of the implants.[25] In that situation, the immediate prosthesis with a denture flange cannot be placed passively in the mouth through the cylinder access holes. If the prefabricated restorations are not placed passively, time must be spent adjusting the interim prosthesis and verifying the complete seating and proper occlusion of the interim prosthesis.

The technique presented in this article used flowable composite resin and adhesive to secure the resin markers. Our previous work suggested that the strength of the bond between the resin markers and the gingiva was sufficient to ensure adhesion.[26] The bond strength did not solely depend on the adhesive properties of the resin; the surface coating adhesive, which leads to strong and durable bonding, was also important. The markers did not come loose, even when patients touched them with their tongue. After removing the markers from the palate, some tissue adhesive remained on the patients' gingiva but was dissolved within an hour. The tissue adhesive used in this technique was N-butyl 2-cyanoacrylate and was approved for clinical use in 1996. Since then, it has been widely used to close superficial lacerations in a variety of surgeries.[27]

SUMMARY

This article presents a digital technique for designing and fabricating an interim implant-supported fixed prosthesis for edentulous patients. The use of this technique allows straightforward and efficient immediate restoration for edentulous patients after implant placement.

REFERENCES

1. Horiuchi K, Uchida H, Yamamoto K, Sugimura M. Immediate loading of Brånemark System implants following placement in edentulous patients: a clinical report. Int J Oral Maxillofac Implants 2000;15:824-30.
2. Grunder U. Immediate functional loading of immediate implants in edentulous arches: two-year results. Int J Periodontics Restorative Dent 2001;21:545-51.
3. Misch CM. Immediate loading of definitive implants in the edentulous mandible using a fixed provisional prosthesis: the denture conversion technique. J Oral Maxillofac Surg 2004;62:106-15.
4. Santosa RE. Provisional restoration options in implant dentistry. Aust Dent J 2007;52:234-42.
5. Ostman PO, Hellman M, Sennerby L, Wennerberg A. Temporary implant supported prosthesis for immediate loading according to a chair-side concept: technical note and results from 37 consecutive cases. Clin Implant Dent Relat Res 2008;10:71-7.

6. Cooper L, De Kok IJ, Reside GJ, Pungpapong P, Rojas-Vizcaya F. Immediate fixed restoration of the edentulous maxilla after implant placement. J Oral Maxillofac Surg 2005;63:97-110.
7. Marchack CB. CAD/CAM-guided implant surgery and fabrication of an immediately loaded prosthesis for a partially edentulous patient. J Prosthet Dent 2007;97:389-94.
8. Joda T, Wittneben JG, Brägger U. Digital implant impressions with the "Individualized Scanbody Technique" for emergence profile support. Clin Oral Implants Res 2014;25:395-7.
9. Verstreken K, Van Cleynenbreugel J, Marchal G, Naert I, Suetens P, van Steenberghe D. Computer-assisted planning of oral implant surgery: a three-dimensional approach. Int J Oral Maxillofac Implants 1996;11: 806-10.
10. Vercruyssen M, Laleman I, Jacobs R, Quirynen M. Computer-supported implant planning and guided surgery: a narrative review. Clin Oral Implants Res 2015;26:69-76.
11. De Vico G, Spinelli D, Bonino M, Schiavetti R, Pozzi A, Ottria L. Computer-assisted virtual treatment planning combined with flapless surgery and immediate loading in the rehabilitation of partial edentulies. Oral Implantol (Rome) 2012;5:3-10.
12. Pozzi A, Gargari M, Barlattani A. CAD/CAM technologies in the surgical and prosthetic treatment of the edentulous patient with biomymetic individualized approach. Oral Implantol (Rome) 2008;1:2-14.
13. Bornstein MM, Al Nawas B, Kuchler U, Tahmaseb A. Consensus statements and recommended clinical procedures regarding contemporary surgical and radiographic techniques in implant dentistry. Int J Oral Maxillofac Implants 2014;29:78-83.
14. D'haese J, Van De Velde T, Komiyama A, Hultin M, De Bruyn H. Accuracy and complications using computer-designed stereolithographic surgical guides for oral rehabilitation by means of dental implants: a review of the literature. Clin Implant Dent Relat Res 2012;14:321-35.
15. Cassetta M, Stefanelli LV, Giansanti M, Calasso S. Accuracy of implant placement with a stereolithographic surgical template. Int J Oral Maxillofac Implants 2012;27:655-63.
16. Schneider D, Marquardt P, Zwahlen M, Jung RE. A systematic review on the accuracy and the clinical outcome of computer-guided template-based implant dentistry. Clin Oral Implants Res 2009;20:73-86.
17. Beyli MS, von Fraunhofer JA. An analysis of causes of fracture of acrylic resin dentures. J Prosthet Dent 1981;46:238-41.
18. Keerthi S, Proussaefs P, Lozada J. Clinical and laboratory steps for fabricating a complete-arch fixed prosthesis using CAD/CAM. Int J Periodontics Restorative Dent 2015;35:473-80.
19. Kanazawa M, Inokoshi M, Minakuchi S, Ohbayashi N. Trial of a CAD/CAM system for fabricating complete dentures. Dent Mater J 2011;30:93-6.
20. Goodacre CJ, Garbacea A, Naylor WP, Daher T, Marchack CB, Lowry J. CAD/CAM fabricated complete dentures: concepts and clinical methods of obtaining required morphological data. J Prosthet Dent 2012;107:34-46.
21. Kattadiyil MT. An update on computer-engineered complete dentures: a systematic review on clinical outcomes. J Prosthet Dent 2017;117:478-85.
22. AlHelal A, Goodacre BJ, Kattadiyil MT, Swamidass R. Errors associated with digital preview of computer-engineered complete dentures and guidelines for reducing them: a technique article. J Prosthet Dent 2018;119:17-25.
23. Persson AS, Andersson M, Oden A, Sandborgh-Englund G. Computer aided analysis of digitized dental stone replicas by dental CAD/CAM technology. Dent Mater 2008;24:1123-30.
24. Güth JF, Keul C, Stimmelmayr M, Beuer F, Edelhoff D. Accuracy of digital models obtained by direct and indirect data capturing. Clin Oral Investig 2013;17:1201-8.
25. Di Giacomo GAP, Cury PR, de Araujo NS, Sendyk WR, Sendyk CL. Clinical application of stereolithographic surgical guides for implant placement: preliminary results. J Periodontol 2005;76:503-7.
26. Fang JH, An X, Jeong SM, Choi BH. Digital intraoral impression technique for edentulous jaws. J Prosthet Dent 2018;119:499-500.
27. Inal S, Yilmaz N, Nisbet C, Guvenc T. Biochemical and histopathological findings of N-Butyl-2-Cyanoacrylate in oral surgery: an experimental study. Oral Surg Oral Med Oral Pathol Oral Radiol 2006;102:e14-7.

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