Received: 21 May 2022 | Accepted: 24 February 2023

DOI: 10.1111/jopr.13671

ORIGINAL ARTICLE

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Integration of conventional and digital surgical guide fabrication techniques for the partially edentulous patient: Reducing the number of surgical procedures for a complete arch implant-supported prosthesis

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Abstract

Surgical procedures on partially edentulous patients for complete arch implant-supported prostheses involve remaining tooth extraction, alveolar bone reduction, and implant placement. Traditionally, partially edentulous patients undergo multiple surgeries, which extends the healing time and results in an extensively prolonged total treatment timeline. This technical article focuses on the fabrication of a more stable and predictive surgical guide to perform multiple surgical procedures in a single surgical appointment and planning a complete arch implant-supported prosthesis for the partially edentulous patient.

KEYWORDS
all-on-4, complete arch, dental implants, integration, multi-purpose, partially edentulous, surgical guide

Partially edentulous patients planned for complete arch implant-supported prostheses generally require multiple surgical procedures performed in stages with healing time between procedures, particularly with implant surgery. The surgical procedures include tooth extraction, bone reduction, and implant placement. The surgical process requires several months for the healing and remodeling of hard and soft tissues and prolongs the entire treatment timeline. Traditionally, partially edentulous patients must receive these surgical procedures due to transformation on the remaining dentition site. Therefore, these patients experience multiple surgical procedures after a series of healing.[1] Highly accurate implant placement by proper planning is the most critical factor in implant dentistry.[2] It is necessary to complete a comprehensive restorative and surgical examination, and surgical procedures must be executed based on a prosthetically driven diagnostic waxing.[3] Cone beam computed tomography (CBCT) and imaging software programs improve accurate planning of implant lengths, diameters, and positions through the three-dimensional visualization of anatomic limitations, available bone, and the desired restoration.[4] The virtual plan can be transferred to surgery using guides fabricated with computer-aided design and computer-aided manufacturing (CAD–CAM) methods.[5] During implant placement surgery, the stability of the surgical guide is of the utmost importance.[6] In dentate or partially edentulous patients, most of the surgical guides are positioned intraorally by resting them on the teeth adjacent to a planned implant site. However, it is difficult to accurately position the guide when patients have highly mobile teeth, a very limited number of remaining teeth, and completely edentulous jaws due to a lack of stability for the guide.[7] There are many studies showing that tooth-supported surgical guides are more accurate than bone or mucosa-supported surgical guides.[8,9] Intraoperative factors, such as mucosa thickness and soft tissue resilience, have been shown to negatively affect surgical guide stability and implant placement accuracy.[10] Therefore, in the partially edentulous patient, it is beneficial to utilize the remaining nonmobile teeth as much as possible to support the surgical guide.

The present article describes an innovative surgical guide fabrication technique for complete arch implant-supported prostheses for partially edentulous patients by integrating both conventional and digital prosthodontic methods. Many technique articles have been previously published introducing the conventional approach of radiographic/surgical guide fabrication without digital utilization and can create a prosthetically favorable radiographic guide that may

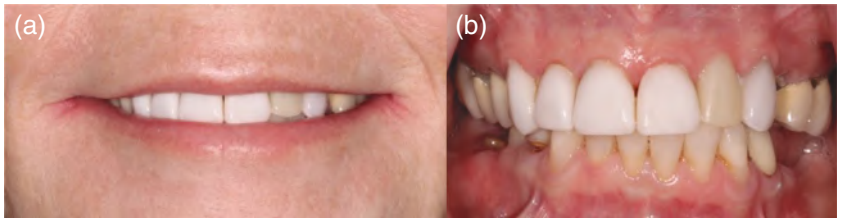


FIGURE 1 (a) Preoperative smile line photo; (b) intraoral maximal intercuspal photo.

result in a less favorable guide surgically.[11–14] Conversely, there are articles introducing only a digital approach for surgical guide fabrication to achieve the accuracy attained by a tooth-supported guide. However, these articles tend to overlook the important prosthetic aspect for future full-arch prostheses and are limited to single-unit or multiple-unit partial dental prostheses. The authors are introducing a technique to fabricate a highly accurate tooth-supported surgical guide with a digital approach for full-arch prostheses on partially edentulous patients by reestablishing the ideal occlusal plane with a conventional approach.

Combining support from stable teeth and mucosa, guide stability is increased, thus increasing prosthetic predictability. The proposed method produces one surgical guide for multiple surgical procedures to be completed in a single visit, thus reducing the surgical procedure timeline to a single appointment for the partially edentulous patient desiring a complete arch implant-supported prosthesis.

In this case, a 58-year-old Caucasian female patient was referred to the graduate Prosthodontic dental clinic for comprehensive dental treatment. The patient had a medical history of GERD and xerostomia. Upon the interview and comprehensive examination of the patient, it was noted that an extremely high risk of caries as well as severe, active, and recurrent caries were present, with the exception of the lower anterior teeth (Figure 1a,b). Various treatment options, fees, benefits, and risks were presented and discussed. For the maxillary arch, the patient elected extraction of remaining maxillary teeth, alveoloplasty, and implant placement for a definitive complete arch implant-supported prosthesis. The patient also elected to receive a maxillary immediate complete denture for esthetics and function during the healing phase of implant therapy. Two phases of tooth extraction (posterior and anterior teeth extraction separately) were planned for the maxillary immediate complete denture.[15]

Conventionally-driven techniques include the fabrication of the immediate complete denture and denture duplication. Given the patient's occlusal plane needing to be reestablished, a conventional posterior wax try-in was performed following the healing from phase one posterior extractions. Once the new occlusal plane was confirmed, a conventional technique of denture duplication with condensation silicone (COLTENE Lab-Putty, Coltene/Whaledent Inc., Cuyahoga Falls, OH, USA) was completed, which combined a posterior wax try-in with the patient's maxillary anterior teeth. The duplicated denture was made with a clear radiographic stent acrylic (BIOCRYL Form-X, Great Lakes Dental Technologies, Tonawanda, NY, USA). A new border of maxillary anterior teeth with the reestablished occlusal plane was scored on the radiographic stent with an acrylic bur. Guttapercha was used to make fiducial marker registrations for dual-scanning with CBCT. The dual-scan with CBCT was reviewed, and surgical procedures were planned in the surgical guide design software (DTX Studio, Nobel Biocare, Brea, CA, USA). The amount of bone reduction and location of implant sites were determined while the anterior dentition was still present, allowing for the fabrication of a surgical guide for a complete arch implant-supported prosthesis that combined both tooth-supported (anterior teeth) and mucosa-supported (hard palate and posterior edentulous areas) components. After all surgical procedures were completed in a single appointment, the immediate dental prosthesis (complete denture) was delivered on the same day.

TECHNIQUE

Annotations: (C) for conventional technique, (D) for digital technique.

1. (C) Fabricate occlusal rim on the partially edentulous arch after posterior teeth extraction.
2. (C) Obtain maxillomandibular relation record to mount the partially edentulous casts on the articulator and set posterior denture teeth for maxillary and mandibular partial wax prostheses. Indicate reestablished occlusal plane for maxillary anterior teeth by blue wax pencil (Figure 2a,b).
3. (C) Block out any undercut areas or gingival embrasures on the teeth of the master cast with a conservative amount of baseplate wax.
4. (C) After coating the cast with separating medium, place the partial wax prosthesis on the cast, and then adapt a layer of baseplate wax on the anterior teeth as a spacer for a scan appliance. Next, duplicate the cast by a conventional denture duplication process with condensation silicone (COLTENE Lab-Putty, Coltene/Whaledent Inc., Cuyahoga Falls, OH, USA) to fabricate a scan appliance with radiographic stent acrylic (BIOCRYL Form-X, Great Lakes Dental Technologies, Tonawanda, NY, USA) (Figure 3a–c).
5. (C) Using an acrylic bur, score the new and corrected new maxillary anterior teeth incisal edge position with the reestablished occlusal plane on the scan appliance (Figure 4a,b). Try the scan appliance with fiducial marker

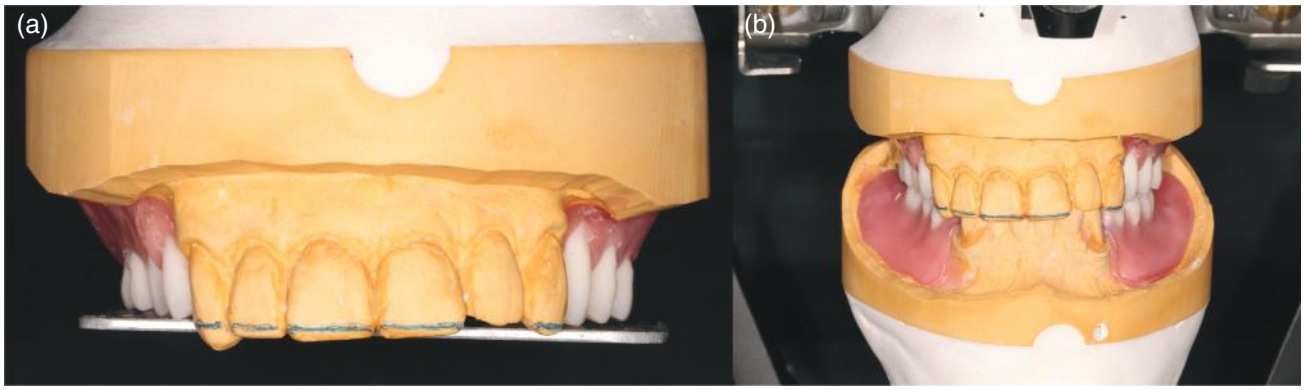


FIGURE 2 Fabrication of wax try-in: (a) adjustment of occlusal plane (blue wax pencil draw indicates new occlusal plane for maxillary anterior teeth); (b) mounted master casts with wax try-in.

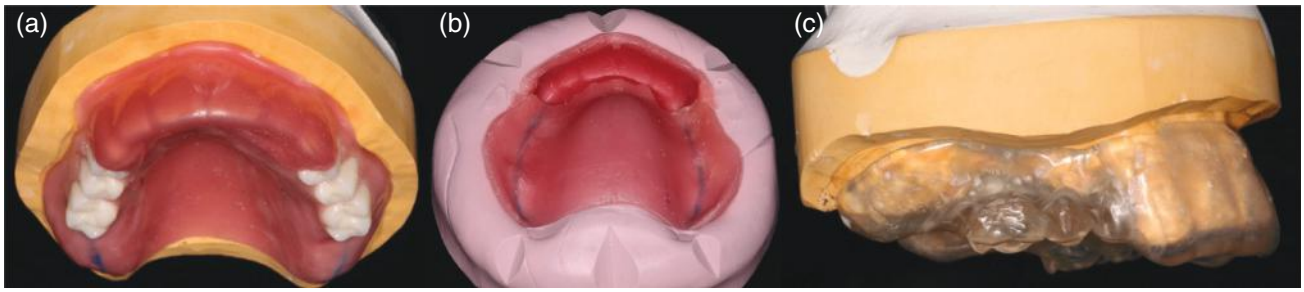
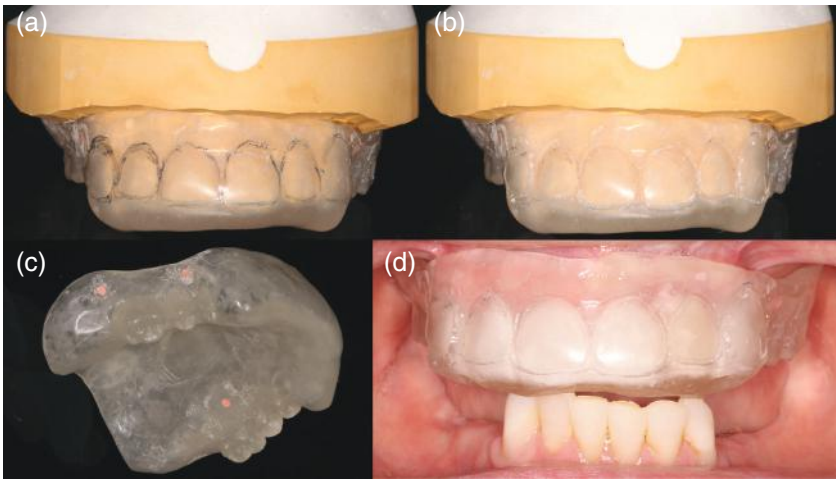


FIGURE 3 (a) Baseplate wax on anterior teeth; (b) duplication of wax try-in, including anterior baseplate wax with condensation silicone; (c) clear stent of duplicated wax try-in.

FIGURE 4 (a) Outline draw of anterior teeth with reestablished occlusal plane; (b) outline scored on scan appliance; (c) scan appliance for dual-scan with fiducial markers; (d) intraoral try-in for dual-scan.



registrations in the patient's mouth and make a CBCT using a dual-scan protocol (Figure 4c,d).

6. (D) Design and fabricate a surgical guide using surgical guide designing software (DTX Studio, Nobel Biocare, Brea, CA, USA) by combining tooth-supportive (anterior teeth) and mucosa-supportive (hard palate and remaining edentulous area) (Figure 5).
7. (D) Place two additional anchor pins anteriorly for additional stability for the guide to ensure the same scanning position while the surgical guide is mainly supported by the remaining maxillary anterior teeth (#s 6 thru 11) and highly stable intraorally (Figure 6a,b).
8. (C) Prepare the osteotomies for maxillary first molar sites (Nobel Biocare Parallel CC WP, Nobel Biocare, Brea, CA, USA) and place posterior implants first. Next, remove the anchor pins and surgical guide from the patient's mouth, and follow with the extraction of maxillary canines and lateral incisors (#s 6, 7, 10, 11). Place the

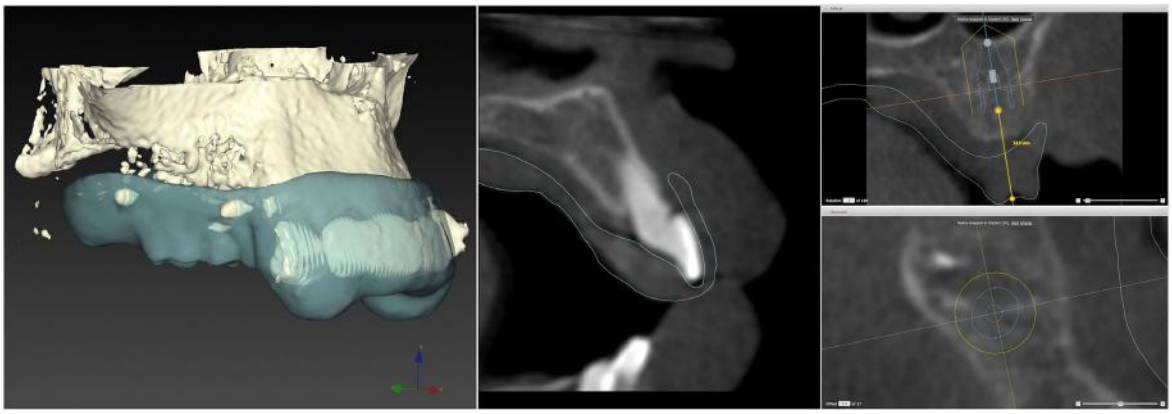


FIGURE 5 Dual-scan of tooth- and mucosa-supported scan appliance, and dual-scan showing scored outline of maxillary anterior teeth (DTX Studio).

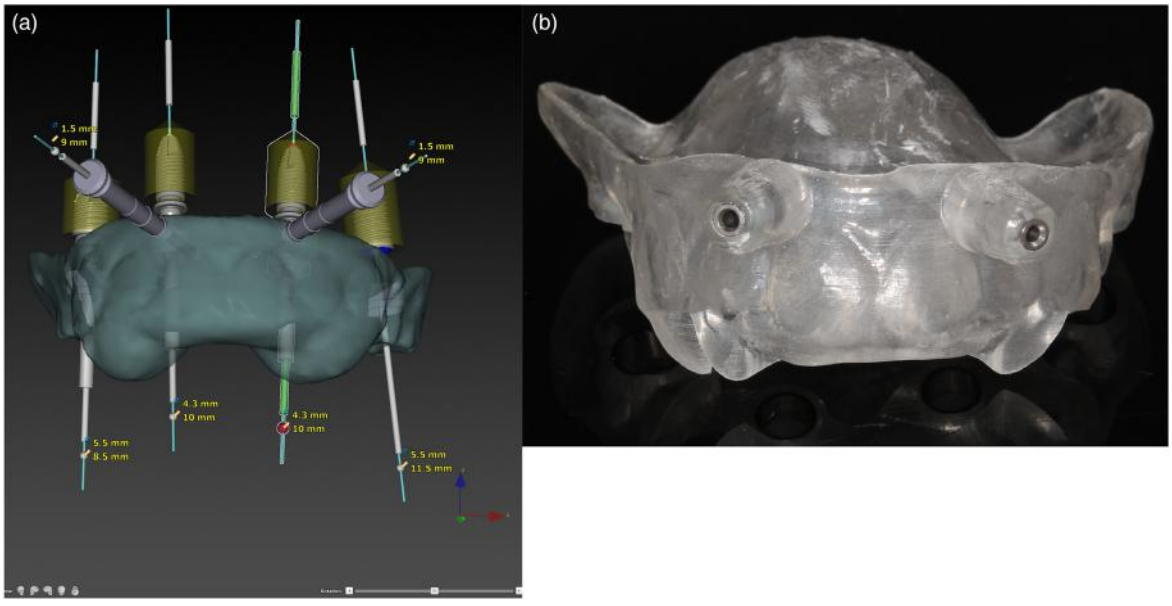


FIGURE 6 (a) Dual-scan for surgical guide showing scored outline of maxillary anterior teeth (DTX Studio); (b) digitally fabricated surgical guide.

surgical guide back into the initial position with maxillary central incisors and insert the anchor pins back into the same position and confirm the initial position and stability of the guide. Next, prepare the osteotomies for two anterior implants (Nobel Biocare Parallel CC RP, Nobel Biocare, Brea, CA, USA) at maxillary lateral incisor sites and place anterior implants. After the implant placements, extract the remaining maxillary central incisors (#s 8, 9). Complete the bone reduction by freehand, based on the preplanned implant depths (Figure 7a–c).

9. (C) Deliver the immediate dental prostheses after all surgical procedures.

DISCUSSION

By combining conventional and digital techniques, the authors have developed a method to enhance the predictability of implant surgery based on a prosthetically driven surgical guide. In complicated cases of partially edentulous patients with malocclusion and canted smile lines of remaining teeth, it is imperative to complete a careful examination to reestablish the occlusal plane with ideal esthetics, thus increasing the predictability of the prosthetic outcome. Clinicians may consider the integration of a conventional technique into the digital workflow in order to pursue the best treatment outcome with limited resources. Depending on the specific situation, certain steps and procedures can be combined to give each patient the most desirable outcome by combining conventional and CAD–CAM systems.

An advantage of combining virtual planning with conventional procedures in a partially edentulous patient is the fabrication of a prosthetically driven implant surgical guide for a complete arch implant-supported prosthesis while reducing the number of surgical appointments. After extraction of the posterior teeth, the patient only had to experience a single-healing phase from anterior tooth extractions,

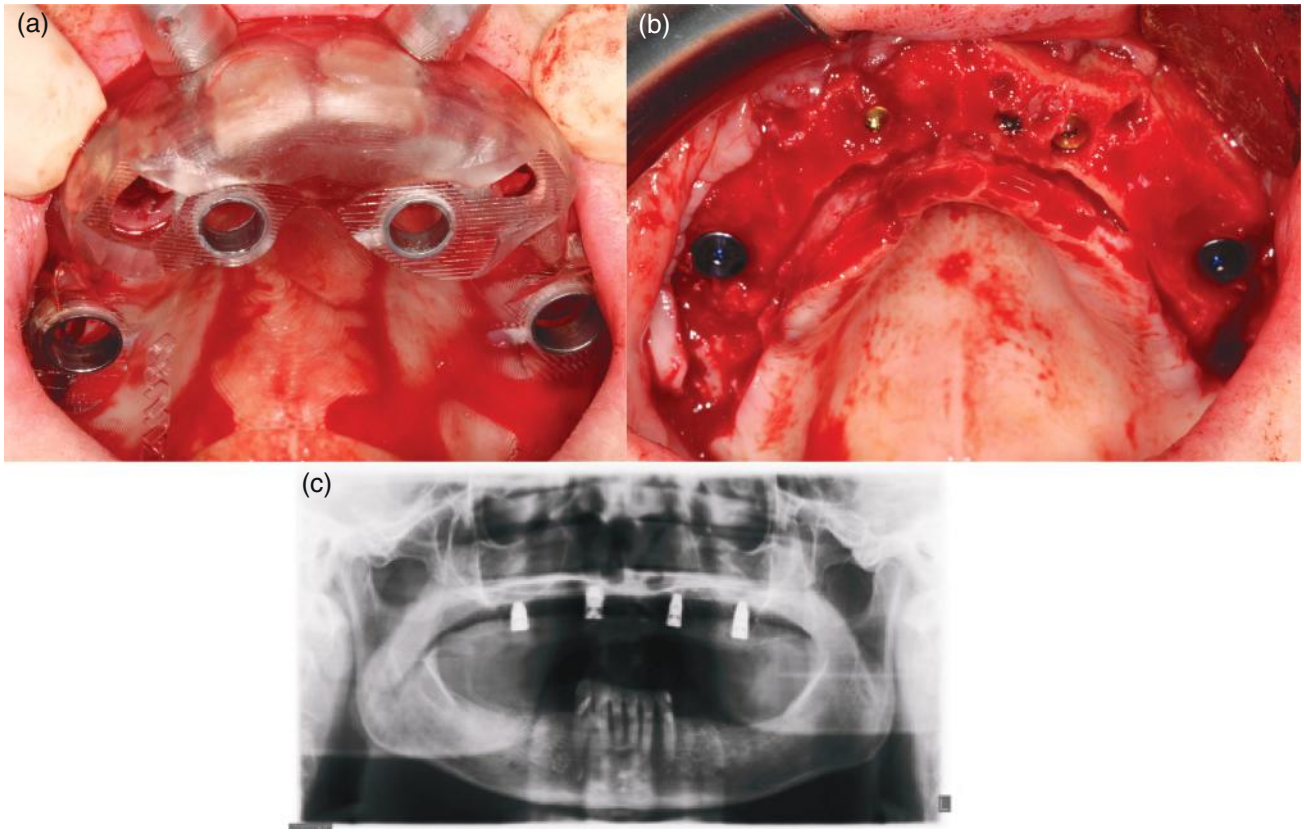


FIGURE 7 (a) Tooth- and mucosa-supported surgical guide; (b) implant placement after tooth extraction and bone reduction; (c) post-op panoramic radiograph after four implants on maxillary arch.

bone reduction, and implant placement, which significantly reduced treatment time.

Nevertheless, the technique has limitations particularly when remaining dentitions demonstrate mobility and are not stable enough to be utilized for a tooth-supportive guide. More clinical cases and research are needed to verify the effectiveness and accuracy of this method for implant surgery.

SUMMARY

The predictability of surgical procedures for a complete arch implant-supported prosthesis was enhanced by fabricating a tooth and mucosa-supported surgical guide utilizing nonmobile remaining dentition. This was accomplished by applying integrated conventional and digital techniques. Furthermore, multiple surgical procedures were completed in a single surgical appointment on a partially edentulous patient for the complete arch implant-supported prosthesis.

CONFLICT OF INTEREST STATEMENT

The authors do not have any conflict of interest in the companies or the materials included in this article.

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REFERENCES

1. Ramfjord SF, Costich ER. Healing after exposure of periosteum on the alveolar process. J Periodontol. 1968;39(4):199–207.
2. Goodacre CJ, Guillermo B, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. J Prosthet Dent. 2003;90:121–32.
3. Binon PP. Treatment planning complications and surgical miscues. J Oral Maxillofac Surg. 2007;65(Suppl 1):73–92.
4. Nickenig HJ, Eitner S. Reliability of implant placement after virtual planning of implant positions using cone beam CT data and surgical (guide) templates. J Craniomaxillofac Surg. 2007;35:207–11.
5. Wat PY, Pow EH, Chau FS, Leung KC. A surgical guide for dental implant placement in an edentulous jaw. J Prosthet Dent. 2008;100(4):323–5.
6. Farley NE. Split-mouth comparison of the accuracy of computer-generated and conventional surgical guides. Int J Oral Maxillofac Implants. 2013;28(2):563–72.
7. Simon H. Use of transitional implants to support a surgical guide: enhancing the accuracy of implant placement. J Prosthet Dent. 2002;87(2):229–32.
8. Ozan O, Turkyilmaz I, Ersoy AE, McGlumphy EA, Rosenstiel SF. Clinical accuracy of 3 different types of computed tomography-derived stereolithographic surgical guides in implant placement. J Oral Maxillofac Surg. 2009;67:394–401.
9. 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.
10. D'haese J, De Bruyn H. Effect of smoking habits on accuracy of implant placement using mucosally supported stereolithographic surgical guides. Clin Implant Dent Relat Res. 2013;15:402–11.

11. Shotwell JL, Billy EJ, Wang HL, Oh TJ. Implant surgical guide fabrication for partially edentulous patients. J Prosthet Dent. 2008;93(3):294–7.
12. Akca K, Iplikcioglu H, Cehreli MC. A surgical guide for accurate mesiodistal paralleling of implants in the posterior edentulous mandible. J Prosthet Dent. 2002;87:233–5.
13. Joda T, Ferrari M, Gallucci GO, Wittneben JG, Brägger U. Digital technology in fixed implant prosthodontics. Periodontol 2000. 2017;73(1):178–92.
14. Arisan V, Karabuda CZ, Ozdemir T. Implant surgery using bone- and mucosa-supported stereolithographic guides in totally edentulous jaws: surgical and post-operative outcomes of computer-aided vs. standard techniques. Clin Oral Implants Res. 2010;21(9):980–8.
15. Seals RR, Kuebker WA, Stewart KL. Immediate complete dentures. Dent Clin North Am. 1996;40(1):151–67.

How to cite this article: Jo HC, Williamson RA. Integration of conventional and digital surgical guide fabrication techniques for the partially edentulous patient: Reducing the number of surgical procedures for a complete arch implant-supported prosthesis. J Prosthodont. 2023;32:653–658.
https://doi.org/10.1111/jopr.13671