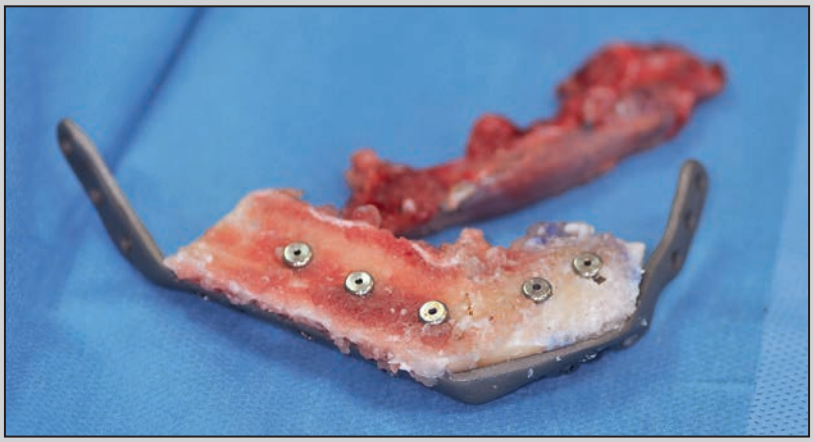






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Computer-Assisted Mandibular Reconstruction with a Single-Step Free Fibula Flap and Simultaneous Implant Placement



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The free fibula flap is a reliable approach used to reconstruct maxillofacial osseous defects. Virtual surgical planning facilitates the execution of such segmental bony reconstruction, usually preceding the placement of endosseous implants for dental rehabilitation. Novel advances in digital technology allow for fabrication of 3D guides for implant placement in the fibula bone segments before their fixation to the facial defect, with reduced ischemic time, reduced treatment time, faster dental rehabilitations, and unprecedented improvements in the overall treatment efficiency. This case report illustrates the use of digitally designed 3D-printed surgical plates for a single-stage surgery of free fibula flap with implant placement. The patient was successfully treated and followed over 2 years. Comparison between preoperative virtual planning and postoperative scans revealed a high accuracy of implant and bone segment positioning. Int J Periodontics Restorative Dent 2022;42:615–621. doi: 10.11607/prd.6348

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Submitted April 27, 2022; accepted May 9, 2022.
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Oncologic patients who undergo resective surgery develop significant functional and esthetic sequelae that require reconstructive interventions. Today, the vascularized free fibula flap (FFF) is the standard reconstructive treatment for mandibular[1] and maxillary defects.[2] It is preferred that dental rehabilitation following FFF involves implants, as the oral anatomy often lacks the vestibular space and retention capacity required for a tissue-borne prosthesis.[3,4]

Traditional approaches used freehand surgery, which is technically challenging and largely dependent upon surgical experience. The use of computer-aided mandibular reconstructions led to unprecedented improvements due to higher accuracy and surgical efficiency compared to the conventional freehand mandibular reconstruction.[5]

Application of computer-aided FFF surgery is a novel method that uses printed guides for surgical positioning of implants within the fibula bone before fixating the latter to the recipient mandibular sites with a titanium plate, as opposed to the current two-stage protocols in which implant placement is delayed due to fixating the fibula block in the oral cavity. A single-stage FFF with implant placement offers inarguable advantages in terms of surgical procedure efficiency and reduced

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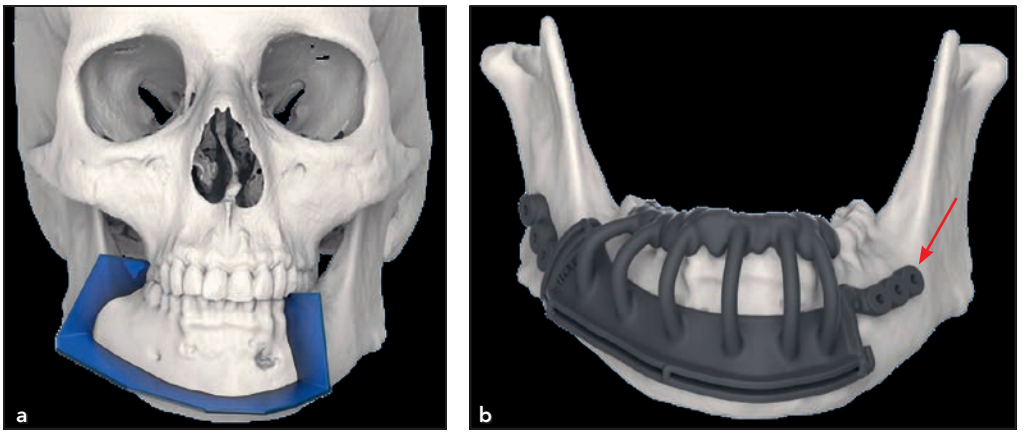


Fig 1 *Computer-assisted reconstruction for virtual planning.* (a) *Limit of the resection.* (b) *Design of the cutting guide, with lateral holes for adapting the guide and reconstruction plate (arrow).*

time, among others. Despite the enthusiasm for applying digital planning in FFF techniques, reports are scarce, and the literature needs better clarification of the efficacy, case selection, and generalizability of the single-stage FFF with implant placement. Therefore, the purpose of this case report was to illustrate the use of 3D-printed surgical plates in a patient treated with one-stage FFF surgery with implant placement, and to compare the postoperative outcomes with the preoperative digital plan.

Materials and Methods

A 50-year-old woman was scheduled for the resection of a relapsing ossifying fibroma that invaded an extensive part of the right mandibular side, including the vestibular cortical bone. Considering the age of the patient, the type of tumor, and the wide extension of the segment planned for resection, it was decided to perform a reconstructive surgery by means of vascularized FFF.

Preoperative Virtual Planning

Preoperative assessment included computed tomography (CT) of the skull and face as well as CT angiography of the lower limbs to assure adequate perfusion of the leg after the FFF was raised. Routine preoperative investigations with hematologic and anesthetic assessment were also performed. The patient's CT data were imported for 3D model reconstruction with Mimics Innovation Suite 24 (Materialise).

To perform the preoperative virtual planning, the information provided by the DICOM (Digital Imaging and Communications in Medicine) CT files were matched with the STL (standard tessellation language) files from the intraoral scan (IOS) of both dental arches (Trios3, 3Shape). All data extracted from CT and IOS were processed by Geomagic Freeform software (Artec 3D).

The surgeon (G.S.) indicated the borders of the resection area, which were used to draw and prepare the first cutting guide (Fig 1). Additionally, three holes were positioned at both ends of the defect for the adaptation screws (2.3 mm) used to fixate the reconstruction plate.

The number and position of implants were decided with reference to the preexisting dentition and optimal occlusion (Fig 2). Consequently, the surgical cut of the fibula flap was drawn. The patient-specific surgical guide was created to facilitate osteotomies of the fibula bone, screw-hole drilling, and guided implant placement. The guide was used to locate the bone contour of the fibula and facilitate the osteotomy position and direction; it also contained several screw-holes used for temporary fixation (Fig 3).

The final virtual plan consisted of cutting guides for resection and for the fibula blocks, a 3D printed model of the resected arch, and the patient-specific titanium plate.

All models and cutting guides were printed with certified polyamide (Jet Fusion, HP), and the patient-specific plate was printed with grade 2 pure titanium using selective laser sintering technology. Cutting guides and the titanium plate were cleansed and sterilized before surgery. All

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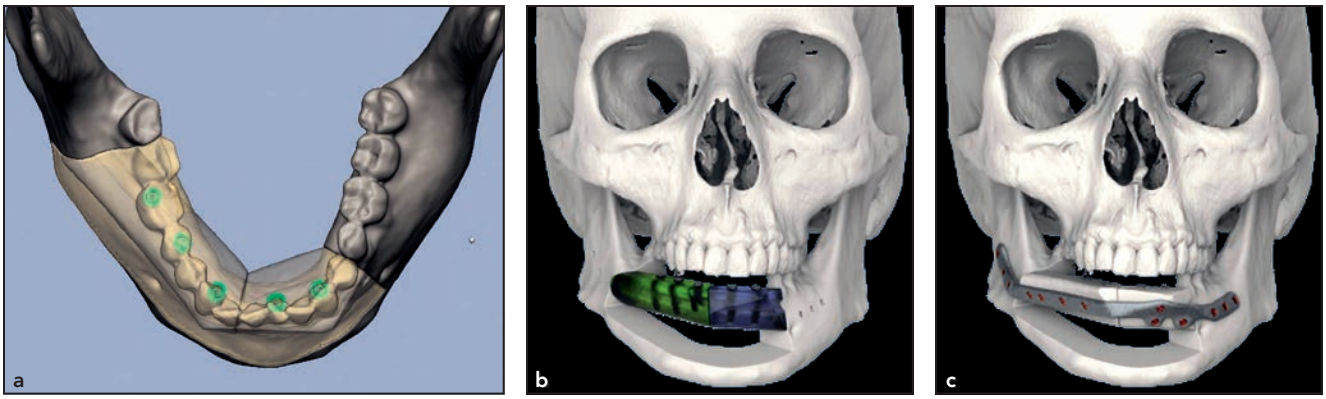


Fig 2 (a) *Implant positions with reference to the preexisting dentition.* (b) *Virtual position of the harvested FFF after implant insertion. The green and purple sections represent the two FFF bone blocks.* (c) *Virtual position of a patient-specific titanium plate for FFF fixation.*

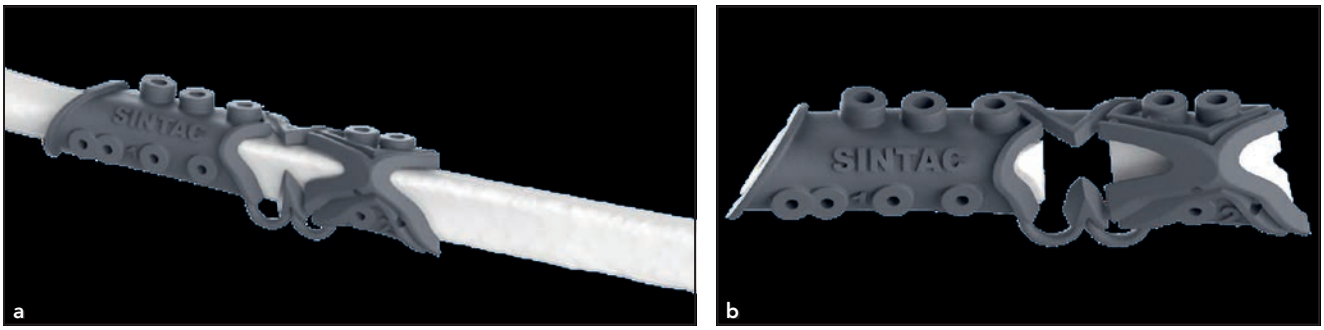


Fig 3 *Virtual design of the surgical guide to segment the fibula bone, with holes for implant placement.*

procedures were executed strictly following the tenets of the Declaration of Helsinki. Written informed consent was obtained from the patient.

Surgical Technique

Surgical procedures were performed with the aid of computer-assisted surgical guides. Jaw resection was performed by means of Piezosurgery inserts (Mectron) (Fig 4).

The FFF was harvested following the printed cutting guide and separated into two blocks (Fig 5). The positions of reconstructive fibular segments were optimized to ensure excellent defect contouring and implant support. The blocks were fixed to the guide and drilled through the specific drilling holes. Then, implants (Brånemark System MKIII TiUnite RP, Nobel Biocare) were guided and placed in the proper sites in the fibula blocks.

The fibula blocks fixed to the titanium plate were positioned on the resected arch and screwed in place using the predrilled holes as a reference. Before fixing the titanium plate to the mandible, the surgeon checked the implant positions with a tooth-supported guide (Fig 6).

The flaps were sutured to fully cover the reconstruction and implant platforms. The total surgical time for the entire procedure was 415 minutes.

Three months after surgery, the patient underwent implant uncovering and IOSs for prosthetic rehabilitation. The digital plan of the prosthesis was performed with DTX Studio Lab, following the original shape and position of teeth (Fig 7). The milled titanium frame was checked for passive fitting and veneered by composite resin. The implant-supported partial restoration was screwed over the implants, with a good functional and esthetic

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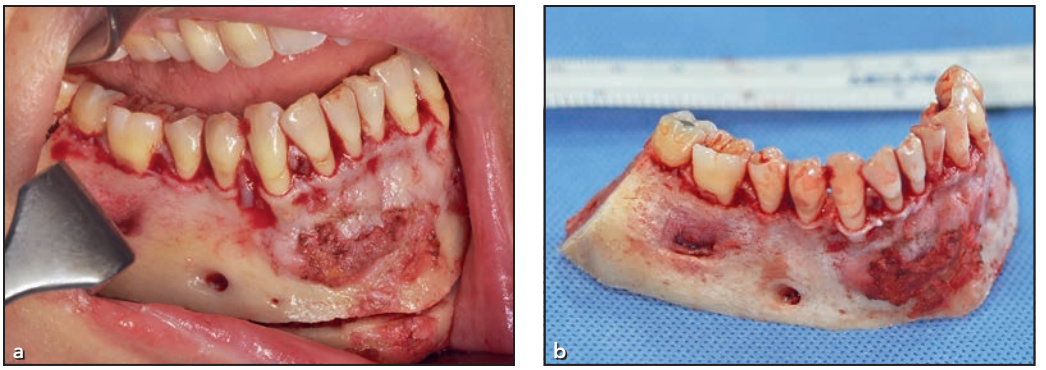


Fig 4 (a) *Intrasurgical view of the guided arch resection and* (b) *the resected arch.*

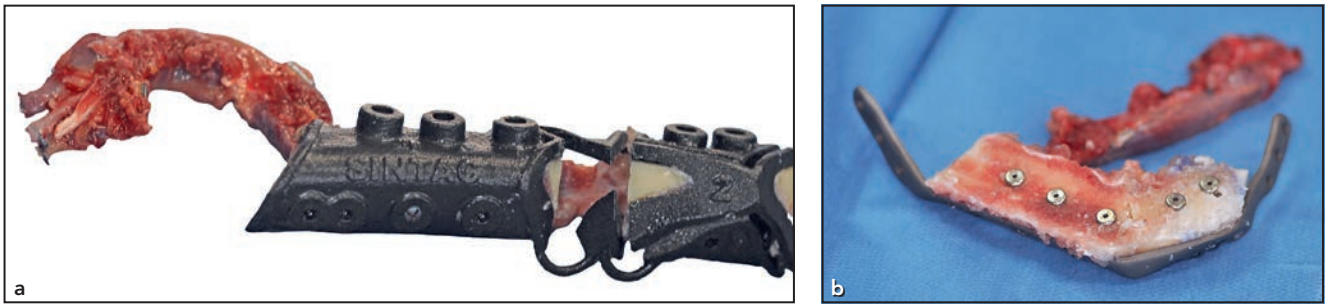


Fig 5 (a) *Segmented fibula bone was fixed to the implant insertion guide.* (b) *The FFF was fixed to the patient-specific titanium plate.*



Fig 6 *Virtual design of the tooth-supported guide to check implant positions.*

result (Fig 8). The patient received proper oral hygiene instruction for teeth and implants.[6,7]

Outcome Assessment

A new CT scan was performed 1 month after surgery, before implant uncovering surgery. The accuracy of the 3D implant position and the overall reconstructive surgery were evaluated by comparing the virtual plan with the actual positions of the implants, bone graft segments, and titanium plate. Postsurgical CT data were extracted using Mimics 22 (Materialise), and a virtual model determined the segment positions. The 3D model was superimposed to the preoperative digital plan with Geomagic Design X (Artec 3D) to evaluate the discrepancies between the virtual plan and the real position of bone blocks.

A joint laboratory (CUSTOM3D) between Industrial Engineering Department of the University of Florence and Careggi University Hospital performed the volumetric analysis. A supplementary analysis was performed to evaluate the accuracy of implant placement by comparing postsurgical CT scans and IOSs of the implant positions.

Peri-implant tissue health was evaluated every 6 months (at 6, 12, 18, and 24 months) with probing-based measurements (probing depth, recession, Gingival Index, and Plaque Index)[8] and intraoral radiographs. Diagnosis of peri-implant health, mucositis, or peri-implantitis was performed according to the case definitions of the 2017 World Workshop.[9] Patient-related outcome measures (PROMs) relative to phonetics, chewing comfort, stability, cleanability, esthetics, and overall satisfaction were each recorded on a 10-cm visual analog scale (VAS; 0 = the worst outcome, 10 = the best outcome]) on a yearly basis and

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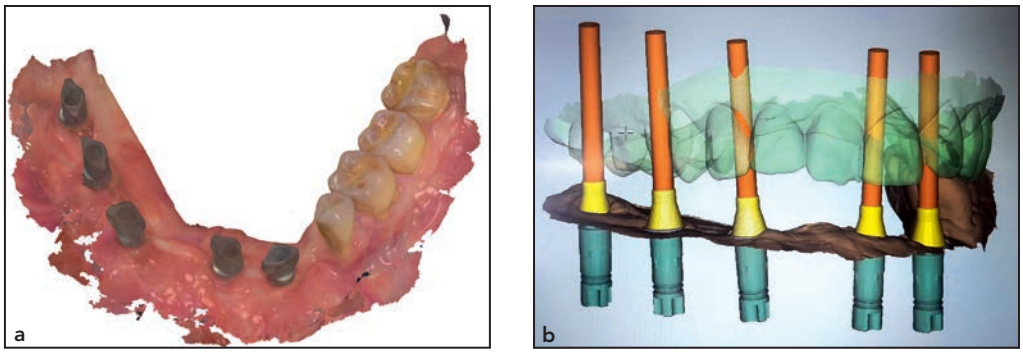


Fig 7 *Three months post-surgery.* (a) *Intraoral scan and* (b) *digital model of the patient for the prosthetic restoration.*



Fig 8 (a) *An implant-supported partial denture was* (b) *placed in the patient with esthetic results.*

were discussed between the patient and operators.

Results

The patient was successfully treated, with five implants placed within the transferred fibula flap. Peri-implant clinical parameters[8] were evaluated at 6, 12, 18, and 24 months after prosthesis delivery, and good peri-implant health was reported over 2 years of follow-up.

Peri-implant probing depths remained < 4 mm for all implants during the 2-year follow-up. The most distal implant, in position 46 (FDI tooth-numbering system), showed a probing depth of 5 mm, a higher Gingival Index than mesial implants, and a higher Plaque Index. At the 2-year follow-up, no implants were diagnosed with peri-implantitis, implant 46 was diagnosed with peri-implant mucositis, and all other implants maintained healthy tissues. Stability of crestal bone was maintained over 2 years (Fig 9). PROMs regarding phonetics, chewing comfort, stability, cleanability, esthetics, and overall satisfaction all achieved VAS scores higher than 6 (out of 10) throughout the 2-year period.

The preoperative digital planning and the postoperative CT showed minimal discrepancies between the planned and obtained positions of the bone blocks and titanium plate. A second comparison was performed between virtual implant positions and the real positions recorded by IOS. The interimplant distance showed perfect agreement between the virtual plan and the obtained implant placement. Most of the variation in implant positioning was secondary to the fixation of bone blocks to the titanium plate, and of the titanium plate to the mandible. Superimposed models showed that both the blocks and titanium plate were placed in a position slightly lower than the virtual plan (Figs 10a and 10b); as a result, the implants had positions that were

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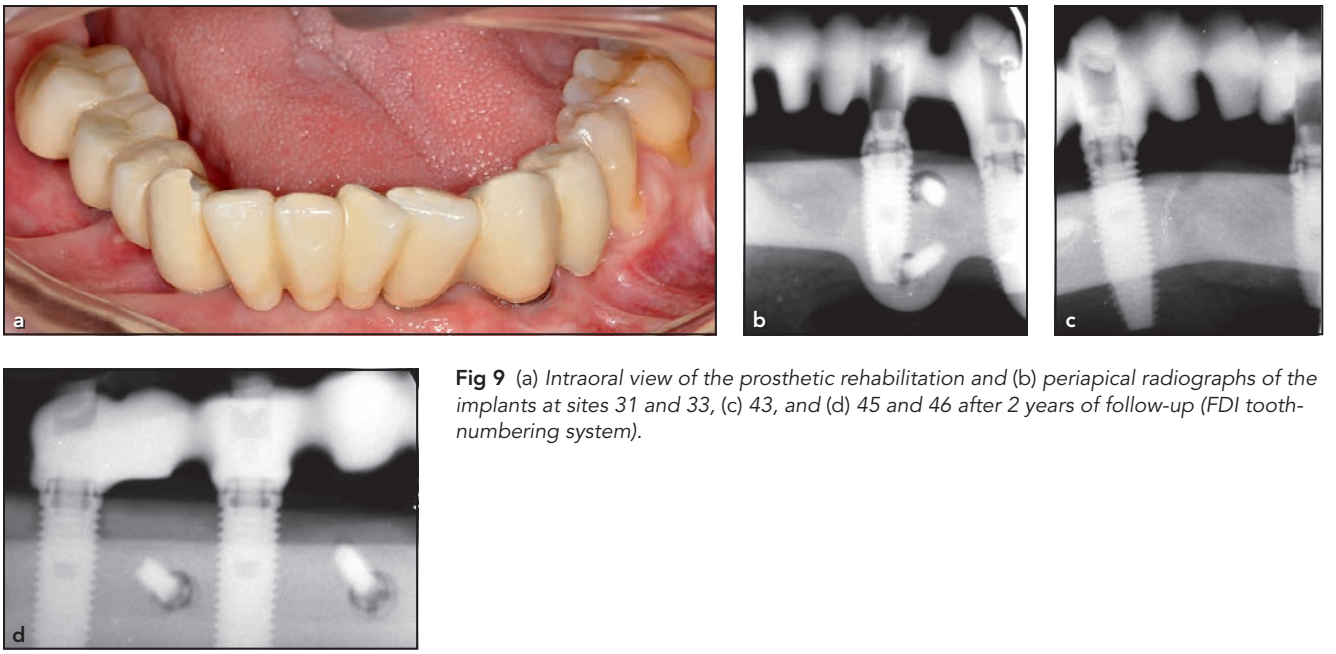


Fig 9 (a) *Intraoral view of the prosthetic rehabilitation and* (b) *periapical radiographs of the implants at sites 31 and 33,* (c) *43, and* (d) *45 and 46 after 2 years of follow-up (FDI tooth-numbering system).*

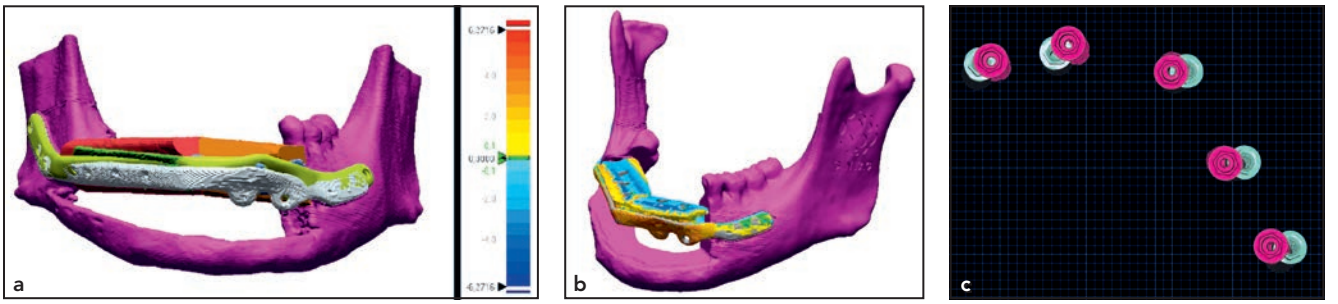


Fig 10 (a and b) *Maps of discrepancies between the virtual plans and the final results.* (c) *Comparison between the virtual (pink) and real (gray) implant positions, recorded via intraoral scans.*

more facial (Fig 10c) and apical than their virtual counterparts.

Discussion

Arch reconstructing with FFF and subsequent implant placement is a necessary step to restore function and esthetics in oncologic patients.[10] Digital planning of maxillofacial surgical procedures significantly improves the accuracy of midfacial reconstructions, with a better anatomical bone position, a subsequently facilitated prosthetic rehabilitation, and improved patient esthetics.[11,12]

The present case report illustrates a novel application of computer-assisted FFF consisting of a single-stage FFF reconstruction and implant placement. Virtual planning allowed the five implants to be positioned in the fibula segment before translocation into the recipient site, as opposed to the delayed implant positioning reported in traditional approaches.[13]

One of the most striking advantages of the reported technique is the possibility to perform three main surgical procedures (resection of the affected arch segment, reconstruction of the resected part, and implant placement) in a single surgical session. Patients benefit from fewer surgical appointments, a lower total

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operative time, lower overall morbidity, faster reconstructive time, lower ischemic time, and a shorter recovery period. In addition, the time between resection and prosthesis delivery decreases, with beneficial effects on mastication and oral-health related quality of life. Digital planning can predict arch shapes, leading to favorable esthetic outcomes.

The main limitation of this approach is the need for dedicated training in digital design applied to maxillofacial surgery. The resection and reconstructive guides must be extremely precise because once the implants are placed in the fibula bone, limited opportunity is left for reshaping the bone in case of poor fitting.

Future reports on the computer-assisted single-stage FFF technique should enroll a larger sample size and better define the case selection and the large-scale external repeatability of this approach.

Conclusions

The present report advances the literature on computer-assisted mandibular reconstruction with FFF. Virtual planning allowed surgical guides to be created for implant placement in the fibula block before its fixation to the mandibular recipient site. Implant positioning facilitated the prosthetic rehabilitation and replicability of the original digital plan. Finally, peri-implant health was maintained over 2 years of follow-up, with good facial esthetics and patient satisfaction.

Acknowledgments

No funding was available for the realization of this case report. The authors declare no conflicts of interest.

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