Flapless Approach for Removal of Bone Graft Fixing Screws and Placement of Dental Implants Using Computerized Navigation: A Technique and Case Report

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This article presents a technique for the removal of the screws used to fix a bone graft and for the placement of dental implants in a flapless approach that utilizes the tracking technology of a computerized navigation system. A 24-year-old female patient injured in a terrorist bombing suffered from tooth loss and a bone defect in the maxilla. The area was grafted with bone from the chin in preparation for the placement of dental implants. Four months following the grafting procedure, the fixing screws were removed and the dental implants were placed in a flapless approach by the application of a specialized computerized navigation system. This technique emphasizes the potential of computerized navigation approaches in the facilitation of minimally invasive oral surgery. Int J Oral Maxillofac Implants 2006;21:314–319

Key words: *bone grafting, computer-assisted surgery, dental implants, flapless implant surgery, navigation surgery, screws*

Flapless implant surgery is increasingly used in contemporary implant dentistry. The postoperative benefit to the patient in reduced pain and swelling has prompted this surgical approach.[1,2] However, in sites where autogenous bone has been grafted and fixed with screws, this approach is generally unfeasible. In these cases, reflecting a flap is frequently imperative to allow the removal of the fixing screws prior to placement of the implants. Only in the minority of cases can all fixing screws be palpated underneath the alveolar mucosa and removed with minimal cuts.

Resorbable fixing screws have been used with resorbable plates for fixation of maxillary and mandibular osteotomies to avoid a second surgical intervention.[3–5] However, the application of these resorbable systems for the fixation of onlay alveolar grafts is not possible since their resorption time of approximately 18 months is much longer than the 3- to 6-month healing period of autogenous bone grafts. When resorbable pins have been used to stabilize autogenous bone grafts for alveolar ridge augmentation, incomplete resorption, residual pinholes, and foreign body reaction were demonstrated 6 months following the grafting.[6]

Computerized navigation surgical systems are now implemented in various surgical disciplines.[7,8] Significant advances in technology and accuracy allow its use in minimally invasive procedures. In this report the application of a computerized navigation system for the removal of bone graft fixing screws and placement of dental implants by a flapless approach is described.

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Fig 1a Casts demonstrating the patient's vertical alveolar bone defect on the maxillary left side.

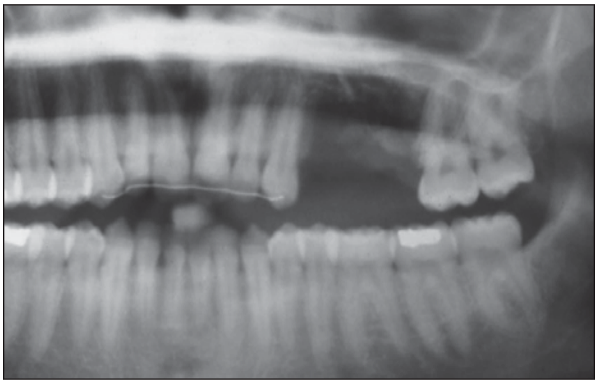


Fig 1b Panoramic radiograph depicting the significant alveolar bone defect on the maxillary left side.

CASE REPORT

A 24-year-old female patient was injured in a terrorist bombing and suffered soft tissue laceration of the left cheek, loss of the maxillary left first and second premolars and the first molar, and a comminuted fracture of the maxillary alveolar bone.

Six months following the injury the patient sought implant-supported rehabilitation. On examination, a bone defect 4 mm wide and 4 mm deep was found (Fig 1). The alveolar bone defect was augmented using an onlay graft that was harvested from the chin and supplemented with bovine-derived bone mineral (Bio-Oss; Geistlich Pharma, Wolhusen, Switzerland). A resorbable collagen membrane was placed over the site (Bio-Gide; Geistlich Pharma). The autogenous graft was secured in place with 3 fixing screws (Mincro; OsteoMed, Dallas, TX) for the healing period (Fig 2). After the bone augmentation procedure it was noted that the buccal vestibule at the implant site was shallow and that the oral mucosa closely approached the gingival margins at the edentulous ridge.

To optimize the position of the implants and minimize invasiveness, the implant surgery was assisted with a specialized computerized navigation system for dental implants[9,10] which had been used in the presurgical phase of the implantation procedure (Image Guided Implantology system [IGI], DenX Advanced Dental Systems, Moshav Ora, Israel). Since the patient was missing substantial keratinized gingiva on the buccal aspect of the edentulous ridge, augmentation with free keratinized gingival graft from the hard palate was planned. To stabilize and protect the graft, a customized acrylic resin surgical stent was fabricated to cover it.[11] The stent was supported by the 1-stage implants and also assisted in the re-establishment of the vestibule at the buccal site.[12]

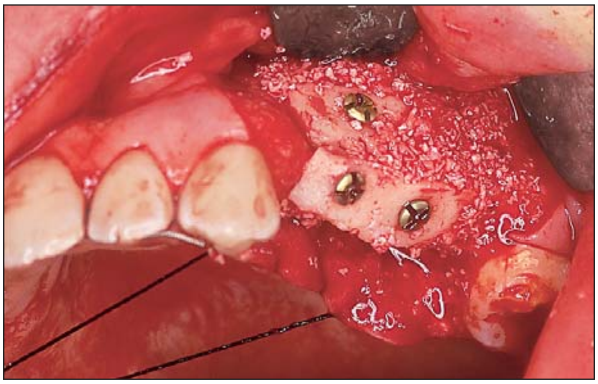


Fig 2 The onlay graft secured in position by three screws and supplemented with bovine-derived bone mineral.

The Presurgical Phase

Dental Computerized Tomography. Four months following the grafting, the patient was referred for standard dental computerized tomography (CT). She was fitted with a customized acrylic resin occlusal template mounted on the maxilla from the right second molar to the right first premolar, clear of the planned implantation site. The occlusal template was designed to include a U-shaped registration mold consisting of special fiducial markers that acted as points of reference (Fig 3). During the surgical phase, the occlusal template with the reference markers interfaced the patient with preacquired imaging data. Artificial radiopaque crowns were waxed and attached to the occlusal template at the position of the missing teeth to simulate the desired position for the definitive restoration.

Digital Treatment Planning. The CT imaging data were imported to the IGI processing unit and reformatted to provide 2-dimensional (2D) slices and a 3-dimensional (3D) view of the patient's anatomy. Using the specialized IGI software, the surgeon and

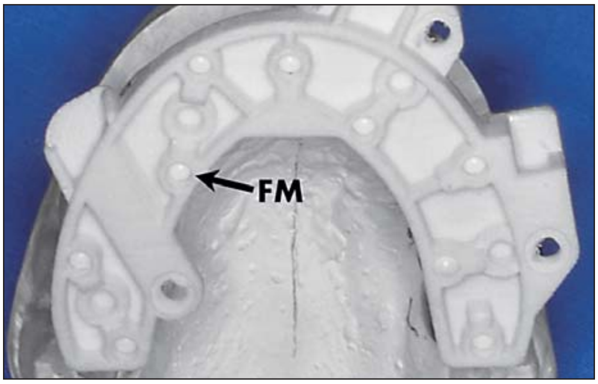
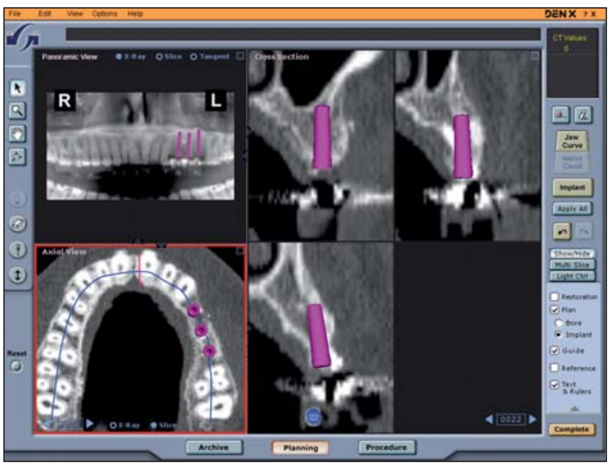


Fig 3 *(Left)* Occlusal view of the U-shaped registration mold attached to the acrylic resin occlusal template. Note the fiducial markers (FM) embedded within the mold.

Fig 4a *(Below left)* Screenshot of the digital treatment plan displayed in the axial, cross-sectional, and panoramic views. The position and angulation of the 3 implants are planned with exact 3D reference to the anatomic structures.

Fig 4b *(Below right)* Screenshot of the fixing screws as identified on the dental scan in the axial, cross-sectional, and panoramic views.



the referring prosthodontist were able to jointly evaluate the augmented alveolar bone together with the prosthetic needs (ie, the captured image of the radiopaque crowns), and to decide on the implant treatment plan for the patient. The final treatment plan consisted of 3 implants in the positions of the maxillary left first and second premolars and the first molar. The planned position and angulation for each of the implants was accurately marked with the software on the imaging data and saved for the surgical phase (Fig 4a). Based on the imaging view, the previously placed fixing screws were detected and marked (Fig 4b).

The Surgical Phase

Registration. Immediately before the implant surgery, the customized occlusal template was seated on the patient's teeth to register the patient's position against the preacquired imaging data. The occlusal template was attached to an optical sensor that signaled the dynamic position of the patient to a 3D optical detector. The surgical handpiece was outfitted with sensors that allowed its position within the surgical field to be tracked. Following a registration procedure, the system was able to coordinate the spatial position of the handpiece with that of the patient and to provide integrated imaging of the surgical field.

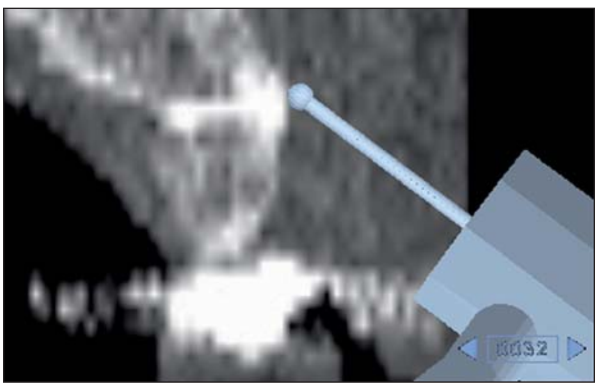
Removal of the Fixing Screws. At the time of surgery, none of the fixing screws could be palpated underneath the alveolar mucosa. Therefore, the specialized trackable handpiece of the IGI system was mounted with a round drilling bur and used to explore the alveolar mucosa at the grafted site (Fig 5). Simultaneously, the navigation system was put into an auto-paging mode in which it displayed an imaging of the actual position of the surgical drill accurately superimposed on the anatomic structures in the dental scan. Once the surgical drill pointed directly to 1 of the fixing screws (as indicated by the integrated imaging), it was applied to create a pinpoint access cut (Fig 6). This procedure was repeated, and all 3 fixing screws were located and removed with minimal cutting.

Placement of the Implants. Once all 3 fixing screws had been removed, the implants were placed

Fig 5 *(Right)* The specialized trackable handpiece, outfitted with special sensors *(a)* and mounted with a round drilling bur, being used to identify the underlying position of the fixing screws. Note the acrylic resin occlusal template *(arrow)* mounted on the patient's right maxillary posterior teeth and attached to an optical sensor plate *(b)*. This fittedtemplate enabled continuous monitoring of the patient's spatial position.

Fig 6a *(Below left)* Cross-sectional view of the integrated imaging with the surgical drill used to locate the underlying position of the fixing screws. The surgical drill was pointing directly over the head of the central fixing screw.

Fig 6b *(Below right)* Removal of the mesial horizontal fixing screw via a minimal access cut directly over the screw head.



in a flapless procedure. Using computerized navigation, the surgical drill was directed to the exact planned positions of the implants. Available on the navigation screen were high-resolution piloting indicators that guided the surgeon to align the handpiece to the exact position and angulation necessary to establish the desired placement of each of the implants. The primary center position of the implants was initially marked with the round drilling bur on the gingiva, and a tissue punch incision was then made to remove the gingiva at this location (Fig 7). The drilling sequence was completed, and the 3 implants (Tapered Screw-Vent; Zimmer Dental, Carlsbad, CA; 3.7 mm wide and 13 mm long) were self-tapped into position (Fig 8).

Keratinized Tissue Graft and Restoration of the Implants. Three months following implant placement, a free gingival graft of keratinized tissue was harvested from the hard palate mucosa and grafted on the mucosal buccal aspect of the implants. The graft was further stabilized by a customized acrylic resin stent that was supported by the 1-stage implants. Three months later the implants were loaded with the definitive fixed screw-retained porcelain-fused-to-metal prosthesis, replacing the missing teeth (Fig 9).

DISCUSSION

Computer-aided surgery has evolved from the preoperative diagnosis and planning stages, and is now part of the actual intraoperative protocols.[13] The advanced technology of 3D imaging-based navigation allows for precise intraoperative orientation of the surgical probe in relation to the anatomic structures. This distinctive attribute has been demonstrated as highly beneficial in detecting and retrieving foreign bodies from the head and neck.[14,15] Based on the preoperative imaging the safest and shortest surgical routes can be planned, and surgery can then be executed in a minimally invasive approach.

In the case presented herein, this innovative feature was used to detect the underlying position of previously placed bone graft fixing screws and to remove them with minimal access incisions. By eliminating the need for a full-thickness flap, the postoperative alveolar bone resorption that has been reported with flap opening has been avoided.[16,17] The advantages of flapless implant procedures also include reduction in postoperative swelling and decreased patient discomfort.[1,2,18] However, since in this approach the keratinized gingiva is not apically

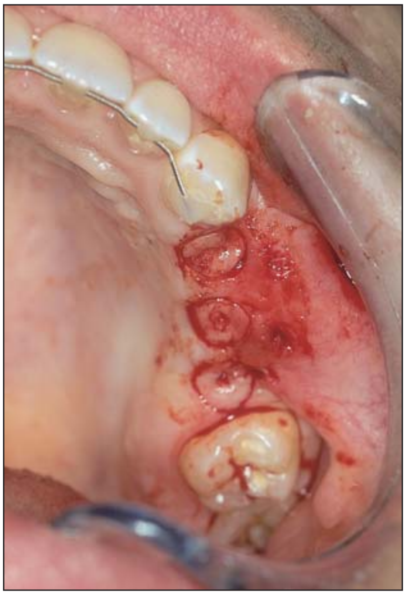


Fig 7 *(Left)* Clinical view of a punch incision. The incision was made around the primary mark that indicated the center of the implant's planned position and was placed using the piloting indicators provided by the computerized navigation system.

Fig 8 *(Below)* Postoperative panoramic radiograph of the implants in position.

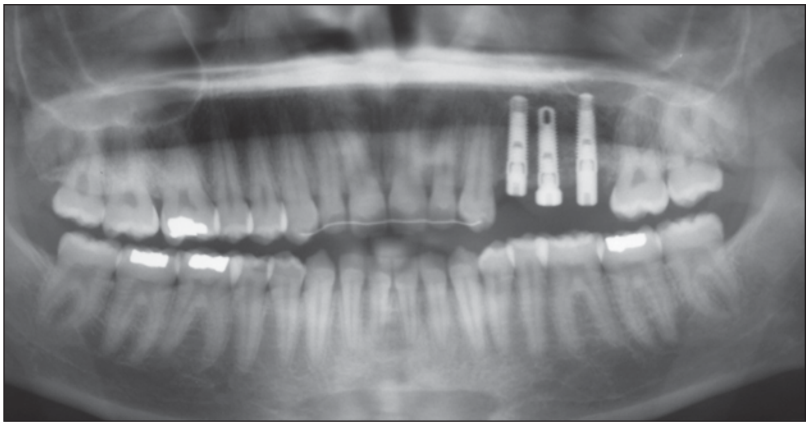


Fig 9a Occlusal view of the definitive screw-retained porcelain-fused-to-metal prosthesis. Note the openings of the screws demonstrating the tripod arrangement of the implants and their correspondence to the crown-units of the prosthesis.

Fig 9b One-year follow-up of the definitive screw-retained porcelain-fused-to-metal prosthesis. Note the results of the free keratinized gingival graft and the reestablished buccal vestibule.

relocated but rather excised, it should be limited to cases in which there is an adequate zone of attached gingiva. In the case reported herein there was a substantial lack of attached gingiva, and the oral mucosa closely approached the gingival margins at the edentulous ridge. Therefore, it was planned to augment the keratinized gingiva using a free gingival graft of keratinized tissue from the hard palate.

Several reports have indicated the benefits of using a protective membrane for preserving the volume of autogenous bone grafts used for alveolar ridge augmentation.[19–21] The mean horizontal and vertical dimensions of the augmentation are reported to decrease by 23.5% and 42%, respectively, during the healing period of autogenous onlay grafts if a membrane is not placed.[22] In the case presented, a resorbable membrane was used to avoid a second flap procedure. It is speculated that minimizing interference with the bone remodeling process at the recently grafted site will maximize the augmentation results.

Following retrieval of the fixing screws, implant surgery could proceed as a flapless procedure. With the integrated imaging of the dental drill next to the anatomic structures, the surgeon was able to monitor the progress of drilling and avoid plate perforation and damage to vital structures. The intraoperative navigation of the dental drill also allowed for precise implementation of the preoperative digital plan and the establishment of favorable prosthetic positions for the implants.[23–25]

Image-guided technology constitutes a reliable surgical aid that brings a spectrum of applications into the operating theater. Its implementation in implant dentistry has been facilitated through improvements in accuracy and ergonomics. In contrast to computer-generated drilling templates, which allow only 1-way flow of information from the pre-acquired imaging to the surgical field,[26,27] computerized navigation systems allow more interactive implant surgery. The imaging generated enables backflow of data, providing constant feedback on surgical progress and allowing intraoperative modification of the treatment plan. The real-time reading of the surgical instrument enables intraoperative localization and facilitates noninvasive surgical approaches. With further improvements in user friendliness and with reduced cost, the use of computerized navigation surgery can increase in the years to come.

CONCLUSIONS

Removal of bone graft fixing screws and the placement of dental implants may be achieved in a flapless approach utilizing computerized navigation. This technique emphasizes the potential of computerized navigation in facilitating minimally invasive surgery in implant dentistry.

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