Guided dental implant surgery can optimize implant placement positioning, increase predictability, and decrease surgical invasiveness through flapless techniques. Static surgical guides have been used to accomplish this task, though limitations of patient opening and lack of coolant contact with the surgical site have been clinically significant weaknesses. Technologic advances have allowed robotically guided implant placement using haptic guidance. The absence of a static stereolithographic guide over the surgical area allows for optimal access and adequate cooling during osteotomies. The aim of this case series was to present the workflows of both static and robotic guidance in the same patient and measure deviations from the presurgical planning software to determine the practicability and accuracy of robotic guidance. Based on this case series, it can be concluded that using robotically assisted implant surgery can yield deviation results that are comparable to static CAD/CAM stereolithographic surgical guides. Robotic surgery can be performed predictably with minimal deviation in both simple and complex clinical situations. Further testing and analysis are needed to confirm this case study’s results in a larger cohort of patients. Int J Oral Maxillofac Implants 2020;35:e86–e90. doi: 10.11607/jomi.8231

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Successful dental implant outcomes are dependent on precise prosthetically driven implant placement to minimize stresses on the implant body and its prosthetic components.1,2 CBCT has allowed dental surgeons to visualize osseous anatomy and bone characteristics such as quality and quantity in 3D.3,4 CBCT and CAD/CAM have been used by dental surgeons to duplicate presurgical plans by utilizing stereolithographic surgical guides. Static guided dental implant surgery can optimize implant placement positioning, increase predictability, and decrease surgical invasiveness through flapless techniques.5–8 Utilizing 3D treatment planning software, the implant position can be virtually planned at a safe distance from critical anatomical structures and in the most favorable prosthetic orientation.9 The resulting surgical plan can be transferred to the patient during surgery using static CAD/CAM stereolithographic surgical guides.10–12 Manufacturer-specific guided surgery kits include modified drills with longer shanks and integrated depth stops to compensate for the thickness of static surgical guides and limit depth and angulation of drilling to the desired plan.10 Implant mounts or carriers are designed to engage the surgical guide to restrict drills to the desired position, angulation, and depth.10

The disadvantages of static navigation lie in its nomenclature and design. One cannot deviate from the presurgical plan unless the surgical guide is set aside and freehand surgery is utilized, negating the positive features of static implant guidance. Stereolithographic guides can be cumbersome, especially in posterior sites, and may not be possible in certain molar areas due to limited patient opening and access for longer drills. The obstruction of the surgical field with a stereolithographic guide can prevent adequate coolant from entering the surgical site, resulting in a detrimental rise in bone temperatures and the potential for necrosis.11 Additionally, the absence of real-time feedback of drill positioning can limit information available to the surgeon intraoperatively.

Technologic advances have allowed robotically guided implant placement to combine the benefits of haptic static guidance with real-time dynamic navigation. The lack of a static stereolithographic guide over the surgical area allows for optimal access and adequate cooling during osteotomies. The presurgical plan can be modified at any time during the procedure, and those changes can be executed immediately. Currently, the only FDA-approved robotic guidance in implantology is represented by the Neocis Yomi device (Fig 1). Registering the CBCT implant surgical plan to the patient involves an intraoral reference splint that is affixed with autopolymerizing resin to the contralateral side of the patient’s arch to be treated. A magnetic fiducial array with embedded beads in multiple planes is magnetically affixed to the intraoral reference splint, and a CBCT scan of the patient’s arch is taken. The fiducial

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array allows the robotic software to register and orient the CBCT scan for precise implant planning. Once the implant positioning is planned in a similar fashion to static guidance programs, the patient tracker arm extends from the robotic device and is attached to the intraoral reference splint by means of a thumb screw. This allows for intraoperative tracking of patient motion and real-time feedback of where implant drills are within the osteotomy site. A landmark is placed at a definable point within the planning software, and the same reference point is found clinically to ensure accurate matching between the software and patient.

Haptic feedback provides physical guidance by means of software-mediated limitations to the robotic guidance arm, preventing drill deviations from the presurgical plan. This computer-driven motion restriction provides angulation and depth control in the form of haptics and visual and audio cues. The robotic guidance arm utilizes a device-specific handpiece that is controlled by the surgeon at all times. All drills are measured before use and entered into the robotic software prior to each osteotomy.

This case study compares static guided surgery to robotic guided surgery by the same clinician within the same patient. Postoperative CBCT scans were taken to assess healing and implant positioning. Deviations from the presurgical planning software were analyzed to determine the accuracy of static and robotic guidance.

**STATIC GUIDED SURGERY**

A male patient 64 years of age presented with a fracture of the maxillary left first premolar to the level of the osseous crest. Radiographic analysis showed a large periapical radiolucency (Figs 2 and 3). After careful assessment and review of treatment options, the patient opted for extraction with guided bone regeneration followed by static guided implant surgery. The fractured tooth was removed, and the apical lesion was enucleated. A 50/50 mixture of allograft and xenograft (AlloOss, NuOss, Ace Surgical Supply Company) was placed and covered with collagen membrane (Conform, Ace Surgical Supply Company) and sutured in place with polyglycolic acid (PGA) sutures. After 6 months, imaging was taken to evaluate the site for implant placement. Treatment options were reviewed with the patient a second time, and the patient elected for implant placement using static surgical guides. The implant planning appointment included a CBCT of the region of interest using the Carestream 81003D. The CBCT data were saved in the digital imaging and communications in medicine (DICOM) format. The patient’s clinical dental arch was captured by the Cerec Omnicam intraoral scanning system (Dentsply Sirona) and converted to a
stereolithographic file. The digital radiograph and the digital dental arch were imported into implant planning software (360DPS, 360Imaging), and the presurgical implant planning was performed. Computer-aided manufacturing of the surgical guide was performed by an EdenV260 3D printer using MED610 resin. A manufacturer-specific surgical guide sleeve corresponding to the planned implant size was inserted into the surgical guide (Fig 4).

Consent was obtained, and implant surgery was performed using the previously described static surgical guides and the Nobel Biocare Guided Surgical kit for the NobelActive implant system. Tissue punch and implant osteotomies were accomplished through the surgical guide, and a 3.5- × 15-mm implant was placed through the guide using the manual torque wrench at 20 NcM. The guided implant mount and surgical guide were removed to assess implant stability. A cover screw was placed, and the surgical site was closed during healing (Fig 5). A postoperative CBCT scan was taken to assess final positioning and establish a baseline for the healing process (Fig 6).

Static guided deviation analysis outcomes were as follows: At the crestal position, the horizontal deviation was 0 mm buccolingually and 0.2 mm to the distal mesiodistally. At the apical position, the horizontal deviation was 0.7 mm to the buccal buccolingually and 0.4 mm to the mesial mesiodistally. In the vertical direction, the deviation was 0 mm. Buccolingual angular deviation was 3 degrees, and mesiodistal angular deviation was 6 degrees (Fig 7).

ROBOTIC GUIDED SURGERY

The same patient, now 66 years of age, fractured the maxillary left second premolar just above the gingival margin (Fig 8). After careful assessment and review of treatment options, the patient opted for extraction with guided bone regeneration followed by robotically guided implant placement. The fractured tooth was removed, and a xenograft bone graft (Bio-Oss, Geistlich) mixed with advanced platelet-rich fibrin (aPRF; Choukroun Centrifuge) and collagen membrane (Bio-Gide, Geistlich) were placed and sutured with PGA sutures. Imaging was taken after 6 months to evaluate the site for implant placement (Fig 9). Treatment options were reviewed with the patient a second time, and a discussion regarding static versus robotically guided surgery proceeded.

On the day of the robotic implant procedure, consent was signed, and the intraoral reference splint was relined in place with autopolymerizing resin on the patient’s maxillary right quadrant using CoolTemp Natural bisacryl composite material (Coletene Whaledent). The magnetic fiducial array was attached to the intraoral reference splint, and a low-dose (0.3-um voxel) CBCT scan was taken using an iCat Flx (Imaging Sciences). The DICOM files were uploaded into the robotic planning software, the implant positioning was finalized, and a landmark position was chosen (Fig 10). The robotic drills were calibrated, and osteotomy drills were measured before use. A 3.5 ×10-mm Adin Touareg ClosFit implant (Adin Implant Systems) was placed and torqued to 25 NcM. A cover screw was placed, and the surgical site was buried during healing. A postoperative low-dose CBCT scan was taken to assess final positioning and establish a baseline for the healing process (Fig 11). A periapical radiograph was also taken (Fig 12).

Robotically guided deviation analysis outcomes were as follows: At the crestal position, the horizontal deviation was 0.5 mm to the lingual buccolingually and 0.3 mm to the mesial mesiodistally. At the apical position, the horizontal deviation was 0.5 mm to the lingual buccolingually and 0.5 mm to the mesial mesiodistally. In the vertical direction, the deviation was 0.4 mm in
Fig 8 Preoperative periapical radiograph of the maxillary left second premolar; robotic guidance.

Fig 9 Postextraction and ridge preservation periapical radiograph of the maxillary left second premolar; robotic guidance.

Fig 10 Robotic implant planning of the maxillary left second premolar. CBCT with intraoral reference splint and fiducial array imported into Yomi robotic device for implant planning and landmark placement. Landmark is represented by light blue crosshairs on distobuccal cusp of the maxillary left first premolar.

Fig 11 Postoperative CBCT images of the maxillary left second premolar; robotically guided implant placement.
the apical direction. Buccolingual angular deviation was 0 degrees, and mesiodistal angular deviation was 1 degree.

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