REVIEW ARTICLE

DYNAMIC 3D NAVIGATION SYSTEMS FOR DENTAL IMPLANT SURGERY: A REVIEW

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ABSTRACT

One of the latest innovations in implant dentistry is dynamic navigation. Dynamic navigation allows surgeon to place implants with accuracy similar to stereolithographic guides based on 3D, prosthetically directed plans[1]. Advantages include real time feedback, improved visualization, a streamlined digital workflow. This article discusses the technology and workflow of different dynamic navigation systems and its application for guided implant placement.

Keywords: *Dynamic navigation, dental implants, CBCT*

INTRODUCTION

Computer guided surgery is a technique that allows for the positioning of dental implants based on a virtual preoperative plan. The patient can be scanned, planned and can undergo surgery the same day. Plan can be altered during surgery when clinical situations dictate a change. The entire field can be visualized at all times. Accuracy can be verified at all times. Lesser time, as period between upload and delivery of guides is eliminated. Implant size, position and dimensions can be changed. Heat production is minimized because adequate irrigation can be used.

NAVIGATION SYSTEMS

ROBODENT (Neosis, neosis.com)

The Robodent contains a computerized program, optical camera, and set of sensors, much like the GPS. This instrument allows early planning of implant positions in the jaws through 3D Imaging. Surgeon watches the computer screen, and is guided by the "virtual dental simulator" which remains constantly linked to the plan displaying on the computer screen, the optical camera, and the sensors in the surgeon's hands. This is an innovative method known as the 3S Implant - Simple, Secure & Safe.

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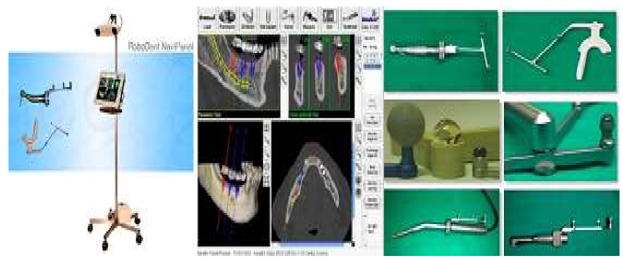
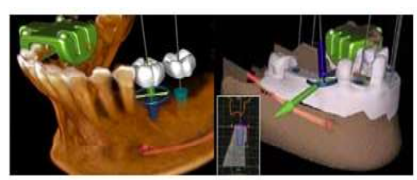


X GUIDE (X- NAV, X- NAVTECH.COM)

X-Guide is compatible with most CBCT systems, including small FOV. Plan the implant position with DTX Studio. DTX Studio Clinic helps you acquire and consolidate diagnostic data, and DTX Studio Implant enables you to bring your implant treatments to a whole new level. Mark 3 points on the CBCT rendering in the X-Guide software. Register the same 3 points in the patient's mouth using the probe tool. Interactive turn-by-turn guidance gives you the ability to improve the precision and accuracy.

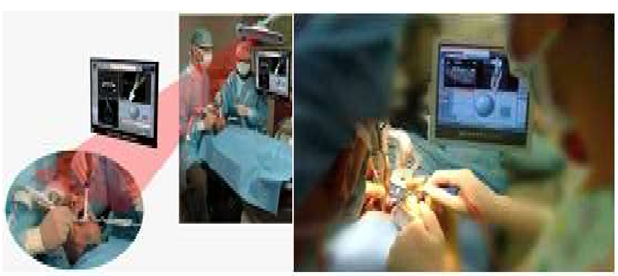


NAVIDENT (CLARONAV, CLARONAV.COM)

Navident offers dentists an easy to use, accurate, highly portable and affordable way to plan the desired restoration and implant placement. Navident is compatible with any implant size and type available in the market. Register the CBCT scan to the patient by selecting 3-6 landmarks on the screen and tracing those landmarks in the mouth with a tracer tool. Following a brief drill or implant calibration, Navident dynamically present the deviation between the actual/planned position and orientation of the drill/implant, guiding the surgeon to accurately implement the plan. Navident performs flapless surgery, reduces discomfort, reduces risk of infection and faster recovery, avoids unintentional iatrogenic damage to nearby anatomical structures.

IMAGE GUIDED IMPLANT (IGI)

The Image Guided Implant Dentistry System is the world's first dental navigation technology to utilize 3D imaging and motion tracking. Through the use of a CT scan and a computerized surgical navigation system, the IGI enhances safety and promotes ideal dental implant placement. Tracking is completely fluent in all directions (including from behind the handpiece) and there is no on-screen lag time. TRAX™ system comprises a camera and light emitting diodes (LEDs) arrays on both the handpiece and patient-tracker. They track at the speed of light and there is no ambiguity as to the location of our tiny LEDs (which consume only a few pixels), hence high accuracy. Other systems use a slower, less accurate, passive LED technology.



INLIANT (NAVIGATE SURGICAL, NAVIGATE SURGICAL.COM)

A fiducial, recognized as an anchor point, is affixed to the patient and held in place with a stent during the initial CBCT scan, and again during surgery. During surgery a patient tracker is attached to the stent. Cameras track markers located on both patient tracker and dental handpiece to determine the relative position of the drill and patient which is displayed on a monitor. With nothing attached to the handpiece, the clinician's ergonomics and tactile feedback remain unchanged. Inliant's proprietary markers enable the cameras to accurately track the handpiece position. Advantages include no pre-surgical calibration required, sleek design / space-efficient.

DISCUSSION

Imaging technology has transformed the field of implant dentistry and has led to significant improvements in accuracy and greater predictability in prosthetic outcomes. A systematic review demonstrated that, on average, CT-guided implant surgery with static guides has around 1 mm entry point deviation and around 15 degrees of angle discrepancy when compared to treatment plans.[5] However, that and another systematic review also demonstrated that large standard deviations exist (ranging up to 7.5 mm for entry point deviation and more than 15 degrees angle discrepancy).[6] Block et al has demonstrated that dynamic navigation has the potential to further improve accuracy measurements compared to static guides but that, on average, the clinician must perform at least 20 cases using the technology before the learning curve is mastered.[7] A recent publication by Stefanelli et al, data were obtained on 231 implants placed in healed ridges using a flapless or minimal flap approach under dynamic guidance by a single surgeon using the same navigation system. Of the 89 arches operated on, 28 (125 implants) were fully edentulous. For all implants, the mean deviations (SD) were: 0.71 (0.40) mm for entry point (lateral) and 1 (0.49) mm at the apex (3D). The mean angle discrepancy was 2.26 degrees (1.62 degrees) from actual versus planned implant positions. The accuracy measurements for partially edentulous patients using a thermoplastic stent attachment and for fully edentulous patients using a mini-implant-based attachment were nearly identical. No significant accuracy differences were found between implant positions within the different sextants. Guided insertion of the implant itself reduced angular and apex location deviations. Most interestingly, the accuracy of implant placement improved during the study period, with the mean entry point, apex deviation, and overall angle discrepancy measured for the last 50 implants (0.59 mm, 0.85 mm, and 1.98 degrees, respectively) being better when compared to the first 50 implants (0.94 mm, 1.19 mm, and 3.48 degrees, respectively).[8] Static guided surgery has many challenges, most of which involve either planning errors or iatrogenic errors that occur during surgery. Certain clinical situations, such as limited mouth opening or interdental space limitations, may preclude the use of stereolithographic surgical guides. Improper implant placement has repeatedly been found to be a factor in esthetic failures and/or bone loss.[9,10] These types of limitations do not apply to dynamic navigation surgery. Because static stereolithographic guides provide no reference of tooth position, most inaccuracies are realized after surgery. Dynamic navigation provides the ability to verify and validate, in real time, positional accuracy of osteotomy site preparation and implant placement. In addition, real-time navigation affords an opportunity to edit the plan during surgery. Because the operating field is fully visualized and unrestricted, changes to implant positioning or dimension can be implemented when regional anatomy warrants modification unforeseen during the planning phase.

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