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Guiding Our Implants: Using Dynamic Surgical Guidance to Maximize Predictability

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Guiding our Implants

Using Dynamic Surgical Guidance to Maximize Predictability

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ABSTRACT

Dynamic surgical guidance (DSG) is a recent advance in implant dentistry, used to maximize the efficiency and predictability of implant surgeries. A study, conducted by Navigate Surgical Technologies using the Inliant system, was undertaken in Toronto, Canada, to analyze the success and accuracy of this technology. Twenty-three implants placed in 22 subjects were examined. The results showed that implant placement using Inliant was extremely accurate when compared to the presurgical plan. Additionally, there were no significant errors or deviations in implant placement. The study concluded with the Food and Drug Administration of the United States granting safety approval for the Inliant system. As such, it is reasonable to expect that DSG, including the Inliant system, can and should be safely implemented by more practitioners as the technology becomes readily available.

With constant advancements in medical technologies, opportunities to improve on "older" techniques are continuously emerging. This includes the field of implant dentistry, where there have been numerous steps taken to improve techniques over the past few decades. Studies have shown that implants have over a 96% success rate after 10 years.[1] While impressive and, arguably, one of the most predictable procedures in the dental field, there are still challenges and areas that can be modified with dental implants to enhance the experience for both the patient and the clinician.

Traditional Implant Surgery

Some clinicians prefer to place implants "freehand" or without the use of an external guide. Invariably, this technique is the easiest to execute, as less materials, planning and fabrication time are needed prior to surgery, and a lab is not required. The concern with freehand placement would be a potential lack of accuracy as to where the implant is placed, compared to its intended position.

According to a study conducted by Schnutenhaus et al., freehand implant placement resulted in average angular deviations of 8.7 ± 4.8 degrees, implant shoulder position deviations of 1.62 ± 0.87 mm, mesiodistal deviations of 0.87 ± 0.75 mm, buccolingual deviations 0.70 ± 0.66 mm and apiocoronal deviations 0.95 ± 0.61 mm, when compared to an initial plan.[2] The study also found that these values had large ranges of variation depending on the specific site, with a wider range found in the mandible, as well as the timing of implant placement, with larger deviations in sites with more recent bone grafting.

The most basic form of a surgical guide is an acrylic stent. This requires a model cast of the patient's arch and a wax-up at the edentulous site(s). An acrylic stent can help direct the surgeon in terms of an initial mesiodistal and buccolingual entry point; however, it has little benefit with regard to the angulation and depth of implant placement.

The increased availability and use of cone-beam computed tomography (CT) scans have permitted the creation of surgical guides that are based on patient-specific anatomy and help to ensure that an implant is placed in the proper three-dimensional position. In general, guided implant surgery using this technique is quite precise, with angular variations up to five degrees and positional variations up to 2.3 mm.[3]

Traditional, static implant guides have been used for decades and have proven to be successful. Yet, they still present with significant limitations. Static guides may have compromised adaptation to the dentition due to their rigid form, and although impressions or digital scans are used for their fabrication, there have been concerns about achieving the necessary intimate fit of a guide. This may occur if there are any inaccuracies in the impression/scan, minor shifting of teeth, and/or slight mobility influenced by tissue resiliency. Several dozen studies were analyzed which curated a list of deviations, including tooth-supported and bone-supported guide mean deviations of 1.40 mm and 1.33 mm coronal, 1.8 mm and 1.57 mm for apical, 4.8 and 4.63 degrees for angular and 0.8 mm and 0.47 mm for depth deviations, respectively.[4]

Using a static guide also requires increased space for instrument access, which is, notably, a challenge in posterior regions and in patients with limited mouth opening. Further, there has been concern about reduced levels of irrigation that reach the surgical site when using a static guide.[5] This is a consequence of the tight fit between the drill and guide sleeve, preventing irrigation from reaching the osteotomy, where it is required to avoid overheating and subsequent necrosis of the osseous structures. This intimate fit also reduces tactile sensation when preparing an osteotomy, which has been another critique of static guides. These limitations and concerns, while all with potential remedies, have given rise to the search for new methods of guiding implants during surgery.

Introduction of Dynamic Surgical Guidance

A recent advancement in implant dentistry, known as dynamic surgical guidance (DSG), has gained popularity in an effort to overcome the noted limitations of traditional guided and freehand surgery. Dynamic surgical guidance, which can be thought of as a "global positioning system" to place the implants, is a computer-guided modality providing in real time, three-dimensional feedback of the drill and implant location through motion-tracking devices in the surgery.[6]

A literature review conducted by Parra-Tresserra et al., studied the effectiveness of dynamic surgical guidance versus static-guided surgery.[7] They concluded that "dynamic navigation shows a better accuracy and precision of implant placement" when compared to static guides. The importance of three-dimensional placement was emphasized, as it can lead to improved esthetic and prosthodontic outcomes, long-term hard- and soft-tissue stability, and idealized occlusal loading. These were all shown to be more predictably achieved when using DSG.

Inliant, developed by Navigate Surgical Technologies (Vancouver, Canada), is one example of a DSG system. According to the company, the use of Inliant dynamic guidance "delivers real-time surgical navigation for free-hand dental implant procedures."[8]

Inliant utilizes various sources of information to plan and guide the placement of implants. They include: the handpiece; an intraoral fiducial and patient tracker; and the digital connector/reader.

The handpiece is a traditional handpiece in terms of design and feel but is marked with a specific series of laser etchings (Figure 1). The intraoral fiducial is made with a thermoplastic material that is molded to the patient's dentition in an area remote to where the implant is being placed, which then hardens to form a personalized stent, and is worn during a cone-beam tomography (CT) scan.

During the surgery, a patient tracker, also marked with specific laser etchings, is inserted into the fiducial and worn by the patient (Figure 2). The digital connector is stationed

Figure 1. Laser-etched handpiece.

Figure 2. Laser-etched patient tracker attached to fiducial.

Figure 3. Digital connector; digital connection on stand with computer; example of integration of digital connector and stand in operatory setting.

above the surgical space with two cameras angled to read both the handpiece and the patient tracker (Figure 3). Upon recognizing the laser markings, the connector is able to relay the position of the surgical site, as well as the handpiece, and, by extension, the drill, to produce an image on the computer. The resultant image provides a real-time, dynamic representation of where the drill is in the patient's bone.

Numerous aspects of DSG have proven to be advantageous over previous incarnations of guides, including consolidating treatment into a single appointment, increased safety and predictability from real-time feedback, lower preprocedure costs and improved ergonomics for the clinician.[9] An added benefit to this technique is the ease of implementation. One study found that even in novice hands, this technique can be viewed as reliable and easy-to-learn, which may be extremely useful to newer clinicians interested in this technology.[10]

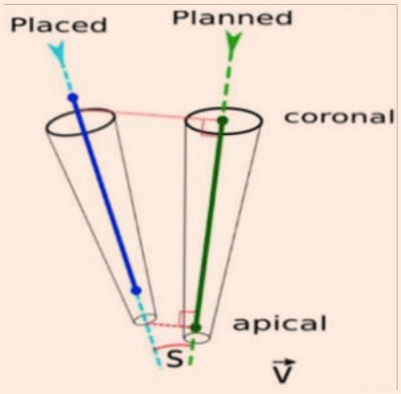

Figure 4. Apical and coronal lateral deviations, where coronal is distance from top (coronal) point in planned to axis of placed implant; apical is distance from apical point in planned to axis of placed implant; and S is angular deviation between placed and planned implant.

	Angle Deviation (°)	Coronal Deviation (mm)	Apical Deviation (mm)
Average	2.91	0.64	0.90
Range	0.746 - 6.542	0.082 - 1.504	0.053 - 1.871

Figure 5. Results from Toronto Inliant study. Angular, coronal and apical deviations were assessed.

The Toronto Inliant Study

From July 2021 to August 2021, an in-office study was conducted at Prosthodontic Associates, a private practice in Toronto, Canada. After appropriate instruction and training with Inliant, a group of surgeons, including three prosthodontists and one periodontist, used this system to place implants. Throughout the study, multiple surgical sites were included, involving all four quadrants and different tooth locations. In total, 23 subjects, aged 19 to 76 years old (average age 55.7 years old), were included. The implant surgeries were planned using the Inliant software, executed using Inliant DSG, and then evaluated with a postoperative CT scan.

Angular deviation, coronal deviation and apical deviation, when compared to the initial plan, were assessed and reported (Figure 4). While the study was not sponsored by a specific company, the implants used were provided to the participants at no charge by Southern Implants Ltd.

The results of the study were obtained by comparing the initial implant plan to the final implant position, assessed on the postoperative CT scan (Figure 5). Angular deviation varied from 1.40 to 2.95 degrees. Coronal and apical measurements ranged from 0.29 to 0.70 mm and 0.32 to 0.89 mm, respectively. These measurements were achieved by comparing the pre- and postoperative CT scans. Comparatively, all the acquired measurements were marginally smaller than the values obtained from the static guide (bone- and tooth-supported) study conducted by Gerhardt et al.

Statistical analysis was completed for each of the three deviations measured. The hypothesis for angular deviation was analyzed via the one-sample Wilcoxon signed-rank test, whereas the coronal and apical deviations were analyzed using a one-sample T-test. All hypotheses analyzed concluded that the Inliant system produced equally successful cases to the predicate LLC.

X-Guide Surgical Navigation System*

To ensure thorough evaluation, ANOVA completed testing to evaluate any difference between the clinicians and found there was no significant difference, but it highlighted that due to the small sample size, it may be difficult to reach a definitive conclusion. Overall, it was concluded that the Inliant system produced implant placements at an equivalent accuracy to that of the predicate device.

The major limitation within this study is the sample size of 23, versus other studies that included anywhere from 20 to 140 implants. However, based on the results of this study, the United States Food and Drug Administration granted safety approval for the device, and it is now available for use in the U.S.

Next Steps

Now that the Inliant system has been approved for use in the U.S., a larger scale study may be of value to provide conclusions with more power. From there, it is reasonable to expect this technology to increase in usage within dental practices across the country, including not only Inliant, but also a surge of alternative companies offering the same ultimate goal of utilizing dynamic surgical guidance to increase surgical precision and accuracy. The short learning curve and minimally required equipment make it quite amenable to anyone placing dental implants.

While not every implant surgery requires a guide, the benefits of DSG compared to traditional static guides for most cases are very transparent. Practitioners wanting ultimate safety, accuracy and efficiency for their surgeries should consider how DSG can potentially help them achieve these goals.

The authors declare no conflict of interest with their manuscript. Queries about this article can be sent to Dr. Endres at sendres1221@gmail.com.

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