Review Article

A Review on Guided Surgical Implant Placement and Free Hand Implant Placement

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Abstract

The emergence of concept of prosthetically driven implant dentistry has shown the importance of pre-planning of three-dimensional implant positioning and executing planned position in the surgery. Recent advances in digital technology such as static and navigated computer-assisted implant surgery help in achieving it.

Keywords: Dynamic-navigated implant placement, Free hand implant placement, Static computer-assisted implant surgery.

Introduction

A critically important factor in implant placement is the optimal three-dimensional (3D) implant position, as it can ensure the proper design of the prosthesis. In case of freehand dental implant placement procedure, the surgeon will rely on their knowledge of the anatomy of the jawbone and the position of the adjacent teeth to determine the optimal location and angle for the implant placement. They will also use their tactile sense to gauge the density and quality of the bone. Recent advance in digital technology helps in pre-operative planning and executing the planned treatment intraoperatively. In addition, two types of guided implant surgery protocols are described in the literature static and dynamic. Static technique utilizes computer technology for virtual implant position planning before surgery. During the surgical intervention, the planned implant position is transferred to the surgical site by a 3D-printed surgical guide.[1,2] Angulation and depth of implant osteotomy are controlled by guided surgical drills through a metal sleeve embedded in the surgical guide. Dynamic-guided surgery systems were introduced to the field of implant dentistry at the beginning of the year 2000. The dynamic approach, also called navigation, refers to the use of a surgical navigation system that reproduces the virtual implant position 4 directly from computerized tomographic data and allows intraoperative changes of the implant position. These systems are based on motion tracking technology that allows real-time tracking of the dental drill and the patient throughout the entire surgery.[1,3] The purpose of the study is to provide a review on aids that can be utilized for surgical placement of implant.[4]

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Discussion

Treatment outcome – fully guided (FG) versus free hand (Table 1)

According to research, both static- and dynamic-guided surgeries have been shown to have similar failure rates. However, there is some debate among researchers about the relative effectiveness of these two approaches. Some studies, such as the one conducted by Hermann *et al*., have suggested that static-guided surgery using a pre-made template is associated with fewer errors than real-time navigation using dynamic guidance systems.[5,6] However, other studies have not found statistically significant differences between these two approaches.[4] It is true that dynamic navigation systems can be more expensive and complicated for private practitioners, compared to cost-efficient stereolithographic alternatives for static guided surgery. In addition, not all cases may be suitable for computer-guided implant placement, and the decision to use this approach should be made on a case-by-case

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Table 1: Studies comparing clinical outcome of guided and free hand surgery

Author and year of study	Type of study	Type of guided surgery used	Clinical outcone
Pozzi *et al*., 2014[10]	RCT	Static guide	No significant difference was found between free hand placed implant and computer-guided implant
Tallarico *et al*., 2018[11]	RCT	Static guide	Both approaches show successful results over 5 year follow-up Free hand approach shows high post-operative swelling due to flap elevation
Alevizakos *et al*., 2019[12]	Retrospective case study	Static guides	High accuracy
Smitkarn *et al*., 2019[8]	RCT	Static computer-assisted surgery	More accuracy shown by computer-assisted than free hand place surgery
Varga *et al*., 2020[9]	RCT	Static guides	Improved accuracy when using guides as compared to free hand

basis. The accuracy of guided implant surgery systems is defined as the deviation between the planned and placed position of the implant, and this accuracy is evaluated quantitatively in three-dimensional coordinates. The use of implant planning software has been established in preoperative planning and the creation of individual surgical guides. However, variability in the accuracy of guided implant surgery has been reported due to errors originating from intrinsic and extrinsic sources.[7] These errors can affect the final position of the implant and may be influenced by factors such as calibration. Calibration is the process of verifying that the virtual world matches the clinical arena, and it is required at 2 time points during the workflow: The transformation of data from the clinical field to the digital platform and the shift back from the digital planning to the physical environment of the patient's mouth. The accuracy of guided implant surgery depends on various factors, including the quality of the digital imaging, the accuracy of the software used to plan the implant placement, the skill and experience of the surgeon, and the calibration of the system. Reducing errors in guided implant surgery is highly dependent on proper calibration in both static and dynamic guidance, and the potential for errors should be considered during each transition of data from the digital to physical environment.[8] In dynamic guidance, calibration is still necessary but requires different attention compared to static guidance. Since the cone-beam computed tomography scan is taken before surgery and is not a real-time, actively acquired image, it is important to calibrate the relationships of the hand instruments and the orientation of the patient's head with the static image. Calibration needs to be performed before drilling and with every change of drills to ensure accuracy in implant drilling and placement.[9,10] Dynamic guidance systems use real-time navigation to direct the drilling and placement of the implant based on the pre-planned position and inclination. During the surgery, the system tracks the position and orientation of the hand instruments and updates the virtual image of the surgical site in real-time, allowing for adjustments to be made as necessary. Calibration is crucial to ensure that the virtual image accurately reflects the patient's anatomy and that the real-time tracking is accurate.[3,11,12]

Dynamic versus static navigation (Table 2)

In dynamic navigation implant placement, the software then uses this information to plan the optimal placement of dental implants, taking into account factors such as bone density, available space, and the desired final position of the implant.[10,11,13] During the surgery, the clinician uses real-time feedback from the software to ensure that the implant is placed correctly and with proper parallelism. If necessary, the clinician can modify the planned surgical approach based on the feedback provided by the software, allowing for adjustments to be made in real-time to ensure the best possible outcome for the patient.[14,15] Overall, the dynamic navigation software represents a significant advancement in dental implant surgery, providing clinicians with greater precision and control, and ultimately improving the outcomes for patients undergoing this type of procedure. Disadvantages of dynamic navigation procedure is its accuracy depends on the spatial relationship between the reference points and the patient.[16-18] If there is an error in this relationship, it can lead to mistakes during the procedure, such as drilling at the wrong angle or implant placement in the wrong location. Therefore, it is important to ensure the accuracy of the reference points and the calibration of the system before using dynamic navigation in surgery.[15,19-21]

Mucosa support versus bone supported versus tooth/crown supported guide in static-guided surgery

If bone architecture allows for the flapless approach, a mucosa-supported guide should be the first choice in partially or fully edentulous patient, disadvantages of mucosa-guided surgery is a flapless surgery that will prevent the access to the bone, soft-tissue augmentation procedures would have to be limited to the tunnel approach. Bone-supported guide surgery is associated with an increase in patient morbidity, greater post-operative pain, higher analgesic consumption, post-operative swelling, and longer chair-time. Tooth/crown supporter guides in combination with mucosa-supported guides in flapless FG surgeries provide the highest accuracy in 3D implant positioning between the pre-surgical planning and the final implant placement.[17]

Guide visibility – closed guides versus open guides (Table 3)

Closed guide stent allows very less visibility to the surgical site. They are most used type of guides in FG surgery.[15] This kind of stent avoids modification of bone drilling during the surgery. One of the major disadvantages of closed type guide is that they do not allow cooling fluid to come in direct contact with the drills during bone preparation. In case of Unlike closed guides, open guides do not fully cover the surgical field and allow for direct visualization of the bone and soft tissue during

Table 2: Studies comparing of clinical outcome of static-guided implant placement and dynamic-navigated implant placement

Author and year of study	Type of study	Type of guided surgery used	Clinical outcone
Guzmán *et al*., 2019[21]	*In vitro* study	40 implants were placed 20 each	Both static-guided and dynamic-navigated allow accurate implant placement
Wu *et al*., 2020[13]	Retrospective study	38 implant placed using dynamic navigated surgery 57 implant placed using static-guided surgery	Dynamic navigation implant placement shows high accuracy than static-guided implant placement
Kivovics *et al*., 2022[14]	*In vitro* study	Study conducted on dynamic navigation implant placement, static-guided implant placement, free hand placement	Dynamic navigation implant placement was comparable to static computer-assisted implant surgery
Yotpibulwong *et al*., 2023[15]	RCT	Author has utilized dynamic navigation method, static computer-guided placement, combined method, and free hand method	Combined static and dynamic computer-assisted implant surgery is more accurate than two alone

Table 3: Studies comparing effect of closed and open static surgical guides

Author and year of study	Type of study	Purpose of study	Outcome
Gargallo-Albiol *et al*., 2021[17]	*In vitro*	Compare the drilling temperature in open versus closed static guides	Intra bone temperature is 1 degree higher when using closed static guides
Waltenberger *et al*., 2021[16]	*In vitro*	Studied on different types of template design on heat generation	It has no significant effect on heat generation, it influence on the effective volume of cooling liquids
Li *et al*., 2022[18]	*In vitro*	Compare the outcome of open sleeve and closed sleeve system in extraction socket site	Open sleeve system provides better outcome than closed sleeve system in an extraction site but not in healed site
Abuhajar *et al*., 2023[19]	*In vitro*	Heat generation in limiting and non-limiting surgical guides	Limiting surgical guides have higher heat generation. but clinically insignificant

the implant placement procedure.[16,17] Open guides typically have a frame or support structure that provides stability and accuracy during drilling and implant placement, but do not cover the entire surgical site. The open design allows for improved visibility, which can be particularly helpful in cases where there is limited space or access to the surgical site.[18,19] However, open guides require careful planning and may require additional skill and experience to use effectively.

Review on advantages and disadvantages of dynamic and static navigation-guided implant placement

There is a lot of studies in the literature which explored the advantages and disadvantages of dynamic and static navigation. Static navigation can further be divided into FG- and half-guided (HG) implant surgery. Systematic review conducted by Gargallo-Albiol *et al*. has conducted a systematic review on the advantages and disadvantages of implant navigation surgery.[17] Dynamic navigation is a technique used in dental implant surgery that involves the use of a 3D software to track the movement of surgical instruments in real-time during the procedure. This technology allows for highly precise and accurate placement of dental implants, as the position and orientation of the implant can be monitored throughout the entire surgical process. In contrast, static navigation involves the creation of a surgical guide based on a pre-operative CT scan. This guide is then used during the procedure to ensure accurate placement of the implant. While static navigation can also be highly accurate, it does not allow for the same level of real-time monitoring as dynamic navigation. Both dynamic and static navigation have their advantages and disadvantages, and the choice of technique will depend on various factors such as the complexity of the case, the surgeon's experience and preferences, and the available technology. Ultimately, the goal of navigation surgery in the dental implant field is to improve patient outcomes by reducing the risk of surgical errors and complications, and by achieving optimal implant placement and stability.[20]

Drilling and implant placement – FG versus free hand and HG, FG implant

Placement involves the use of a surgical guide that covers the entire surgical site and directs the drilling and placement of the implant. The guide is designed based on a 3D scan of the patient's mouth and allows for highly precise and accurate placement of the implant. HG implant placement involves the use of a surgical guide that covers only part of the surgical site, typically the area around the implant site. This technique allows for some freedom of movement and flexibility during the drilling and placement of the implant, while still providing guidance and support. Freehand implant placement involves placing the implant without the use of a surgical guide. This technique requires a high degree of skill and experience and may be used in cases where a guide is not feasible or necessary.[17,18,20] Each technique has its advantages and disadvantages and may be chosen based on factors such as the patient's anatomy, the complexity of the case, and the surgeon's

skill and experience. FG implant placement is generally considered the most accurate and precise technique, while freehand placement requires the most skill and experience.

Conclusion

The use of dynamic navigation systems for implant placement has been shown to provide higher accuracy compared to free-hand implant placement. The use of real-time feedback and advanced planning software allows for optimal placement of the implant, taking into account various factors that can affect its stability and success. However, it should be noted that these systems are expensive and require specialized training to use effectively. In addition, the use of free-hand implant placement still remains a viable option for clinicians who are experienced and skilled in this technique. Ultimately, the decision to use a dynamic navigation system or free-hand technique will depend on various factors such as cost, availability of technology, clinician experience, and patient-specific needs.

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