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Review Article

Dynamic implant navigation system: Enhancing accuracy, safety, and efficiency in implant dentistry

Sankar Madhavan[1,*], Vineetha Venugopal Menon[2], Joseph Johny[3]

[1] *Dept. of Prosthodontics, Sree Anjaneya Institute of Dental Sciences, Calicut, Modakkallur, Kerala, India*
[2] *Dept. of Dentofacial Orthodontics, Sree Anjaneya Institute of Dental Sciences, Calicut, Modakkallur, Kerala, India*
[3] *Dept. of Oral Medicine & Radiology, Sree Anjaneya Institute of Dental Sciences, Calicut, Modakkallur, Kerala, India*

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ABSTRACT

Dynamic implant navigation system (DINS), a novel technology that has revolutionized the field of implant dentistry. DINS is a computer-guided system that uses three-dimensional imaging and real-time feedback to aid in the placement of dental implants. The system offers improved accuracy, safety, and efficiency compared to traditional implant placement techniques. This review article discusses the principles and components of DINS, its clinical applications, advantages and limitations, and its future prospects.

1. Introduction

When it comes to planning and positioning implants, implantologists have many alternatives. Planning and implementing dental implant therapy has benefited from advancing technologies in planning software and office-based imaging. Dynamic Implant Navigation System (DINS) is a modern technology in dentistry used to place dental implants more accurately and precisely. It is an image-guided navigation system that uses three-dimensional (3D) imaging to plan and place dental implants. This technology enables dentists to perform a minimally invasive implant placement procedure, which results in reduced surgery time and improved outcomes.

2. Discussion

2.1. *How dynamic implant navigation system works*

The dynamic implant navigation system works by using specialized software and tracking sensors to create a real-time map of the surgical field, enabling the surgeon or dentist to plan and execute the implant placement with greater accuracy. These systems incorporate several components that work together to facilitate real-time navigation during surgery.

The navigation system may be Active or passive.

1. The active tracking system uses arrays that emit infrared light that is tracked to stereo cameras
2. Passive tracking system arrays use spheres that reflect infrared light emitted from a light source back to a camera.

The primary components of a DINS system include:[1,2]

1. Navigation software: The software is the central component of the DINS system. It uses advanced algorithms to create a 3D virtual model of the patient's

* *Corresponding author*.
E-mail address: drsankarmadhavan@gmail.com (S. Madhavan).

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jawbone, which is based on preoperative CT or CBCT scans. The software also allows the surgeon to plan the optimal implant placement based on the available bone quality and quantity. During surgery, the software tracks the position of the drill in real time, providing feedback on the accuracy of the drilling depth and angulation.

2. Navigation camera: The camera is a tracking device that monitors the position and movement of the drill in real time. It uses infrared light to detect the position of the drill and transmit this information to the navigation software (Figure 1). The camera is placed above the patient's mouth and tracks the position of the drill as it is being used.
3. Drill stent: A moldable thermoplastic stent that is placed directly on the patient's natural dentition (i.e., the retainer) and has a retainer arm extending outwards from the retainer body makes up a patient jaw attachment (Figure 1). The patient can be spatially registered in relation to the jaw attachment thanks to a fiducial marker that is affixed to the retainer and serves as a CT marker. The implant operation maintains the same link to the CBCT image that was acquired and used for case planning because the same retainer is used.
4. Implant placement tools: These are the tools that are used to place the implant in the prepared site (Figure 1). They include drills, drivers, and other instruments that are used to create the implant site and place the implant. These tools are used in conjunction with the navigation system to ensure accurate placement of the implant.

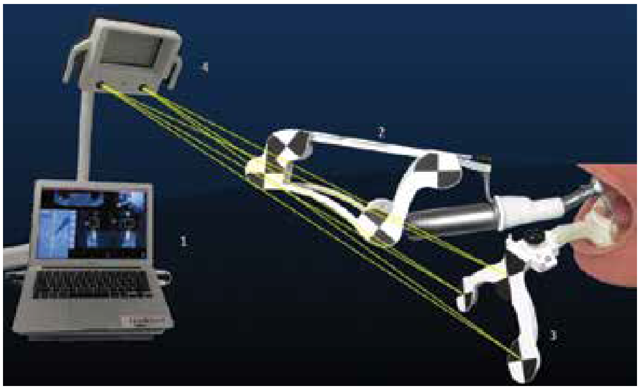

Fig. 1: The dynamic navigation system described consists of a computer (1) and an optical position sensor (4). The stereoscopic optical position sensor (micron tracker) (4) detects and triangulates checkerboard targets marked on the drill tag (2) and jaw tag (3), providing instant feedback during the operation.[2]

3. Advantages of the Implant Navigation System

The use of a Dynamic Implant Navigation System (DINS) in dentistry provides several advantages over traditional implant placement techniques. These advantages include:

Improved accuracy and precision: DINS allows for precise planning and execution of implant placement, resulting in improved accuracy and precision. A study by Vercruyssen et al. (2017) found that the use of DINS improved the accuracy of implant placement to within 1 mm and 5 degrees of the planned position.[3]

Reduced surgical time: DINS reduces surgical time by allowing for faster and more efficient implant placement. A study by Block et al. (2017) found that the use of DINS reduced the surgical time by an average of 50% compared to traditional implant placement techniques.[4]

Reduced risk of surgical complications: DINS reduces the risk of surgical complications by providing real-time feedback on the position and orientation of the drill. A systematic review and meta-analysis by Sun et al. (2020) found that the use of DINS significantly reduced the incidence of surgical complications such as perforation of the sinus or nerve injury.[1]

Improved patient outcomes: The improved accuracy, reduced surgical time, and reduced risk of complications associated with DINS can lead to improved patient outcomes, including improved implant survival rates. A study by Pozzi et al. (2016) found that the use of DINS resulted in a 98.3% implant survival rate at 3 years.[5]

3.1. Skill and training required for dentist to use DINS

The use of the Dynamic Implant Navigation System (DINS) requires specific skills and training for dentists to ensure safe and effective use of the system. Here, I will discuss the necessary skills and training required for dentists to use DINS based on available literature.

1. Proficiency in implant placement: Before learning to use DINS, dentists must have a thorough understanding of implant placement principles and techniques. Dentists must be able to plan and execute implant placement without the aid of DINS to ensure that they have a solid foundation to build upon when using the system.
2. Proficiency in computer-aided design (CAD) software: DINS requires the use of CAD software to create a virtual model of the patient's jaw and to plan the implant placement. Dentists must be proficient in using the software to design a treatment plan that takes into account the patient's unique anatomy, occlusion, and esthetic goals.
3. Familiarity with DINS hardware and software: Dentists must be familiar with the DINS hardware and software to use the system effectively. This includes

understanding the components of the system, how to calibrate the equipment, and how to troubleshoot any issues that may arise.[6]

4. Understanding of the limitations of the system: Dentists must be aware of the limitations of the DINS system to ensure that they do not rely solely on the technology and overlook important clinical factors that may affect implant placement. For example, dentists must consider the quality and quantity of available bone, the presence of adjacent teeth and nerves, and the patient's oral hygiene habits.[4]

The use of DINS requires a specific set of skills and training for dentists to ensure the safe and effective use of the system. Dentists must have a solid foundation in implant placement principles and techniques, be proficient in CAD software, and be familiar with the DINS hardware and software. Dentists must also be aware of the limitations of the system and participate in continuing education and training to maintain proficiency in using DINS.

3.2. Comparison of DNIS system to other implant guiding systems

Comparison of DINS with other computer-assisted implant placement systems in terms of accuracy, efficiency, and cost-effectiveness.

1. Accuracy: A systematic review and meta-analysis of 25 studies compared the accuracy of DINS with static surgical guides and freehand implant placement. The authors found that DINS resulted in significantly higher implant placement accuracy than static guides and freehand placement. In addition, DINS provided greater accuracy in challenging cases, such as in patients with severe bone defects.[1] Similar results were found in a recent meta-analysis that compared DINS with other computer-assisted implant placement systems, such as static surgical guides and cone beam computed tomography-guided implant placement.[6–9]
2. Efficiency: DINS has been shown to be a time-saving technique compared to traditional implant placement methods. A recent meta-analysis compared the efficiency of DINS with static surgical guides and found that DINS reduced the average surgery time by 5-10 minutes per implant, resulting in shorter overall treatment times. In addition, the use of DINS has been shown to reduce the number of surgical visits needed and improve patient satisfaction.[10,11]
3. Cost-effectiveness: The cost-effectiveness of DINS compared to other computer-assisted implant placement systems is an area of ongoing research. While DINS may be more expensive than traditional implant placement methods, studies have suggested that DINS can lead to fewer surgical complications and a higher success rate, which may ultimately result in cost savings.[12] However, more research is needed to determine the long-term cost-effectiveness of DINS compared to other computer-assisted implant placement systems.

3.3. Challenges and limitations of DINS

While Dynamic Implant Navigation System (DINS) offers many potential benefits for implant placement procedures, there are also some challenges and limitations associated with the technology.

1. Learning curve: One of the primary challenges associated with DINS is the need for training and experience. The system requires a certain level of technical skill and knowledge to operate effectively, and there may be a learning curve for dentists who are new to the technology. A study conducted by Noh Y et al found that although DINS was associated with high accuracy in implant placement, it required more time and training than traditional implant placement methods.[13]
2. Hardware and software limitations: DINS relies on a combination of hardware and software, and both components may have limitations. For example, the accuracy of DINS may be affected by the quality of the intraoral scanner used to capture the patient's oral anatomy, and the software may not be able to accurately register images from different sources.[13] Additionally, the hardware may be affected by factors such as vibration or movement during the procedure.[14]
3. Patient factors: DINS may not be suitable for all patients. For example, patients with certain medical conditions or anatomical variations may not be able to use the system, and the system may not be able to accurately register the patient's anatomy in some cases. In addition, the use of DINS may require additional radiation exposure for patients, which can be a concern for some individuals.[15]
4. Cost: DINS may be more expensive than traditional implant placement methods, and the cost of the system may be a limitation for some dentists or patients. A study conducted by Kim Y et al found that while DINS was associated with higher accuracy and shorter surgical times than traditional implant placement methods, the cost of the system may limit its use in some clinical settings.

4. Future of Dynamic Implant Navigation System in Dentistry

Dynamic Implant Navigation System (DINS) is a rapidly evolving technology in implant dentistry, and its future looks promising Enhanced accuracy: One of the primary goals of DINS is to improve the accuracy of implant placement. Ongoing research is exploring ways to further enhance the accuracy of the technology, such as incorporating real-time monitoring and feedback systems, improving image registration algorithms, and refining the design of surgical templates. A study conducted by Lee C-Y et al found that the use of DINS in combination with custom surgical guides was associated with high levels of accuracy in implant placement.

Automation and artificial intelligence: DINS has the potential to be integrated with automation and artificial intelligence (AI) systems to further enhance the precision and efficiency of implant placement procedures. For example, AI algorithms could be used to optimize implant positioning and design custom surgical guides based on a patient's unique anatomy. The use of a semi-automated implant placement system, which incorporated DINS and AI, was associated with high accuracy and reduced surgical times.

Expanded applications: DINS may have applications beyond implant placement, such as in bone grafting and sinus lift procedures. Researchers are exploring ways to adapt the technology to these procedures, such as by developing specialized surgical guides or incorporating real-time imaging and monitoring systems. The use of DINS in combination with a computer-aided design/computer-aided manufacturing (CAD/CAM) system was effective in fabricating custom bone grafts for implant placement and was also found to produce high accuracy in the immediate placement of implants following extraction.[16–18]

Patient-specific treatment planning: DINS has the potential to revolutionize treatment planning by allowing for more personalized and precise implant placement. By incorporating patient-specific data, such as bone density and soft tissue thickness, into the treatment planning process, dentists may be able to optimize implant positioning and reduce the risk of complications.

5. Conclusion

DINS is a technology that has made strides in its development to enable dentists to work with great accuracy on the basis of pre-surgical 3D planning. Real-time position accuracy verification and validation have considerable promise for improving surgical accountability and transparency to improve patient outcomes.

6. Conflict of Interest

There are no conflicts of interest in this article.

7. Source of Funding

None.

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Author biography

Sankar Madhavan, Professor

Vineetha Venugopal Menon, Assistant Professor

Joseph Johny, Assistant Professor

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