Review Article

Dynamic Navigation – the Future of Implant Dentistry

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Abstract

This review will give us thorough understanding and knowledge regarding the utilization of dynamic navigation (DN) in implant dentistry. With DN, you can track the drill's position during the implant process, avoiding damage to surrounding critical anatomical tissue and avoiding surgical difficulties. DN enhances the precision of implant positioning, depth, and angle, while notably cutting down on procedure duration. It allows the clinicians to have better understanding about the mechanism and workflow of DN system and allow them to use this technology in implant dentistry.

Keywords: Digital dentistry, Dynamic navigation, Virtual implant placement.

Introduction

Dental implants are often employed as a substitute for missing teeth when compared to bridges and dentures. Long-term results are predictable, alveolar bone is stabilized, and shape and function are restored without causing harm to neighboring teeth with implants. Yet, implant placement presents a number of difficulties since it frequently necessitates planning and positioning the implant in bone, which is just adequate with very little margin for errors and room for correction to prevent cortical perforations and impingement on other vital anatomical structures. Accurate placement and angulation are also necessary to provide restorations that complement neighboring and opposing teeth both aesthetically and functionally.[1] The advancement of software for implant planning has significantly enhanced the positioning of implants in three dimensions, meeting the needs of both anatomy and prosthetics effectively. Guided surgery's allows clinicians to utilize anatomical information obtained from CBCT in the process of planning prosthetics, ensuring implant placement meets criteria for a reliable, aesthetically pleasing, and functional outcome, while also honoring anatomical structures.[2] In the year 2000, dynamic navigation (DN) was introduced to enhance precision in the field of dental implantology by furnishing the operator with a real-time navigation. DN utilizes pre-operative CBCT information to virtually strategize treatment before the procedure, and directs the placement of the bur in real-time throughout the operation.[3] The purpose of developing the dynamic guided navigation system was to facilitate the real-time visualization of anatomical structures like bones and teeth, as well as drill tips, during implant surgery. This system type enables the placement of implants in a pre-determined, prosthetic-focused position, resulting in increased success rates and reduced complications. As real-time feedback is available, any incorrect positioning or misalignment of the drill during osteotomy can be promptly adjusted. During the implant surgery, the relevant positional changes can be performed whenever necessary.[4] This review article describes the workflow of DN system used in implant dentistry.

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Generation of Dynamic Navigation

First generation

The workflow of first-generation is in the sequence, stent, scan, plan, and place. Stent will be used to guide the planned implant position. In scanning, CBCT will be carried out with the radiographic markers in place. Next, treatment planning will be carried out with help of the CBCT scan and implants will be placed with dynamic navigation system.

Second generation

The introduction of trace registration due to technological progress aims to remove the necessity for stents or fiducial

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markers, thus revitalizing the sequence as Trace and Place. This tracing method entails recognizing the intrinsic elements within the scan, like teeth, implants, abutments, bony ridges, and bone screws, as fiducials. After completing trace registration, implants can be positioned using dynamic navigation.

Third generation

In the third-generation, the optical sensor device will be moving in accordance with the handpiece direction, whereas in first- and second- generation, the optical sensor device is fixed.

Principle of DN

Dynamic systems, a type of computer-assisted surgery, employ optical tracking. There exist two categories of optical motion tracking systems: Active and passive.

Active tracking systems utilize arrays emitting infrared light, which stereo cameras track, whereas passive tracking systems utilize arrays of reflective spheres, reflecting emitted infrared light from a source back to a camera. Passive technology is currently the most widely used system.[5] To effectively employ a passive optical DN system during CBCT scanning, it is necessary to securely attach fiducial markers to the patient's dental arch. The arch can be aligned with the cameras by connecting an assortment of fiducial markers to the device. The array is fastened to the clip holding the fiducial markers and placed extra orally. In addition, the implant handpiece features an array that, when paired with the fiducial markers on the clip, enables triangulation, resulting in precise navigation (Figure 1).[6]

Components of DN System

DN consists of two devices, registration device and motion tracking device. Registration device consists of ball tipped stylus whereas motion tracking device consists of drill tag, optical sensor, calibrator, jaw trackers, head trackers in which jaw tracker, and head tracker will be placed on the patient.[7]

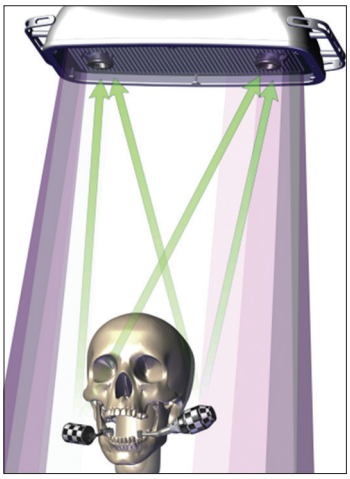
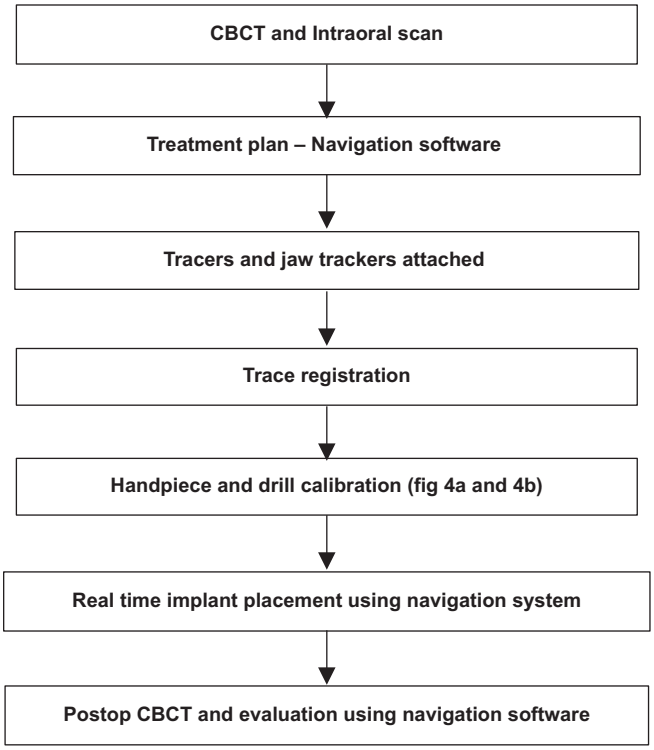


Figure 1: The drill and arrays attached to the patient must remain visible to the overhead stereo cameras for precise monitoring on the screen

Registration device helps to mark the location over the jaw surface which enables the optical tracing virtually. Drill tag, which is a motion tracking device, will be attached to implant handpiece and the calibrators help in activating the drills, handpiece, other devices which will be used in the DN system. Optical sensor is the main component of this system which emits infrared light and captures the position of patient as well as the surgical instrument, which can be virtually viewed on the projection screen (Figure 2). Then the jaw tracker and head tracker which are motion tracking device and this will be placed in the patient. Jaw tracker will be placed in the mandible where as head tracker will be placed in the maxilla (Figure 3a and b).

Workflow of Dynamic Navigation system (Figure 4)



Advantages

Treatment planning is made easier because CT scanning, planning, and surgery can all be completed in a single appointment. By preventing accidental iatrogenic harm to surrounding anatomical components such as nerves and sinuses, this dynamic guidance system can lead to a more predictable outcome as well as patient acceptance and pleasure.

There is good flexibility in usage, as the DN system works with any implant system, making it easier for the clinician to work with it. Since DN primarily depends on virtual guidance, it prevents the occurrence of guidance failures caused by broken or ill-fitting guides, presenting an extra benefit. The surgery can be viewed virtually through a large screen, and there is improved clinician ergonomics. Block *et al*. noted that the main advantage of DN is its increased precision with regard to implant angulation. Throughout the process, the planned path of treatment may be adjusted based on input from the

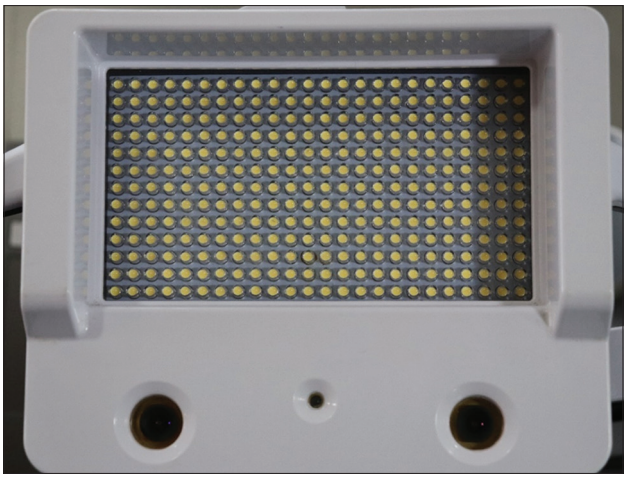


Figure 2: Optical sensor device

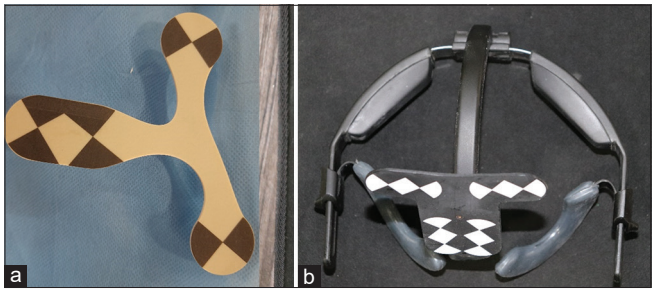


Figure 3: (a) Mandibular jaw tracker, (b) Maxillary head tracker

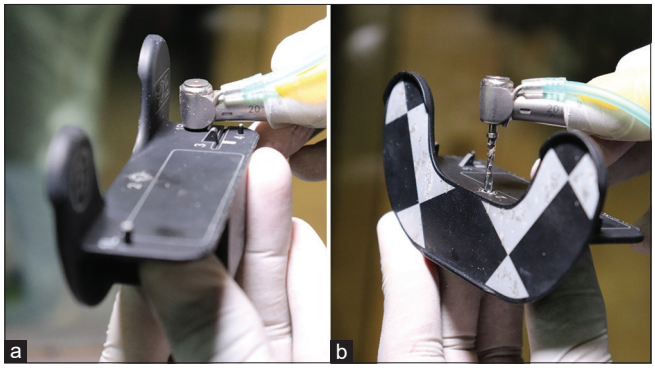


Figure 4: (a) Handpiece calibration and (b) Drill calibration

clinician, gathered via the navigation software, facilitating precise placement of implants with appropriate alignment.[8-10]

Disadvantages

A system malfunction that changes the spatial orientation of reference points might result in inaccuracies during the drilling and implant positioning procedure. To prevent an iatrogenic error for the patient, vigilance is required at every stage of the surgical procedure, and before working with patients, a training period is necessary for clinicians.[8] Surgeons who have little familiarity with technology and virtual image processing might struggle when shifting to a new practice method. In addition, adopting new technology presents a learning curve for individuals at every level of technological proficiency. Panchal *et al*. (2019) evaluated the learning curve for the DN system, and study results showed that the clinician became proficient in its use only after 10–20 implants with this technology.

Discussion

The term "DN" describes the process of placing implants using a surgical navigation system that can designate a virtual implant's location based on CT data. In addition, the system's motion tracking technology facilitates live monitoring of both the patient and implant drills throughout the procedure. If needed, adjustments can be made to the planned implant positioning and its dimensions, such as length, width, and shape, to accommodate the patient's intraoral condition more effectively. The evaluation of accessibility and precision in clinical settings is exceedingly important with the invention of this digital technology. Wu *et al*. (2020) assessed the precision of DN in contrast to a static surgical guide (SSG) for dental implant positioning. Their findings indicated that the variances between the DN and SSG cohorts did not reach statistical significance. In their 2023 study, Tao *et al*. conducted a comparison of the precision in dental implant positioning between DN and augmented reality-driven DN systems. Their study revealed that although the augmented reality-powered DN system showed comparable precision to the conventional DN system in positioning dental implants at both the coronal and apical levels, it displayed a greater angular deviation.[11] Precise positioning of implants is necessary to yield successful results in aesthetics, mastication, and longevity. Inaccurate implant placement may still be salvageable, but it will necessitate further prosthetic modification in the form of wider cement margins, slanted screws, unique abutments, longer chair times, and higher expenses for both the patient and the dentist.[12] Nirula *et al*. (2023) conducted study on feedback on dental implants with DN versus freehand and concluded that immediate post-operative pain perception and levels of comfort were better with DN. They also concluded that future of robotics in dentistry also had a huge welcome among patients as they were intrigued with the provision of visualizing the live surgery, understanding the procedure position of implants in their jaw.[13] Furthermore, clinical trials are needed to establish the accuracy of the DN system, compared to conventional free-hand and guided systems of implant placement.

Conclusion

The discipline of implant dentistry has undergone a revolution because of DN. DN improves safety, accuracy, and precision during surgery by offering real-time guidance. It enables dental professionals to design the ideal implant place, navigate intricate anatomical structures, and avert possible problems. Furthermore, patient-specific surgical guides that maximize implant alignment and reduce the need for intraoperative corrections can be created through the combination of DN and computer-aided design and manufacturing technology. With the further development of DN and its integration with cutting-edge technologies like augmented reality and artificial

intelligence, dental implant placement could advance even further, improving patient outcomes and predictability.

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