Diving Deep into the Concepts of Dynamic Navigation System in Implant Dentistry: A Review

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Abstract:- The concept of implant placement in accordance with pre-surgical planning with a prosthetic focus with the aid of 3D planning software has been referred to as navigation surgery. [2] Dynamic and static navigation were both introduced with the emergence of navigation surgery in dental implantology. Throughout the entire treatment, real-time tracking of the drilling of the bone and implant insertion is possible, thanks to dynamic navigation using a three-dimensional (3D) software. Static navigation, on the other hand, involves sequential drilling of bone and implant placement using static surgical templates.[8] With incredible precision, both strategies aim to transfer pre-surgical design planning to the patient's mouth, which will in turn provide predictable treatment with outstanding functional and aesthetically pleasing outcomes. The application of dynamic navigation in clinical practice has grown recently as a result of the advancement of computer technology and the associated computer-aided approaches.[2]

Keywords:- *Dynamic Navigation, Static Navigation, Real-Time Tracking, Implants, Trace Registration.*

I. INTRODUCTION

For individuals with partial or complete edentulousness, dental implants are considered to be the gold standard treatment modality. There has been a growing demand for more precise prosthetic-driven implant placement for the best aesthetic and functional restoration.[1] From an aesthetic and functional aspect, proper implant placement in three dimensions (3D) with the appropriate angulation, depth, position of the platform and the apical implant is crucial. Additionally, this assures the preservation of the nearby anatomical structures, enables proper prosthetic rehabilitation, enables the attainment of good aesthetics outcomes, and adds to the success of implant and rehabilitation over the long term. A crucial indicator of successful implantation is the accuracy of implant placement.[2]

Surgery complications like hemorrhage, sinusitis, and nerve damage are prevented by attaining the appropriate three-dimensional (3D) position of the implant. Additionally, it prevents aesthetic outcomes, such as the necessity for hard and soft tissue grafting procedures, proper prosthesis contours, symmetry, allowing proper access for hygiene, determining the type of restoration (whether cement or screw-retained), and long-term stability of the soft and hard tissues, as well as the long-term success of implant therapy.[2]

Navigation surgery as well as other terms like computer-aided surgery, computer-assisted surgery, and image-guided surgery have been used to explain this concept. With the aid of specialized 3D implant planning software and preoperative cone-beam computed tomography (CBCT), proper implant placement can be easily achieved. Therefore, navigation implant surgery has been designed to ensure that patients who undergo surgery experience less deviations from the virtually anticipated implant position. Two strategies- dynamic navigation and static navigation were introduced with the development of navigation surgery in the field of dental implantology.[2]

In order to enhance the accuracy of implant insertion, Dynamic Navigation (DN) makes use of three-dimensional exploration software along with bone drilling and implant insertion, giving surgeons a real-time navigation tool on a screen similar to a GPS. Static navigation surgery involves the use of stereolithographic surgical templates with metal tubes, that are supported by teeth, bone, or mucosa, while drilling and implant insertion is being done (fully guide templates).[2]The application of dynamic navigation in clinical practice has grown recently as a result of the advancement of computer technology and the associated computer-aided techniques.[3]

II. NAVIGATION SURGERY

It has been demonstrated that prosthetically driven planning is effective for attaining functional and aesthetic rehabilitation in an ideal and predictable manner.[3] Both dynamic and static navigation utilize a software for 3D planning of surgery using a rehabilitative prosthetic approach, and both entail the same phases of implant planning in CBCT data.[2]

DN makes use of a navigation system to display on a monitor with its software the position of surgical instruments as they are tracked in real time on the CBCT. This technique is different from the static approach since it displays continuous, real-time feedback of the surgery on a monitor without the use of a surgical template. Using this virtual reality device, the surgeon can operate on the patient dynamically, carry out the planned implant procedure, and alter his or her plan at any time in response to the clinical circumstances.[2] With static approaches, this is impossible. Since there is limited access to cooling liquids when using closed drilling templates, this might potentially result in overheating of the bone.[3]

On patients with limited mouth opening or who need simultaneous graft placement, surgical templates are not advised.[2] In comparison to implants placed using templates supported by the teeth, those placed utilising mucosa-supported templates exhibit larger variations from the intended implant position.[3] DN has proved to be successful when employed for zygomatic implant osteotomy despite the fact that surgical templates are not practicable for long drills and that there is currently no effective mechanism for placement of zygomatic implants using surgical guides.[2]

III. DYNAMIC NAVIGATION SYSTEM

The Robodent system, which made history in the field of dynamic surgery in 2002, was the first dynamic navigation system.[4] However, it did not become widely known. Other dynamic navigation systems for dental implants include the Navident dynamic navigation system by Claronav company (Toronto, Canada, 2015), which originated from dynamic procedures in medicine.Another technology that works by the principle of stereoscopic triangulation, utilizing optical video cameras is X-Guide (Nobel Biocare, 2017).The Inliant (Navigate surgical), Image Guided Implant (IGI), and YOMI (Neocis) are few other 3D dynamic navigation tools.[5]

The most important factor in the field of implant navigation surgery is the precision with which the presurgical plan of the implant position is transmitted to the patient's mouth. It has been reported that DN is comparable to the static fully guide and has a higher accuracy than free-hand techniques.[2]

➢ *Applications of Dynamic Navigation*

Dynamic navigation system was first employed in the field of medicine during craniomaxillofacial surgeries to identify foreign bodies in the head and neck and perform pathological reconstruction. Ophthalmology, vascular surgery, and neurology are other specialties that make use of dynamic navigation system.[6]

➢ *Components That are Essential in Dynamic Navigation System*[6]

- Handpiece with engraved markers
- Fudicial marker
- Sensors/tracking arrays
- Software for implant planning and surgical guidance

➢ *Mechanism of Dynamic Navigation*

Tracking is a technique used in Dynamic Navigation Surgery to dynamically follow the motion of an instrument in space, determine its location in respect to the patient, and display that image on a screen.[2]

Optical tracking technology forms the basis of dynamic navigation mechanism.Both active and passive navigation systems are available.

- A system for active tracking employs arrays that produce infrared light that is tracked by stereo cameras.
- Passive tracking system arrays make use of reflective spheres to reflect back infrared light from a light source to a camera. The patient and drill should be over the line of sight of the tracking camera[7]

The most extensively employed system is passive tracking technology.

Both the patient and the surgical instruments employed have the tracking system attached. The tracking arrays reflect the infrared light that is above the patient, which is subsequently captured by the stereo cameras that are placed above the patient. The position of the patient and the surgical instrument is thus captured by the dynamic navigation. The surgeon carries out the procedure while viewing the dynamically captured real-time image that is displayed on the screen.[7]

➢ *Steps Involved in Dynamic Navigation*[6]

- The initial stage of the procedure involves fabricating a stent with a fudicial marker attached to it. The stent is constructed chairside by softening a thermoplastic material in hot water bath at 140–160°F for 3 minutes, which is then shaped to properly adaptover the teeth with a snap fit. To gain access to the implant site, the stent is then trimmed. Fiducial marker is attached to the stent once they have been constructed and the stent can be worn while a CBCT scan is performed.
- Fudicial marker for edentulous situations needs stabilising the fiducial using screws that are 4 or 5 mm long and 1.5 mm in diameter.
- The stent with the c incorporated can then be used, while a CBCT scan is performed.
- Intraoral scan and CBCT is usually employed to plan the prosthetically- driven placement of implant as well as to design the abutment and crown.
- Both the jaw tag and the drill tag are fastened to the stent and the handpiece, respectively. The light source is captured by the drill tag and the jaw tag, which further reflect it back to the sensors for the real - time tracking. The stent with the jaw tag attached to it is then adaptated over the teeth. As the screen is set up for the surgery to start, the drill axis and drill tip are calibrated.
- As soon as the operator starts drilling, a virtual drill pops up on the screen, progressing in 3D as it goes. The flapless method is used. Real-time evaluations are made of the consolidated and intended position. Following tip calibration, consecutive sizes of the drill are changed in the site of preparation.[6]

On completion of the drilling, the tip of the implant to be placed is also calibrated, before inserting it into the prepared site. A brief description of the colour sequence is displayed on the monitor during surgery.

The depth indicator switches colour from green to yellow, when the drill is 0.5mm from the intended site and turns red, when the osteotomy has to be stopped. Both the depth of the osteotomy site in millimetres and the degree to which the drill bit axis deviates from the intended implant axis are displayed on the navigation screen.

Maintaining the suction is the responsibility of the surgical assistant, who must also alert the surgeon to any significant deviations from plan during implant insertion or when irrigation is not present.[6]

The standard DN procedure requires the use of fiducials (rigid objects with known shape). At the time of the CBCT and the surgery, these must be retained in the mouth without moving; otherwise, irreversible calibration mistakes could happen, producing inaccurate results and jeopardising the pre-surgical plan. In addition to the potential for spatial interference with the surgical site, another drawback of using fiducial with stents is the requirement for an additional CBCT, which increases patient exposure to radiation. A recent innovation called Trace Registration (TR) sought to address the aforementioned shortcomings.[9]

IV. TRACE REGISTRATION WORKFLOW

TR utilizes fiducials for edentulous (screws) or in its absence, preferentially for structures like teeth, abutments, and restorations that are typically apparent in the CBCT, as opposed to employing fiducials with stents. The structures that will serve as a reference for DNS calibration must be detected by the DNS prior to surgical procedure using a "surface contact scan"known as Tracer. Tracer is usually employed to trace between three and six short paths over areas within the arch, and the data collected by the Tracer ball-tips is then aligned with the CBCT data using the DN software.[9]

Three steps make up the TR protocol:

- Plan: CBCT data as well as 3D implant software have been employed to plan the prosthetically directed implant surgical procedure.
- Trace Registration: Based on tracing structures detected and marked on the CBCT. On positioning the tracer’s balls tip on the patient structures for trace registration, as well as by comparing the actual position of the tracer tip with the markings shown on the DN monitor, the surgeon is able to verify the accuracy of the registration clinically.
- Place: Implant placement is navigated in accordance with the treatment plan. The depth, angulation, site of entry for the drills, and implant insertion are all shown in real time.
- Trace Registration is found to be as efficient as conventional registration techniques employed in DN surgery that involves the use of fiduciary marker and thermoplastic stent.[9]

➢ *Merits of Dynamic Navigation*

- Without the delay or expense of constructing a static surgical guide stent, implant specialists can assess a patient, scan the patient, plan the implant placement, and complete the implant surgery all on the same day.
- When clinical circumstances demand a modification, this technology also enables the implant surgeon to alter the implant's size, system, and location parameters during surgery.
- Significantly reduces the chances of trauma to the patient by giving surgeons the assurance that an implant is properly placed in bone without the need to open a flap.
- It also enables the surgeon to evaluate the precision of the procedure at every stage.
- overcomes the inherent limitations of human eyesight.
- by eliminating the necessity to bend the neck or back during the procedure, it offers outstanding ergonomics.
- permits the surgeon to carry out the osteotomy and position the implant with restricted direct vision in the mouth in patients with restricted mouth opening or in situations involving posterior implant placement with challenging visualization.
- Additionally, it enables the placement of implant in interdental spaces suchas those in the region of mandibular incisors, where guidance tubes with static guides cannot be used.[7]

➢ *Demerits of Dynamic Navigation*

- It is necessary to invest in the equipment.
- It is expensive.
- The technique has a learning curve attached to it.
- For edentulous patients, further surgery was necessary for the attachment of tracking plates and fiducial screws.[6]

➢ *Dynamic Navigation Versus Static Guided Surgery Approach*

The drawbacks of a static surgical guide include insufficient irrigation during drilling, limited vision, and the difficulty in modifying the surgical protocol unless the stent is removed. Dynamic navigation, on the other hand, circumvented these restrictions by offering precision and the flexibility to make adjustments during the operation.[6]

V. CONCLUSION

For implants to be successful over the long term, they must be positioned properly. Clinicians strive to achieve perfection in implant placement, and one of the most significant aspects that was improved while employing dynamic navigation was the angular deviation of the implant placement. We can accurately locate the implant and boost the implant prosthesis' success rate by using cutting-edge tools like dynamic navigation.[6] Trace Registration technology offers a fully digital workflow, eliminates the tedious and technique-sensitive process of fabricating a custom stent prior to surgery, eliminates the necessity for a second CBCT scan with fiducial markers, and enhances the accessibility to the area of interest since surgery is not carried out with a thermoplastic stent in place. This technique makes DN more effective and widely usable.[2]

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