DYNAMIC NAVIGATION IN DENTAL IMPLANTS - THE NOVEL DIGITAL APPROACH IN IMPLANT DENTISTRY- A REVIEW

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ABSTRACT

Technological advancements in the field of implant dentistry have reached heights and dynamic navigation is a novel digital method with real time tracking using computer guided navigation for the placement of implants. The method uses sensors and tracking arrays in either active or passive mode for capturing real time imaging and carrying out the surgery based on the preplanned position of the implant. Although there are a few limitations in the system it has revolutionized the field of implant dentistry with its precise and accurate positioning of implant and contributing to the overall success of the treatment.

Keywords:Guided surgery, digital implant dentistry, real time navigation, implantology, implant advancements

INTRODUCTION

Replacement of teeth with implants have become one of the most sought-after treatment and with technological advancements the efficiency and accuracy of the treatment has grown rapidly. Optimal implant positioning plays a vital role in the overall success of the prosthesis with consideration to the mesiodistal, apicocoronal and buccolingual positioning and placement. Today, implants may be placed by either the free-handed approach, by using guided surgical technical such as the static surgical stents and recently technological advancement have provided with dynamic navigation in surgical implant placement. Dynamic navigation is a guided surgery technique which utilizes real time tracking technology for the accurate placement of implants based on CBCT data generated from the patients.[1]

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APPLICATIONS OF DYNAMIC NAVIGATION

Dynamic navigation was first introduced in the medical field for craniomaxillofacial- based procedures for the purpose of locating foreign bodies within the head and neck and for pathological reconstruction procedure. Other fields which utilise dynamic navigation include ophthalmology, vascular surgery and neurology[9] .

DYNAMIC NAVIGATION SYSTEM

The first dynamic navigation tool was the Robodent system which created history in the field of dynamic surgery in 2002[7]. However it was not popularised. The other dynamic navigation systems introduced for dental implants were the Navident dynamic navigation system (Toronto, Canada, 2015) by the Claronav company which evolved from the medical dynamic surgeries. X-Guide (Nobel Biocare, 2017) is another system that functions by stereoscopic triangulation using optical video cameras. Other 3D dynamic navigation systems are the Inliant(Navigate surgical),Image Guided Implant(IGI) and YOMI(Neocis)[9].

COMPONENTS REQUIRED FOR DYNAMIC NAVIGATION

1. Handpiece with engraved markers
2. Fudicial marker
3. Sensors/tracking arrays
4. Software for implant planning and guidance during surgery

MECHANISM OF DYNAMIC NAVIGATION

Dynamic navigation mechanism is based on optical tracking technology.

The navigation system may be Active or passive. [1]

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

The passive tracking technology is the most commonly used system.

The tracking system is attached to the patient and to the surgical equipment used. The infrared light is positioned above the patient and this light is reflected by the tracking arrays which is then captured by the stereo cameras which are positioned above the patient. By this the dynamic navigation captures the position of the patient and the surgical instrument . The dynamically captured real time image is then projected onto the screen and the operator carries out the

surgery by visualizing the screen. (Figure 1)

STEPS IN DYNAMIC NAVIGATION

1. Fabrication of stent with fudicial marker

The first step is the stent fabrication for attachment of the fiducial marker. The stent is fabricated chairside using a thermoplastic material by placing it in a hot water bath at 140-160 °F for 3 minutes and softened. The material is then moulded over the teeth and stent is fabricated and ensured a close adaptation over the teeth with a snap fit. The stent is then trimmed for access to the implant site.

After the stent is formed the fiducial marker is attached to the stent. The stent with the fiducial is now fitted for CBCT scan.

Fudicial marker for edentulous conditions

Attachment of the fiducial marker in edentulous conditions requires stabilization of the fiducial by using screws of 4mm or 5mm in length with a diameter of 1.5mm.

2. CBCT scan

The CBCT scan is now performed with the stent and fiducial marker in the patient's mouth.

3. Treatment planning

Prosthetically driven positioning of implant is planned by using the intraoral scan and CBCT.

The implant position is determined and the abutment and crown can also be designed.

4. Drill tip calibration

The drill tag is attached to the handpiece and jaw tag is attached to the stent. The drill tag and the jaw tag are the ones responsible for receiving the light source and reflecting it back to the sensors for the live tracking.The stent with the jaw tag is then fitted over the teeth.

The drill axis and the drill tip are calibrated and the screen is placed in position to begin the surgery.

5. Real time tracking and implant placement

The virtual drill appears on the screen as the operator begins the drilling and the progression of the drill is visible in 3D. A flapless approach is followed. The consolidated and planned position is assessed in real time. Consecutive drill sizes are changed in the preparation site after calibration of the tip.

After the drilling is completed the implant tip is also calibrated and is placed in the implant site.

Description of colour sequence on screen during surgery

During the drilling process when the drill is 0.5mm away from the targeted site, the colour of the depth indicator changes from green to yellow. When the colour changes form yellow to red it denotes the need to stop the osteotomy.

The navigation screen also demonstrates the depth of the osteotomy site in tenths of a millimeter, deviation of the drill bit axis in degrees from the planned implant axis.

The role of the assistant during the surgery is to maintain the suction and to notify the surgeon regarding any gross deviation during the implant placement or when there is a lack of irrigation.

ADVANTAGES OF DYNAMIC NAVIGATION[1,3]

- Surgery is performed on the same day of treatment planning as there is no need for guide fabrication which is time consuming
- The operator can change the size and system during the surgery
- Due to the short surgical instrumentation the system can be used in patients with limited opening especially in the second molar region
- Minimal trauma to the surgical site as it involves a less invasive approach
- Accuracy is verified in real time
- Overcomes inherent inaccuracies of human vision
- Provides good ergonomics by eliminating the need to bend the neck or back while placing the implant.

DISADVANTAGES OF DYNAMIC NAVIGATION [1,3]

- Investment of the equipment is required
- Cost is high
- There is a learning curve associated with the procedure
- In edentulous patients, additional surgery required for the placement of fiducial marker and tracking arrays.

Dynamic navigation over the static guided surgery approach[5,8]

Static surgical guide has certain limitations such as inadequate irrigation during the drilling procedure, poor visualization and inability to modify the surgical protocol unless the stent is abandoned. However dynamic navigation overcame these limitations by providing accuracy and ability to make changes during the surgery.

Efficacy of Dynamic navigation

Studies done by MS Block [2,6] had compared the depth and the angular deviation with three different surgical techniques- the free hand approach, the static surgical guides and the dynamic navigation method. Results had shown that the apical depth deviation was about 0.97% for the freehand approach, 0.81% for the dynamic navigation and 1.01% for the static surgical guides from the preplanned depth. The mean angular deviation was about 6.39 % for free hand , 2.94 % for dynamic navigation, and 3.98% for the static surgical guide from the predetermined angulation. The study concluded the greater accuracy of the dynamic navigation system when compared to that of the free hand approach and the use of static surgical guides.

Also, the surgeon's efficiency in navigation was a critical factor in the accuracy. On studies conducted by Golob Deeb et al and Stefanellie et al it was found that the angular deviation gradually and surgical time gradually decreased after repeated placement with dynamic navigation, concluding that there was a learning curve associated with the procedure.[4]

CONCLUSION

An optimal positioning of the implant is required for the long-term success of implants. Clinicians aim to perfect the placement of implants and one of the most important factors improved during using the dynamic navigation was the angular deviation of the implant positioning. With novel equipments like the dynamic navigation we can provide accurate positioning of the implant and increase the success rate of the implant prosthesis.

Conflict of interest: There are no conflicts of interest.

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Legends for figures:

Figure 1 : Mechanism of dynamic navigation

FIGURE 1 :