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Review Article

Dynamic Navigation in Oral Implantology-A Review

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Abstract

Dental implants have gained popularity over the last decade, as the most accepted treatment for the replacement of missing teeth, in almost all age groups. Conventional implantology has been practiced by clinicians with a high success rate, provided other clinical parameters are maintained at a certain level. However, conventional, or static guided approaches is by large an arbitrary approach that comes with its own drawbacks. These techniques depend heavily on the clinician's experience. Hence, the development of the dynamic navigation systems for placing dental implants is becoming increasingly popular. These systems have an advantage of a real-time three-dimensional view of the placement and accuracy in the post-treatment outcomes as well.

Keywords: Dental Implants; Dynamic Navigation; Static Guided Approach; Conventional Approach; 3d Implantology

Introduction

A dental implant is a fixture that replaces missing or unrestorable teeth. A permanent or removable dental prosthesis is retained and supported by a structure made of alloplastic materials that is implanted into the oral tissues beneath the mucosa, periosteum, or into or through the bone. This treatment modality is one of the most sought-after options, thanks to its long-term reliability and decreased risk of damage to adjacent teeth. Implantologists have several options when it comes to implant planning and placement. Dental implant treatment planning and placement has benefited immensely from accelerating technological capability in office-based imaging and complex simulation and planning software. Static implant guides have been created using a combination of software and imagery to provide predicted precision in implant placement. Dynamic navigation technology has taken the process one step further by giving surgeons a real-time navigation tool to increase the accuracy of implant placement.

History of oral implantology

Implant dentistry the second oldest dental profession; exodontia (oral surgery) is the oldest [1].

Around 600 AD	Pieces of shells used as implants to replace mandibular teeth by Mayan population
1809	A gold implant tube inserted into a fresh extraction site by J. Maggiolo
1930	Strock brothers used Vitallium screws to replace missing teeth
1940s	Formiggini and Zepponi developed post-type of endosseous implants
1940s	Dahl developed subperiosteal implant in Sweden
1946	Strock designed a two-stage screw implant that was inserted without a permucosal post. The abutment post and individual crown were added after this implant completely healed. The desired implant interface at this time was described as ankylosis
1967	Dr. Linkow introduced blade implants, now recognized as endosseous implants
1980s	Per-Ingvar Branemark (the father of modern implantology) developed the first titanium implants to be approved by the FDA for replacement of teeth. He also played a role in the evolution of the concept of osseointegration [2].

Table a

Anatomical and physiological considerations

Prior to implant placement, it is essential to have a thorough understanding of anatomical landmarks and their changes in order to achieve a precise surgical process and protect the patient from iatrogenic consequences. To choose the right implant and plan the best implant position for the current clinical situation, it is crucial to carefully evaluate various anatomical factors, including the position of the mandibular canal, the maxillary sinus, the width of the cortical plates, and the existing bone density. Nasal floor, nasopalatine canal, and maxillary sinus are significant anatomical features of the maxilla. A frequent consequence is iatrogenic sinus perforation. By choosing short implants and doing a sinus lift and bone augmentation treatment, this issue can be resolved.

The position of the inferior alveolar canal, which houses the inferior alveolar nerve and artery, is the most crucial anatomical factor to take into account when placing an implant in the mandibular arch. During implant insertion, damage to these crucial tissues may result in discomfort, altered sensation, excessive bleeding, etc. Therefore, it is crucial to establish the mandibular canal's position and configuration before implant insertion.

Drawbacks of the conventional free-handed approach

Currently, a majority of dental implants are placed freehand, without any form of computer 3-D planning. Only adjacent and opposing teeth are used by the surgeon while creating an osteotomy, and the implant is then placed arbitrarily. When placing multiple implants to restore multiple missing adjacent teeth, a calliper or periodontal probe often is used to ensure appropriate spacing of the implants in a mesiodistal dimension. Intraoperative radiographs may or may not be taken to evaluate the osteotomy and implant position. The most important factor, however, is the clinical emergence of the implant in a restorable position. Position and angulation can be estimated with the use of direction indicators, but the final position must be evaluated at the time of placement by the surgeon. Many of the complications associated with the placement of dental implants can be related directly to inaccurate positioning [3]. These include the following:

Damage to the inferior alveolar nerve

- Floor of mouth hematoma
- Damage to adjacent roots
- Sinus infections from unintentional sinus perforations
- Fractured implants due to off-axis loading
- Periimplantitis due to food impaction and off-axis loading
- Poor aesthetics secondary to thin buccal, labial bone, and soft tissue
- Interproximal bone loss secondary to placing implants to close to adjacent teeth and implants.
- Increased prosthetic complexity and cost.

Implantologists are now using more sophisticated techniques for implant planning and placement since freehand methods make it difficult to visualise the appropriate position and angulation during surgery and are unpredictable.

Static guided approach

A variety of surgical guides can be utilised to help with position and angulation. A stone cast-based static surgical guide is the most basic kind. Cast-based surgical implant guidelines help to ensure that the implant is positioned in a restorable manner but do not consider the shape of the bone. The use of computer-aided design and computer-aided manufacturing surgical templates based on digital planning of implant position, taking into account both the restoration and the bony anatomy, on specialised planning software is a further development with computer-guided implant surgery, also known as guided surgery or static navigation. (4) A number of characteristics have been identified that affect the precision of implants placed using guided surgery. Precision of cone beam computed tomography (CBCT), model matching to CBCT file, accuracy of guide manufacturing, tolerance of guide sleeve, tissue support of the guide, accuracy of guide seating, patient maximum opening, completely or semi-guided procedure, and operator expertise have all been mentioned. Even for skilled surgeons, guided implant insertion exhibits less variation and more predictability than freehand implantation [5].

Drawbacks of static guided approach

There are a number of clinical situations in which a static guided procedure may be difficult or impossible, such as [6]

- A patient with a small maximum opening that prevents the use of the guide and longer implant drills or
- A patient with a short interdental distance that prevents the fitting of guide tubes.
- Despite the fact that static guided surgery is often quite accurate at placing implants, there is a chance that severe positional deviations could happen because of CBCT discrepancies and/or improper guide placement.
- In order to reduce heat generation in the bone during implant insertion, surgical handpieces with internal or external irrigation as a cooling are used. The surgical template (bone supported guide) acts as a physical barrier between the drills and the external irrigation supply. The mucosa also is a barrier if the surgery is flapless (soft tissue supported guide) as in many fully guided surgeries.
- Advanced regenerative and reconstructive procedures cannot be performed without flap reflection.

Development of the dynamic navigation system

Numerous medical specialities, such as ophthalmology, otolaryngology, orthopaedics, vascular surgery, neurosurgery, and surgical oncology, utilise dynamic navigation. These professions regularly employ DN to carry out straightforward and intricate processes with greater accuracy and precision. In the past, oral and maxillofacial surgeons in hospitals have been the main users of DN in the field of dentistry [7]. The medical DN systems employed were mostly created for craniomaxillofacial-based treatments, such as identifying foreign bodies inside the head and neck and orthognathic, trauma, pathology, and reconstructive procedures.

The Dynamic Navigation systems, which use optical tracking, are a type of robotic or computer-assisted surgery (CAS) equipment that is currently offered in the United States and several regions of Europe. Both active and passive optical motion tracking systems are available. Passive tracking system arrays use reflective spheres to reflect infrared light emitted from a light source back to a camera, whereas active tracking system arrays emit infrared light that is tracked to stereo cameras. The patient and drill need to be out of the tracking camera's field of sight. Passive DN technology is currently the most widely used DN technology. It also enables the data to be transferred to a third-party software or dental laboratory. A light emitting diode (LED) light source shines light over the patient. The surgery field and patient are both illuminated from above. Tracking arrays, which are passive patterned arrays affixed to the patient and the surgical tool being tracked, reflect the light. Two stereo cameras mounted above the patient record the reflected light. The position of the patient and the instruments in relation to the presurgical plan is then calculated by the DN system. This is carried out dynamically or in real-time. The surgeon and crew are then shown a virtual image on a display. The surgeon can perform the intended implant procedure while working dynamically on the patient thanks to this virtual reality technology. Depending on the clinical situation, the surgeon may alter the plan at any time [8].

Workflow of dynamic navigation [9]

During CBCT scanning, a passive optical dynamic navigation system needs to use fiducial markers that are firmly fastened to the patient's arch.

↓

With the addition of an array, the device containing the fiducial markers enables the registration of the arch to the cameras.

↓

The clip with the fiducial markers is joined to the array, extraorally. Using the array on the implant handpiece and the fiducial markers on the clip, triangulation and consequently accurate navigation are made possible.

↓

To precisely follow the drill and patient-mounted arrays on the monitor, they must be in the line of sight of the overhead stereo cameras.

↓

If required, a small flap could be made to expose the crestal bone.

↓

The standard drilling procedure for implant sites is followed.

↓

With little direct view of the drill in the patient's mouth, the surgeon uses the navigation screen to steer the drilling.

↓

The fiducial markers must first be fastened to the arch in order to begin the dynamic navigation process. On the patient's teeth, a clip with three metallic fiducial markers is affixed in a location that will not require surgery.

↓

Radiopaque teeth can be utilised in the mouth as an imaging guide, enabling subsequent virtual implant positioning.

↓

The clip should be worn during the CBCT scan. The clip can then be removed and stored for use during the surgery.

↓

The computer of the navigation system is configured with the DICOM data set. Then, a simulated implant is inserted. The platform diameter, apical diameter, and length in increments of 0.1 mm are used to produce the implants generically.

↓

The orientation of the implant is adjustable. The array is connected to the clip with the fiducial markers during surgery.

↓

The drill lengths ought to have been recorded throughout the planning stage. After that, the surgeon arranges the patient so that the above cameras are in clear view.

↓

The drills should be positioned to match the depth of the three-dimensional graphics displayed on the screen.

↓

Depending on the desire of the clinician, the implant can be totally or partially guided by hand placement.

Any of the following situations calls for dynamic navigation

- Placement of implants in patients with a limited mouth opening.
- Placement of the implant on the same day of the CBCT scan.
- Placement of implants in difficult-to-access locations such as the second molar.
- Placement of implants when direct visualization will be difficult.
- Placement of implants in tight interdental spaces when static guides cannot be used owing to tube size.
- Placement of implants adjacent to natural teeth in situations in which static guide tubes will interfere with ideal implant placement.

Figure a: Handpiece Tracker.

Figure b: Fiducial Marker Tray.

Figure c: Impression Tag.

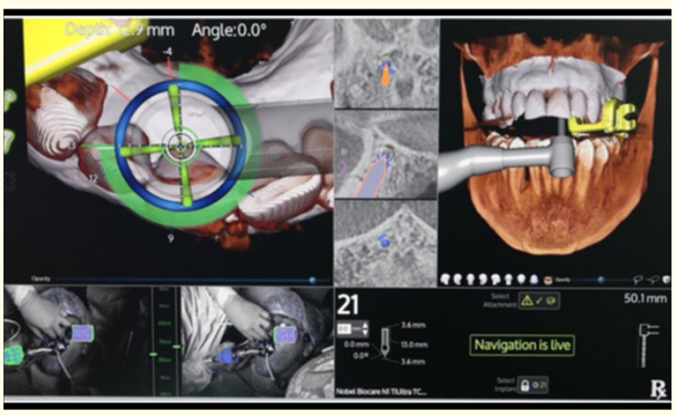

Figure d: Implant placement with dynamic navigation system [10].

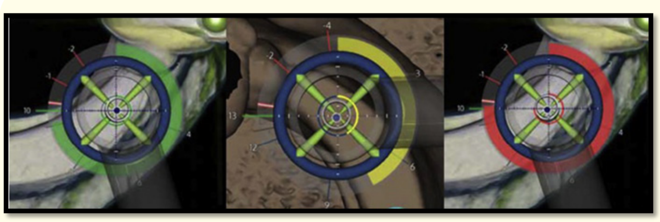

Figure e

When the drill is 0.5 mm from the desired depth during implant drilling, the depth indicator's colour changes from green to yellow. When to stop increasing the osteotomy depth is indicated when the yellow turns red [11].

Future perspective

Digital technologies have been actively integrating into many facets of human existence in recent years, offering a high level of efficiency and ease. The foundation of conventional planning is the idea of sequential, step-by-step planning. Its fundamental flaw is the inability to immediately prepare and present to the patient the end result of a multi-stage treatment. Prior to each new step of the therapy, planning is carried out sequentially, and the initial data for it are the outcomes of the preceding stage.

At the same time, each new stage is planned by multiple professionals rather than just one, and their interpretations of the outcome may vary. Such planning presumes that these experts share a common understanding of the target outcome and the best way to get there. Teamwork is essential to this idea. A recent 4D modelling idea is based on one-step (simultaneous) final planning as opposed to step-by-step planning. Its peculiarity is that all the clinical 3D modelling functionality (mandible positioning/moving dento-alveolar fragments, teeth alignment, artificial tooth placement, and implant planning) are integrated into a single unit and function in such a way that the planning of various interrelated treatment stages be performed prior to the treatment, and have the option to correct any stage. Since the suggested computer planning paradigm operates not only in 3D virtual space but also in virtual time, it can be referred to as 4D planning [12].

Similarly, 4D scanners or cameras can also prove to be extremely beneficial for full arch implant impressions, that are not only accurate but can also be performed within a few seconds. One such example is the iCam4D system, which is a hand held "camera unit" consisting of four cameras and one projector. It combines photogrammetric and structured Light scanning techniques to capture 3D data.

However, these technologies are expensive and require a lot of knowledge about the working of these systems.

Conclusion

Regardless of stomatognathic system atrophy, sickness, or injury, the aim of modern dentistry is to return the patient to normal profile, function, comfort, aesthetics, speech, and health. On average, people are living longer. This fact ensures the future of implant dentistry for multiple generations of dentists. Single tooth replacement with dental implants is becoming more common. An improved knowledge of the intricate nature of implant surgery and prosthetics has resulted from the natural transition from analogue 2-D imaging and diagnostics to digital 3-D imaging and diagnostics. The surgical team can now more clearly understand the limitations of freehand surgery because of the expanding use of these digital 3-D diagnostic and therapeutic techniques. The surgeon can efficiently carry out digital implant treatment plans thanks to DN. High-level statistical evidence amply demonstrates how Computer Aided Surgery outperforms freehand surgery in terms of accuracy and precision.

Bibliography

1. Block MS. "Dental Implants: The Last 100 Years". *Journal of Oral and Maxillofacial Surgery* 76.1 (2018): 11-26.
2. Buser D., *et al*. "Modern implant dentistry based on osseointegration: 50 years of progress, current trends and open questions". *Periodontology 2000* 73.1 (2017): 7-21.
3. Nevins M. "Implant dentistry: a continuing evolution". *International Journal of Periodontics and Restorative Dentistry* 34.3 (2014): s7.
4. Mezger U., *et al*. "Navigation in surgery". *Langenbeck's Archives of Surgery* 398 (2013): 501-514.
5. Clarke JV., *et al*. "Measuring the positional accuracy of computer assisted surgical tracking systems". *Computer-Assisted Surgery* 15.1-3 (2010): 13-18.
6. Gerbino G., *et al*. "Management of needle breakage using intraoperative navigation following inferior alveolar nerve block". *Journal of Oral and Maxillofacial Surgery* 71 (2013): 1819.
7. Bobek SL. "Applications of navigation for orthognathic surgery". *Oral and Maxillofacial Surgery Clinics of North America* 26 (2014): 587.
8. O'Mahony A and Spencer P. "Osseointegrated implant failures". *Journal of the Irish Dental Association* 45.2 (1999): 44-51.
9. Esposito M., *et al*. "Biological factors contributing to failures of osseointegrated oral implants. (II). Etiopathogenesis". *European Journal of Oral Sciences* 106.3 (1998): 721-764.
10. Battista E., *et al*. "Dynamic Navigation System for Immediate Implant Placement in the Maxillary Aesthetic Region". *Applied Sciences* 12.11 (2022): 5510.
11. Panchal N., *et al*. "Dynamic navigation for dental implant surgery". *Oral and Maxillofacial Surgery Clinics* 31.4 (2019): 539-547.
12. Ryakhovsky Alexander and Ryakhovsky SA. "A New Concept of 4D Virtual Planning in Dentistry". *Advances in Dentistry and Oral Health* 12.3 (2020): 555832.