



Computer Guided Implantology: For Optimal Implant Planning

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Abstract

The CBCT guided technique allows the virtual planning of oral Implant placement. With its help, many points can be assessed including bone thickness and density, implant angulation, proximity anatomical structures, and restorative and aesthetic concern. Using computer guided implant placement, the operator can also pre-assess the need for bone augmentation procedures.

Keywords: Guided implant placement; Implant dentistry; Surgical guide

Introduction

Recently, dental implants have considerably contributed towards the rehabilitation of partially edentulous patients. It has become a predictable way of tooth replacement. In order to improve treatment outcomes, extensive research aroused from Branemark protocol where he described the original two-stage surgical protocol. Currently, the concept of prosthetic driven Implantology is gaining attention. It focuses on non-invasive surgical and restorative techniques [1].

The angulation, depth and size of implant depend on the prosthetic outcome. Any discrepancy associated with implant malpositioning can cause peri-implant bone resorption, soft tissue loss and unaesthetic appearance. As rightly stated by Buser et al, correct placement of the implant is based on a three dimensional assessment of the site including mesiodistal, buccolingual and occlusogingival direction.

With meticulous planning within these dimensions and maintaining a minimum of one thickness of 1.5 mm around implant, achieving functional and esthetic acceptance becomes highly predictable [2]. With the interest of achieving accurate and precise implant position, digitally planning with guided placement offers valuable contribution, thus avoiding complications [3]. The computer-based Implantology involves virtual planning using a CBCT of the associated jaw and radiographic stent called the Dual scan technique. This helps in deciding the most appropriate implant position with respect to anatomical structures and prosthetic outcome [4].

Guided implant surgery

When implant surgery is done using a surgical guide, it is referred to as a static procedure. Today most of the implant placements are done using this technique. CBCT has become an integral part of treatment planning. It helps in the visualization of height and width of available bone acting as implant bed, thickness of the soft tissue, proximity of the adjacent teeth, roots and vital anatomic structures such as maxillary sinuses, mandibular canal, mental foramen, and incisive canal [3].

Once the CBCT images are imported into the software program, the operator can virtually visualize the most optimum position of implant specific to the patient's anatomy. The process of virtual planning begins with converting the patient's existing prosthesis into a radiographic guide by adding radiographic markers such as gutta percha. Two CBCT scans are done, first the guide is scanned alone and in second the patient is scanned wearing the radiographic guide. Surgical guides can be fabricated from these radiographic guides by

CADCAM machine, which helps in accurate and planned implant placement. Such precision reduces patient morbidity and follows a predicted treatment plan [5].

Types of Surgical Template

3 types of surgical guides can be fabricated for a precise guided implant placement:

Teeth-supported

These guides are fabricated for partially edentulous patients using teeth as support for the guide.

Mucosa-supported

These guides are fabricated for completely edentulous patients, where the mucosa is used to support the guide. Inter-arch records are made to determine the vertical dimension. These guides are secured during surgery with the help of fixation screws to prevent movement of the guide.

Bone-supported

These guides can be used in partially or completely edentulous patients, but primarily they are used in patients with atrophied mucosa that prevent proper seating of the guide. A full thickness flap is raised, exposing the bone to seat the guide (Table 1).

Guided Surgery Systems

Many known implant planning systems are available in the market. Some of them have been listed below.

Advantages

Patient benefits

Maximum comfort: The technique is less invasive. Usually a

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Manufacturer	Guided surgery software
Nobel	Nobelguide
Materialise dental	SimPlant
Dentsply	Facilitate (Astratech)
Biodenta	Bioguide
3Shape	Implant studio
Straumann	Codiagnostix
Sirona	Implant 3D (galileos)

Table 1: Implant planning systems.

flapless approach is planned. This reduces pain and swelling, that reduces the number of appointments and patient morbidity [6].

Cost-saving: Pertaining to the reduced appointments and faster healing, the technique is less expensive [6].

Fast treatment: Guided planning of implant placement involves fabrication of immediate prosthesis from the surgical guide that can be worn by the patient soon after surgery [7].

Operator benefits

Increased predictability and safety: As the entire surgery is virtually planned including implant location, depth and angulation, the operator achieves higher safety and predictability. 3D-surgical planning program results in exceptional predictability and optimal implant placement [8].

Easy to perform: This concept a complete solution from the virtual planning to prosthetic rehabilitation, which makes the process of implant surgery easy and conductive [9].

Reduced equipment: It does not need extensive surgical instruments due to flapless and less invasive technique [10].

Indications

Multiple implant placements

When three or more implants are planned, it involves meticulous planning regarding inter-implant and tooth implant spacing, angulation, achieving parallelism among implants and teeth, proximity to vital anatomic structures, and relationships between implant positions and planned prosthesis [11].

Proximity to vital anatomic structures

Accurate planning should be done to avoid any accidental damage to the vital anatomical structures such as mental nerve, inferior alveolar nerve, and nasopalatine/incisive nerve during implant placement, as it could lead to permanent parasthesia and associated loss of function [2].

Proximity to adjacent teeth

It is advisable to maintain a distance of 1.5mm from the adjacent teeth. CBCT and planning software are useful as they have the ability to isolate the roots of adjacent teeth and allows adequate clearance between planned implant position and adjacent teeth and roots [2].

Compromised bone volume

3-D view of patient's jaws helps to identify deficient width or height of bone in prospective implant position due to thin, or odd bony contours. The anatomy often dictates implant placement. CBCT enable the operator to plan grafting procedures in advance without causing intraoperative intricacy or undesired implant position.

A very common finding is a thin bony labial plate in edentulous maxillary anterior region that results in exposed implants, finally leading to failure and removal of implants, further jeopardizing the bone anatomy [3].

Prosthetic driven implant placement

Accurate and predictable implant positioning using guided implant planning and is critical for the final esthetic and functional outcome of the prosthesis. It involves reverse planning that involves planning of ideal contour and arch position followed by planning of implant placement in appropriate location [12].

Flapless surgery

This provides less invasive procedures without raising a full thickness flap that optimizes patient comfort by minimizing tissue injury. Complications associated with flap surgeries can cause dehiscence, infection, and tissue necrosis [6].

Need for tissue augmentation

CBCT guided implant planning allows evaluation and visualization of complex anatomy. Numerous soft tissue and hard tissue grafting procedures are commonly performed for implant site preparation. Block bone grafts, ridge splitting, sinus lift, alveolar distraction procedures, soft-tissue and connective-tissue grafts have become common.

Limitations

Guided implant surgery has the following limitations:

- Surgery is expensive due to special surgical kit designed for guided surgery and cost of surgical template fabrication.
- Patient's bone cannot be checked during flapless surgery.
- Long learning curve.
- Template may break during surgery.
- Deformation of the stereo lithographic surgical guide may result in malpositioning of implant.

Errors

- Errors during image acquisition and data processing.
- Error during surgical template fabrication using Stereo lithography [13].
- Error during template positioning and movement of the template during the drilling [14].
- Mechanical error caused by the bur-cylinder gap [15].
- Long burs are used due to additional height of the template [16].

Computer-aided navigation in implantology

Computer-assisted navigation systems are being used extensively in neurosurgery, orthopedics, and ear, nose, and throat surgery. Navigation technology used in dental Implantology provides outstanding contribution by guiding the operator intraoperative, thus preventing any mistakes during the surgery [9].

Navigation is a real-time technology based on the global positioning system (GPS) concept, transferred to the human dental anatomy [17].

The patient's dental anatomy is captured on the CT using fiducially markers and planning is transferred to the real patient during surgery by superimposing the markers.

The system guides the operator to prepare the recipient site according to the predetermined virtual planning in terms of angulation, depth and position of implant.

In case of deviation from the planned path of drilling the system will trigger an audio and visual alert. This helps the surgeon to maintain the planned course and avoid encroaching on vital anatomical structures during surgery [7].

Discussion

The goal of dental Implantology is the accurate and predictable replacement of a patient's lost dentition. This involves meticulous planning involving the surgical and restorative team working together on the diagnosis, planning, and reconstruction. 3 dimensional visualization of anatomy of patient's anatomy has changed the way of approaching a case for dental implants. It has changed from the available bone dictating the implant position to a more predictable and precise prosthetic driven treatment plan [15].

Use of panoramic radiograph was condemned as it provides only a two-dimensional view that does not indicate the buccal-lingual width known as the "third dimension" of the proposed implant site [18].

Introduction of CBCT scanners enabled the operator to visualize the height and width of available bone for implant placement, thickness of the soft tissue, proximity and root anatomy of adjacent teeth, extent of the maxillary sinuses, sinus septae, and other vital anatomical structures such as the mandibular canal, mental foramen, and incisive canal [15].

It is very important to seat the guide properly in the patient's mouth to achieve the planned implant position. If the radiographic guide were not placed correctly, the resulting implants would be placed differently using the surgical guide than from the actual planned position [9].

The estimated scanning time is 70 seconds. Errors have been reported due to patient movement during the CT scan, especially for elderly patients. This caused an angular deviation of approx. 3.1 degrees in the maxilla and 2.4 degrees in the mandible. Therefore it is important to maintain patient position during scanning [9].

Fiducial markers in radiographic guides can be gutta percha or use of 20% to 30% barium sulfate mixture in the acrylic to allow for radiopacity of the planned restorations in the CT/CBCT images. In the double scan technique, first scan is made of the prosthesis alone, while the second scan is made with the patient wearing the radiographic guide. The scans are transferred to the planning software using DICOM (Digital Imaging and Communication in Medicine). The radiographic markers on both the scans are then superimposed to virtually plan the optimum implant position specific to the patient's anatomy. Decisions can be made regarding the type and size of the implant, its position within the bone, its relationship to the planned restoration and adjacent teeth and/or implants, and its proximity to vital structures before performing surgery on the patient [19]. Surgical drilling guides can then be fabricated from the virtual treatment plan. These surgical guides are used by the clinician to place the planned implants in the same positions as those of the virtual treatment plan, allowing for more accurate and predictable implant placement and reduced patient morbidity [20].

Conclusion

The location, size, angulation and depth of implant are planned before beginning the surgery. Patients undergo less invasive surgery without flap elevation leading to faster healing and early rehabilitation that makes it an acceptable treatment plan. This results in minimizing the treatment time and enhanced patient comfort.

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