Guiding Implants the Virtual Way

Deeksha Sharma*, Himanshu Arora**

*Reader, Department of Prosthodontics including crown and bridge, Manubhai Patel Dental College and Hospital, Vadodara, Gujarat.**Senior Lecturer, Department of Prosthodontics including crown and bridge, Manubhai Patel Dental College and Hospital, Vadodara, Gujarat.

Abstract: With the technology scaling new heights in medical/dental sciences, it comes down to the clinicians ease to begin with a new procedure. Implant surgery is one such field which has constantly evolved over times. Along with the knowledge in the field, proper execution of implant placement procedure is required. Thus the need of a guiding tool for a successful placement of implant in its prosthodontically driven space cannot be underestimated. Surgical stents are one such tool that enable us to place implant in planned position and at perfect angulation. Fabrication of these stents has now evolved from a simple chair side procedure to a fully CAD processed mechanism. Thus enabling accurate execution of diagnostic plan. [Deeksha S NJIRM 2017; 8(3):149-152]

Key Words: implant placement, surgical template, stereolithography

Author for correspondence: Deeksha Sharma, A 101 Sonal Highlands, Opposite Shapath apartments, near SBI bank 30 mtr. Road, Gotri, Vadodara 390021, M: 8141007846 E-Mail : dr.deeksha.sharma @gmail.com

Introduction: The success of implant therapy begins with appropriate treatment planning and properly performed implant placement surgery. And this depends not only on the level of implant integration in the bone but also on the position of the implant, as implant position affects the esthetics and function of the restoration.

Generally, it is agreed that implant position should be prosthodontically driven.[1] First implants were placed by use of simple periodical and panoramic radiographs.[2] This often led to a compromised final prosthesis with a jeopardized occlusal scheme and poor esthetics.

More recently, with adoption of the philosophy of prosthodontically driven implant placement, customized surgical templates have become a routine part of implant placement.

Aided by the radiographic/surgical template, the surgeon can avoid undesirable implant site preparation and minimize unnecessary osteotomy, resulting in favorable design of the prosthesis, reduced surgical trauma, decreased surgical time, and increased patient comfort.[1]

Many types of surgical guides have been developed and used in dentistry. Generally, the surgical guide fabrication process begins with a diagnostic tooth positioning, either through a diagnostic waxing, denture teeth arrangement, or via the duplication of the preexisting dentition/restoration.

Diagnostic Imaging And Diagnostic Templates: The widespread use of dental implants in partially and completely edentulous patients has brought about a need to preoperatively depict and quantify accurate bone height and contour by radiographic examination. These examinations also provide information about the locations of vital anatomic structures, adjacent to the sites of implant placement. e.g.. The maxillary sinuses and nasal fossae, and the inferior alveolar canals and mental foramina.

Diagnostic Templates: The purpose of diagnostic radiographic template is to incorporate the patient's proposed treatment plan into the radiographic examination. This enables evaluation of the ideal position and orientation of implant, identified by radiographic markers incorporated into the template. Study prosthesis is first made on diagnostic casts. Then this prosthesis is duplicated and used as a radiological guide that includes a radiopaque material that allows visualization of the tooth position on the radiological exam.[3] Once this ideal prosthetic tooth position and its axis are defined, a computerized tomography (CT) exam is performed with the radiological guide in the mouth. The precision of CT enables use of complex and precise diagnostic template. The surfaces of the proposed restorations and the exact position and orientation of each dental implant should be incorporated into the diagnostic CT template. The need for more accurate placement of implants has led to the development of numerous template designs.

Techniques: These include the labial outline surgical guide made from a wax arrangement of the proposed definitive restoration, a clear vacuum-formed matrix, a duplicate of the existing restoration and other methods Designs for diagnostic CT templates have evolved from a simple reproduction of the wax up to one produced from a processed acrylic reproduction of the diagnostic wax up to more sophisticated types fabricated with specifically designed radiopaque denture teeth. There are various techniques of fabricating a diagnostic template using either acrylic or vacuform sheet. A diagnostic template is made by acrylic and modified by coating the proposed restoration with a thin film of barium sulfate. Also a hole is drilled through the occlusal surface and is filled by guttapercha. In another technique, vacuform sheet is used. The occlusal hole is filled by a blend of 10% barium sulfate and 90% acrylic. Latest advancement has been the radiopaque teeth specifically designed for the fabrication of diagnostic templates for fixed and removable implant supported restorations.[4] The radiopaque material is an integral component of the CT scan tooth. (ivoclar)

Tomography examinations can also be used for imaging of diagnostic template but is less precise than those fabricated using CT scan. The simplest template is made by a vacuform of the patient's diagnostic cast with 3mm ball bearings placed at the proposed implant site. The implant site in the tomograms is identified by the one in which the ball bearing is in sharp focus. These templates may also incorporate metal cylinders or tubes at the proposed implant sites. Diagnostic templates can be modified and used as surgical templates.

Surgical Guide Template: It has long been recognized that meticulous presurgical evaluation and planning are essential to achieve predictable results. Acknowledgement that a surgical template would be helpful in more accurately placing the implants came soon thereafter.

To establish a logical continuity between diagnosis, prosthetic planning, and surgical phases, use of a transfer device is essential during implant surgeries. The restoring dentist fabricates the surgical guide template after the presurgical restorative appointments, once the final prosthetic design, occlusal scheme and implant location, size and angulations have been determined.

Radiographic templates used in diagnostic imaging can be converted into surgical templates by removing the marker and creating a channel in the acrylic base and called as RADIOGRAPHIC - SURGICAL TEMPLATE OR RST.**[5]**

A radiographic-surgical template (RST) can illustrate the appearance of final prosthesis, final tooth contours, symmetry, lip support, its relationship to the periodontium and the procedures needed to accomplish it.

The surgical guides can be used to locate healing screws at the second stage surgery. The surgical template dictates the implant body placement that offers the best combination of knowledge and skill.

Ideal Requirements (Carl Misch [4]):

1. Should be stable and rigid when in place
2. Should not be bulky
3. Maintain surgical asepsis
4. Should not be difficult to insert and withdraw
5. Should not obscure surrounding surgical landmarks
6. Should be transparent and allow easy access for surgeon

Sicilia[6] et al has suggested 5 characteristics of an ideal surgical template:

1) It should allow proper orientation of the implant in a mesiodistal and buccolingual position.
2) Proper contrast should be maintained during diagnostic imaging procedures.
3) It should be stable during oral manipulation.
4) It should provide adequate surgical access and visibility.
5) There should be enough freedom to alter implant position within the confines of the surgical template.

Types Of Surgical Templates: To construct a surgical guide modification of the radiographic guide is often possible if an ideal wax up of the teeth was used.
It dictates the tooth position and after verifying bone availability, enlargement of long axis channels guarantees accurate implant guidance.
Lazzara[7] categorized surgical guide templates as
1. Variable position surgical guide templates
2. Fixed position surgical guide templates

These acrylic resin templates are adapted over casts at diagnostic wax-up stage. Grooves or lines in the acrylic resin are made to guide the implant drill.

Advantage:
a) These are quick and simple to fabricate.

b) It has plastic or metal tubes in acrylic resin that dictate the position and angulation of surgical drills and implants.

Disadvantage:

a) They allow too much flexibility in the final positioning of the implant.

b) The tube restricts the positioning of the surgical drill and allows the surgeon no_flexibility during the implant placement procedure.

Advanced Surgical Guidance: It is seen that modification of radiographic guide to a surgical guide allows for a precision of less than 1mm at the implant apex and a good control of the angulations.[4] To refine surgical guidance, innovative developments in software technology and manufacturing techniques have been applied to fabricate highly accurate templates.

These technologies allow for more accurate implant positioning by guaranteeing transfer of implant planning to the surgical field and by forcing the surgical drills into a steady position. These technologies also open venues to new surgical techniques such as flapless osteotomies, while improving operative timing.[8] Advanced surgical guides require computed tomography scanning as a prerequisite for analysis because of superior precision. These guides also necessitate a software supported rendering to improve planning by using a 3D visualization.

Surgical guidance can be categorized into 2 groups

Use of **computer aided manufacturing of guides**, using virtual planning of implant positions. No modification is possible as the surgeons have the guide before the procedure.

Use of **navigation techniques,** with no guidance of the drill but software provides real time feedback to the surgeon in order to compare execution with planning. Hence modifications are possible during surgery.

Computer Assisted Design And Manufacturing Of Surgical Guides: For fabrication of surgical guides, the dentist plan is used to design the guides, and CT files are used to prepare the guides to be borne on hard or soft tissue. For fabricating a template for an edentulous patient, guided implant surgery protocols can be used. Existing denture serves as a radiographic template. Multiple 2-mm holes placed into the dentures at different levels and in areas both buccally and palatally and filled with gutta percha as radio-opaque markers.

Scan is done with these dentures in mouth and without. The CBCT data is then formatted and transferred into a 3-demensional implant planning software program.[9] Implant positions and sizes, as it relates to bone availability and associated vital structures, can be digitally evaluated and placed.

Super imposing the two sets of scans allows correlating the correct planned implant position in relation to the position of the denture teeth on the prosthesis. Data is then transferred to a milling center to fabricate a stereolithography surgical guide and duplicate denture.

These guides will at the time of surgery, direct the placement of implants into the identical positions as planned for a flapless surgical approach. Also it will allow for creating a cast from which the interim, immediate prosthesis will be created.

Stereolithography (SLA): A rapid prototyping machine using the principle of stereolithography is used to fabricate the SLA models and guides templates. Briefly, the SLA method consists of a vat containing a liquid photo-polymerized resin. Process where high powered ultra-violet lasers are directed into a basin of liquid polymer resin solidifying those areas.[10]

The part is created in layers from the bottom up, each layer only thousandths of an inch thick. The result is a precise physical copy of the virtual computer model significantly lower in price than conventional prototyping, and delivered in a fraction of the time. The digital dentistry industry has now started using the latest in Stereolithography technology to generate solid or flexible, highly detailed functioning parts from drawings, blueprints, or 3D-CAD files.

Once the first slice is completed, a mechanical table immediately below the surface moved down 1 mm, carrying with it the previously polymerized resin layer of the model. Then, the laser polymerizes the next layer above the previously polymerized layer. In this manner, a complete SLA model of the subject's jaw is created. The surgical templates are fabricated in a similar manner. The SLA machine also read the diameter and angulations of the simulated implants and places selectively polymerized resin around them, forming a cylindrical guide corresponding to each implant. The surgical-grade stainless steel tubes are connected into the cylindrical guide. The precise angulations and mesio-distal and bucco-lingual positioning of each implant, as planned using 3D computer simulation software, are transferred to the SLA surgical guide. Software programs are capable of maximizing stability and implant retention by detecting the best insertion path while avoiding undercuts within the bone. Other features like irrigation holes, sufficient area for finger pressure and buccal extensions (when required) are included.

Also serial templates are fabricated to accommodate increasing drill diameters. After completing the designs, the guides are processed with the stereolithographic method and stainless steel tubes are pressed into place. The dentist receives the anatomical model and surgical guide by mail

Surgical Navigation: Afore mentioned steps of taking a CT scan and transferring the scannographic guide to the software are done. This guide includes markers for cross referencing jaw positions with the CT scan and virtual implant planning is performed. For surgery the hand piece is equipped with a 3D positioning device such as electromagnetic digitizers or light emitting diodes. Before surgery the registration device is repositioned and a preliminary matching process is performed by locating radio opaque markers. Both, the registration device attached to the patient and the headpiece possess light emitting diodes (LEDs) that can be located in the space via infrared cameras mounted above the dental chair. Once this registration takes place, surgery may begin using the reference body to locate the patient's jaw and the diode equipped headpiece to locate the surgeon's movements.

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Conflict of interest: None
Funding: None
Cite this Article as: Deeksha S, Himanshu A. Guiding Implants the Virtual Way. Natl J Integr Res Med 2017; 8(3):149-152