

Guided surgery in dental implantology

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Abstract

Dental implant surgery requires precise planning due to various anatomic limitations and restorative goals. The greatest challenges in the surgical and the prosthetic stages of dental implant surgery are due to diagnostic failure and poor case planning. With the advent of new technology surgical guides and templates can be fabricated which has made it possible to achieve more reliable agreement between the planned and final position of dental implants. These templates fabricated by sophisticated data acquisition methods and virtual planning software, seat directly on bone. They are preprogrammed with the individual depth and angulation during 3D computer simulation. It has improved preoperative planning reducing the surgical morbidity. This article reviews the concept of virtual planning and procedure of stereolithography for fabrication of surgical templates during implant planning and placement.

Keywords: Dental implant, Guided implant surgery, Surgical guide, Rapid prototyping technology, Stereolithographic template, Radiographic template.

Introduction

Implant placement has become a common practice in dental care. It is a great challenge for the surgeons and prosthodontists to make it a success as most of the implant failures occur due to improper diagnosis and poor case selection. With the advancement of digital dentistry 3-dimensional images can be acquired which aids in virtually defining treatment planning. This has improved conventional prosthetic approaches. It has aided in fabrication of surgical guides which help in exact positioning of implant in bone with respect to location and angulation. Thus the accuracy of implant placement has improved with the use of rapid prototyped surgical guides and templates. It has also made it easier for the patients to understand the proposed procedures.

Surgical guide is a device which is used to place implant in accurate position. It has to be made very precisely to not allow for any intraoperative changes and provide desired information to achieve pleasing results. They can be manufactured in laboratory, manually or using CAD/CAM technology.

Traditionally fabricated surgical guides have certain limitations in achieving optimal results. These are:

1. Usually surgical template is manufactured in laboratory using a diagnostic cast which is rigid and nonfunctional representation of soft tissue.
2. It does not allow visualization of anatomical structures in parasagittal sections which further hinder the accurate assessment.
3. Conventionally the surgical guides are fabricated using auto polymerizing or composite resins which are rigid and results in improper seating. This limits the stability of surgical guide on soft tissues.

However, with the advancement in 3D technology, a direct three-dimensional view of the surgical site can be achieved. This has made it possible in performing surgeries more accurately and obtaining the desired results.³

The implant placement planning can be done with the development of various software programs. These

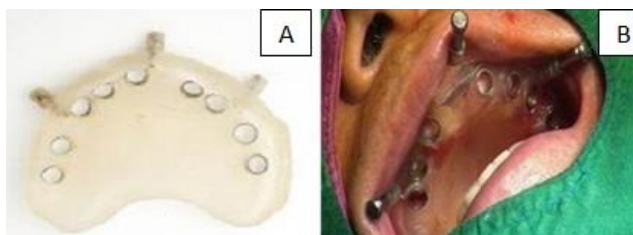


Fig. 1: Surgical guide

programs are then integrated with the rapid prototyping methods for fabricating surgical templates.

Rapid prototyping technology

With the help of rapid prototyping technology, prototypes are produced quickly from three dimensional computer aided design model. It involves adding material successively in layers, to create a solid of predefined shape. Stereolithography is one of the several methods of rapid prototyping technology used to create 3D-printed surgical templates.

It has made it possible to achieve more reliable agreement between the planned and final position of dental implant. These templates seat directly on bone and are preprogrammed with the individual depth and angulations during three dimensional computer simulation.⁴

Guided implant surgery

Guided implant surgery in dentistry involves the process of reconstructing intraoral state in three dimensions with the help of high quality CBCT and using this data for planning implant placement over a virtual model. A surgical guide is then fabricated with the help of rapid prototyping technology. This guide or template is used for accurate placement of dental implants.⁵

It involves the following steps:

1. Fabrication of radiographic template
2. Computed tomography scan procedure
3. Implant planning by using implant surgical planning software
4. Fabrication of stereolithographic templates
5. Surgical procedure

Fabrication of radiographic template

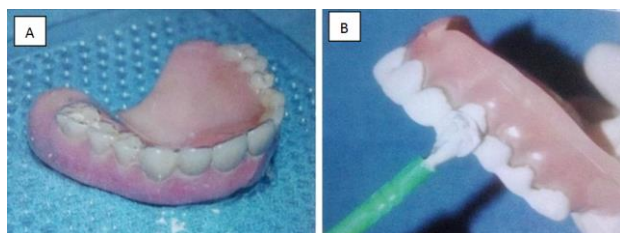


Fig. 2: Radiographic template for complete dentures

A radiographic template is fabricated with patient's existing complete dentures or on a duplicate study cast. It aids the dentist to envisage the location of planned implants in the oral cavity. Various radiopaque markers are used in determination of implant location. These include radiopaque varnishes, gutta percha, barium sulphate in resin powder, etc.

With patient's existing complete dentures, a vacuum-formed clear template with clear thermoforming material is formed. Using barium sulphate monomer and polymer, the facial and lingual surfaces of the template is painted and allowed to dry.

In case of partially edentulous patients a vacuum-formed clear template is fabricated on duplicate cast. A mixture of clear tooth acrylic and barium sulphate is poured in the edentulous area of the template. Template is removed from the cast. It is trimmed and polished as needed.

Radiographic template can also be fabricated in laboratory by duplicating the existing dentures. For this, denture duplicator flask is used. Mix and fill half of the flask with alginate. Place the denture into alginate with teeth perpendicular to the bottom of the flask. Lubricate the alginate and exposed denture with separating medium. Fill the other half of the flask along with the ridge part of the denture with alginate. Close the flask. After alginate is set, open and remove the dentures. Pour clear acrylic resin into the incisal and occlusal surfaces ensuring no bubbles. Pour remainder of mixture into palate or vestibule area and cure it.⁶

The computerized tomography scan procedure

The cone beam computed tomography is a type of x-ray equipment which is used to obtain three dimensional images of teeth, sinuses, nerve pathway and bone in a single scan. It produces images on DICOM format.

Planning with software

The raw data obtained from CT scan is converted into three dimensional information with the help of various software available. The two most common surgical templates are from Sim Plant, which are termed surgiguide and from Nobel Biocare which are termed surgical templates. Other commercially available

software programs include Implant Master, Easy guide, codiagnostix.

The planning software helps in visualization of the jaw bones in four views: axial, cross-sectional, panoramic and three dimensional reformatted data. This allows visualization of involved anatomical structures in three dimensions aiding in selection of length and diameter of implants to be placed by the dental team. Thus a three dimensional replica of implant of exact dimension is reproduced in desired location on computer model of the patient's jaw.

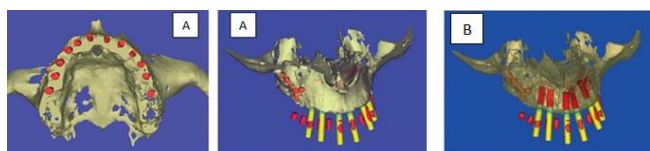


Fig. 3: **A:** Three dimensional view during implant simulation; **B:** Three dimensional view in bone transparency mode

Fabrication of stereolithographic template

At this stage, a rapid prototyping machine which uses the principles of stereolithography is employed to fabricate the stereolithographic models.

The stereolithographic apparatus consists of vat which contains a liquid photo polymerized resin. A laser which is mounted on top of the vat moves in sequential cross sectional increments of 1mm, which correspond to the slice intervals which are specified during the CT formatting procedure. The laser polymerizes the surface layer of the resin on contact. Once the first slice is completed, a mechanical table which is immediately below the surface moves down 1mm, carrying with it previously polymerized resin layer of the model. The laser now polymerizes the next layer which is above the previously polymerized layer. In this manner, a complete stereolitho graphic model of the patient jaw is created.⁷

The surgical template is manufactured using stereolithography in similar manner. The stereolithographic machine selectively polymerizes the resin which is around them forming a cylindrical guide after reading the diameter and angulations of the simulated implants. Surgical template made using this technique seat directly on bone. It has metal sleeves which correspond to each fixture site.

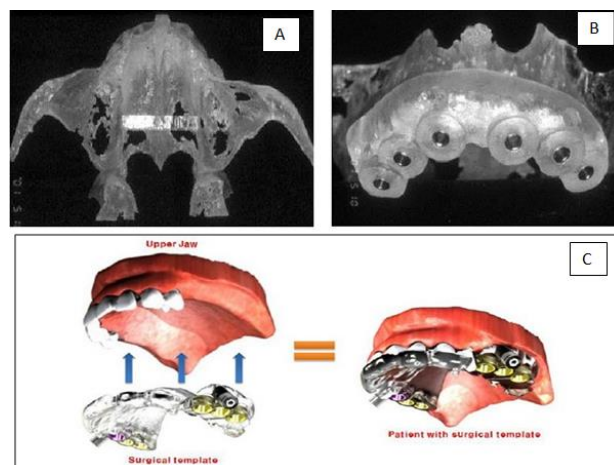


Fig. 4: **a):** Stereolithographic model of patient's maxilla; **b):** Stereolithographic model of patient's maxilla with SL template; **c):** Surgical template seat directly on bone

Surgical procedure

At the time of surgery, stereolithographic template is seated directly on the bone. The unique surface topography of the bone which is recorded by the CT scan and is incorporated in the stereolithographic template results in a precise fit without need for an external fixation.⁸

The various steps involved during surgical procedure are:

1. Excess areas are removed with the help of a bur and the template is disinfected.
2. Surgical template is placed on the surgical site.
3. An anchor drill is used to drill and insert the anchor pin.
4. Tissue punch is used for punching through the soft tissue.
5. Anchor pin is taken out and the surgical template is removed.
6. Excess soft tissue is removed. Surgical template is placed and anchor pin is reinserted.
7. Drill with 2mm drill guide and 2mm drill.
8. Then drill with 3mm drill guide and 3mm drill.
9. Guided surgery mount is attached to the implants and all implants are placed.
10. Anchor pin is removed and surgical template is detached.
11. Pre-made provisional restoration is attached.

With the advances in MRI technology in recent times, it has become possible to reveal cancellous bone and cortical bone detail through thin slice high resolution images. This not only show bone quality and thickness but also position of relative structures. Thus MRI images can be used successfully when complemented with rotational panoramic x-rays for planning and placement of implants.

Additional template accuracy technique for positioning implants in important areas such as inferior alveolar nerve and maxillary sinus is placement of surgical template with a tube technique using Coen's drill guide in combination with a mathematical equation to find the clinical and radio graphic discrepancy to help ensure accuracy of placement.¹⁸ Some practitioners have extended template technology to include reconstruction of the osseous support for a missing interdental papilla between adjacent implants by means of an interimplant papillary template. Besides, these precision templates can be used in performing flapless surgeries. It is also helpful in prosthesis preparation before surgery used for immediate loading.

Conclusion

For an ideal implant treatment planning and in order to achieve a successful final treatment outcome, a surgical guide that faithfully reproduces planned implant positions can play a pivotal role.

This has been achieved clinically by complementing 3-D technology with simple mechanical system for manufacturing computer aided surgical guide. It enables the transfer of preoperative implant axis planned on three dimensional imagery to a surgical template. Hence, a precise placement of implants in otherwise contraindicated sites having critical anatomical structures has become possible as it has eliminated the manual errors made during placement of implants. Thus mapping of implant site three dimensionally has enabled surgeon to reduce chair time. It has minimized trauma to the tissues, enhancing osseointegration.

The major limitation of computer aided implant surgery in comparison to conventional technique is that it requires substantially greater investment and effort. Stereolithographic materials have inherent

potential problems in their fabrication which can lead to light sensitivity and expansion or shrinkage of material over time. Sterilization and handling of stereolithographic material can also present problems.

So it is important to emphasize to all clinicians who are interested in these technologies that there is a strong learning curve involved in the successful integration of CT technology and CT guided surgery. They should keep their knowledge updated on these technologies prior to clinical use. In addition to good diagnosis and patient selection, knowledge of the complete protocols, CT scans, treatment planning software programs and guided surgery instrumentation and techniques are all instrumental in successful treatment outcomes.

Source of Funding

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Conflict of Interest

None.

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