Review Article

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Surgical Guides: A Journey Through Time

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ABSTRACT

Background: Dental implantology has emerged as a practical alternative to traditional prosthodontics. Since the beginning, placement of implant in the bone to achieve a prosthetic solution that fulfils biologic, aesthetic and biomechanical requirements has been a challenge. In the past, implant site and inclination were dictated by residual bone quality. The desire for predictable prosthesis led to the development of prosthetically guided implantology. This concept establishes the correct implant position during the diagnostic stage according to planned definitive restoration. In prosthetically guided implantology where ideal placement of implant is determined by the definitive restoration, use of radiographic and surgical stent in conjunction with dental CT scan can play an important role. A stent is an appliance used for radiographic evaluation during treatment planning for implant placement and during surgical procedures to locate optimal implant placement site. The stent with dental CT scan enables the dental team to identify specific sites of prospective implant surgery and hence determines the optimal position and angulation of implant relative to occlusal load.

Keywords: Stent, Surgical guide, implant.

INTRODUCTION

Precise planning of implant placement is dependent to a great extent on accurate preoperative information about the bone topography. Accomplishing predictable reconstruction and aesthetics, for single or multiple tooth replacement with dental implants is challenging. The trajectory of an implant, especially in a buccolingual direction, is seldom consistent with that of the natural tooth, primarily because of bone loss. The surgeon must place the implant in a region where there is adequate quantity and quality of bone to provide functional support.

Since the oral cavity is a relatively restricted space, a high degree of accuracy in placement of implant is very important for success of the prostheses. This can be achieved by means of a surgical guide which provides adequate information regarding implant placement and at the time of surgery it fits on to the existing dentition or on to the edentulous span. This article evaluates the conventionally used radiographic templates with their fabrication, advantages, disadvantages and a review of computer aided surgical guide.

DISCUSSION

Surgical guide is defined as guide used to assist in proper surgical placement and angulation of dental implants. The main objective of surgical template is to direct the implant drilling system and provide an accurate placement of the implant according to the surgical treatment plan. To precisely transfer the plan to the operative site, customized conventional radiographic or computer

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image guided surgical templates have become a treatment of choice.

The rationale for utilization of a surgical template is based on the following objectives:

1. It should provide the surgeon an accurate visualization of the ideal implant sites with the desired path of abutment emergence and corresponding axis in relation to the final prosthesis.
2. It should dictate the proper orientation of surgical drills during implant site preparation with calibrated channels created through the resin material.
3. It should provide a guide for assessment of alternative implant sites when bone topography proves to be incompatible with the initial expectations.

The ideal characteristics of the ideal surgical template are

1. Good orientation- It must offer a Vestibular and mesiodistal limit that enables the placement of the implant in a desired position and allows the creation of a good emergence profile, leaving a convenient space for the papillae, making transmission of occlusal forces easier, and preventing the need of a access hole for the abutment screw on the buccal surface, which interferes with esthetics.

2. Contrast – It must have a system of contrast for use during diagnostic imaging procedures.

3. Correct fixation- It must be placed in the mouth in a reproducible and stable way, so that it does not move during oral manipulation, allowing more reliable information to be obtained.

4. Comfort – It must not restrict surgical access or tissue reflection, but permit both good visibility and simultaneous external irrigation.

5. Freedom of choice- It must allow the surgeon to make appropriate decisions regarding intra surgical anatomic findings, and to continue the intervention using the information provided by the surgical template, even though final implant position may not be as initially planned.

Disadvantages:

1. It cannot guide the surgeon throughout the surgical procedure.

2. It decreases access for surgical site

3. It decreases access for external irrigation.

4. It does not give a scope for surgeon to alter the osteotomy site, if surgical site is found not suitable as it was diagnosed

5. It is difficult to use drills of different diameters

The fabrication of the surgical guide templates is then based on one of the following design concepts:

(1) Non limiting design

(2) Partially limiting design

(3) Completely limiting design

These design concepts are classified based on the amount of surgical restriction offered by the surgical guide templates

Nonlimiting Design

Nonlimiting designs only provide an indication to the surgeon as to where the proposed prosthesis is in relation to the selected implant site. This design indicates the ideal location of the implants without any emphasis on the angulation of the drill, thus allowing too much flexibility in the final positioning of the implant.

Blustein et al and Engelman et al described a technique in which a guide pin hole was drilled through a clear vacuum-formed matrix. This hole indicated the optimal position of the dental implant. However, the angulation was determined by the use of adjacent and opposing teeth.

It has been observed that the use of these guides may result in unacceptable placement of the access hole and/or unacceptable implant angulation. Hence, these templates can serve as imaging Indicators during the surgical phase of implant placement.

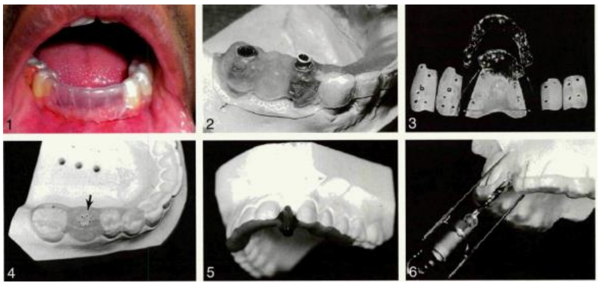


Fig 1. Vacuum-formed template. FIGURE 2. Brass tube incorporated into the surgical guide. FIGURE 3. Bilaminar dual-purpose surgical guide. FIGURE 4. Gutta-percha guide. FIGURE 5. Metal sleeve guide. FIGURE 6. Surgical guide attached to the head of the contra-angle hand piece.

Partially Limiting Design

In such designs, the first drill used for the osteotomy is directed using the surgical guide, and the remainder of the osteotomy and implant placement is then finished freehand by the surgeon. Techniques based on this design concept involve fabrication of a radiographic template, which is then converted into a surgical guide template following radiographic evaluation. Various authors have proposed different techniques involving modifications in the following stages of fabrication, namely, material used for the fabrication of the surgical template, radiographic marker used, type of imaging system used, and the conversion process involved in converting the radiographic template into a surgical template. All the techniques failed to completely restrict the angulation of the surgical drills.

Completely Limiting Design

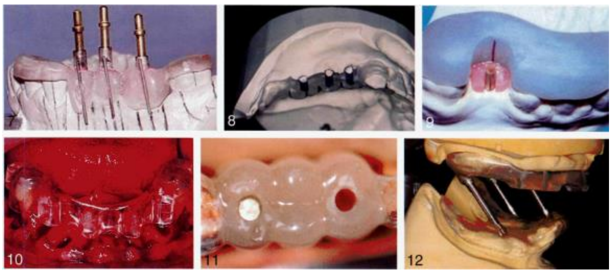
Completely limiting design restricts all of the instruments used for the osteotomy in a buccolingual and mesiodistal plane. Moreover, the addition of drill stops limits the depth of the preparation, and thus, the positioning of the prosthetic table of the implant. As the surgical guides become more restrictive, less of the decision-making and subsequent surgical execution is done intraoperatively.

This includes 2 popular designs: cast-based guided surgical guide and computer-assisted design and manufacturing (CAD/CAM) based surgical guide.

Cast-based Guided Surgical Guide

The surgical guide is a combination of an analogue technique done along with bone sounding and the use of periapical radiographs in a conventional flapless guided implant surgery. The periapical radiograph is modified using digital software to help in transposition of root structure onto the cast.

The cast is then sectioned at the proposed implant site, and bone-sounding measurements are transferred to help in orientation of the drill bit to perform a cast osteotomy. A laboratory analog is placed in the site, and a guide sleeve consistent with the implant width is modified using wires that are used to create a framework around the teeth. Vinyl polysiloxane occlusal registration material is used to form the superstructure (Figures 13 and 14)



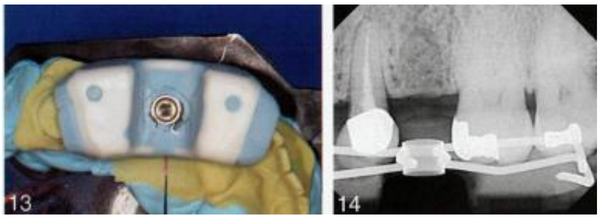


Fig 7-14. FIGURE 7. Guide pins attached to the surgical guide to verify alignment of implants. FIGURE 8. Facial portion of surgical template removed before surgery.. FIGURE 9. Two-piece implant placement surgical guide. FIGURE 10. Surgical guide for immediate implant placement following staged tooth extraction. FIGURE 11. Radiographic rod removed following radiographie analysis. FIGURE 12. Surgical guide connected to mandibular record base. FIGURE 13. Cast-based surgical guide. FIGURE 14. Radiographic view of the cast-based surgical guide.

CAD/CAM-based surgical guide

CAD/CAM technology uses data from computerized tomography scan (CT) to plan implant rehabilitation. The CT images are converted into data that are recognized by a CT imaging and planning software.

This software then transfers this presurgical plan to the surgery site using stereolithographic drill guides. CAD/CAM-based surgical guides offer many advantages. For example, the virtual 3- dimensional (3D) views of the bony morphology allow the surgeon to visualize the surgical bone site prior to implant placement; risks such as inadequate osseous support or compromise of important anatomic structures are avoided; incorporation of prosthetic planning using a scanographic template allows the treatment to be optimized from a prosthodontics and biomechanical point of view and the technique promotes flapless surgeries, allows presurgical construction of the master cast and provisional restorations, and facilitates immediate loading. Accuracy of CAD/CAM technology in dental implant planning and predictable transfer of the presurgical plan to the surgical site has been documented. However, the effectiveness has not yet become an established fact and still needs ongoing research. This technique has certain drawbacks. Special training for familiarity with the entire system and special equipment is necessary

Also, a considerable number of technique-related complications were observed. The various complications recorded were related to inaccurate planning, radiographic stent error, intrinsic errors during scanning, software planning, the rapid prototyping of the guide stent, and the transfer of information for the prosthetics. However, if the clinician recognizes these sources of inaccuracy, efforts can be made to minimize the error and optimize patient treatment.

In recent years, dental implant rehabilitation has faced demands from prosthetic and aesthetic areas that call for increasingly ideal outcomes, which require a precise surgical planning and placement. Anatomic limitations and bone quantity and quality can now be evaluated by using more sophisticated radiographic techniques, although transferring this information to the surgical phase has been at best a difficult task. Recently, computer aided design and manufacturing have made it possible to use data from computerised tomography to not only plan an implant rehabilitation, but also to transfer this information to the surgery. One of these techniques uses stereolithography, a laser driven polymerisation process that fabricates an anatomic model and surgical templates. This novel approach not only allows the precise translation of the treatment plan directly to the surgical field, but it also offers many significant benefits over traditional procedures.

CAD/CAM technology in dental implant planning can be divided into following steps

•Fabrication of a radiographic template.
•The computerised tomography scan procedure.
•Implant planning by using interactive implant surgical planning software.
• Fabrication of stereolithographic templates.
• Surgical procedure.

Fabrication of a Radiological Template

A radiographic template allows the clinician to visualize the location of planned implants from a restorative standpoint. It is a exact replica of the desired prosthetic end result. Various radioopaque markers such as gutta-percha balls and strips, metal pins and tubes, radioopaque varnishes and lead foil or barium sulphate in resin powder, aid in determination of the implant location. By creating a diagnostic wax up or by duplicating an existing denture, the radiographic template can be fabricated. While fabricating it, patient's appropriate centric position and vertical dimension are noted. A vinylpolysiloxane interocclusal index is fabricated, which can be later used to stabilize the surgical template.

The Computerised Tomography Scan Procedure

Computerised Tomography (CT) is considered to be more accurate than conventional tomography, since it exhibits a uniform magnification. CT was founded by Sir Godfrey Houndsfild and Allen M.Cormack in 1972. The technique of dental CT, which is also called Dentascan, was developed by Schwarz et al., in 1987, when these investigators fist used curved multiplanar reconstructions of the jaw. When computed tomography, or more specifially, cone beam computed tomography or CBCT (3D X-ray imaging) is used pre–operatively to accurately pinpoint vital structures which include the inferior alveolar canal, the mental foramen, and the maxillary sinus, the chances of complications may be reduced, as are chair time and number of visits. Cone beam CT scanning, as compared to traditional medical CT scanning, utilizes less than 2% of the radiation, provides more accuracy in the area of interest, and is safer for the patient. CBCT allows the surgeon to create a surgical guide, which allows the surgeon to accurately angle the implant into the ideal space. Helical CT, along with advancements in stereolithography, has allowed the development of a CAD/CAM processed surgical guide which can be placed on the bony site. But recently, cone beam CT has been recommended for dental imaging, as it presents identification of anatomical landmarks and provides high accuracy and low-radiation exposure levels.

Double Scanning Procedure

Van Steenberghe D et al. introduced use of double scan procedure for integration of the radiological template within the craniofacial model. A double-scan technique is used to acquire the CT data. Either spiral CT scanners or cone-beam CT scanners can be used. The data acquisition from the CT scan must be compatible and adequately detailed slices of about 0.4 mm—to acquire images of the jaws which are being treated. The first scan is performed with the patient wearing the scanning denture and with the bite index in place, ensuring the correct placement of the denture and arrangement of teeth during the scan. The second scan is then performed with the scanning denture alone being positioned in the CT scanner, in the same orientation as it was in during the first scan. After the CT scanning procedures, the bite index is preserved for the upcoming laboratory procedure.

Implant Planning Stage

The computer software uses the radiopaque markers which have been placed in the scanning denture, to perform an accurate fusion of the two separate scans. Resulting from this fusion is an exact representation of the patient's bone structure and scanning denture in 3D space. At this point, the virtual surgical procedure can be performed. In 1986, Fellingham et al., first demonstrated the use of interactive graphics and 3D modelling for surgical planning, prosthesis, and implant design. By using the software, the dental team can select implants of specific lengths and diameters from a database of most commercially available implants and it can reproduce a 3D replica of exact dimensions in the desired location on the computer model of the patient's jaw.

Once the computer simulation is completed It is saved as a ".sim'' fie which is sent to the processing centre via e-mail This file transfers geometrical information which consists of numerous triangles. This triangulated data is the interface to the stereolithographic apparatus (SLA).

Fabrication of Stereolithographic Templates

In 1986, Dev et al, developed a computer-controlled, indirect milling machine for reproduction of an anatomical structure. Further development resulted in a rapid prototyping of stereolithography. A rapid prototyping machine which uses the principle of stereolithography is employed to fabricate the stereolithographic models. The SLA consists of a vat which contains a liquid photo polymerised resin. A laser which is mounted on top of the vat moves in sequential cross sectional increments of 1 mm, 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 1 mm, carrying with it the previously polymerised resin layer of the model. The laser now polymerizes the next layer which is above the previously polymerised layer. In this manner, a complete stereolithographic model of the patient's jaw can be created. Approximately 80% of the total polymerisation is completed in the vat; the remaining 20% can be completed in a conventional ultra–violet light curing unit. The surgical templates are fabricated in a similar manner. They are built onto the surface anatomy of the stereolithographic model and are connected to it by a series of minute triangles that are later removed during the finishing process. The SL machine also reads the diameter and angulation of the simulated implants and it selectively polymerizes resin which is around them, forming a cylindrical guide which corresponds to each implant. A technician removes supporting resin triangles and connects surgical grade stainless steel tubes into the cylindrical guide. In this manner, surgical templates which seat directly on the bone and have metal sleeves which correspond to each fiture site, are generated .Two sets of surgical templates which contain different sleeve diameters which correspond to the incremental size of the osteotomy drill which is being used, are required. The precise depth, angulation, and mesiodistal and bucco-lingual positioning of each implant, as are planned during the computer simulation, are pre-programmed in the template. Windows on the buccal aspect allow access for external irrigation. Use in surgical procedures. The templates can be sterilised by using most common techniques without a loss of properties. These include low temperature steam and formaldehyde at 80ºC. The template itself has been fabricated from stereocol resin (Zeneca Specialties, Blackley, Manchester, UK), which is a photo-polymerised resin and it has been FDA approved to accurately guide the osteotomy drills.

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 S-L template, results in a precise fix without the need for an external fixation. Once the template is seated, the osteotomies are carried out. The configuration of the sleeves, as they relate to the drill, is such that there is only one direction for axial movement. Once the implants are placed, conventional protocol is followed, based on the implant system which is being used.

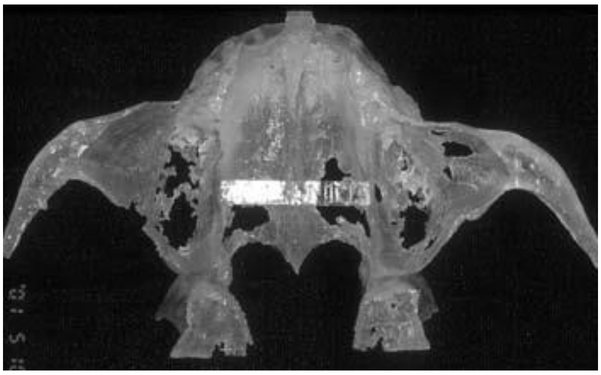


Fig 15: Stereolithographic model of the patient's maxillae.

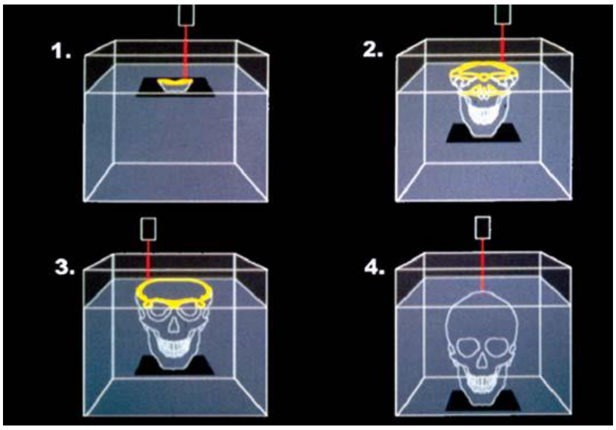


Fig 16: Principle of stereolithography (Medical Modeling Corp., Golden, CO).

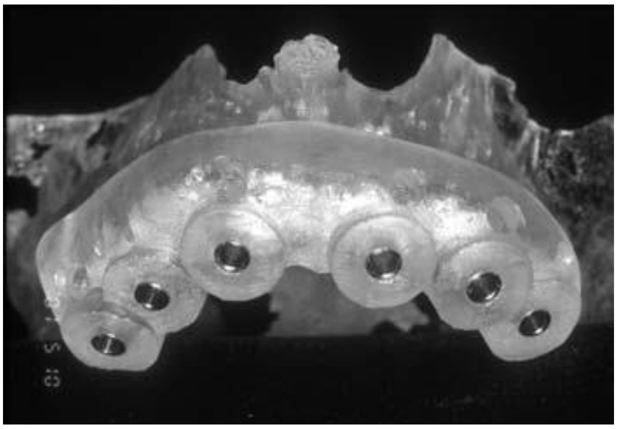


Fig 17: Stereolithographic model of the patient's maxillae with SL template. Metal sleeves of varying diameters accurately guide the osteotomy drill. The buccal aspect allow access for external irrigation.

CONCLUSION

In order to achieve a successful final treatment outcome, a position at least equivalent to the maximum deviation of the implant placement is necessary. This has been best achieved clinically with the help of a computer aided surgical guide. But compared to the conventional technique, limitation with computer-aided implant surgery requires substantially greater investment and effort. Based on clinical data, image guidance is not required for cases with sufficient anatomic orientation and bone height. Computer aided planning and image guided surgery can be carried out, when implant positioning is to be precisely executed, and when safe positioning of implants with optimal use of available bone, and whenever a CT scan is recommended as a diagnostic means.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

Widmann G, Bale RJ. Accuracy in computer-aided implant surgery: A review. Int J Oral Maxillofac Implants. 2006;21:305–13. [PubMed]

2. Takeshita F, Suetsugu T. Accurate presurgical determination for implant placement by using computerized tomography scan. J Prosthet Dent. 1996;76:590–1. [PubMed]

3. Pesun IJ, Gardner FM. Fabrication of a guide for radiographic evaluation and surgical placement of implants. J Prosthet Dent. 1995;73:548–52. [PubMed]

4. Marchack CB, Moy PK. The use of a custom template for immediate loading with the definitive prosthesis: A clinical report. J Calif Dent Assoc. 2003;31:925–9. [PubMed]

5. Chiu WK, Luk WK, Cheung LK. Three-dimensional accuracy of implant placement in a computer-assisted navigation system. Int J Oral Maxillofac Implants. 2006;21:465–70. [PubMed]

6. The glossary of prosthodontic terms. J Prosthet Dent. 2005;94:10–92. [PubMed]

7. Drill guides for every case scenario: SurgiGuide Cookbook. Available from: http://www.materialisedental.com/materialise/view/en/2395185 SurgiGuide+dental+drill+guide+Cookbook.html. [Cited on 2009 Jan 25]

8. Brief J, Edinger D, Hassfeld S, Eggers G. Accuracy of image-guided implantology. Clin Oral Implants Res. 2005;16:495–501. [PubMed]

9. Arfai NK, Kiat-Amnuay S. Radiographic and surgical guide for placement of multiple implants. J Prosthet Dent. 2007;97:310–2. [PubMed]

10. Meitner SW, Tallents RH. Surgical templates for prosthetically guided implant placement. J Prosthet Dent. 2004;92:569–74. [PubMed]

11. Solow RA. Simplified radiographic-surgical template for placement of multiple, parallel implants. J Prosthet Dent. 2001;85:26–9. [PubMed]

12. Lal K, White GS, Morea DN, Wright RF. Use of stereolithographic templates for surgical and prosthodontic implant planning and placement. Part I. The concept. J Prosthodont. 2006;15:51–8.[PubMed]

13. Lal K, White GS, Morea DN, Wright RF. Use of stereolithographic templates for surgical and prosthodontic implant planning and placement. Part II A clinical report. J Prosthodont. 2006;15:117–22.[PubMed]

14. Basten CH, Kois JC. The use of barium sulfate for implant templates. J Prosthet Dent. 1996;76:451–4.[PubMed]

15. Basten CH. The use of radiopaque templates for predictable implant placement. Quintessence Int. 1995;26:609–12. [PubMed]