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GUIDED IMPLANT SURGERY

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ABSTRACT

There has been a tremendous increase in the use of dental implants to replace missing teeth, in the last decade. This has led to a dramatic rise in the number of implant complications primarily misguided and incorrectly placed implants. This complication could be easily overcome by using surgical guides for implant positioning. Although conventionally made surgical guide are being used, the clinical outcome is often unpredictable, and even if the implants are well placed, the location and deviation of the implants may not meet the optimal prosthodontic requirements. High accuracy in planning and execution of surgical procedures is important in securing a high success rate without causing iatrogenic damage. This can be achieved by computed tomography, 3D implant planning software, image-guided template production techniques, and computer-aided surgery. This article evaluates about the various systems of conventionally made surgical guides using radiographs and also newer computer generated surgical guides in detail.

KEY WORDS: Computer-aided design/computer-assisted manufacture, computed tomography, implant, surgical guides.

INTRODUCTION:
Implant supported oral restorations have become an increasingly popular treatment option for partially edentulous and completely edentulous patients, also even in patients with severe bone loss and in locations which all previously not considered for implant placement has been made possible by means of bone augmentation, regeneration and soft tissue regeneration procedures.[1]

Earlier implants were place only in the area with greatest amount of bone, regardless to placement of final definitive restoration. Result being, the placement of implant was not as accurate as intended. Even a minor variation caused difficulties in fabrication of final prostheses.[2]

Lack of consideration of the anatomical structure during pre-surgical phase was found to result in failure. Accurate placement of implant is required to achieve the best functional and aesthetic result. This can be effectively 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.[3]

Surgical Template:
Glossary of prosthodontic terms (Gpt), defines surgical template as a guide used to assist in proper surgical placement and angulation of dental implants.[4] It enables prediction and minimal invasive surgery. 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. Customized conventional radiographic or computer image guided surgical templates have become a treatment of choice.

A surgical guide consists of two components: The guiding cylinders and the contact surface. The contact surface fits either on an element of a patient's gums or on the patient's jaw (i.e., the bone, the teeth). Cylinders within the drill guides helps in transferring the drill in the exact location and orientation.[5] The implant must be placed such that firstly the bottom and sides are covered fully by bone or bone-replacement material. Care should be taken of not damaging any neighbouring anatomic structures. These are in particular the mandibular nerve in case of mandible and the schneiderian membrane of the maxillary sinus in maxilla and also the roots of adjacent teeth. Thirdly, position of the implant has to be compatible with the intended final prosthodontic restoration.[6]

Customized Conventional Radiographic Surgical Template:
The surgical template makes use of a conventional radiographic method, and requires a thorough radiographic examination and proper diagnosis of the bony. Panoramic radiography is still the standard for planning of implants. However, precise measuring of the bone architecture is impossible, because OPG's have a magnification factor that is not always uniform. Therefore, a better assessment of the bone dimensions in panoramic radiographs is by determination of the magnification factor (Mupparapu and Singer 2004).[7]

Conventional dental panoramic radiography and plain film radiography are usually performed with the patient wearing a radiographic template with integrated metal spheres or rods, sleeves, guide posts at the position of the wax up. Based on the magnification factor and the known dimensions of the metal, the depth and dimensions of the implants are planned. The implant placement planning is guided by quality and quantity of bone, as well as the position of the teeth for esthetics and phonetics.

Fabrication Process:
Several types of surgical guides have been reported in the literature. Some are designed for placement of a single implant, while other reports present designs for implant fixed partial dentures, multiple single implants, and implant-retained overdentures. Some of the most commonly used techniques are mentioned briefly here.

Diagnostic casts of the dental arches are made from irreversible hydrocolloid impressions. A diagnostic wax up of the proposed case of an implant supported FPD is done. A silicone impression of the cast with the waxed FPD is made as a mold. A clear, chemically activated acrylic resin is poured into the mold space and cured. Access holes are made according to information obtained from the cast model for initial surgical drill. Stainless steel guide sleeves of uniform length are cut and placed in access holes and cured.[8]

Another method to prepare a radiographic guide is from vacuum formed templates. After the diagnostic wax up of the final restoration is completed, duplication is made and a cast is poured. The vacuum formed template fabricated is placed over the cast and the edentulous space is filled with radio opaque material (Barium sulphate, lead strip, gutta percha).[9]

In another method, the two vacuum formed templates are used, one over the blocked out diagnostic cast and the other over the duplicate cast of the diagnostic wax up with a clear plastic sheet is made. Both the templates are returned to the unaltered diagnostic cast. The edges of the two templates are trimmed to make them coincident. The diagnostic wax template is removed and filled with clear orthodontic resin or radio opaque material. The filled template is placed over the template of the unaltered diagnostic cast. Holes are made according to information obtained from the radiograph for placement of implants, followed by placement of drill guides.

The milling technique is an accurate technique in which it employs parallel holes in the surgical guide. This technique needs the aid of a conventional dental surveyor. All the conventional made radiographic guides can be converted to an

accurate surgical guide by means of this milling technique. Limitation in this technique is, it requires special equipment which is not commonly available in private dental practices. In addition, the practitioner needs a certain amount of experience and knowledge to operate this machine properly.[10]

However, panoramic radiography which is still the standard and widely used, has diagnostic limitations, such as expansion and distortion, setting error, positional artifacts and there is no information regarding the dimension of bone in bucco-lingual direction. Further these surgical templates are fabricated on dental casts, which is a rigid, non-functional surface without the knowledge of underlying soft tissue resiliency and bone topography. Anatomical landmarks are not precisely located, it does not show the lingual blood vessels, and approach is always two dimensional. So thereby more chances of malpositioning the implants during placement, resulting in less stability during surgery. The success of the final outcome always depends on clinician skill requires more chair time, leading to stress on the dentist and patient. Although conventional surgical templates will allow the placement of implant guiding, they do not provide exact 3D guidance.[1]

Computer generated surgical template:
To overcome the limitations associated with conventional radiographic surgical template, computer generated surgical template have evolved.[1] A computer generated surgical guide provides a link between our treatment plan and the actual surgery by transferring the simulated plan accurately to surgical site. This surgical guide is made using the stereolithography process and is custom manufactured for each patient.

Stereolithography, a rapid prototyping technology, a newer outcome in dentistry allows the fabrication of surgical guides from 3D computer generated models for precise placement of the implants. The surgical templates fabricated by this technology are pre-programmed with Individual depth, angulations, mesio-distal and labiolingual positioning of the implant to be placed.[9]

Fabrication of stereolithographic templates requires patient's computed tomography (CT) image. In CT, multi planar reformatting allows one to reformat a volumetric dataset in sagittal, axial, and coronal cuts and also helps in building multiple cross-sectional and panoramic views. Shaded surface display and volume rendering methods generate 3D reconstructions of the entire dental arch and their relevant structures, including nerves, which makes dental CT the most precise and comprehensive radiologic technique for dental implant planning. Software's specially planned has been adapted to allow practitioners to virtually view the implant site and plan location, angle, depth, and diameter of virtual implants, which are superimposed on the 3D data. Following backward planning, the diagnostic wax up has to be visualized through CT scan with radiographic templates in place.[1]

Procedures in fabrication of stereolithographic templates:
1. Radiographic template
2. CT scan procedure
3. 3D computer simulation
4. Fabrication of surgical templates

A radiographic template fabricated using radio opaque marker is kept in patient mouth while performing CT scan procedure.[10]

During the scan, this indicates the position of the teeth and gingival tissues. During fabrication, a diagnostic wax up is established, representing the outline of the final restoration, and is then transferred into a radiographic guide.[9]

Diagnostic casts of the dental arches are made from irreversible hydrocolloid impressions. A diagnostic wax up of the proposed definitive restoration (in case of an implant supported FPD) is done. A silicone impression of the cast with the waxed FPD is made as a mold. After retrieving the silicone impression, the waxed FPD is removed and in case if the implant site is of full arch, a duplicate of a denture is made so that a radiographic stent can be made from it. A clear, chemically activated acrylic resin is poured into the mold space and cured.[11] As an alternate, a duplicate cast is made in Type IV dental stone and a radiographic template is made using vacuum formed matrix or barium sulfate as the radio-opaque marker. Access holes are made according to information obtained from the cast model, as in case of conventional radiographic guide.

If the patient is a new denture wearer, complete denture wax up is done to establish the setup of denture teeth with phonetics, esthetics and proper vertical dimension of occlusion. The fabrication of an ideal denture is necessary, to avoid varied dimensions that plays a primary controlling factor in minimizing deviated angulations.[11]

The radiographic template, thus fabricated act as an exact replica of desired prosthetic end result, and are usually supported with different radiopaque markers such as gutta percha balls, sleeves, disks and tubes, radiopaque varnishes or lead strip or foil. Some authors prefer metal pins for better accuracy.[11] In order to stabilize the template, the patient can be instructed to use denture adhesive during the scanning procedure. In case, if it is a completely edentulous condition, six to eight radiopaque markers are placed into the guide. A bite index is created to ensure a correct positioning of the radiographic guide in the patient's mouth during scanning.

The understanding of underlying bony architecture and anatomic structures are prerequisites for appropriate implant planning. In general, the quality of CT data depends on the slice thickness and the influence of possible artifacts. The thinner the slice thickness and the smaller the voxel size, the higher the resolution and accuracy of measurements of delineated structures. Movement and metallic artifacts of some dental restorations may lead to geometric distortion and an invalid acquisition.[1]

To summarize stereolithography fabrication process.
1. A CT scan procedure is performed with a radiographic template fabricated using radio opaque marker in place.

2. Data obtained from CT scan procedure is either sent to master site of a particular software company or dentist can view the virtual 3D model from different angles using the software to customize the treatment plan.

3. The final proposed treatment plan is sent to SLA that scans the image and fabricates the template.

Double scan protocol:
For artifact free, high resolution digitization of the radiographic guide, some authors have developed a specific double-scan technique. In this technique, the first scan is a scan of the patient wearing the radiographic guide. The second scan is a scan of only the radiographic guide. Based on the spherical markers visible in both scans, the scans are superimposed onto each other, resulting in a 3D bone model of the patient together with a 3D model of the radiographic guide.[12]

The combination of a 3D bone model, including the 3D radiological dataset and the 3D radiographic guide model, enables the clinician to place implant locations according to anatomical, functional and esthetics needs and demands. In order to achieve this, the clinician virtually positions the implants, with the optimal length and diameter. Any of the modifications in 3D location and implant type, size or shape can be done in the 3D setting or in the reslice viewer. After finalizing the planning, the corresponding surgical template is designed. The surgical template thus fabricated contains all the necessary planning information-It is customized according to location, type and size of the planned implants.

Making a computer aided template:
CAD-CAM is a rapid prototyping technique wherein after the generation of a 3D treatment plan, software slices from the file is sent to a machine that fabricates the part slice by slice. Two main methods of rapid proto typing are[13] 1. Additive – widely used 2. Subtractive – less effective.

Stereolithographic apparatus consists of a vat, which contains a liquid photo polymerized resin. Corresponding to slice intervals, a laser that is mounted on top of vat moves in sequential cross sectional of 1 mm increments, to produce a template. Polymerization process of photo polymerized resin occurs in layers. Once, the surface layer of the resin on laser contact gets polymerized, a mechanical table immediately below the surface layer moves down 1 mm, carrying with it the previously polymerized resin layer. The laser now polymerizes the next layer over the previously polymerized layer of the model. In stereolithography Apparatus (SLA) only 80% of the total polymerization is completed in the vat, whereas the remaining 20% can be completed in a conventional ultraviolet light curing unit.[9]

The so produced surgical template is provided with surgical grade stainless steel tubes with sleeves that are 5 mm in height, 0.2 mm wider than osteotomy, and also with drill limiting angulation deviation to 5°. Buccal window is made so that it enhances retention during surgery. Usually, three 2 mm holes are placed into the buccal surface of each side of the denture.[12]

Advantages:
1. More precise placement of implants.
2. Preservation of integrity of anatomic structures.
3. High geometrical accuracy of 0.1 mm.
4. Shorter treatment times, surgery times.
5. Less invasive, flapless surgery and therefore less chance of swelling.
6. Less post-operative strain on dentist and patient.
7. Transparency of material which allows seeing through the model.

Disadvantages:
- Lack of visibility and tactile control during surgical procedure.
- Insufficient mouth opening jeopardizes surgical procedure.
- A risk of damage to vital anatomical structures.

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. However, compared to the conventional technique, limitations with

computer-aided implant surgery included substantially greater investment and effort. Based on clinical data, image guidance may not be required for cases with sufficient anatomic orientation and bone height. Computer aided planning and image guided surgery with templates/guides can be carried out, when implant positioning is to be precisely executed, and when safe positioning of implants with optimal use of available bone, is desired.

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