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Precision Redefined: A Narrative Review of Implant Guiding System

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ABSTRACT

The implantation of dental implants is one of the most famous choices for patients who are missing teeth. Dental implants are becoming increasingly common, so it is crucial to place them precisely to prevent them from failing. Surgical guides are essential for transferring the digitally planned treatment regimen to the actual surgical sites and for achieving accuracy during implant planning and placement. Surgical guides for implants are defined and discussed in this article, along with their functions, types, and benefits.

Introduction:

As the global population ages, more and more people are experiencing tooth loss. A person's dietary status and mental health are badly affected by the stigma of a lifelong impairment until they undergo prosthetic rehabilitation.[1] Dental implants, which can mimic the appearance and feel of real teeth, are a sturdy and aesthetically pleasing alternative to dentures and bridges. Unfortunately, there are costs associated with implant placement that might arise from incorrect diagnosis, a lack of planning, and the use of the improper surgical technique. Using surgical

templates for placing implants is a common and effective way to control these issues.[2] Glossary of prosthodontic terms (GPT 10), defines a surgical guide as: "1. any device used as a guide for surgically shaping the alveolar process or positioning of gingival tissues; 2. a guide used to assist in proper surgical placement and angulation of dental implants; 3. a guide used to assist in establishing the desired occlusion during orthognathic or grafting surgery."[3]

Components for Surgical Guides: The guiding cylinders and contact surface form a surgical stent. The contacting surface adjusts to fit the patient's tooth or osseous region, depending on whether they are missing teeth or have some teeth. By directing the osteotomy drills, the guiding drills' internal cylinders help translate the intended scheme into exact coordinates and angle. [2]

Function of Surgical Guides: With the help of surgical guides, the computerised implant plan is correctly sent to the operating field. Better patient outcomes, a higher implant survival rate, and fewer invasive operations are all possible thanks to its use, in addition to shorter implant surgical times and increased precision.[2,4]

Importance of surgical guides: Surgical guides are crucial in oral implantology due to a number of reasons. Some of the most important reasons why it is crucial in implant surgery are:[5]

1. Accuracy and Precision: Surgical guides provide an enhanced level of accuracy and precision when placing the implants. They are planned using digital treatment planning by taking into consideration the patient's anatomy, intended prosthetic result, and optimal implant positioning. By employing a surgical guide, the surgeon is able to adhere to a preplanned pathway and angulation, thus achieving the precise implant placement sites as planned.[6]

2. Enhanced Safety: Using surgical guides makes implant surgery safer. Guides lessen the likelihood of harm coming to critical structures like nerves, blood vessels, or neighbouring teeth by directing the drilling tools and controlling the angle and depth of the implant placement. This makes the operation safer and reduces the likelihood of problems.

3. Increased efficiency: Implant placement is made easier and faster with the help of surgical guides. Using a guide, the surgeon is able to perform faster and more accurate work, hence cutting down on the overall operating time. It is particularly advantageous in the case of complex treatments or multiple placements since it

allows for efficient and predictable delivery of the treatment protocol.

4. Improved Aesthetics and Prosthetic Results: The use of surgical guides allows the optimal aesthetic results in implant dentistry. With precise placement of the implants concerning the final prosthetic outcome, guides allow for right alignment, emergence profile, and perfect soft tissue contours. This helps in creating esthetic-looking and harmonious restorations.[7]

5. Consistency and Predictability: Surgical guides provide a higher level of predictability and consistency in implant positioning. They reduce the dependence on manual judgment during surgery and present a standardized procedure based on the preplanned treatment. This results in more predictable results, reducing the possibility of errors or deviations from the planned implant position.

6. Patient Communication and Understanding: Patient communication and understanding can be enhanced by surgical guides. Patients can understand the treatment process and desired outcomes better by seeing the planned positions of the implants and by exhibiting the surgical guide. This improves patient satisfaction, confidence, and cooperation during the treatment process.

Applications of Surgical Guides:

1. Direction of the implant fixtures and osteotomy drills at the correct depth, place, and inclination.
2. Hints on the quantity of bone to be reduced or soft and hard tissue harvesting if necessary.
3. Used for improvement in planning and visualization of the finished prosthetic outcome, increasing procedure predictability.
4. Used as an effective teaching tool for dental professionals and students, offering a hands-on and visual aid for learning exact implant placement techniques
5. Offering a clear roadmap for the procedure and drastically reducing the time required for surgery, improving efficiency for the surgeon and the patient.[8,9]

Advantages of Surgical Guides: Using surgical guides increases the precision of implant surgery, decreasing manual errors, implant surgery time, and post-operative surgical problems. It provides a minimally invasive procedure, flapless surgery, leading to the preservation of anatomic structures, less chance of swelling, safety of surgery, and offers the patients and clinicians with psychological benefit.[2,4,8,10,11]

Disadvantages of Surgical Guides: Fabrication of surgical guides is itself a

time-consuming process asking for an additional cost. The biggest disadvantage is its non-fitting while doing surgery if there is a change in the soft or hard tissue around it (inflammation around tooth or on soft tissue, loss of adjacent tooth). The occurrence concerning dislocation or fraction of the surgical guides during surgery due to insufficient stabilization is common. Using surgical guides may sometimes reduce the haptic control and clarity of vision while performing the implant surgery, and it poses a huge challenge in patients with insufficient mouth opening.[8,10,11,12]

The Requirements of Surgical Guides:

- When placed in the right location, the guide should be stable and rigid.
- It shouldn't obscure nearby surgical landmarks or be bulky and challenging to insert.
- When placing implants or performing bone grafts, the operative field must not be contaminated by it.
- It must be transparent. Thus, with the template in situ, it is easier to see the bony ridge and drilling.
- A template must allow for several surgeries and re-sterilization.
- Surgical asepsis, transparency, dimensions, and the template revision capability are some other ideal requirements of surgical guides.[11,13,14]

Extension of surgical guides: The template should adapt properly on and around teeth for proper stabilization while positioning the guide stent if there are still teeth in the treated arch. If there are no remaining teeth, than guide should extend till the hard palate, maxillary tuberosities, or mandibular retromolar pads. Accordingly, the template/guide can be employed during post-soft tissue reflection from implant surgical site and preparation of osteotomy implant.[15]

Various types of surgical guides: Surgical guides have multiple forms, depending on the level of precision and adaptability required based on the clinical situation. The main types are enumerated as follows: [2,8,11,12,15]

1. **Based on the area of operation:**
    - Guides for partially edentulous sites (depending on the amount of the edentulous space)
        - tooth supported
        - bone supported

- Guides for completely edentulous sites
  - mucosa supported
  - bone supported

2. **Based on the support derived by the surgical guides:**
   - Tooth supported,
   - Bone supported, and
   - Mucosa supported
3. **Based on the accessibility:**
   - Open sleeve
   - Closed sleeve (increased accessibility)
4. **Based on utility:**
   - Pilot guides- The sleeves only allow pilot drills
   - Complete drill guides- Use drill keys or sleeves. Different sleeves for different diameters of drills, which are changed concomitantly as osteotomy is widened.
   - Safe guides/easy guides- Allow both osteotomy preparations with surgical drills and installation of implants.
5. **Based on material:**
   - Self/light cure acrylic resin,
   - Metal-reinforced acrylic templates;
   - Vacuum-formed polymers,
   - Milling,
   - CAD-CAM prosthesis,
   - Stereo-lithographic models.
6. **Based on technique of fabrication:**
   - Conventional freehand,
   - Milling,
   - Computer-aided design/ computer-assisted manufacture (CAD-CAM)
7. **Dynamic and Static:**

- While dynamic systems do not provide as much accuracy as static ones, they do allow for real-time visualisation during surgical procedures. Using them requires a lot of effort, money, and room.

- Due to their template-based design, static systems are very accurate in clinical settings. The 3-D printing process uses digital pictures from a CBCT or intraoral scanner to create them. Bone, mucosa, or teeth can support it.

8. **Based on the amount of surgical restriction offered by the surgical guide templates:**
   - Non-limiting design
   - Partially limiting design
   - Completely limiting design

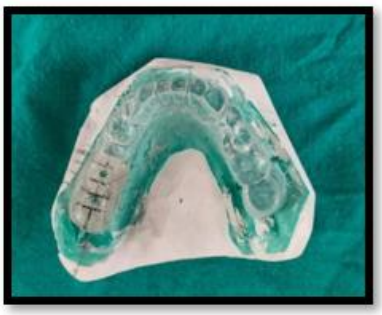

Fig. 1: Non-limiting design

Fig. 2: Partially limiting design

Fig.3: Completely limiting design

Conventional surgical guides:

Conventional surgical guides are fabricated without advanced digital aids by manual planning using basic materials like acrylic or similar materials. They are often fabricated based on diagnostic wax-ups or stone models using different radiopaque markers. Some standard techniques for the construction of surgical templates are highlighted here.

1. After making the impression with alginate, diagnostic cast was made and diagnostic wax-up was done to identify the placement of implant position. Once wax-up is done, silicone mold was fabricated on this cast and it was poured with clear self-cure acrylic. After it dets, drills were made at the intended positions and stainless-steel guide sleeves of implant drill size were inserted and cured again using the self-cure acrylic.[2]
2. Another technique is the use of vacuum-formed templates to make the radiographic template. A duplicate cast is made from the final restoration of the diagnostic wax-up. The cast is then covered with the vacuum-formed template, and a radiopaque material is filled into the

edentulous space. The different types of radiopaque markers used are light-activated calcium hydroxide, barium sulfate, gutta-percha, lead strip, metallic spheres, baseline, coloured chalk powder mixed with dual-cure composite resin, brass wire, a mixture of barium and varnish, aluminium tubes, silicone, etc.[13,16-27]

3. Another technique uses a pair of clear vacuum-formed plastic sheet templates. Two templates are made: one over the blocked-out diagnostic cast and the other over the diagnostic wax-up of the copy cast. The original diagnostic cast is used to reposition both templates. We trim the edges of the two templates to make sure they line up perfectly. After the diagnostic wax-up cast's template is removed, it is filled with either a radio-opaque substance or a transparent orthodontic resin. Then, the mould is adjusted over the mould. After the radiograph data is used to determine where the implants will be placed, drill guides are positioned according to the holes that will be drilled.[2,19]

Computer-generated surgical guides: Computer-generated surgical templates have been developed in order to get beyond the drawbacks of traditional radiography surgical templates.[8] These guides are planned using different specific software programs like Artma Virtual Implant™ (VISIT®), coDiagnostiX®, Easy Guide, Implant Logics™, ImplantMaster™, Med 3D®, NaviGuide System® (RoboDent GmbH), Procera Software®, Simplant®, SurgiCase ®, etc., and manufactured using computer-controlled fabrication systems.[28] Afterwards, the guides are produced using stereolithography, a rapid prototyping technology, and computer-aided design/computer-assisted manufacturing (CAD/CAM).[11]

To plan the implant surgeries data from the CT scan was used by the CAD-CAM technology.[29] In this step, the CT scan is transformed into a format that the CT imaging and planning software can recognise. Then, the stereo-lithographic drill is used to transmit the picture to the surgical site.[11,20,21]

The 3D designs made in the computer are made into real templates by a newer prototyping technology called Stereolithography.[11,31] A laser positioned above the SLA vat polymerises the liquid photo-polymerizing resin in increments of 1 mm. In a vertical pattern of 1 mm intervals, polymerisation happens as the laser travels. As it descends 1 mm, a mechanical table just below the surface carries each resin that has been polymerised

earlier. During the CT formatting procedure, the polymerization of the resin occurs in increments and in a similar interval of time.[32] Thus, the process involved in SLA is fully pre- programmed with the inclusion of measurements regarding mesio-distal, bucco- lingual, depth and angulations of the implant to be placed.[11]

Current technologies: The idea of computer-assisted implant surgery (CAIS) was brought about by advancements in planning software and prototyping techniques. CAIS encompasses digital pre-surgical planning and guided surgical operations. Computer-assisted implant surgery (CAIS) can be categorised into two main types: static CAIS and dynamic DCAIS.[30] In SCAIS, the dentist uses a template to check the depth and angle of the implant osteotomy site. This improves the treatment's prognosis in the long run. In order to increase the accuracy of implant placement while minimising harm to important anatomical structures such as the maxillary sinus, the inferior alveolar nerve, etc., DCAIS employs dynamic navigation technology during implant placement operations. By allowing the dentist to dynamically alter implant placement during surgery, DCAIS mitigates or eliminates most of SCAIS's drawbacks.[12,33]

One recent development is the use of surgical robots to place implants. The first commercially available, FDA-approved dental implant surgical robot was developed in 2017 and is known as YOMI. It was a semi-autonomous robotic system that could drill and install implants without human intervention.[33,34]

Conclusion: With advancements in surgical reconstructive procedures and increased demands for prosthetics, precise diagnosis, planning, and placement are critical.[11] With the provision of accurate pre-surgical planning and real-time guidance, implant guiding systems enhance implant placement accuracy, efficiency, speed, and safety. The use of implant guides reduces patient discomfort, optimises prosthesis outcomes, and decreases surgical errors. These procedures continue to be essential in achieving a successful and predictable implant rehabilitation as technology evolves. Dentists must make use and maximize the advantage of surgical templates to achieve optimal implant surgery success rate.

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