IMPLANT SURGICAL GUIDES ARE THEY USEFUL?

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Abstract:
One of the most common errors causing implant failure or prosthetic failure is the improper positioning of the implants. The innovation of the implant surgical guide provides an extra step of safety to the surgery and also prosthetic planning before the placement of the implant helps in designing a more precise guide. This also allows in assessing the bone or soft tissue augmentation needs.

Historically there are three main types of surgical guide designs
1) Non-guided
2) Partially guided
3) Fully guided

The non guided design concept is rarely used nowadays due to the inherent inaccuracies involved in the fabrication and great potential for errors.

Partially Guided
This concept means the initial pilot drill is guided using the surgical template and then the rest of the sequential drilling is done by the surgeon freehand following the pilot drill osteotomy. This has significantly better accuracy than the non guided concept but still the chances of error as the sequential drilling is done is still possible. The various techniques used is mentioned in the following tables (table 1-4)

The Fully Guided
This concept means the full sequential drills

Key words:
Implant surgery, surgical stents

Most of the current studies available show good survival rates for dental implants. However there are equal number of studies which show complications and errors too. One of the most common errors causing implant failure or prosthetic failure is the improper positioning of the implants. A secondary but equally as serious an error is impinging on anatomical structures like the inferior alveolar nerve or the maxillary sinus. Damaging for example the lingual artery can lead to a life threatening emergency.

How can the implant surgeon avoid such errors and be safe and keep the patients safe? Training and experience plays a big role in the expertise of the implant surgeon and the safety of the procedure.

The innovation of the implant surgical guide provides an extra step of safety to the surgery and also prosthetic planning before the placement of the implant helps in designing a more precise guide. This also allows in assessing the bone or soft tissue augmentation needs.
and the angulation of the drills are guided so theoretically the chances of error are low. However it should be made clear that improper design or lack of experience cannot be avoided by using a fully guided surgical template. The surgeon should have adequate training and ability to recognise errors in surgical guide design and be able to place the implant freehand based on knowledge of anatomical structures and not solely dependent on the surgical guide.

The fully guided concept can be broadly classified into 1) Cast based guide 2) CAD CAM/3D printed guides.

The cast based guide was the ones made before CAD-CAM/3d printing became popular. This involved bone mapping and using periapical radiographs with grids and using digital software to superimpose the root structures onto the cast, the cast is then sectioned at the implant site and the bone mapping measurements are then transferred over to the cast. This is then utilised to aid in performing a cast osteotomy. A lab analog is placed in the cast osteotomy site and a suitable drill sleeve consistent with the implant site is then chosen and waxed up for the surgical template.

The CAD-CAM/3d print based surgical guide is constructed using data from a Computed Tomography or CT data in the early days and Cone Beam CT currently. The advantage of this technique is the CT data is converted into data that can be recognised by CT imaging and planning software. This also allows visual representation of

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**Step 1 – Scan Patient**

**Step 2 – generate STL model either by optical scan, impression inversion or CBCT scan of the impression or model**

**Step 3- stitch the model and the scan data of patient using common points**

**Step 4- outline the surgical guide extension**
the anatomy, matching the diagnostic waxup and assessing the osseous and soft tissue requirements. This also helps the biomechanics and moment calculation of the proposed prosthesis.

However even the CAD-CAM guides are not infallible, some of the complications that has been observed 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.

The classical protocol for fabricating the fully guided surgical template has four main steps, however there are now variations to each of these steps but it is not in the scope of this articles to go into detail on the variations.

The four main steps are

1) Fabrication of the radiographic stent.
2) The CBCT scan
3) Prosthetic and Implant planning using digital interactive software
4) Fabrication of the stereolithographic guide

The radiographic stent is usually the diagnostic wax up constructed for accuracy of the future planned prosthetics. This template is then used to aid in the tomography and using a coordinate system is superimposed on the CBCT data of the patient. This is then used by the 3D interactive software to do the virtual surgery for placing the implants and then the data required for the surgical template is generated.

The surgical template data is then sent to the stereolithographic machines and either milled or printed based on the availability of a CAD-CAM milling machine or a stereolithographic printer where a laser will activate and cure liquid resin to form the surgical template. Suitable guide tubes are then placed into the printed or milled guide matching the sequential drills and the depth stops to prevent the over insertion of the drills are incorporated into the surgical guide.

One of the current software packages available which allows detailed planning but in very simple steps and not with a big learning curve is BlueSky Plan (BlueSky Bio, USA) the following is a simplified workflow screen capture from the software.

Conclusion

There is no doubt that a well designed surgical guide can aid in the safe insertion of the dental implants. However it is not a substitute for adequate training and knowledge of anatomy.

References

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<td>Engelman et al.</td>
<td>Auto polymerizing acrylic resin</td>
<td>Metal bearings</td>
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<td>Remove lingual surface, leaving only facial surface of the teeth in the proposed implant site</td>
<td>Inexpensive, easy, improved visibility, external irrigation</td>
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<td>Adian et al.</td>
<td>Auto polymerizing acrylic resin</td>
<td>Lead foil over the maxillary and mandibular incisors, left mandibular occlusal plane, intaglio surface of mandibular trial denture</td>
<td>Lateral cephalography</td>
<td>Determine implant trajectory and location using radiopaque images; use cephalometric tracing paper, protractor, and surveyor to reproduce these data in a resin plane joining maxilla and mandible</td>
<td>Guides implant position and trajectory, serves as a bite-block, retracts the tongue and flap, allows sterile field, lessens chance of titanium contamination</td>
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<td>Tarlow</td>
<td>Acrylic resin duplicate denture; vacuum-formed thermoplastic matrix (0.02 inch) adapted over duplicate denture</td>
<td>Dual-curing composite resin mixed with colored chalk</td>
<td>CT</td>
<td>Remove anterior lingual portion of matrix; remove anterior labial portion of duplicate denture</td>
<td>Indicated in anterior edentulous mandible; matrix dictates implant location and angulation, with minimal interference to surgical access</td>
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<td>Espinosa Marino et al.</td>
<td>Heat polymerizing acrylic resin</td>
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<td>Stellino et al.</td>
<td>Acrylic resin provisional FPD</td>
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<td>Pesun and Gardner</td>
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<td>Reduce vertical height of the guide; remove gutta-percha</td>
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<td>Takeshita et al.</td>
<td>Denture base: auto polymerizing acrylic resin; teeth: mix powder consisting of 4:1 ratio of resin polymer and barium sulfate with monomer</td>
<td>Stainless steel tubes</td>
<td>Panoramic radiography, CT</td>
<td>Remove tube sprues</td>
<td>Barium sulfate depicts outline of the predesigned superstructure; stainless steel tubes represent location and inclination of the intended implant placement</td>
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<td>Sicilia et al.</td>
<td>Orthodontic wires and auto polymerizing acrylic resin</td>
<td>Contrast blocks, gutta-percha blocks</td>
<td>CT</td>
<td>Using wire, create 2 profiles of the missing teeth – occlusal and gingival Join these to acrylic resin block to make template solid and add self-retaining feature Profiles mark the vestibular and mesiodistal limit of the teeth; the profile replaces buccal surface of the template</td>
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<td>Minoretti et al.</td>
<td>Vacuum-formed thermoplastic matrix or auto polymerizing acrylic resin</td>
<td>Guide sleeve</td>
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<td>Insert Kirschner wires through mucosa/bone using dental handpiece; fit guidance cylinders fitting trephine drill ($\phi = 3.5$ mm, MI Dental Implant system) to the guide wire Indicated in completely edentulous patient or in augmented alveolar ridges where template position after flap reflection is difficult Improves precision of implant placement – improving guidance during drilling process</td>
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<td>Ku and Shen</td>
<td>Vacuum-formed thermoplastic matrix filled with auto polymerizing resin acrylic resin</td>
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<td>Remove marker with carbide bur Single implant therapy or short-span implant-supported prostheses</td>
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<td>Becker and Kaiser</td>
<td>Vacuum-formed thermoplastic matrix (0.020 inch) and orthodontic resin</td>
<td>$\frac{3}{16}$ and $\frac{5}{16}$ inch brass tubes</td>
<td></td>
<td>Attach $\frac{3}{16}$ inch tube to the template $\frac{5}{16}$ inch tube guides the pilot drill Precise surgical guide resulting in a functional and esthetically pleasing restoration</td>
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<td>Cehrelli et al.</td>
<td>Vacuum-formed thermoplastic matrix (2.0 x 125 mm)</td>
<td>Pins (1 mm diameter)</td>
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<td>Fabricate 2 acrylic templates covering only residual ridges with guide channels of 2 diameters inner lamina: remove foil covering edentulous ridges, secure bur ends bilaterally – guides insertion of removable surgical acrylic resin template; outer lamina: remove palatal portion, prepare occlusal holes Posterior maxillary region with poor bone density; outer lamina contains radiopaque markers for radiographic evaluation and verify alignment of implants; inner lamina accepts 2 removable surgical guides bilaterally</td>
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<td>Almog et al.</td>
<td>Custom tray material/auto polymerizing resin with vacuum-formed thermoplastic matrix (0.02 inch)</td>
<td>Lead strip (2 mm) vertically on the lingual/palatal wall of the buccal access groove</td>
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<td>Remove lead strip Surgical ostectomy but more error in the buccolingual placement</td>
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<td>Almog et al(^{12}) Gutta-percha guide (Figure 4)</td>
<td>Custom tray material/auto polymerizing resin with vacuum-formed thermoplastic matrix (0.02 inch)</td>
<td>Gutta-percha</td>
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<td>Auto polymerizing acrylic resin</td>
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<td>Used when CT is not required for evaluation of buccolingual angulation of available bone</td>
<td>Indicated in posterior edentulous mandible; reference axis on the perpendicular plane guides mesiodistal implant angulation; retracts the mucoperiosteal flap linguually improves site visualization</td>
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<td>McArdle(^{16})</td>
<td>Vacuum-formed thermoplastic matrix, light cured restorative material</td>
<td></td>
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<td>Construct 4-mm thick flat horizontal plane; construct perpendicular resin plane on lingual side of the flat plane; prepare guide channels; transfer mesiodistal reference axis to the perpendicular part</td>
<td>Single tooth implant-supported restorations; flexible material</td>
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<td>Koyanagi(^{17}) (Figure 6)</td>
<td>Auto polymerizing acrylic resin</td>
<td>Orthodontic wire, stainless steel ball, gutta-percha point</td>
<td>Conventional tomography</td>
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<td>Template guides the head of the contra-angle handpiece, preventing the drill from contacting the template; allows objective assessment and determination of implant location, inclination, and depth for individual treatment cases</td>
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<td>Kopp et al(^{18}) (Figure 7)</td>
<td>Auto polymerizing acrylic resin</td>
<td>Barium sulfate liquid coat, thin orthodontic wire (0.014-0.016 mm) glued to the buccal aspect</td>
<td>CT</td>
<td>Modify surveyor table using a protractor Secure 22-mm diameter milled cylinders in the template</td>
<td>Cylinders guide pilot drill Buccal guide wire guides all future drills in the buccolingual and mesiodistal direction</td>
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<td>Tsuchida et al(^{19}) (Figure 8)</td>
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<td>Silicone impression material</td>
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<td>Silicone markers: clear radiopaque markers that do not create artifacts in CT scanning</td>
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<td>Windhorn*</td>
<td>Light polymerizing custom tray material</td>
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<td>Use wooden stick as reference for molding resin around handpiece head</td>
<td>Wooden stick simulate implant location and angulation 2-piece implant placement guide</td>
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<td>Al-Harbi and Verrett*</td>
<td>Auto polymerizing acrylic resin</td>
<td>CT of arch prior to extraction; treatment planning using SimPlant software</td>
<td></td>
<td>Transfer planning data to surgical guide using milling machine; trim occlusal surface and buccal flanges; maintain 5-mm coronal-apical thickness of resin</td>
<td>For immediate implant placement following complete arch odontectomy; stable guide following staged tooth extraction</td>
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<td>Afrai and Kiat-Amnuay*</td>
<td>Auto polymerizing acrylic resin</td>
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<td>Wat et al*</td>
<td>Auto polymerizing acrylic resin mixed with barium sulfate (ratio of 4:1)</td>
<td>Barium sulfate cylindrical channels drilled at proposed implant sites in radiographic template</td>
<td>CT</td>
<td>Remove nonsalvageable teeth to modify guide; place guide on the mounted cast; connect to the record base fabricated on the opposing arch, using embedded stainless rods and tubes</td>
<td>Convenient, economical, less traumatic, stable for edentulous arch opposing a partially edentulous arch, compatible with all implant systems</td>
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<td>Oh and Saglik*</td>
<td>Auto polymerizing acrylic resin (DRPD); attach vacuum-forming thermoplastic matrix (1 mm) to the DRPD using acrylic resin</td>
<td>Stainless steel or titanium cylinders</td>
<td>Panoramic and periapical radiography, lateral cephalography, CT</td>
<td>Cylindrical marker guides the pilot drill</td>
<td>Thermoplastic sheet engages the remaining dentition, assists in an accurate orientation, and maintains the DRPD to serve as a surgical template; permits stable intraoral placement of denture for successful implant placement</td>
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