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Review Article

Advantages of the T.A.C Protocol for the Preparation of Precision Surgical Guides in Implantology

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Abstract

The present article describes the TSC Protocol (tubes, support, connectors) for construction of surgical guides for implant placement, its fundamental principles and its advantages in relation to other systems.

Keywords: *TSC Protocol (Tubes, Support, Connectors); Precision Surgical Guides; Implantology*

Introduction

Precision guides for implant placement are increasingly necessary since they allow to perform implant insertion according to the prosthesis [1], speed up the procedure, reduce trauma to the patient and drastically improve predictability in relation to the 3D position of the implants [2]. Together with assisted navigation systems, they have shown that it is possible to obtain a more precise position of the implants compared to their free-hand insertion [3].

For its preparation, tomographies of the jawbone (DICOM files - Digital Imaging and Communication On Medicine) are related to scans of the mouth or models of the mouth, and if necessary facial scans (STL files - Stereo Lithography) that are superimposed with each other through “overlapping” procedures [4-6].

The techniques to be able to associate these files with each other are different in dentate or edentulous patients, and this gives the name to the different types of guides [7]:

- **Guides based on models or intraoral scans:** The program links the STL file with the DICOM files, taking as a reference the teeth present in both.
- **Guides based on radiographic index or modified double scan method:** As there are no teeth or they are not in adequate quantity and location, it is necessary to make a device that allows linking the STLs with the DICOMs, which is called radiographic index and which must be scanned placed in the mouth and also outside the mouth to be able to serve to relate both files.

In addition, from the standpoint of support, the surgical guides can be [7]:

- **Dental Supported:** This means that the guide will seat and hold onto the remaining teeth of the patient.
- **Mucosal supported**: It is when the guide sits on the mucosa of edentulous mucosa edges. Usually fixed with screws or nails that go through the mucosa and reach the bone.
- **Dental and mucosa supported:** It is when the guide partially sits on both teeth and mucosa.
- **Bone support**: It is when the guide sits directly on the bone and has a bone support through fixation screws.

- **Implant supported:** It is when there are already cases of implants placed and the support is given by said implants.

Regardless of the linking method, or the type of support, surgical guides should have some basic requirements [7].

Stability

They must be stable and not allow an axis of rotation. Preferably they should cover the entire possible surface of the maxilla, either upper or lower. In addition, any fulcrum that may be generated must be neutralized, applying an adequate support based on tripodism (Figure 1 and 2).

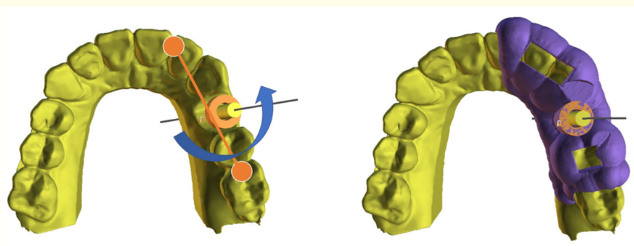

***Figure 1:** When there is no tripod, the guide is less stable because it can rotate.*

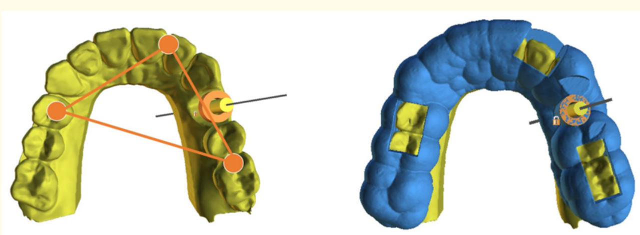

***Figure 2:** When there is tripodism, the guide is more stable because it cannot rotate.*

In the places where this tripodic support is carried out, it is convenient to locate inspection windows, to be able to verify if the guide is supported correctly.

Inspection windows are essential to be able to visualize the contact of the guide, either in the teeth, the mucosa or other surfaces. These windows must be positioned in strategic places such as equidistant places to see the support tripod or places of high retention, for example. edentulous area of a dental element or diastemas. In addition, they must be large enough (one occlusal face and half extension) to make a quick and effective visualization that the guide seats correctly (Figure 3). The windows can also be used to irrigate during drilling, even generating them on the guide tubes (Figure 4).

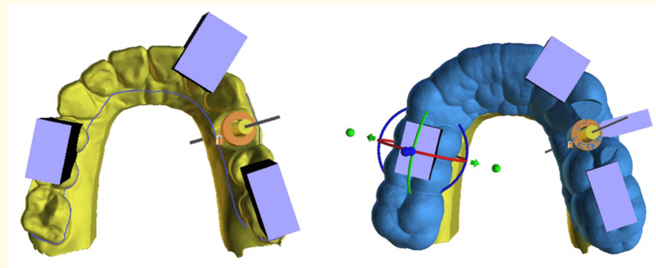

***Figure 3:** Note in the design the extension of the inspection windows.*

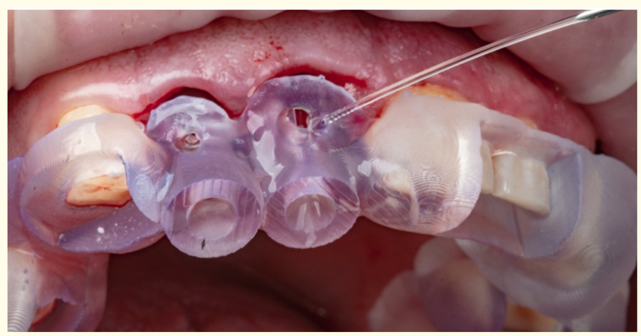

***Figure 4:** Inspection windows on the vestibular surface of the tubes to enhance irrigation.*

Retention

Surgical guides must also have retention. Unlike what happens in the design of a mouth guard, to make a surgical guide the prosthetic equator must be invaded; the programs or software are already prepared to give an axis of insertion and relief in the retentive areas. This invasion above the prosthetic equator allows the surgical guides to remain stable when placed in the mouth (Figure 5).

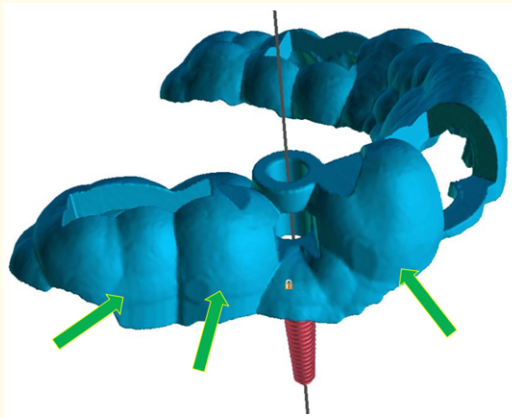

Figure 5: *The extension of the guide must be below the equator of the teeth.*

Rigidity

Surgical guides must have rigidity, and this is determined, on the one hand, by the material we use to construct them (milled or printed), and, on the other, by the design of the guide. The thickness preset by most of the programs is 3 mm, but it can be varied according to each case [8]. Different types of reinforcements can even be made in critical areas of the guide to increase its rigidity (Figure 6).

Figure 6: *Vestibular reinforcements in the work area to increase rigidity.*

Also note the inspection windows and the half-round design of part of the tubes to improve irrigation.

Following the principles outlined above, when designing a surgical guide, three fundamental areas should be taken into account: the entry tubes of the drill, the tripod supports of the guide where the inspection windows are generally placed, and the connectors of these elements.

This has been called the TSC Protocol (Tubes, Support, Connectors) [7].

Tube: It is the entry cylinder of the drill, for its design several factors must be considered: the implant guided surgery system to be used, use of metal sleeves or not, use of drill handles or not, and the diameter, height and the displacement (offset) of the tube in relation to the position of the implant.

Support: These are the necessary points so that the guide in the mouth does not tilt. When a guide is designed with lack of support, a fulcrum is generated that will produce a movement that is not detected; and at the time of surgery, during drilling, those movement would allow the implant position to change with respect to what was planned. For this reason, inspection windows must be placed to verify if the guide supports correctly (tripodism). These windows must be large enough to allow quick and safe inspection.

Connectors: is the union of everything mentioned above. It constitutes the surface of the surgical guide, and they are the elements that guarantee retention and rigidity. It must be taken into account that this surface does not obstruct the final positioning of the guide, for example when making flaps. For this, windows can be designed to move the flaps. The connector must be wide edentulous enough since the wider the more stable. So then, in edentulous patients as wide as possible, in partially edentulous patients preferably occupying the entire maxilla and holm oak of the dental equator, and in combined guides as wide as possible so as not to lose rigidity.

It is necessary that the guide has good retention, delimiting the periphery of this below the prosthetic equator, using the software to manage the fit and the undercuts. Only when there are elements that modify the shape of the teeth, such orthodontic brackets, should it not exceed the dental equator (Figure 7).

Figure 7: *TSC Protocol Guide with long tubes, wide windows, retention below the dental equator, except for the anterior sector where there are brackets.*

The TSC Protocol (or Loys-Maestri protocol) [7] is based on the use of conventional implant kits, without the need for sleeves or drill handlers for guided surgery kits, but on the design of a tube that allows the use of an adapter (extension drill instrument) to replace sleeves or drill handlers.

The design of the guide is based on creating a tube of the length of the drill extender plus the length of the drill subtracting the length of the implant. For example, if you have a drill that plus the extension add up to 30 mm and a 10 mm implant is to be placed, the displacement that the end of the tube (offset) must be placed in the software is 20 mm. The length of the tube will always depend on the length of the implant and the length of the extender (Figure 8).

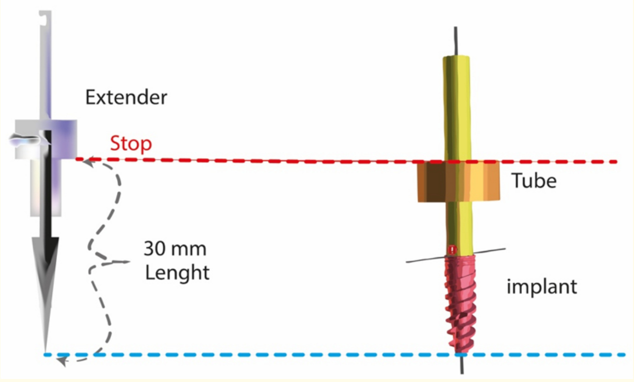

Figure 8: *Scheme of how the length of the tubes (offset) is calculated in the TSC protocol.*

The internal diameter of the tube must be the external diameter of the drill extender used, so if a Neodent extender (code 103.091) (Neodent Curitiba Brazil) is used whose external diameter is 3.5, this diameter should be the internal diameter of the tube, but is necessary to add 0.2 mm more to avoid excessive friction on the tube wall, so 3.7mm of diameter is placed in the corresponding tool of the software that is being used for the internal hole of the tube (Figure 9).

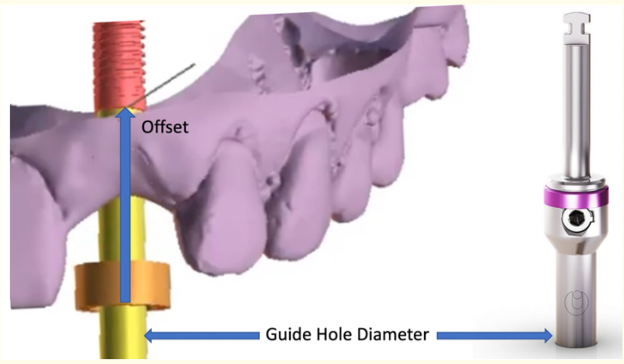

Figure 9: *Scheme of how the internal diameter of the tubes is calculated in the TSC protocol.*

The guides therefore do not use sleeves, nor is it necessary to have a guided surgery kit since conventional kits of any brand of implants can be used.

The offset or displacement is the distance established between the implant platform and the guide tube (the upper or lower face of the same depending on the design software). Specific guided surgery systems generally use a fixed offset for all implant lengths. This generates in certain clinical situations (post-extraction implants or flapless techniques) collision between the tube and the mucosa, which causes a reduction in the height of the ring by the software to avoid the collision. This reduction creates less stability during the osteotomy. In addition to collisions with the mucosa, collisions of the tube are sometimes generated with neighboring teeth due to the proximity of the tube with it, for example in situations of reduced prosthetic space or wide diameter of the tube, which reduces the possibility of using metal sleeves or conditions the positioning of the implant to these.

The TSC protocol bases its guide design on modifying the offset in relation to the length of the implant, the length of the drill and the height of the drill extender (variable offset). These designs allow the generation of guides with sufficiently long tubes, despite the reductions made by the software due to collisions, which generates a great advantage during the osteotomy procedure, generating greater accuracy between planning and the final implant position.

In conventional guided systems with sleeves, the interproximal reduction of the tube can cause it to completely lose its integrity, losing guiding capacity. This does not occur with longer tubes where despite the reduction being performed, the tube maintains its integrity towards the most coronal area.

What has been said allows to obtain the following advantages:

1. Costs are not increased nor does it depend on the existence of a stock of specific products such as metal sleeves; it is executed with a reduced number of surgical devices in addition to the use of conventional drills, thus being highly accessible.
2. The use of conventional drills allows that if the guided surgery is aborted for any reason, the analog surgery can be performed with the same surgical kits.
3. By not using drill handlers, the use of the drill does not generate friction against metallic areas, therefore wear is less, increasing its useful life.
4. Reduces the need for the thickness necessary for contiguous metal sleeves or contiguous to the present teeth.
5. Increase the real guiding length since the tubes are significantly longer than when placing sleeves.
6. Longer tubes generate greater stability during trepanation, presenting greater rigidity and less bending.
7. The greater capacity to absorb the stresses on the part of the tube without suffering bends allows to avoid erroneous inclinations during drilling.
8. Longer tubes help the operator to find and maintain the correct milling axis.
9. The great length of the tube allows to generate modifications such as irrigation windows, inspection windows and modifications with personalized designs (example: front of the guide with teeth) without the tube losing its qualities.
10. The drilling is always with a stop, avoiding having to be aware of the depth marks.
11. Possibility of performing guided surgery with conventional kits to which the operator is accustomed.
12. Versatility of the protocol in different clinical situations.

Discussion

Surgical guides are a method of trepanation and insertion that increases precision when placing dental implants and constitutes one of the options of what is called “computer-assisted surgery” [9]. They constitute a “static” form of assisted navigation, with results that so far are comparable with “dynamic” computer assistance. D’haese J., *et al*. show that with both methods, static and dynamic, it is possible to optimize implant placement based on the three-dimensional position of the final restoration [10].

Planning around the final restoration is essential to obtain adequate functional and aesthetic results. And it is using surgical guides that complications can be reduced and the possibility that the final restoration is correct increases drastically [11]. This is especially important when working on what is called immediate insertion of dental implants, for the special anatomical conditions that are generated when working with a socket instead of a healed bone [12]. Also, when working on designing the critical and subcritical profile [13] of the restoration at the time of planning the guide [14].

It should be considered that when the guides are tooth-supported, the possibility of complications is very low [15,16], however when there are no teeth the difficulties increase [17-19] since the stability of the guides decreases. In any case, surgical guides improve the results in relation to manual placement. Smitkarn P., *et al*. [16] showed about fifty-two patients received 60 single implants that the median (IQR) deviations in angles, shoulders and apexes were 2.8 (2.6)°, 0.9 (0.8) mm and 1.2 (0.9) mm, respectively, in the static CAIS group, and 7.0 (7.0)°, 1.3 (0.7) mm and 2.2 (1.2) mm, respectively, in the freehand group. Statistically significant differences were founded.

Putra., *et al*. [19] in their systematic review and meta-analysis of the factors that influence the accuracy of surgical guides, describe that the edentulous space type, surgical guide manufacturing procedure, and guided surgery protocol are the facts that can influence the accuracy of computer-guided surgery in partially edentulous patients. They found that higher accuracy was obtained when the implants were placed in edentulous spaces in between teeth, with CAD/CAM manufactured surgical guides, and using a fully guided surgery protocol. The TSC protocol seeks to further improve these conditions.

Laleman., *et al*. [20] in their systematic review of surgical guides in edentulous patients, analyze the benefits of using this technology, emphasizing the possibility of performing flapless interventions in many cases, and having a much better control of the implant position depending on the prosthesis.

On the other hand, El Kholy., *et al*. [21] described that the accuracy of statics surgical guides used was significantly affected by the number and type of teeth used for its support. Guides supported by 4 teeth were not significantly different from accuracy of full-arch-supported guides ($p > .05$). Guide support by posterior teeth was associated with an increased level of accuracy, when compared to anterior teeth guide support. Implants placed in extraction sockets were associated with significantly higher 3D and angular deviation values ($p < .05$), and surgical guides with a distal extension situation resulted in significantly higher deviation values ($p < .05$). When using the TSC Protocol, the length of the tubes is significantly increased, which improves precision in all cases, but especially in post-extraction. Likewise, the results show that in terms of implant survival, both analog and digital systems are comparable [16] but in terms of 3D position and ease of performing an adequate prosthetic restoration on implants, guided surgery systems offer undeniable advantages, although they should be used carefully [18-20]. Abdelhay., *et al*. [22] showed that both guided and free-hand implant placement techniques resulted in a high implant survival rate. However, implant failure rates were almost three times higher in the free-hand implant placement category.

The design of a surgical guide in any of its forms is optimized if it is based on the TSC protocol presented in the present work.

Conclusion

The TSC protocol optimizes the use of surgical guides for the placement of dental implants, since it produces a greater control of the guided trepanation procedures due to the way in which the guides are designed, allows the use of conventional surgery kits and reduces the guided surgery costs.

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