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Research Article

Protocol T.A.C (T.S.C.) 2.2 for Making Surgical Guides — The Sliding-Tube Concept

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ABSTRACT

The present article describes the TSC Protocol (tubes, **s**upport, **c**onnectors) version 2.2 for construction of surgical guides for implant placement and the possibility of insertion of the implants also.

Introduction

Surgical guides for implant placement are increasingly used as they allow implant insertion to be carried out really according to the prosthesis, speed up surgery, reduce trauma to the patient and drastically improve predictability in relation to the 3D position of the implants [1, 2]. They have also shown that it is possible to obtain a more precise position of the implants compared to free hands insertion of the same [3].

When preparing them, tomographies of the maxillary bone (DICOM files - Digital Imaging and Communication On Medicine) are related to scans of the mouth or scans of models of the mouth, and if necessary facial scans, prosthesis scans, diagnostic wax-up scans, or others (STL files - Stereo Lithography) that overlap each other through “matching” or “overlapping” procedures [4-7]. The use of additive techniques, 3D printing, has drastically improved the precision of surgical guides, and has opened new possibilities in their design [8, 9].

In previous publications the authors have presented the advantages of using the TAC Protocol (T.S.C. – Tube-Support-Connector) to perform the trepanation of the surgical bed to place implants, showing the basic principles for the preparation of surgical guides and emphasizing the advantages of performing the trepanation of the bed for the implants through the guide with excellent three-dimensional control of the same, through the design of a tube without metal sleeves and without the use of drill handlers, but rather by using an extender and calibrating the offset and internal diameter of the tube based on this extender [10, 11]. However, the original TAC protocol was designed only for trepanation, while implant insertion was done manually without any guidance [10, 11].

In the present work, the evolution of the TAC protocol to version 2.2 will be shown, which allows the insertion of the implants in a totally guided way through a sliding tube.

Development

As stated in previous publications, surgical guides must have some basic requirements [10]:

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I Stability

They must be stable and not allow an axis of rotation. Preferably they should cover the entire possible surface of the maxilla, whether upper or lower. In addition, any fulcrum that may be generated must be neutralized, applying adequate support based on tripods. In the places where this tripod support is made, it is convenient to locate inspection windows to be able to verify if the guide is supported correctly.

II Retention

Surgical guides must also have retention. Unlike what happens in the design of a myorelaxant splint, to make a surgical guide, the prosthetic equator must be invaded; the programmes or software are already designed to provide an insertion axis and relief in the undercut areas. This invasion above the prosthetic equator allows the surgical guides to remain stable.

III Rigidity

Surgical guides must have rigidity, and this is determined, on the one hand, by the material we use to build it (milled or printed), and, on the other, by the design of the guide. The default thickness for most programmes is 3 mm, but it can be varied on a case-by-case basis.

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

This has been called the TAC Protocol. (TSP protocol: Tubes, Support, Connectors) (10).

i Tube

It is the input cylinder of the drill. For its design, several factors must be considered: the implant guided surgery system to be used, the use of metal sleeves or not, the use of drill handlers or not, and the diameter, height and the displacement of the tube in relation to the position of the implant.

ii Support

These are the necessary points so that the guide in the mouth does not tilt. When a guide is designed with a lack of supports, a fulcrum is generated that will produce a movement that is not detected; and at the time of surgery, during drilling, this movement would allow the position of the implant to change with respect to what was planned.

iii Connector

It is the union of everything mentioned above. It constitutes the surface of the surgical guide and 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 TAC Protocol (TSP protocol or Loys-Maestri protocol) is based on using conventional implant surgical kits, without the need for sleeves or drill handlers usually used with guided surgery kits, but on the design of a tube that allows the use of an adapter (drill extender) to replace the sleeves and handlers [10]. The design of the guide is based on creating a tube with the length of the extender to be used, plus the length of the drill, subtracting the length of the implant. For example, if you have a drill that plus the extender add up to 30 mm and a 10 mm implant is going to be placed, the displacement that the end of the tube must be placed in the software is 20 mm. The length of the tube will always depend on the length of the implant and that of the extender (Figure 1).

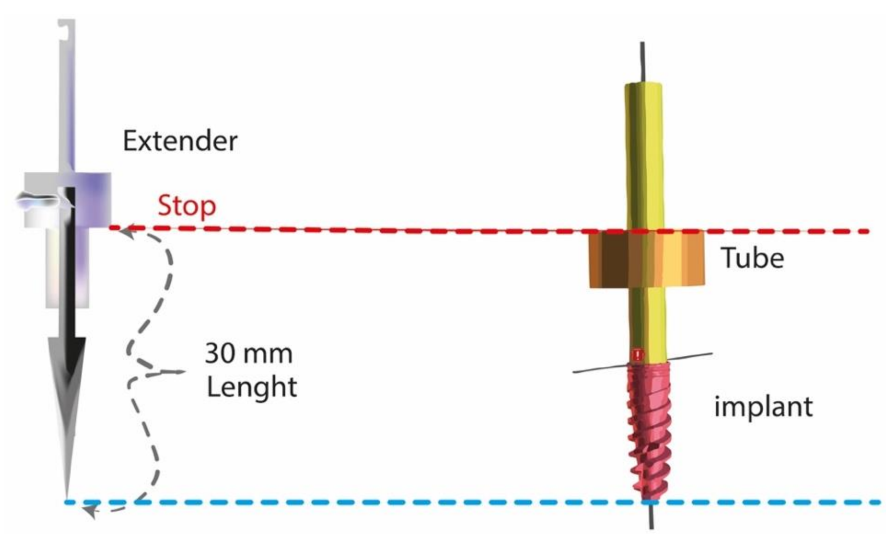


Figure 1: Scheme of how the length of the tubes (offset) is calculated in the TSC protocol.

The internal diameter of the tube is the external diameter of the extender used, so for example if a Neodent extender (code 103.091) is used, the internal diameter will be 3.5, but 0.2mm more is added to avoid excessive friction due to what, 3.7mm is placed when the diameter of internal hole of the tube is setting in the software used (Figure 2).

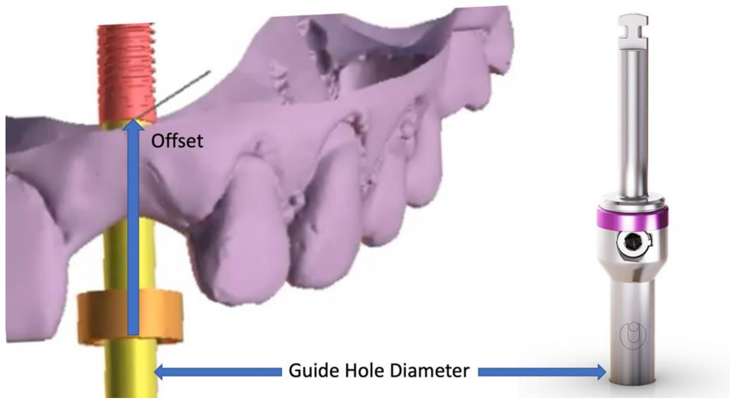


Figure 2: Scheme of how the diameter of the tubes is calculated in the TSC protocol.

Therefore, the guides do not use sleeves, nor is it necessary to have a guided surgery kit since conventional surgery kits of any implant brand can be used. The offset or displacement is the distance established between the implant platform and the guide tube (the upper or lower face thereof depending on the designing 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) a collision between the tube and the mucosa, which causes a reduction in the height of the tube for the sleeve by the software to avoid the collision. This reduction results in less stability during the osteotomy. In addition to collisions with the mucosa, sometimes the tube collides with neighbouring 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 sleeves or conditions the positioning of the implant. 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 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 the planning and the final position of the implant.

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

All the above makes the TSC Protocol have a series of advantages as Loys *et al.* established in previous publications [11]. However, its weakness was that it did not allow guided implant insertion. To solve this problem, a new TAC protocol called 2.2 was designed, which consists of developing a second guide for absolutely guided insertion of the implants, maintaining the possibility of using conventional surgical kits and instruments.

To do this, the surgical guide made in the manner explained above is duplicated and a new guide is prepared based on the driver that will be used for the insertion of the implant(s). This driver, regardless of the length of the implant to be placed, always has a fixed measurement, both in height and in diameter. For example, if the driver is 16 mm long, the offset (or displacement) to place in the guide tube will be 16 mm. The diameter of the internal hole of the tube should be the diameter of the driver plus 0.2 mm of lateral separation, however if the driver measures 3mm, as is often the case, the hole would not allow implants with a diameter of more than 3.2mm to pass. To have an insertion guide tube with an internal diameter of 5 or more mm but with guiding capacity, what is proposed is to "line" the driver with a tube that is printed separately and has an external diameter of 5 mm. mm and an internal diameter of the driver diameter plus 0.2mm. This tube has been called Sliding-tube and in this way the guidance of the implants is absolute since it can be freely raised and lowered within the guide tube so can be used from the first moment of implant insertion. This sliding-tube is 8mm long so it can be moved up and down (Figure 3).

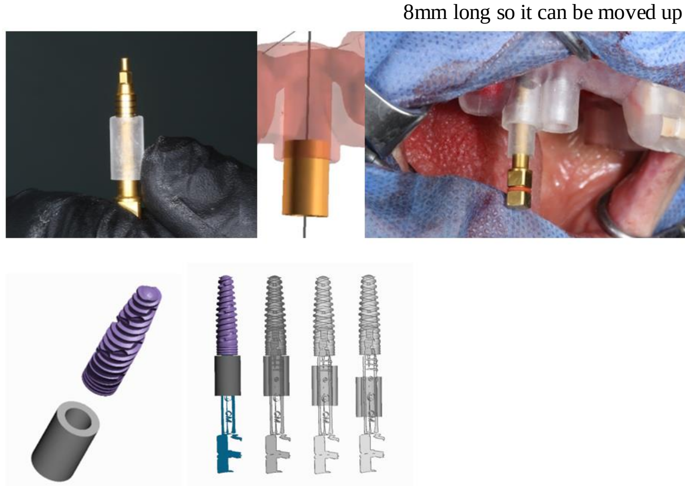


Figure 3: Photographs and scheme of the Sliding-tube.

In this way, an implant insertion guide is generated that will insert the implant in a fully guided manner (Figures 4A and 4B). For this, by using an implant planning software (for example Blue Sky Plan) it is possible to duplicate the drilling guide exactly, only by changing the tube for one of the specified dimensions so that the sliding-tube works and inserting the implant in fully guided way. This can be done through tools such as “create scan appliance guide” having previously selected the drilling guide and after changing the shape of the tube (Figures 5A and 5B).

A

B

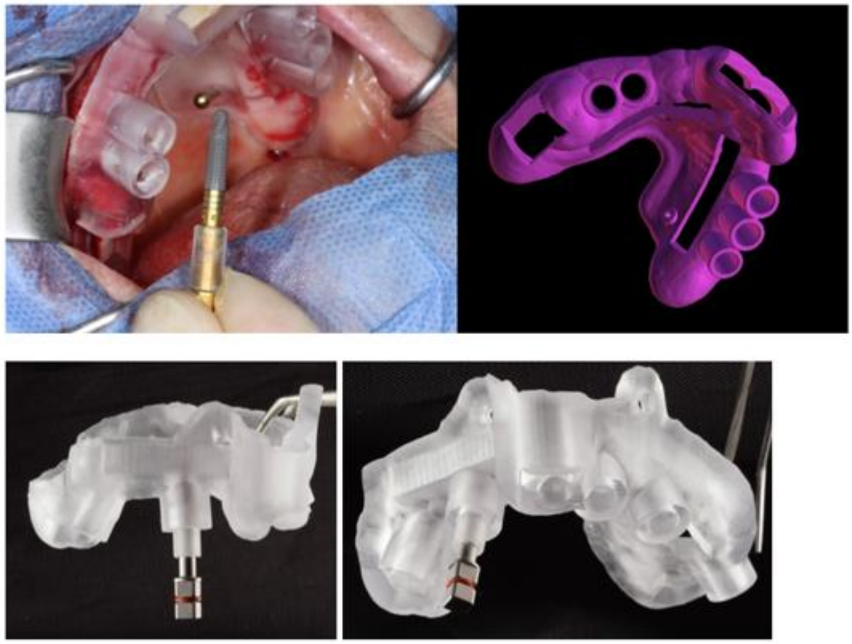
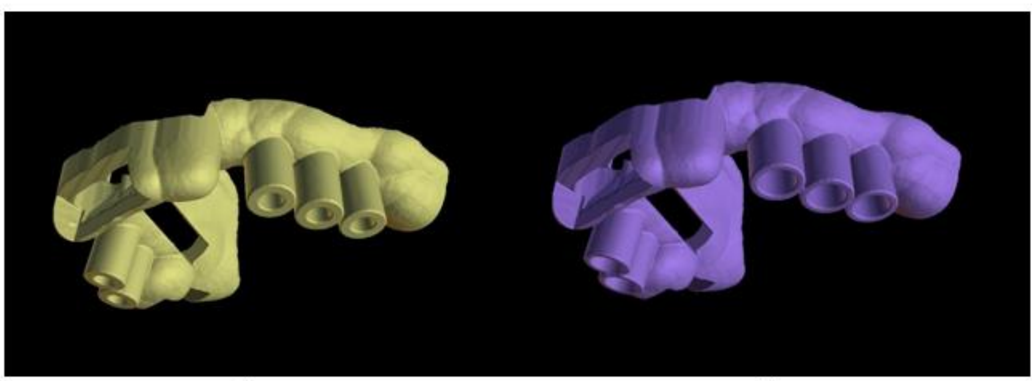


Figure 4: A) Photographs and scheme of a TSC protocol guide and the Sliding-tube. **B)** Photographs of a TSC protocol guide and the Sliding-tube inside the guidance tube.



A B

Figure 5: A) Drilling guide. **B)** implant insertion guide.

Discussion

Surgical guides for trepanation and implant insertion increase operator precision [12]. They constitute a "static" form of assisted navigation, with results that up to now are comparable to "dynamic" assistance and of a much lower cost and complexity [13]. Planning around the final restoration is essential for adequate functional and aesthetic results [14, 15]. And it is using surgical guides that complications can be reduced and the possibility that the final restoration is correct increases drastically [16-18].

The TAC protocol showed a series of advantages by allowing the use of conventional implant surgery kits, preparing a guide that only needs to be designed and calibrated to a suitable drill extender [10, 11]. Its only limitation is that the implants must be placed manually. The TSC 2.2 protocol described in this work shows how to insert the implants in a guided way without needing a guided surgery kit, but instead modifying the guide to achieve this and adding an accessory that is also printed, which is the sliding-tube.

We then work with a drilling guide and another exactly the same but where the only thing that varies is the tube.

Advances in the precision of 3D printing allow both guides to be sleeveless, as they are unnecessary for both drilling and inserting the implants [19-21].

The sliding-tube, having an internal lateral offset of 0.2 to 0.3mm to the driver and a similar external lateral offset to the guide tube, can move and be located in the right place to optimize guiding, in addition to moving freely during the implant insertion to never lose its guidance during insertion, unlike when working with sleeves that generally only begin to effectively guide the implant after the driver penetrates the sleeve and this leaves a few millimeters where the implant is not really guided but it depends on the direction of insertion in which the operator takes it.

Of course, it must always be borne in mind that the guides must be extensive, that is, cover the entire occlusal surface of the maxilla, since small or partial guides tend to displace the drilling to the vestibular area, and the same occurs with the insertion of the implant. With large windows to be able to observe the correct settlement in both guides. And rigid enough to avoid flexing during implant insertion [10, 11]. This is especially important in post-exodontia implants because, due to the way they must be drilling and inserted, this tendency to vestibular displacement increases [22].

In tooth-supported guides, the possibility of complications is very low, however, when there are no teeth, the difficulties increase since the stability of the guides decreases [16, 23]. Likewise, in both situations, the guides must be wide and take the greatest possible extension of the rim [11]. Putra *et al*. 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 can influence the accuracy of computer-guided surgery in partially edentulous patients [24]. They found that higher accuracy was obtained when the implants were placed in edentulous spaces in between teeth, with CAD/CAM manufactured surgical guides, using a fully guided surgery protocol.

El Kholy *et al*. described that the accuracy of surgical guides used in sCAIS was significantly affected by the number and type of teeth used for its support [25]. 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. 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 ($p < .05$). The TSC 2.2 protocol seeks to further improve any of these conditions, since guidance during trepanation and implant insertion is completed by the extension of the tube and the use of the sliding-tube.

There is only one situation in which the use of conventional surgery protocols with guided surgery kits could be indicated and that is when short implants are placed in posterior sectors, first and second molar areas, especially in patients with little opening of the mouth or with antagonist toothed since in the TSC protocol or in the TSC Protocol 2.2 shown in this work, it is necessary to use a long tube, where the shorter the implant, the longer the tube [10, 11]. In any case, these posterior sectors always offer difficulties such as those mentioned even with guided surgery kits due to the extension of the drills of these systems [26]. Colombo *et al*. show that for these extreme situations the conventional protocols would be like the guided ones [1].

Although the results show that in terms of implant survival, both analog and digital systems are comparable, in terms of 3D position and ease of performing an adequate prosthetic restoration on implants, guided surgery systems offer undeniable advantages, although they must be used carefully [4, 16, 23, 24, 26, 27].

Conclusion

The design of a surgical guide in any of its forms is optimized if is based on the TAC 2.2 protocol presented in this work.

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