Pre-Operative Visualization of Surgical Guide Instrumentation:
A Proposed Protocol Improvement for CT Guided Dental Implant Surgery

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OBJECTIVE

The intent of this assessment is to illustrate a protocol for improving the effectiveness of the implant planning phase for guided surgery cases, as to mitigate potential surgical complications associated with limited interarch space.

BACKGROUND

The prevalence of guided surgery is growing with the "digitization" of implant dentistry. The technologies supporting this trend (e.g., CT scanners, 3-D planning software, and surgical guide fabrication) continue to improve, and the cost per case is decreasing due to industrial efficiencies and marketplace competition. Challenges still exist, however, with guided surgery, one of which is the ability to adequately plan for limited interarch space, particularly in the posterior.

The implant planning phase, during which the implant sizes and locations are determined by the clinician, is conducted with a 3-D virtual anatomic model of the patient in (or near) occlusion. Once the surgical planning is completed, a surgical guide is designed and fabricated to facilitate the case plan. The surgical guide design process is typically carried out by a technician working in a different software environment than what the clinician utilized. This creates a dilemma in that neither person is aware of the spatial access requirements for each surgical site nor do they know the respective interarch values at maximum interincisal opening (MIO).

There is an apparent conflict between the clinician's and technician's objectives. The clinician plans a case for superior results, but with inadequate regard for the surgical guide design because they lack much of the necessary information to properly consider this aspect. In an analogous manner, the technician designs the surgical guide to develop osteotomies for and direct the placement of the implants per the clinician's plan, but without a full understanding of the clinical situation (i.e., spatial requirements). So while there is a clear cause and effect relationship between both parties' actions, there are no easy methods by which to communicate this information. This can, and often does, lead to the abandonment of a planned site and/or the need for an intraoperative course change due to the inability to access a site with the required instrumentation.

Schneider et al. [1] reported that the most frequent surgical complication for computer-guided template-based procedures was limited interocclusal distance in the posterior. In regards to this dimensional constraint they explained that, "It can make insertion of the drills through the surgical template impossible and the implantation procedure cannot be carried out as planned." Similarly, Di Giacomo et al. [2] assessed surgical complications associated with surgical guides, and noted that for cases in which posterior access was limited they had to angle the implants mesially. Only 15% of the implants placed during their study were in the posterior segments, but their literature review corroborated the findings from Schneider et al. in regards to limited access being the most frequent surgical complication for guided surgery cases.

Limited access in the posterior is an anatomic consequence, and as such cannot be readily modified. Making provisions for interarch access requirements during the surgical planning phase is possible, as outlined in the following protocol, and will address the aforementioned surgical complications.

MATERIALS AND METHODS

The proposed protocol is intended to counteract the "misalignment" between the clinician planning the case and the technician designing the surgical guide by enabling the clinician to gain a real-time understanding of the interaction between the surgical plan, the surgical guide, and the patient's interarch spatial limitations. Following is an overview of an example workflow:

1. Acquire a CT scan of the patient in occlusion with the scan appliance (see fig. 1a)

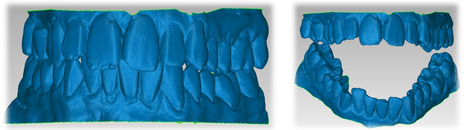

Figure 1: (A) CT Scan in Occlusion and (B) Scan in MIO Position.

2. Acquire a second scan of the patient in the MIO position (see fig.1b), either using CT, an intra-oral scanner (IOS), or a 3D camera. If the latter options are selected there must be visual landmarks from the image data which are common to both datasets (1 & 2), but only a small section of data from both arches is necessary to "register" the articulation. Import the DICOM data from the initial CT scan into the surgical planning software and specify the location of each implant (see fig. 2).

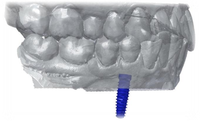

Figure 2: Initial Surgical Plan.

3. Virtually articulate the case into the MIO position, and visualize the instrumentation associated with each site to determine if interference exists with the opposing arch (see fig. 3). If no interference exists and/or no adjustment is desired the case can then be submitted for surgical guide fabrication.

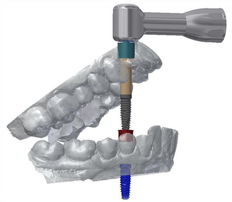

Figure 3: Visualization of Initial Surgical Plan in MIO Position.

4. Assuming interference is detected, one or more of four actions can be taken to try to overcome this. Figure 4 illustrates a combination of the first three options below:

a. Reduce the length of the implant and/or
b. Reduce the depth of the implant seating surface and/or
c. Angle the implant mesially and/or
d. Change the location of the implant

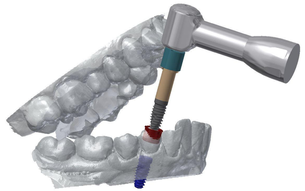

Figure 4: Revised Surgical Plan Visualized in MIO Position.

Functionality would be incorporated into the surgical planning software to articulate the case using a shape matching algorithm and to virtually "float" the instrumentation within the 3-dimensional case plan. The longest stack-up of components required for a particular site would be automatically selected and positioned based on preset parameters (or logic) associated with the surgical guide instrumentation.

Depending on how restrictive the MIO is and the amount of flexibility with which the implant can be repositioned, it is possible that no degree of modification during step (5) will alleviate the interference(s). Regardless, it's better to be aware of this during the planning phase versus learning about an unkown interference during surgery. There are several potential variations of the above protocol depending on the particular case and the surgical planning scheme, but the fundamental concept pre-operative intervention is always applicable.

RESULTS & CONCLUSIONS

The methods outlined above enable the clinician to visualize the resultant instrumentation requirements (maximum size and location) for a planned implant site, and to verify that sufficient interarch space exists. The clinician can then iterate the case plan if necessary to overcome any potential access limitations. Beyond improving the effectiveness of the implant planning phase, this protocol can mitigate surgical complications, reduce unanticipated surgical time, increase patient satisfaction, and advance the acceptance of guided surgery.

REFERENCES

1. Schneider D, Marquardt P, Zwahlen M, Jung RE. A systematic review on the accuracy and the clinical outcome of computer-guided template-based implant dentistry. *Clin. Oral Impl. Res.* 20 (Suppl. 4), 2009; 73–86.

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