The use of existing locators to stabilize a CBCT-software derived surgical guide

Conversion of a mandibular removable to a fixed prosthesis

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Introduction

Dental implants have become one of the most predictable treatment alternatives for patients who are missing teeth. Despite the high success rates, which are well documented, most dental implants are still inserted by a free hand method of delivery. CT and CBCT and have played an increasingly important role in the diagnosis and treatment planning phase, allowing for increased accuracy, predictability, improved appreciation of adjacent vital structures, and decreased complications. The use of CBCT imaging and interactive treatment planning software allows for the simulation of dental implants and abutments, providing the foundation for the fabrication of surgical guides. Surgical guides derived from CT/CBCT datasets have been classified as tooth-borne, bone-borne, and mucosal-borne, and can be fabricated from a variety of methods, including CAD/CAM and stereolithography or 3-D printing of resin material with the incorporation of metal guide tubes.

Stereolithographic guides derived from CBCT data and interactive treatment planning software allow for precise placement of implants around vital structures and reduced alveolar support and control for depth, angulation and position. While most guides have been either supported by teeth, mucosa or bone, other guides have gained support/stability from mini implants. The 2014 Consensus paper (IOMI) reviewed the literature regarding the accuracy of guided surgery for implant placement. The Consensus paper found that bone-supported templates had greater deviations than mucosal or mini implant-supported guides and tooth-supported guides were the most accurate. With regard to accuracy, clinical deviations at the point of drill entry have been reported from less than 1 mm to 1.5 mm. Errors at the apex have been reported to be from 1.5 mm to 3 mm (more dependent on implant length) and angulation errors were reported from 5 degrees to 8 degrees. With these errors in mind, it would be prudent to plan a safety zone of at least 2 mm from adjacent vital anatomical structures to obviate injury. Ideally, increased stability of the template, and the placement of the guide tube...
closer to the top of the implant, should result in a higher degree of accuracy.

When evaluating potential dental implant receptor sites in the anterior maxilla, posterior maxilla, anterior mandible, or posterior mandible, it is imperative that the information derived from the CT/CBCT scan be properly evaluated in all views afforded by the software. Implant placement in the posterior mandible can offer unique challenges. These include lingual undercuts, proximity to the mandibular canal, quality of bone, reduced alveolar support, and limitations of interarch space. Recently, differences in the morphology of the posterior mandible have been elucidated.\(^3\) The mandibular premolar areas have more caudal divergence than the molar areas, which tend to be more parallel. Greatest variations in buccal and lingual width seem to vary most at 4 mm apical to the bony crest. Moreover, males tend to have wider ridges than females, whereas age did not seem to be a significant factor.

**Case report**

A 75-year-old female patient presented with an existing mandibular complete overdenture, supported by three mandibular implants (Straumann) with Locator abutments (Zest, Zest Anchors) (Fig. 1). It was the patient’s desire to have a fixed restoration if possible. After a clinical examination, radiographs, and CBCT scan, it was determined that six additional implants could be placed so that a fixed restoration could be fabricated. Four of them were placed in the posterior mandible and two other in the anterior region. The new implants, located in the posterior mandible, had compromised alveolar bone height and were in close proximity to the mandibular canal. Therefore, the need for additional stabilization of the guide, beyond that derived from the bone support, was paramount. To gain the required stabilization, a plan was developed to use the pre-existing implants with the original Locator abutments as a method of securing a bone-supported template to increase surgical accuracy.

Rathi et al presented a report in which Locator attachments were utilized to stabilize a guide while transitioning a patient from an over-denture to a fixed prosthesis using an ‘All on Four’ protocol.\(^4\) While that article highlights the utility of such a procedure, the current clinical case report underscores the need to ensure the stability of the template when the proposed implant sites are in close proximity to vital structures.

The patient revealed a history of bruxism, which accelerated the loss of retention of the nylon inserts (Locator males), rendering her prosthesis ineffective during function, and required frequent replacement. The need for a completely implant supported fixed restoration became apparent, and the patient was motivated to proceed with the diagnostic phase. The conventional treatment of five implants between the mental foramen to support a fixed-hybrid restoration with a posterior cantilever would not have been acceptable due to the possibility of overloading the implants, given the history of bruxism. Therefore, it was determined that posterior implants were necessary to help distribute the load for a fixed restoration. When implants are placed distal to the mental foramen, the issue of mandibular flexure must be respected, although this affects a very small percentage of patients. To accom-
modate the clinical presentation and the patient desires, a fixed-type implant-supported prosthesis was treatment planned that would include an interlocking type attachment to break the stress of cross-arch stabilization.

Utilizing state-of-the-art CBCT imaging and interactive treatment planning software, it is now possible to accurately assess the relation of the bone and implant receptor site to the desired tooth position. Therefore, in the digital milieu, thought must first be given to how the proposed position of the teeth (if they are missing) can be incorporated into the scan.

In this case, the patient’s existing dentures were duplicated with a radiopaque material (Barriopaque Salvin Dental Specialties) to be worn by the patient during the scan acquisition. During the scan acquisition, the patient wears the duplicated prosthesis with the radiopaque teeth. The scan was set at a 0.3 mm voxel size (i-CAT).

The DICOM data can be interpreted with the native software packaged with the CBCT device (Tx Studio, Imaging Sciences International), or it can be exported to a third party 3-D planning software (SimPlant, DENTSPLY Implants) for purposes of using the advanced treatment planning capabilities. When planning ideal implant positions, it is imperative to use 3-D planning software so that the appropriate length and width implant can be placed in the receptor sites. Implants should be placed optimally in the receptor site, away from vital structures, such as the path of the inferior alveolar nerve, and to insure that there is a sufficient volume of bone (Triangle of Bone) surrounding the implant and that the implant position is consistent with the restorative plan.6,7 After careful evaluation, favorable bone height and width was identified for four posterior implants and two anterior implants.
(Figs. 4a-f). Note that each simulated implant also contained an abutment projection (green), which aligned to the desired radiopaque tooth position.

To ensure accurate restoratively driven planning, the laboratory fabricated denture wax-up was scanned with a desktop optical scanner and then, using advanced software tools, the resulting STL file (standard triangulation language) was subsequently super-imposed on the 3-D volumetric reconstruction, and validated in all views using the radiopaque teeth and existing locator abutments as fiducial markers (Fig. 5). In this way, the trajectories of the virtually planned implants could be sighted through the envelope of the denture teeth (the restorative space). Using the information from the 3-D planning, the holes to receive the temporary abutments could be pre-drilled in the interim fixed prosthesis.

Once the implant positioning was confirmed in the 3-D plan, a CBCT-derived surgical guide was printed in resin by the rapid prototyping process (stereolithography) from an STL file (Fig. 6). This guide essentially carries the 3-D plan to the mouth by virtue of tubes in the guide that will guide the drills to the same trajectory as the planned implant. Additionally, a biomedical model of the mandible was printed to further enhance the pre-surgical planning process (Figs. 7 & 8).

The virtually planned posterior implants were in closer proximity to the mandibular nerve than the ideal safety zone of 2 mm; therefore, it was decided that enhanced stability of the surgical guide could be achieved by connecting the stereolithographic guide to the middle locator abutment with a locator housing embedded in the resin. The increased stability of the guide would thereby improve drilling accuracy.

Prior to surgical intervention, a piece of rubber dam material was sized to the printed biomedical model of the mandible to fit around the Locator abutments to be used during the surgical intervention (Fig. 9). The rubber dam serves to help protect the bone from the potential cytotoxic effects of the methacrylate monomer used to capture the locator housing.

**Surgical intervention**

At the time of surgery, the patient was anesthetised and IV sedation was administered. A slightly lingual crestal incision was made starting just anterior to the retromolar pad to the same location on the contralateral side.

A full thickness flap was then elevated to expose the underlying bone and the three pre-existing implants (Fig. 10). The fit of the bone-borne guide was first verified, ensuring that the flaps did not interfere with complete seating of the guide and that the guide was stable on the bone. Once this was achieved, the area corresponding to the Locator abutments on the surgical guide was reamed out to facilitate proper seating of the guide. A Locator (female) housing with the black
nylon processing male insert was seated on the Locator abutment intraorally. The guide was re-checked for proper circumferential clearance and subsequently picked up with a dual-cure acrylic (Chairside, Zest Anchors) and the rubber dam material was subsequently removed (Fig. 11).

The planned six osteotomies were completed with the surgical template with embedded guide tubes, and the universal drill key system, which allowed for precise drilling of each osteotomy (Universal Drill Kit, SimPlant, DENTSPLY Implants). Four osteotomies were positioned in the posterior mandible and two osteotomies were positioned in the anterior mandible. Each osteotomy was purposely undersized to insure good stabilization of the implants (Touareg Adin Dental Implant Systems). After the template was removed, each implant was hand-torqued into position, and ISQ values (Implant Stability Quotient) were obtained (Ostell). Each implant ISQ value was measured to be 68 ISQ or higher, values consistent with immediate restoration.9,10 All the posterior implants were 5.0 mm in diameter x 6.3 mm in length, except for the implant in the lower left first molar area, which was 4.2 mm in diameter x 6.3 mm in length. The two anterior implants located in the mandibular right lateral area were 4.2 mm in diameter x 16 mm length, and the mandibular right second bicuspid area was 4.2 mm in diameter x 13 mm in length (Fig. 12).

Once the new implants were delivered, the Locator abutments were removed from the three original pre-existing implants, and were substituted with multi-unit screw-receiving abutments which received temporary titanium cylinders (Adin Dental Implant Systems). Additionally, the two anterior implants that were just placed also received multi-unit abutments and cylinders for a total of five implants, which were to be loaded. The posterior implants received cover screws and were buried under the soft tissue after the flaps were repositioned and primarily closed with sutures.

A fully extended acrylic denture was first positioned over the implants, and the posterior intaglio surfaces were hollowed to facilitate proper seating of the denture over the posterior cover screws. The purpose of the pink denture base was to help stabilize the denture while it was being connected to the temporary titanium cylinders. Once the connections were achieved, the pink denture base areas were removed with an acrylic laboratory bur, and the flange area contoured to serve as a fixed implant-supported screw-retained provisional.

**Conclusion**

The process of guided surgical applications for dental implants continues to be refined and improved as the software technology and hardware components evolve. The use of CBCT and interactive treatment planning software have significantly impacted upon the diagnostic capabilities which aid clinicians in accurately assessing individual patient anatomy, providing increased accuracy to determine proper implant receptor sites, locating vital adjacent anatomy, and reducing potential complications. CT/ CBCT-derived surgical...
guides play an important role in taking the virtual plan to the surgical intervention. Regardless of the surgical guide type (mucosal, tooth borne, or bone borne), it is imperative that the template does not move to ensure accuracy of the drilling protocol. Stability can be achieved in various ways, including the placement of pins through the host bone, usually required for mucosal templates, and sometimes for bone-borne templates. Additionally, due to the anatomical restrictions in the mandibular posterior area (i.e. diminished alveolar ridge, vital structures), it is imperative that the computer-aided surgical guide be as stable as possible to ensure accurate drilling, and to avoid potential complications.

The present case report demonstrated how the use of pre-existing implants can be used to aid in the planning phase, and for intraoral fixation and stabilization of the CT/CBCT-derived surgical template. It was helpful that the pre-existing implants had Locator abutments, originally used to stabilize an overdenture prosthesis. Using interactive treatment planning software, receptor sites were determined for the placement of six additional virtual implants to be combined with the original implants to support a new fixed-detachable immediate transitional restoration. The ability to assess both the position of the original implants, and the new implant receptor sites in harmony with the restoratively-driven placement was important to achieve a successful outcome. The enhanced capabilities of 3-D imaging and interactive treatment planning software were combined with the fabrication of a 3-D printed biomedical model of the mandible to facilitate the utilization of the original Locator abutments to improve the stabilization of a bone-supported surgical guide. The clinical protocol insured predictable and accurate results, while helping to reduce patient morbidity. The technique demonstrated in this case report may be applicable to other case presentations when there is an opportunity to utilize pre-existing implants as a method to achieve increased template stability.

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