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Computer-Guided Implant Surgery: Placing the Perfect Implant

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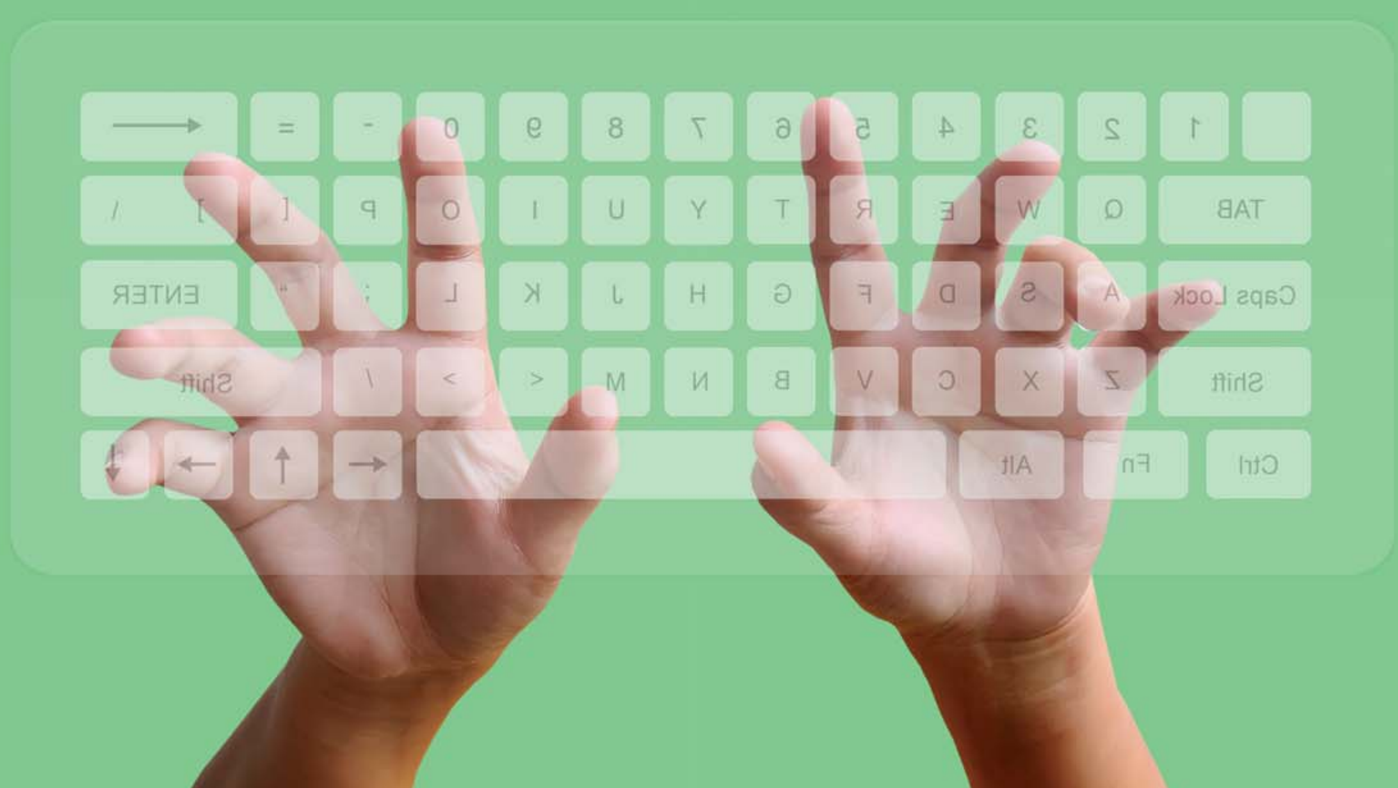

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A Simple, Safe and Affordable Cast-Based Guided Implant Placement System

Lambert J. Stumpel, DDS

ABSTRACT A fully restrictive surgical guide allows controlled execution of a preoperatively planned osteotomy and subsequent implant placement. There are two fabrication modes. One is a digital path, where these guides can be fabricated based on data from a cone beam CT source. Alternatively, 3-D data can be derived from a dental cast and periapical radiographs. The 3D Click Guide is a cast-based, fully restrictive surgical guide that can be generated in the dental office.

AUTHOR

Lambert J. Stumpel, DDS, is the developer of the 3D Click Guide, holder of two patents and author of more than 25 scientific publications. He is in private practice in San Francisco.
Conflict of Interest Disclosure: Lambert J. Stumpel, DDS, is the developer of the 3D Click Guide and the CEO of Idondivi Inc.

Why does an article describing an analog surgical guide appear in an issue dedicated to computer-guided surgery? Because the objective of both the analog and the digital path is identical — produce a fully restrictive surgical guide. Both are capable of doing so. The computer version can be used for many indications, from a single tooth to fully edentulous situations. The analog path on the other hand is best limited to one- to two-implant cases, but is then considerably more economical within this indication field.

A dental implant is an object in space, its position defined by coordinates in all three-dimensional planes, x, y and z. In dentistry, we name those planes mesiodistal, buccal lingual and apical coronal. Each plane is defined by its own specific requirements, which are guided by biologic and prosthetic considerations. During conventional freehand surgery, the operator develops an osteotomy in all three dimensions, mentally combining all into one surgical drill path and executes "freehand," based on hand-eye coordination alone. Guided surgery with a fully restrictive surgical guide requires each of these planes to be considered individually based on various cross sections. A fully restrictive surgical guide can then be fabricated, combining each plane's trajectory into a surgical guide that guides bone drills and implants into a singular path.[1-13]

Large, full-mouth cases, complicated grafting cases and all-on-4 rehabilitation techniques are commonly demonstrated in the literature and in various presentations. The reality is that roughly

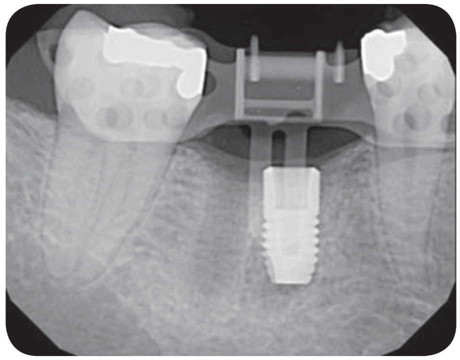

FIGURE 1. Implants placed within the constraints of the original tooth can never be encroaching onto critical anatomical structures. This negated the need for CBCT.

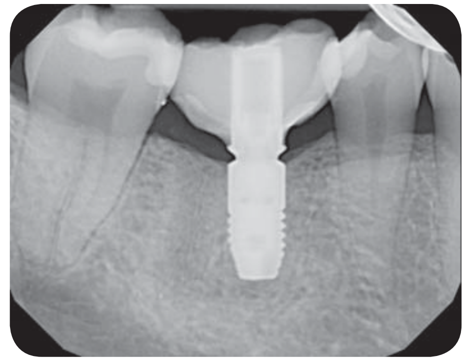

FIGURE 2. Finished implant supported reconstruction. Implant within extraction site.

FIGURE 3. Edentulous situation, note buccal depression.

FIGURE 4. Preoperative radiograph, marked mental foramen and estimated length of implant.

80 percent of all the cases in the world are one- to two-implant cases. Single implants account for 60 percent while 20 percent are two-implant cases.[14]

Straumann AG has released data showing that in 2012 the average number of implants placed in the U.S. by dentists who place implants was 50 to 60.[15] So for every dentist placing more than 500 implants a year, there is a large group of clinicians who place only a fraction of that number. The original model in which one experienced clinician would receive referrals for 20 to 30 implants per year from 20 to 30 referring dentists is rapidly changing.

We see that a growing number of clinicians are placing implants, but with a lower total number of implants placed per operator. This of course has implications for the surgical skill compared to clinicians placing many hundreds of implants per year. The concern is that with less experience, the treatment outcome could be jeopardized. We all know that practice makes perfect. However, we also know that technologies can help bridge the gap. Guided implant surgery is the technology that allows less experienced clinicians to place implants exactly in the required 3-D position and more experienced clinicians to do so in less time. Let's be crystal clear, one still needs all the knowledge. There can be no excuse for poor planning, but the surgical execution is greatly simplified.

Fully restrictive guided surgery requires less skill compared to freehand, nonguided surgery, and it might produce better results.[16-18] However, controlling the cost of medical care in relation to the outcome will be an issue.

It is important to understand exactly what is involved, with guided surgery using fully restrictive surgical guides and how these are fabricated. As this issue shows, high-tech computer-aided design and computer-aided manufacturing (CAD/CAM) produced guides are powered by the data from CT or cone beam CT (CBCT) and designed in a variety of software products. The actual surgical guides can be printed or milled, all with round cylinders allowing dedicated instrumentation to be precisely guided, creating the osteotomies and guiding the implant during placement. The common denominator is that all implant placements need CBCT information. So a CBCT scan is needed first. This is immediately one of the drawbacks. Drawback one might question whether CBCT is not the emerging standard of care. This author wants to argue that it depends. CBCT allow us to see what two-dimensional X-rays cannot. The question is, how much do we need to know and at what cost? Because there is a cost — money and time the patient spends on the study and radiation the patient receives. The benefit is increased knowledge, but how much do we need to know? For example, if one wants to place a 13-mm implant above the mandibular nerve, extensive anatomical knowledge is required. In the same clinical situation, if one desires to place an 8.5-mm short implant, then there is a reduced need to know. Modern literature teaches us that short implants can function equally well compared to longer implants.[18-24] So prudent risk management would favor shorter implants, as there is increased risk associated with increased length. A simple metric: an implant that stays within the boundaries of the tooth it replaces can never be in the mandibular canal or other

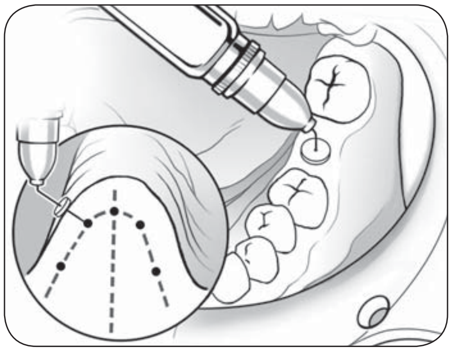

FIGURE 5. Topical anesthetic allows simple bone sounding with dental needle and endodontic rubberstop.

FIGURE 6. Stone cast from overextended impression, capturing edentulous ridge.

FIGURE 7. Dual layered vacuform carrier.

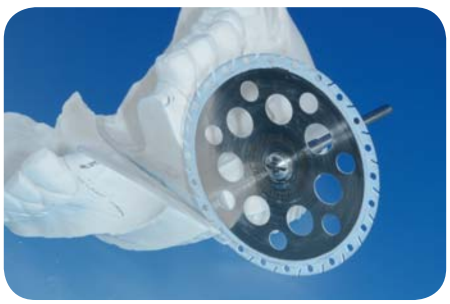

FIGURE 8. Cast is cut at estimated implant position.

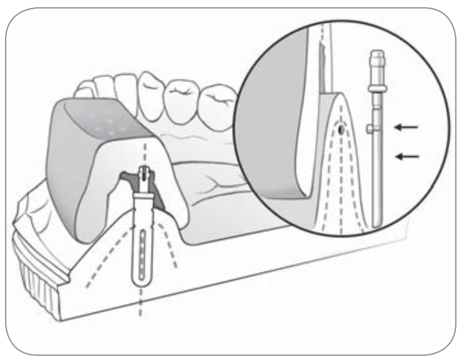

FIGURE 9. A hole is drilled at the desired implant shoulder, the buccolingual positioner is placed to lock in the buccolingual position and the depth of the shoulder of the implant.

FIGURE 10. The prosthetic outcome and the available bone are determining the buccolingual plane.

FIGURE 11. The buccal and lingual wings are positioned for the desired mesiodistal position, while maintaining the previously selected buccolingual position.

FIGURE 12. The wings are attached to the vacuform carrier with ortho-acrylic. Upon setting, the crossbar is removed, exposing the rails for the rotation-block attachments.

critical anatomical structures (**FIGURES 1** and **2**). Does that mean one never needs a CBCT? Of course not, it is absolutely wonderful technology when indicated to increase knowledge, or in combination with CAD/CAM guides. Most dentists will never have the volume to have a return on investment that warrants the purchase of a CBCT. Luckily, many dedicated centers allow access to CBCT information on a referral basis. If we add the costs of the CBCT, the actual surgical guide, the software and the time needed to master the software, for many clinicians the conclusion is that most of the time the use of CAD/CAM surgical guides for one- to two-implants cases is cost prohibitive. CAD/CAM guides require CBCT scan information. The cost of a CBCT scan at a dedicated imaging center in the author's city is $400 and an intraoral scan is $50, amounting to a cost of $450 just for digital input data. There is limited data in the literature on cost; the fee for a CBCT scan in Switzerland is the equivalent of $300.[23] In the U.S. market the main CAD/CAM guide producers currently charge between $300 and $500. This brings the total cost of a CAD/CAM guide to between $750 and $950. This does not include the cost of purchasing the software, yearly maintenance fees or the cost of a radiologist report. In contrast, the described analog guide costs $140 per implant site.

To fill this gap and balance the need for a fully restrictive surgical guide and the need to control costs for the smaller cases, the 3D Click Guide (Idondivi Inc, San Francisco) was developed.

The 3D Click Guide is an in-office, cast-based concept that does not necessarily require CBCT. When deemed necessary and appropriate, it can easily be combined with CBCT information. An experienced operator can produce a guide, from impression-making to radiographic confirmation, in approximately 30 minutes. When fabricated in-office, true same-day surgery is possible.

The final product of this system is similar to a computer guide product produced using CAD/CAM technology. The fully restrictive guide has a dedicated channel through which drills and appropriate keys can be used to create an accurate osteotomy.

Clinical Technique

The following case report demonstrates the merits of this system and the clinical steps for guide fabrication and successful implant placement.

An overextended impression is taken to capture the maximum of the edentulous ridge. Either alginate or vinyl poly siloxane can be used. A stock tray is filled with stiff VPS putty (Examix, GC America Inc., Alsip, Ill.) and covered with a thin sheet of food foil (Saran Wrap, SC Johnson, Racine, Wis.). Once placed in the mouth, finger pressure pushes the putty against the lingual and buccal soft tissue. This will result in a tight adaptation of the soft tissue against the bone. Upon setting, a small portion of new putty is mixed and added to the buccal and lingual of the impression at the treatment area. This is covered with food foil and placed back into the mouth. Additional finger pressure will push down the soft tissue and actively overextend the impression.

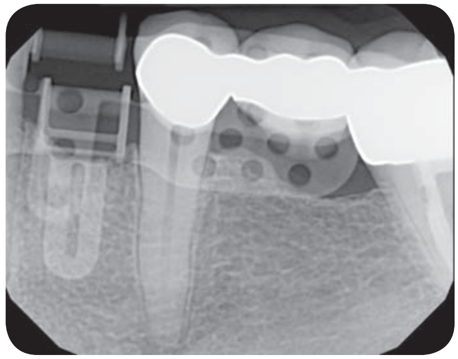

FIGURE 13. Radiographic implant replicas are not overlapping, the X-ray direction is not perpendicular to the ridge; the image is not diagnostic.

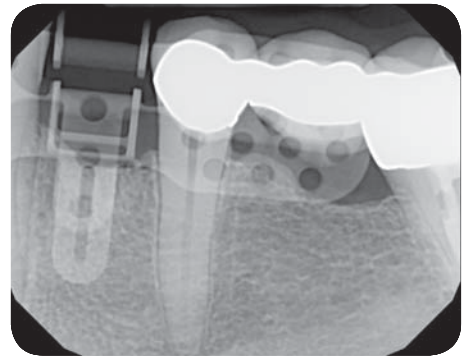

FIGURE 14. The radiographic implant replicas are overlapping, the image is dimensionally correct. The decision is made to create a 3-degree distal rotation from the selected position.

FIG 15. A yellow 3-degree rotation block is selected.

FIGURE 16. Note how the drill guide is 3 degrees toward the distal compared to the originally selected trajectory.

Remove the tray from the mouth, remove the foil. This pre-impression is now filled with injection VPS material and repositioned. The resulting impression has captured a much larger area of the crest than we are commonly used to in dentistry. Alternatively, a stock tray is extended by locally applying orthodontic rope wax (Wax square ropes, Patterson Dental Supply, St. Paul, Minn.) at the site of interest, in the mandible, both lingual and buccal, in the maxilla just buccal. Alginate is mixed to a stiff consistency and the tray is filled. The tray is positioned in the mouth; the soft wax will push the tissues down, exposing the alveolar ridge.

Topical anesthetic is placed on the soft tissue of the edentulous site (**FIGURES 3** and **4**).

The soft tissue thickness is measured using a 27G short anesthetic needle (Fairfax Dental, Miami), with an endodontic rubber stopper; five readings are taken per implant (**FIGURE 5**).

- Deep buccal = 2 mm above deepest point captured by impression capture.
- High buccal = 3-4 mm below crest.
- Deep lingual = 2 mm above deepest point captured by impression.
- High lingual = 3-4 mm below crest.
- Crest can also be measured from X-ray.

The impression is poured into an Accu-trac Precision Die System tray (Coltene/Whaledent Inc., Cuyahoga Falls, Ohio) or DVA twin trays, (Dental Ventures of America Inc., Corona, Calif.) using dental stone (Earth Stone, Tak System Inc., Wareham, Mass.) or VPS casting material (Blu-Mousse/Mach 2 slow, Parkell Inc., Edgewood, N.Y.). Alternatively, a Pindex system can be used (**FIGURE 6**). A denture tooth or wax-up is placed. The buccal gingival outline of the desired prosthetic outcome is marked.

FIGURE 17. Dedicated drill guide in place for 2.0 mm initial drill.

FIGURE 18. 3.2 mm drill guide.

FIGURE 19. 3.2 mm drill with build in stop at 8 mm, creates final osteotomy.

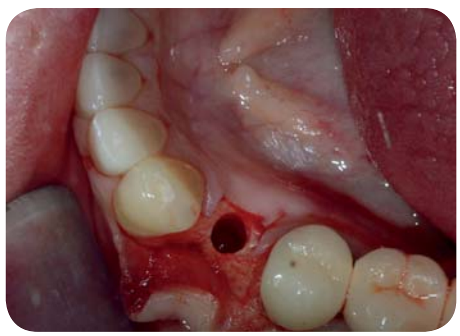

FIGURE 20. 3.2 mm osteotomy for an 8 mm implant.

The shoulder of the implant should generally be 2-3 mm below this line.

A dual layer vacuform carrier is created. Using 1 mm soft-guard material and 0.75 mm bondable material, which are heated together (Essix A+ and model duplication material, Dentsply Raintree Essix, Sarasota, Fla.) (FIGURE 7).

The cast is cut along the mesiodistal (MD) path of the proposed MD axis for the implant (FIGURE 8). The cut is based on an estimation of neighboring roots and the center of the tooth that will be replaced. A radiograph and anatomical information are used as reference. The five tissue-thickness readings are transferred to the cut face of the cast and the markings are connected parallel to soft tissue.

The desired buccolingual (BL) implant axis is marked on the cast relative to bone volume and wax up. The desired top of implant is determined and is followed by drilling a 1 mm diameter hole at the implant axis. The top of the implant is generally 2-3 mm below the buccal gingival outline. This placement will put the top surface of the rotation block 9 mm above the shoulder of the implant (9 + 1 = 10 mm above the drill-guide). The blue buccolingual positioner (BLP) is placed in the hole and lined up with the drawn axis. Fast-setting cyanoacrylate glue is used to secure the positioner (Instant Krazy Glue, Krazy Glue, Columbus, Ohio) (FIGURES 9 and 10). Some cast material is removed from the opposing part of the BLP. The parts of the cast are placed back into Accu-trac tray/ DVA twin trays or a Pindexed cast.

The correction slot of the buccal wing is positioned on top of the BLP. The wings of the radiographic implant replicas (RIRs) are cut/bent as needed for a passive fit. The lingual wing (white) is attached and adjusted. The complete assembly is positioned on top of the BLP (FIGURE 11). The wings and RIRs are secured with a fast-setting poly(methyl methacrylate) (PMMA) ortho-acrylic (Orthodontic Resin, Dentsply, York, Penn.) to create an irreversible solid connection. The cross member is now removed, exposing the retention rails (FIGURE 12).

The surgical guide is placed in the mouth and a radiograph is taken. If the radiograph is exposed perpendicular to the ridge, then the images of the two RIRs will overlap and appear as one (FIGURES 13 and 14). This indicates a diagnostically appropriate image. If the trajectory is as desired, no rotational corrections are needed; then a 0-degree rotation block (green) is selected. If a small correction is warranted, a 3-degree yellow rotation block is selected (FIGURES 15 and 16). A larger correction is possible by selecting a 7-degree red rotation block.

Depending on the manufacturer's drilling protocol, a small diameter initial drill is selected. Drill with the 2.0 mm pilot drill to a short and safe depth and evaluate the length of the osteotomy. The top of the rotation block is 9 mm above the top of the implant. The drill guide is 1 mm thick, so the drill stop should be set at +10 mm for accurate depth control. For example, a 10 mm osteotomy requires the drill stop to be set at 10 + 10 = 20 mm. The final length of the implant can then be determined and the osteotomy can be prepared to length. Subsequent drills of larger diameter are employed to widen the osteotomy as required (FIGURES 17–20).

The implant can now be placed using guidance and depth control (**FIGURES 21–24**).

Various case samples can be viewed in **FIGURES 25–30**.

Conclusion

A fully restrictive surgical guide allows clinicians to control the placement of dental implants. There are two general production modes, digital and analog. The digital CAD/CAM-generated guides have a wide application range but are occasionally complex and cost-prohibitive. The analog system presented in this article is only intended for one- to two- implant cases, but can be generated in one visit and is considerably more economical. A low-cost, fully restrictive surgical guide, as described, might introduce more clinicians to the advantages of guided implant placement. ■

FIGURE 21. 4.0 x 8 mm implant ready for visually guided implant placement.

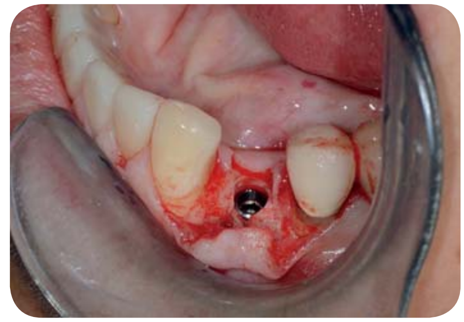

FIGURE 22. Implant placed at planned 3-D position.

FIGURE 23. Healing cap supports the tissue flap, which positions attached tissue towards the buccal.

FIGURE 24. Radiograph of final implant placement.

FIGURE 25. Lower central is challenging clinical situation due to space constraints.

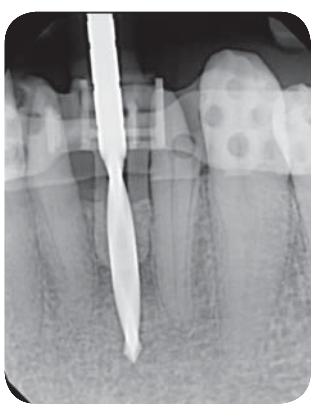

FIGURE 26. A 3-degree rotation block, has created the precise mesiodistal angulation in this very narrow space.

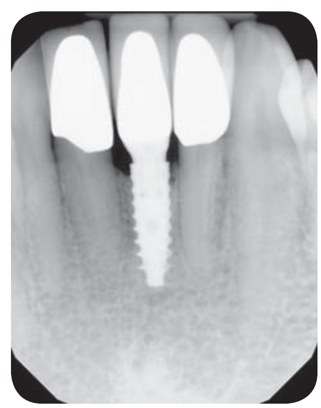

FIGURE 27. Twelve-month recall of implant reconstruction.

FIGURE 28. Congenitally missing lateral often leaves little room for error.

FIGURE 29. Mesiodistal limited space with precise implant placement.

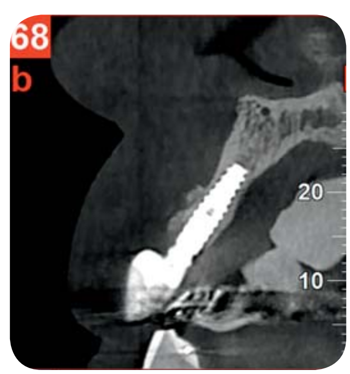

FIGURE 30. Buccolingual limited space with precise implant placement.

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