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IMPLANTS

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Disclosure: Dr. Schlesinger is a key opinion leader for Hahn Implant Systems.

CBCT Guided Surgery: Accurate, Predictable, and Economical

This case report article discusses CBCT guided surgery and why it should be considered as an integral part of predictable and successful implant placement.

INTRODUCTION

As technology advances, patient treatments advance too. The advent and continual development of cone beam computed tomography (CBCT) machines and guided surgery continue to provide clinicians with incredible tools to optimize patient care.

The technique used in CBCT has been applied in medical imaging since 1982.[1] The first CBCT units were developed and sold in Europe in 1996 by NewTom. These units were very large and expensive. As a result, few practitioners had access to this emerging technology. In 2001, this technology was introduced in the United States. As time went on, more companies began manufacturing these machines, which soon became smaller, provided greater image resolution, and came down dramatically in price. Today, a new unit will cost approximately $55,000 to $60,000.

In 1996, when I was in my residency program, we did not have access to this new technology. So, when we wanted to do guided surgery (when I say "guided," I really mean only pilot drill guidance with respect to position and angulation since guided surgery kits had not been developed yet), we would create an aesthetic wax-up of the arch, duplicate it in stone, and then make a plastic suck-down stint; which was then filled with a mixture of acrylic and barium sulfate. Then, holes were drilled through the intended teeth to be replaced. The patient wore this appliance and a conventional head CT was taken. *Whew!* That was a lot of work and we had not even begun to treatment plan the case or perform the surgery. Today, thankfully, it is much easier!

How Does CBCT Differ From Conventional CT Technology?

The biggest difference between the 2 technologies comes down to how the images are captured and the amount of radiation transmitted to the patient. A conventional CT unit spirals around the object to be captured. While spinning, it is capturing images in a fan-shaped manner and then "stitching" them together to create a uniform image (Figure 1). The amount of radiation energy needed for this is very high. In contrast, a CBCT scanner uses low energy fluoroscopy technology, collimating the beam into a cone and provides continuous imaging throughout the process— usually in a single or double pass around the subject. The effective absorbed radiation dose for a complete cone beam volume tomographic image of the maxillofacial area is within the range of a full-mouth dental periapical survey.[2,3]

Types of Guides

Basically, there are 3 types of surgical guides that can be fabricated from the CBCT scan and intraoral information (Figure 2).

1. Tooth-supported guides: These guides use the teeth in a partially edentulous arch for stabilization and reference.

2. Soft-tissue supported guides: These rest and are supported by the soft tissue in a similar manner as a full denture. These usually require fixation pins to stabilize them. A dual-scan technique is also required at work-up.

3. Hard-tissue supported guides: The guide is supported fully by the ridge/hard tissue. It requires extensive soft-tissue reflection and fixation pins.

Tooth-supported guides are generally considered the most accurate.[4] A mucosal-borne soft-tissue guide has the potential to undergo movement in varying directions that could increase the inaccuracy of implant

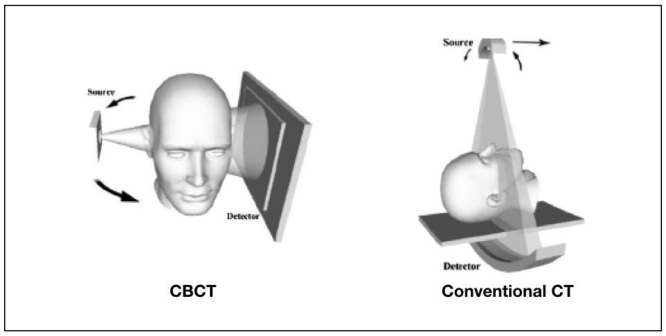

Figure 1. Differences between a conventional CT scanner and a CBCT scanner.

Figure 2. The 3 types of surgical guides.

placement, and hard-tissue supported guides can have added complexity due to the extensive soft-tissue reflection necessary.[5]

One other style of guide is a bone-reduction guide. This type of guide is used similarly to a tooth-reduction guide that your lab team may send you when a preparation is underprepared for a crown. It is used in the same manner as a bone-supported guide. Once placed, the portion of the ridge that is sticking up beyond the guide is reduced (Figure 3). This form of guide is commonly used if the ridge is uneven or needs to be reduced in height to give restorative space for a full-arch restoration. These come in 2 basic varieties: stand-alone guides, where the bone reduction guide and drilling guide are separate, or combination guides, where the drilling guide snaps into the reduction guide after bone is reduced. In my opinion, the second is a much better option in most cases.

How Accurate is Guided Surgery?

The ultimate accuracy of your surgery will depend on the accuracy of the information given to the guide manufacturer and then the accuracy of the actual manufacturing process. Therefore, you must provide an accurate vinyl polysiloxane (VPS) impression (or digital impression) and a good CBCT scan taken with proper patient position, etc. In a perfect world, guided surgery can be extremely accurate. A 2018 review article showed sub-millimeter accuracy of CBCT measurements.[6]

A recent study showed, in cases of one or more missing teeth in the anterior maxilla, that guided surgery gives even experienced surgeons significantly higher predictability and accuracy than freehand surgery. The mean difference in angular deviation differed significantly between groups and was more than 3 times larger for the freehand method. Lateral deviation at the coronal level of the implants was 0.42 mm and 1.27 mm for the guided and freehand methods, respectively, and was 0.52 mm and 1.28 mm at the apical level for the guided and freehand methods, respectively.[7] What does that all mean? When done correctly, a guided surgery is beyond the repeatable accuracy abilities of just about any human.

Some Cautions to Consider

At this point, I would like to give a few words of caution. As an implantologist, you *must* understand, know, and have experience in treatment planning and placing implants freehand. Why, you may ask? If this way of doing implants is so accurate, why would I need to know how to place implants using a free-handed technique? Well, the simple answer to this question is that occasionally the guide may be incorrect in its position with respect to hard and soft tissue. This could be due to an inaccurate intraoral model, a flawed scan, a poor fitting guide, or a combination of the above. In either case, you need to be able to evaluate the situation, to understand the issue, and to decide whether you are going abandon surgery or simply freehand the implant placement.

A lack of hard-tissue volume may require grafting at the time of placement and the surgical plan will need to be modified to accommodate that.

Another issue that can come up, and hopefully you have identified it at the treatment planning appointment, is the lack of keratinized tissue. Since most guided cases are done with a tissue punch access to the bone, the quantity and position of the keratinized tissue in relationship to the implant position becomes an important issue. It may be more prudent to perform the surgery unguided or to reflect the soft tissue first and then complete the surgery guided.

So, if you are planning to jump into guided surgery to place your implants, you should have a good background and education in sound implant principles to really be successful.

Let's now look at what guided surgery involves and consider a couple of case examples.

Surgical Kits and Guides

Most implant manufacturers have proprietary surgical kits to go along with their implant lines. There are also generic kits on the market that can be used with a variety of different implants. These kits come in a variety of forms from only guided drilling to those that have guided drilling and guided placement. Also, these kits come with either keyed or keyless instrumentation.

Proprietary vs Generic Kits

Let's take a moment to define what I just said. The main advantage of a proprietary kit is that the osteotomy created will match the specific implant it is intended to work with. This means that, in most cases, the implant will have the ability to benefit from all its macro-structure characteristics in order to attain the most primary stability. For example, a generic drill may negate the benefits of a specific implant shape, thread pattern, or apex design since it is creating a "fit-all" osteotomy. Does this mean that these generic kits do not work? No, it just means you lose some of the benefits that likely encouraged you to buy the specific implant you are using.

Guided Surgery Only vs Guided Surgery and Guided Placement

Guided-surgery-only kits will guide your osteotomy drills to the appropriate position, depth, and 3-D angulation. Then the guide is usually removed, and the seating of the implant in the osteotomy is done by hand. What does this mean for you? It means that the final position of the implant may be slightly off from what was planned. This discrepancy can increase, especially if you are placing in an area of the mouth with poor bone quality. Not only can the angulation be slightly off, but the position of the restorative platform could vary somewhat from what was planned. On the other hand, fully guided kits give the clinician complete control over not only the osteotomy but also the placement of the implant. This is accomplished by having implant fixture mounts that allow one to deliver the implant through the guide (Figure 4), and the mount controls the angulation *and* the vertical position. This can be a lifesaver if you are trying to "thread the needle" to avoid an anatomic structure or plan to have a provisional restoration fabricated prior to surgery.

Keyed or Keyless Instrumentation

Guide keys allow a manufacturer to specify a single sleeve diameter in a guide and have a kit where all the drills do not have to match that specific sleeve. The keys allow the reduction of the inner diameter of the sleeve to match the outer diameter of varying drill diameters (Figure 5). Usually, the keys are double-ended, and you'll use multiple keys as you work up the osteotomy. These keys work very well but, at times, can be cumbersome to switch out repeatedly between drills. In some circumstances, especially in the posterior, holding the key stable in the sleeve of the guide can be difficult.

Systems that are keyless work by having a single sleeve for specific-diameter implants, and the drills have a standardized hub (Figure 6) that allows them—from pilot to final diameter—to be guided through the sleeve and guide. Basically, fewer parts, less to hold on to, and less chance for error.

How the Planning Software Works and How a Guide is Made

Once a CBCT scan is taken, a represen-

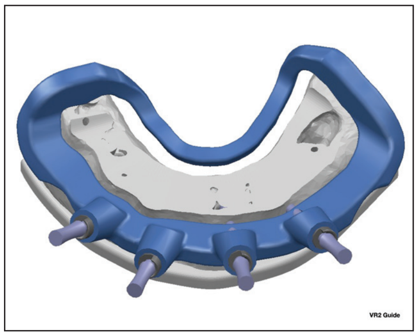

Figure 3. A bone reduction guide for an uneven ridge.

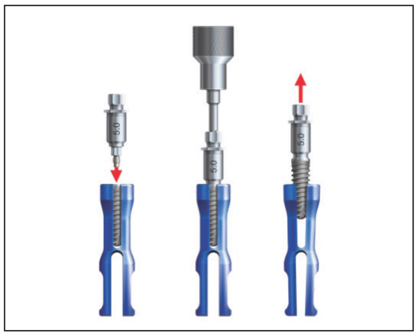

Figure 4. Implant delivery mount.

Figure 5. A surgical guide key.

tation of the intraoral environment must be captured. This can be done conventionally with a VPS material or captured digitally by utilizing one of the many intraoral scanners on the market. The DICOM data from your CBCT scanner and the digital images from your intraoral scan (or VPS impression) will be brought together in the planning software, allowing the clinician or the dental technician to plan the treatment. Once the position of the implant(s) has/have been determined, the software takes over to determine the parameters for fabrication of the guide.

Each planning software will have, within its software library, the specific implant system being used. The data has been provided by the implant manufacturer in the form of an STL (stereolithography) file. This file format is supported by many other software packages; it is widely used for rapid prototyping, 3-D printing, and computer-aided manufacturing.[8] In other words, this is a digital, 3-D model of the implant you plan to place. From this data, the software will calculate the working depth for the guide. This working depth is determined by the implant length, the drill lengths available, and the distance from the top of the sleeve to the tip of the intended implant (Figure 7). Therefore, it is possible that, in 2 different cases replacing the same tooth with the same size implant, the working lengths could be different and the length of the specified drill in the kit may be different. Your guide manufacturer will provide you with a step-by-step "recipe" for your individual case. It will show each drill length and diameter as well as the progression to follow in order to complete the osteotomy and place the implant.

Figure 6. Hub and vertical stop on keyless surgical system.

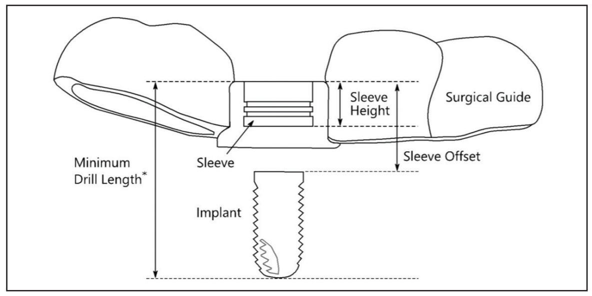

Figure 7. How working drill length is calculated.

Figure 8. Preoperative keratinized surgical site.

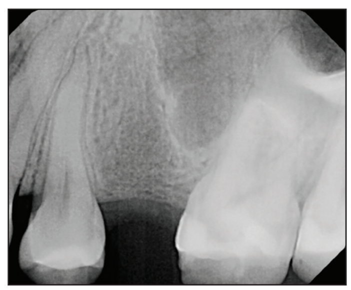

Figure 9. Pre-op radiograph.

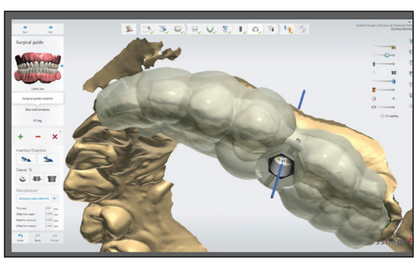

Figure 10. The 3Shape surgical plan.

CASE REPORTS

Case 1

A 37-year-old female patient in good overall health wanted to replace a missing second bicuspid. The area was evaluated intraorally. There was sufficient keratinized tissue to allow for flapless surgery (Figure 8). During the evaluation appointment, it was noted that the maxillary sinus had pneumatized anteriorly into the area where the implant would be placed (Figure 9). If it could be avoided, the patient did not want to have a transcrestal sinus elevation. First, a CBCT scan would be taken, and then guided surgery would be done to place the implant against the anterior wall of the sinus cavity without antral penetration. An intraoral scan was done (TRIOS [3Shape]), and the data was sent to the guide manufacturer (Glidewell Laboratories). The treatment plan report shows the position of the intended placement along with the guide proposal (Figure 10).

The treatment plan was approved via email exchanges of information and images. Once approval was received, the guide was manufactured via 3-D printing and shipped to the office. The case came with the guide and the specific steps necessary to do the surgery (Figure 11). For this case, a 3.5- x 8-mm Hahn Tapered Implant (Glidewell Laboratories) would be placed using a Hahn Tapered Implant Guided Surgical Kit (Glidewell Laboratories) (Figure 12).

Drill Sequence for a 3.5 x 8 Implant

Sequence	Instruments
1	3.5 Tissue Punch
2	3.5 Alignment Drill
3	3.5 A Pilot Drill
4	3.5 x 8 Shaping Drill
*5	3.5 x 8 Dense Bone Shaping Drill
*6	3.5 Bone/Screw Tap

*Optional steps

Figure 11. Surgical "recipe."

Clinical Protocol

After profound anesthesia was achieved utilizing a middle superior alveolar (MSA) nerve block and palatal infiltration (4% Septocaine [Septodont]), the guide was tried in to determine its fit (Figure 13). It is extremely important to make sure that the guide seats completely and accurately.

The included surgical recipe allows for a smooth and efficient surgery. The hard tissue was accessed using a tissue punch. Then the guide was removed, the remaining tissue plug was removed using tissue forceps (Figure 14), and the guide was placed back into the patient's mouth. Following the specified surgical protocol, an alignment drill was used to center the osteotomy within the guide and to provide a purchase point so the pilot drill does not wander before penetrating the alveolus.

The specified-length pilot was taken to full depth (Figure 15). The full depth is determined by the stop on the top of the drill hub, which will come in contact with the sleeve of the guide. Finally, the 3.5-mm former (Figure 16) was taken to full length. Once the osteotomy was completed, the site was checked by sounding the internal walls of the osteotomy with a probe. Then the site was flushed with sterile

Figure 12. Hahn Tapered Implant Guided Surgical Kit (Glidewell Laboratories).

saline to remove any surgical debris.

A fixture mount was placed onto the implant (Figure 17) to be placed and tightened with a driver. This mounted implant was then delivered (Figure 18) through the guide and advanced to its final position with a ratchet wrench (Figure 19). The final seating position is again determined when the stop on the fixture mount comes in contact with the sleeve in the guide (Figure 20), and the flat on the mount matched the flat on the sleeve (both are hexagonal in shape). The mount was then removed, and then the guide was removed from the patient's mouth (Figure 21). Next, an ISQ reading was taken using an Osstell IdX (Osstell) (Figure 22). With the aggressive threads of the Hahn implant, a value of 68 was achieved, which satisfies the requirement for primary stability.[9] A 3-mm healing abutment was placed (Figure 23). The position of the implant was verified in a post-placement radiograph (Figure 24). One can see that the position of the implant was accurately placed, exactly as planned.

Case 2

The advantages of guided surgery are multiplied when placing multiple implants. In this specific case, you will see how easy it is to place 2 or more implants in a quadrant with incredible accuracy and in a short surgical duration.

A 44-year-old female patient presented for a consultation for implants in the lower left quadrant. Her medical history included prediabetes, but she was otherwise in good health. Although this patient had sufficient bone volume (Figures 25 and 26), and this placement would have been straightforward to complete without a guide, she chose to have guided placement of implants to facilitate a flapless approach and to have a more efficient surgical appointment.

The presurgical appointment was carried out in a similar fashion to the previous case, with the exception of the intraoral scan being done with the iTero Element 2 intraoral scanner (Align Technology). Implants were treatment planned to be placed in the Nos. 18 and 19 positions. After the treatment was planned by the DTP Department at Glidewell Laboratories, the surgical report was sent via email to my office (Figure 27). From the treatment plan, we can see that the implants can be placed and the anatomical limitation of the submandibular fossae will be avoided. The plan was approved and the manufacturing of the guide was commenced.

Clinical Protocol

At the surgical appointment, after sufficient anesthesia was achieved (2% lidocaine with 1:100 epinephrine [Henry Schein]), the guide was tried in (Figure 28). As per protocol, the surgery consisted of soft-tissue removal in a flapless manner by utilizing the rotary tissue punch that is included in the system. Once access to the crest was achieved, an alignment drill was used in both sites (Figure 29). Throughout this surgery, since the implant sizes were identical in diameter, it was possible to just switch back and forth between the 2 sites for each step in the preparation in order to expedite the surgery.

Following the alignment drill, a pilot drill (Figure 30) was taken to full length (Figure 31) and then followed sequentially with the successive osteotomy formers (Figure 32). Once the sites were prepared, 360° integrity was checked, and the fixture-mounted implants (Figure 33) were placed through the guide (Figure 34). For this case, a 5- x 8-mm Hahn Tapered implant was placed in the No. 18 location, and a 5- x 10-mm Hahn implant was placed in the No. 19 position. ISQ values were taken, and each implant had values well above the minimum primary stability ISQ value of 55.[10] Again, this can be attributed to the outstanding primary stability these implants routinely attain. After rinsing the internal connection with a chlorhexidine solution (Henry Schein), 3.0 mm tall concave healing abutments were placed (Figure 35). A postoperative radiograph was taken to verify the accuracy that can be achieved using a guided surgery protocol (Figure 36).

CLOSING COMMENTS

An advantage of guided surgery, as

Figure 13. Try-in of guide.

Figure 14. Removal of tissue plug after punch.

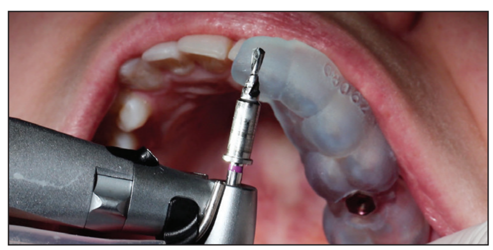

Figure 15. Pilot drill.

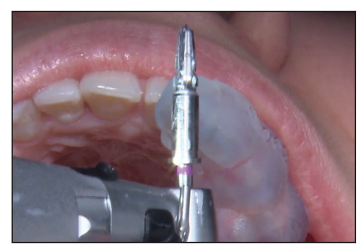

Figure 16. Final 3.5-mm drill.

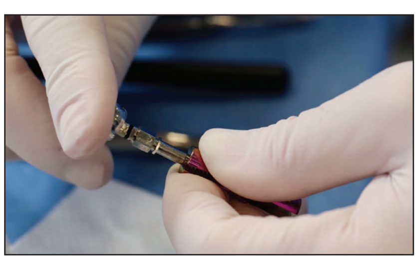

Figure 17. Attaching fixture-mounted implant to ratchet.

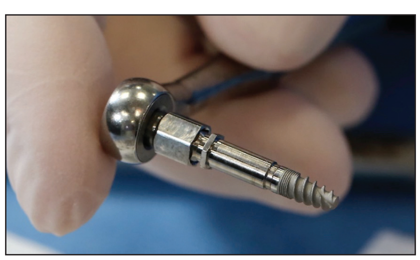

Figure 18. The implant, ready to be delivered.

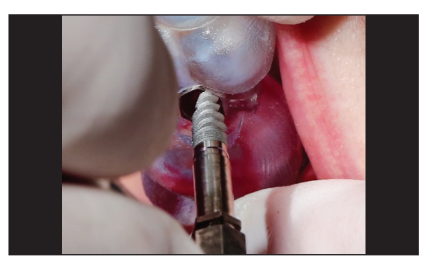

Figure 19. Guided placement of the implant.

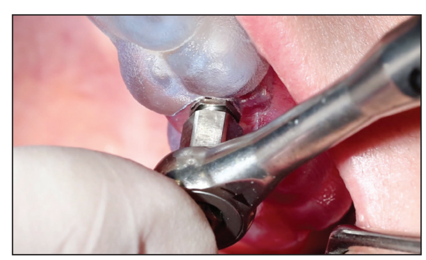

Figure 20. Final seating of the implant.

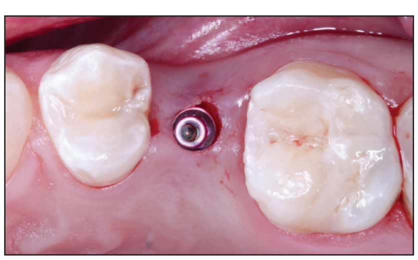

Figure 21. Completed implant placement.

Figure 22. Taking an ISQ reading.

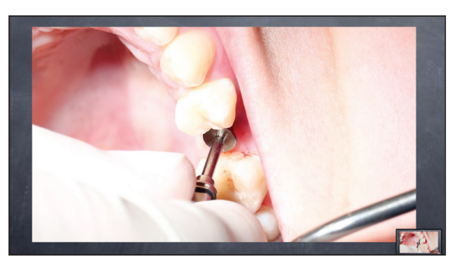

Figure 23. Placement of a 3-mm healing abutment.

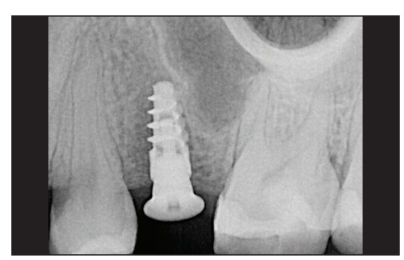

Figure 24. Final placement radiograph.

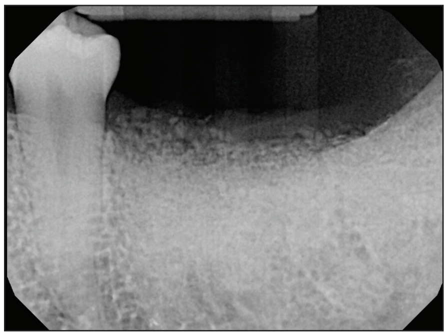

Figure 25. Pre-op radiograph of lower left quadrant.

Figure 26. Intraoral view.

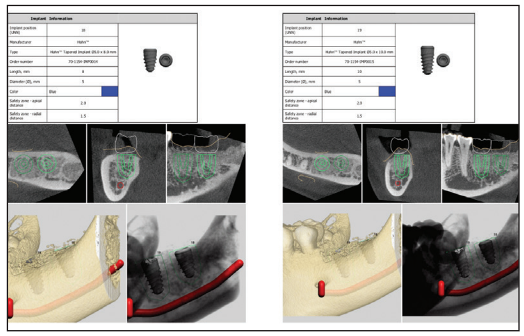

Figure 27. Guided treatment plan.

Figure 28. Try-in of guide.

Figure 29. Alignment drill.

Figure 30. Pilot drill.

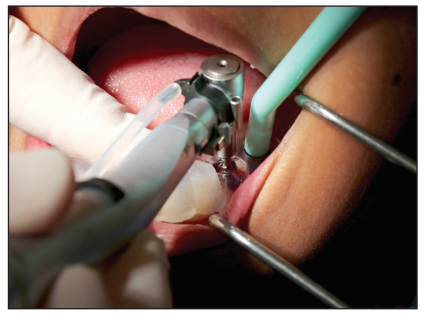

Figure 31. The pilot drill was taken to full length.

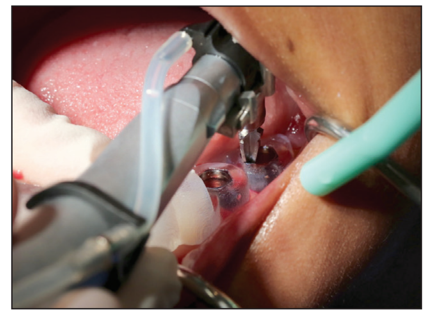

Figure 32. Final 5-mm-diameter osteotomy former.

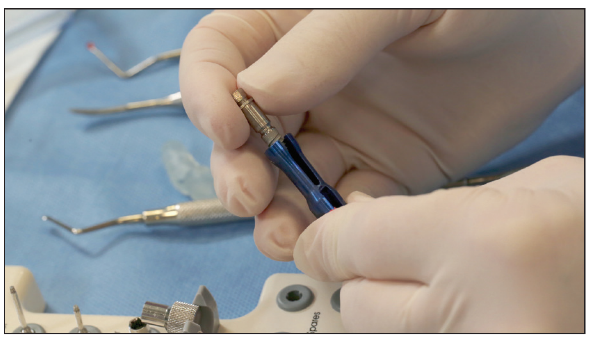

Figure 33. Removing the mounted implant from the carrier.

Figure 34. Both implants, fully seated through the guide.

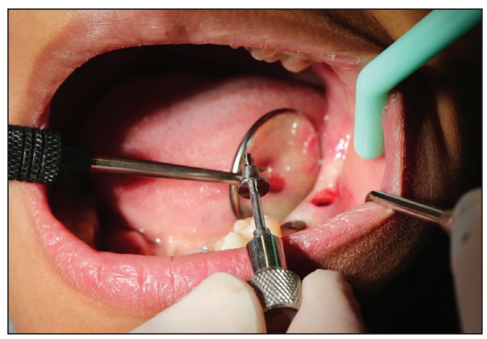

Figure 35. Placement of 3-mm healing abutments on both implants.

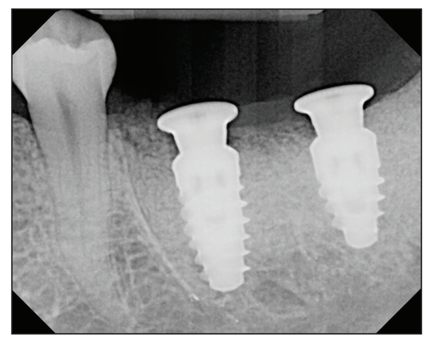

Figure 36. Final radiograph, verifying position of implant Nos. 18 and 19.

previously alluded to in this article, is the speed at which these surgeries occur. The 2 cases presented here were carried out with surgical times (after onset of anesthesia) of 5 minutes and 8 minutes and 35 seconds, respectively. This results in a much more tolerable experience for the patient and, in addition, helps the clinician optimize production while optimizing the quality of the outcome. Another advantage comes later in the restorative phase of treatment; the more accurately the clinician places implants with the restorative outcome guiding placement, the easier, more straightforward, and longer lasting the restorations will be.

CBCT-guided implant surgery and placement is not only opening up the possibilities of economical implant placement to more practitioners, but it is making it safer and more predictable for the patients who are under our care.

Isn't it about time to consider acquiring and implementing technology that will change the way you place dental implants?✦

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