Horizontal Ridge Augmentation Under a Removable Partial Denture and Implant Placement

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Implant planning has moved in recent years to virtual planning with a CBCT scan and fabrication of a surgical guide based on that virtual planning. Unfortunately, positioning based on prosthetics is typically missing from the CBCT scan. Use of a diagnostic guide fabricated in office permits information from ideal prosthetic positioning to improve virtual planning and subsequent fabricated of a corrected surgical guide. This becomes more important when insufficiencies in the ridges horizontal aspects (width) will require ridge augmentation to allow later implant placement. This article discusses a case with insufficient ridge width and determination of where augmentation is required to house implants in ideal prosthetic positions, the subsequent grafting, implant placement and restoration.

Key Words: ridge augmentation, guided placement, Surgical guide, CBCT

Introduction

Bone resorption occurs after tooth extraction. The resorption is increased when implants are not immediately placed. Resorption is due to the lack of localized bone stimulation. This is exacerbated when: (1) periodontal disease was the cause of tooth extractions, or (2) an extended time elapsed since the extractions. When multiple adjacent teeth are missing, it is common that a partial removal prosthesis (partial denture) is worn, which may add to more residual buccal bone loss due to a lack of internal bone stimulation and added external pressure on the residual.[1] This is especially true in the maxilla, where the bone is less dense compared to the mandible.[1] Additionally, the buccal osseous plate is less dense than the lingual plate of bone and therefore resorbs faster.[2] Resorption at the buccal aspect of the ridge complicates surgical implant placement from an anatomical and prosthetic perspective. When bone loss results in: (1) narrowing of the ridge (horizontal bone loss) and (2) decreased ridge height (vertical bone loss), augmentation may be necessary to provide sufficient ridge dimensions for proper implant placement. Traditional radiographs only provide a 2-dimensional view of the area being planned for implant placement. Cone beam computerized tomography (CBCT) systems provide a more complete 3-dimensional view that visualizes the missing buccal-lingual dimension.[3] However, prosthetic positioning is typically missing from CBCT scans.[4] That missing information can be acquired with the use of a diagnostic guide worn during the scan. The diagnostic guide has the ideal prosthetic positions for the planned implants.[5,6] That data can then be used in virtual planning to better determine where the implants need to be positioned and if osseous ridge augmentation is needed. When ridge augmentation is performed as a prelude to implant placement, a new diagnostic guide can be fabricated and used to design and fabricate the surgical guide based on virtual planning.[7,8]

Guide Right system for fabrication of CBCT-based implant surgical guides

Implant surgical guides may be fabricated in the lab or in the office. The benefits of in-office fabrication are: (1) decreased guide preparation time, (2) decreased cost for diagnostic and surgical guides, and (3) affording an in-office preliminary guide that can be worn during the initial diagnostic CBCT scan. Wearing the guide during the diagnostic CBCT scan allows for proper planning of implant position and angulation. Once grafting is completed, necessary corrections can be made to the final surgical guide.

The components of the Guide Right system (DePlaque, Victor, NY) consist of: (1) straight and offset guideposts (Figure 1a), (2) straight and angled guide sleeves (Figure 1b), (3) a 3/32-inch pilot drill, and (4) additional drills with depth stops that match the interior of the guide sleeves (Figure 1c). The offset guideposts are designed as 2 pieces. The upper portion is available in 0- to 3.5-mm offset in 0.5-mm increments. Regarding the guide sleeves, the guide sleeve inserts are available to guide each successive drill in the intended sequence to the final osteotomy diameter or allowing use of the final implant-brand drill for the final osteotomy drill. The following case will detail fabrication of the preliminary CBCT guide and then necessary correction for fabrication of the final surgical guide to be used for implant osteotomy creation and implant placement.

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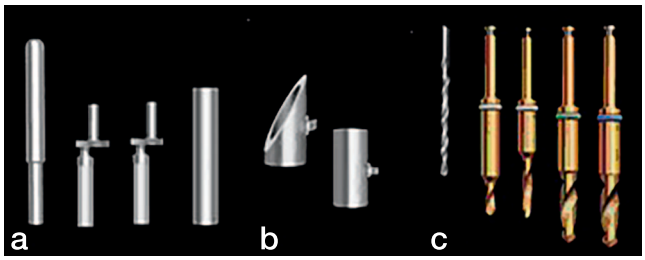

Figure 1. Components of the Guide Right guide system: (a) guide posts, (b) guide sleeves, and (c) drills.

Case

A 74-year-old female patient presented for consultation with a maxillary partial denture that displeased her. She desired dental implant placements to aid in retention of a new removable prosthesis. Teeth #2 (maxillary right 2nd molar), #3 (maxillary right 1st molar), #4 (maxillary 2nd premolar), #7 (maxillary right lateral incisor), and #14 (maxillary left 1st molar) were the only remaining maxillary teeth. Tooth #14 presented with a periapical lesion that was deemed to have a poor long-term prognosis.

Treatment options were discussed with the patient and a treatment plan was developed based on the patient's finances and clinical presentation. The agreed–upon treatment plan included placement of implants at sites #11 (maxillary left canine) and #13 (maxillary left 2nd premolar), with osseous grafting to improve bone width at those sites to accommodate the implants. Tooth #14 would be retained as long as possible to stabilize the current partial denture during graft healing and later implant placement. During planning, site #6 was analyzed for possible future implant placement but would not be performed as part of the initial planned implant treatment.

Preliminary impressions were taken for planning purposes and a cast fabricated. A hole was made in the cast at the planned implant site numbers 6, 11, and 13 with a 3/32-inch drill in a lab handpiece at the ideal prosthetic positions (Figure 2a). A straight guidepost (DePlaque) was then placed into each of the 3 sites on the cast and a guide sleeve (DePlaque) was placed onto each guidepost with the retention element positioned on the lingual (Figure 2b). A diagnostic guide was then fabricated by connecting the guide sleeves with resin and then light-cured (Figure 2c). For stability, the resin was extended onto the remaining teeth when inserted on the maxillary model. The guideposts were then removed from the sleeves in the resin on the cast and the diagnostic guide was completed (Figure 2d).

Intraorally, the diagnostic guide was inserted in place of the patient's current partial denture and a CBCT scan was taken to evaluate the ideal placement of the implant platform in relation to the available bone and anatomy.

The CBCT scan with diagnostic guide in place was imported into virtual implant planning software (Carestream Dental, Atlanta, GA) and analyzed for implant placement at the planned implant site numbers 11 and 13. Site numbers 11 and 13, when viewed in a cross-section view, demonstrated an inadequate width of bone ($<$4 mm) in the buccal-palatal dimension. (Figures 3 and 4) At site #11, a virtual implant was placed, demonstrating that the width was inadequate to accommodate a 3.3-mm implant (Figure 5). This was similar at site #13 (Figure 6). To accommodate implant placement, these insufficient ridge widths would require osseous grafting on the buccal and palatal aspects. There was an adequate height of bone at both sites to allow implant placement without augmenting ridge height (Figure 7).

The patient presented for osseous grafting surgery and signed appropriate consent forms. Local anesthesia was administered by local infiltration (3 carpules Orabloc articaine hydrochloride 4% with 1:100 000 epinephrine, Pierrel Research USA, Wayne, PA). An incision was made at the center of the ridge with a #15 scalpel blade from the mesial of tooth 7 to the mesial of tooth 14; buccal vertical releasing incisions were made at each end of the incision and a full-thickness flap was elevated. Bleeding points were created in the osseous bed that would accept the graft. The osseous plates were decorticated with a carbide bur (#2 round) to better prepare the receptor site and allow host cells into the graft material being placed. Osseous graft material consisting of 2 pieces of OsteoGen (Impladent, Queens, NY) 6 $\times$ 12 mm cut in pieces, 150 μg Infuse (Medtronic, Minneapolis, MN), plus 1.0 mL sterile saline was mixed in a sterile dish, and then added to 1.0 gm of cancellous particles (Puros, Zimmer Biomet, Palm Beach Gardens, FL). Infuse is a recombinant human bone morphogenetic protein-2 (rhBMP-2) applied to an absorbable collagen sponge carrier (ACS) and is an osteoconductive material. The combined effects of the components of the mixed graft better stimulate bone conversion, yielding better quality bone at a more rapid rate then single component graft material.

The graft mixture was placed over the buccal lateral aspect

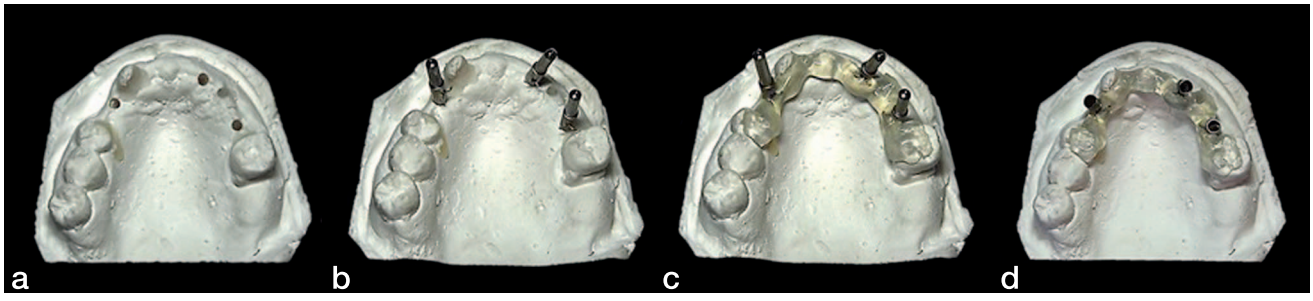

Figure 2. Fabrication of the diagnostic guide starts with drilling holes in the cast at ideal prosthetic positions: (a), guide posts and guide sleeves are placed into those holes; (b) light-cure resin is placed over the sleeves retentive element on the lingual and on the lingual and occlusal surfaces of adjacent teeth; (c) and the diagnostic guide is completed and ready for the CBCT scan intraorally (d).

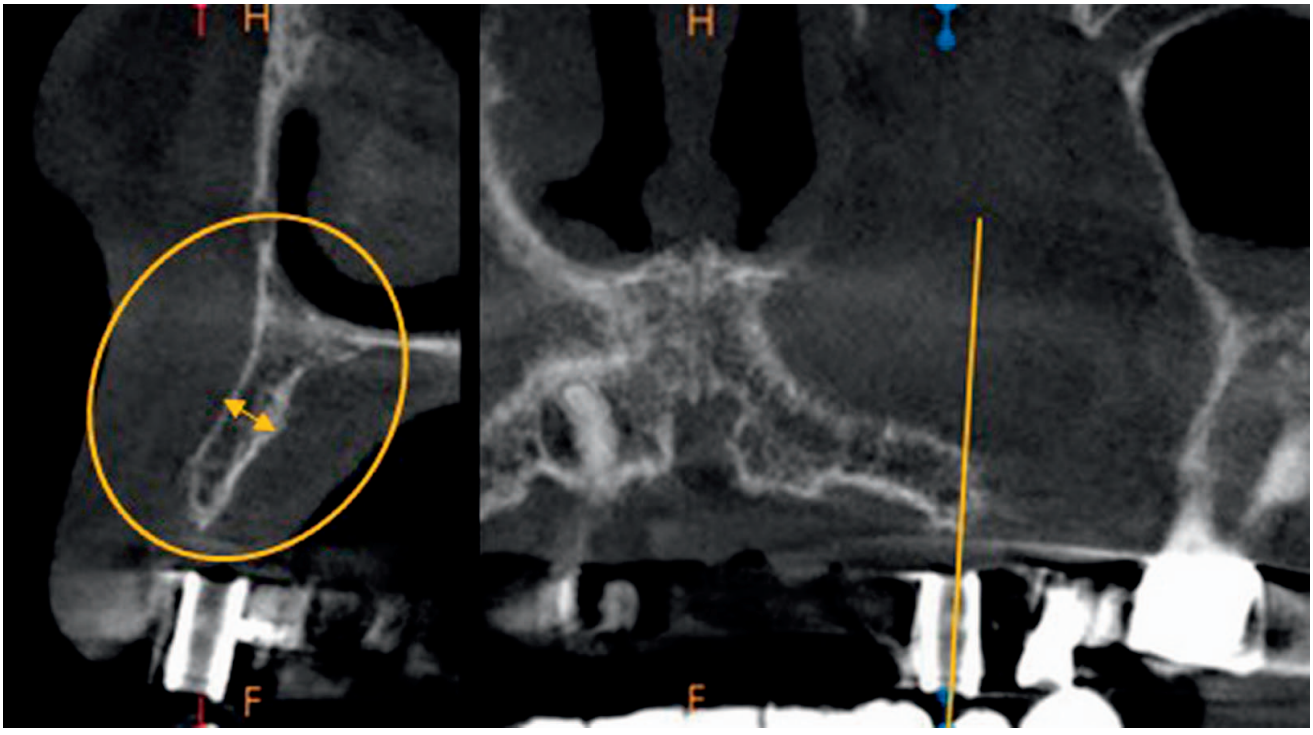

Figure 3. CBCT analysis of the diagnostic guide at site #11 confirms inadequate width of available bone for implant placement at the planned site.

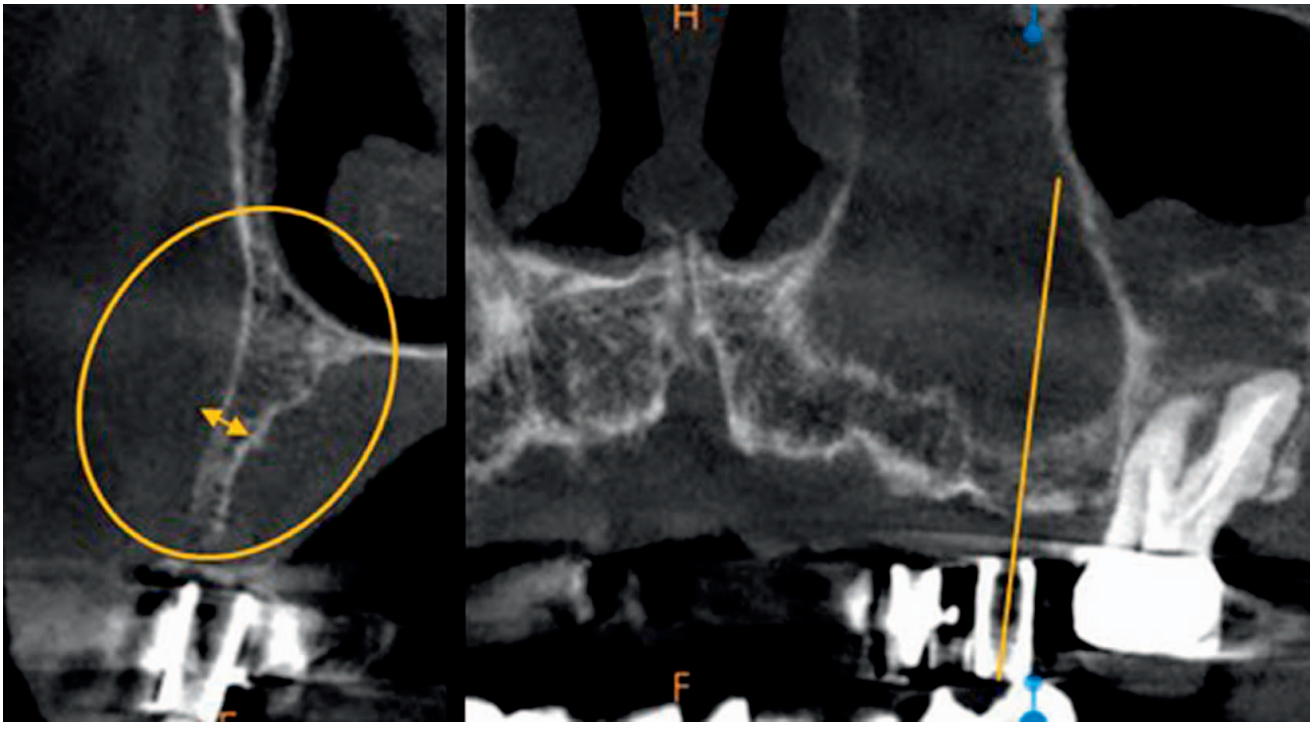

Figure 4. CBCT analysis of the diagnostic guide at site #13 confirms inadequate width of available bone for implant placement at the planned site.

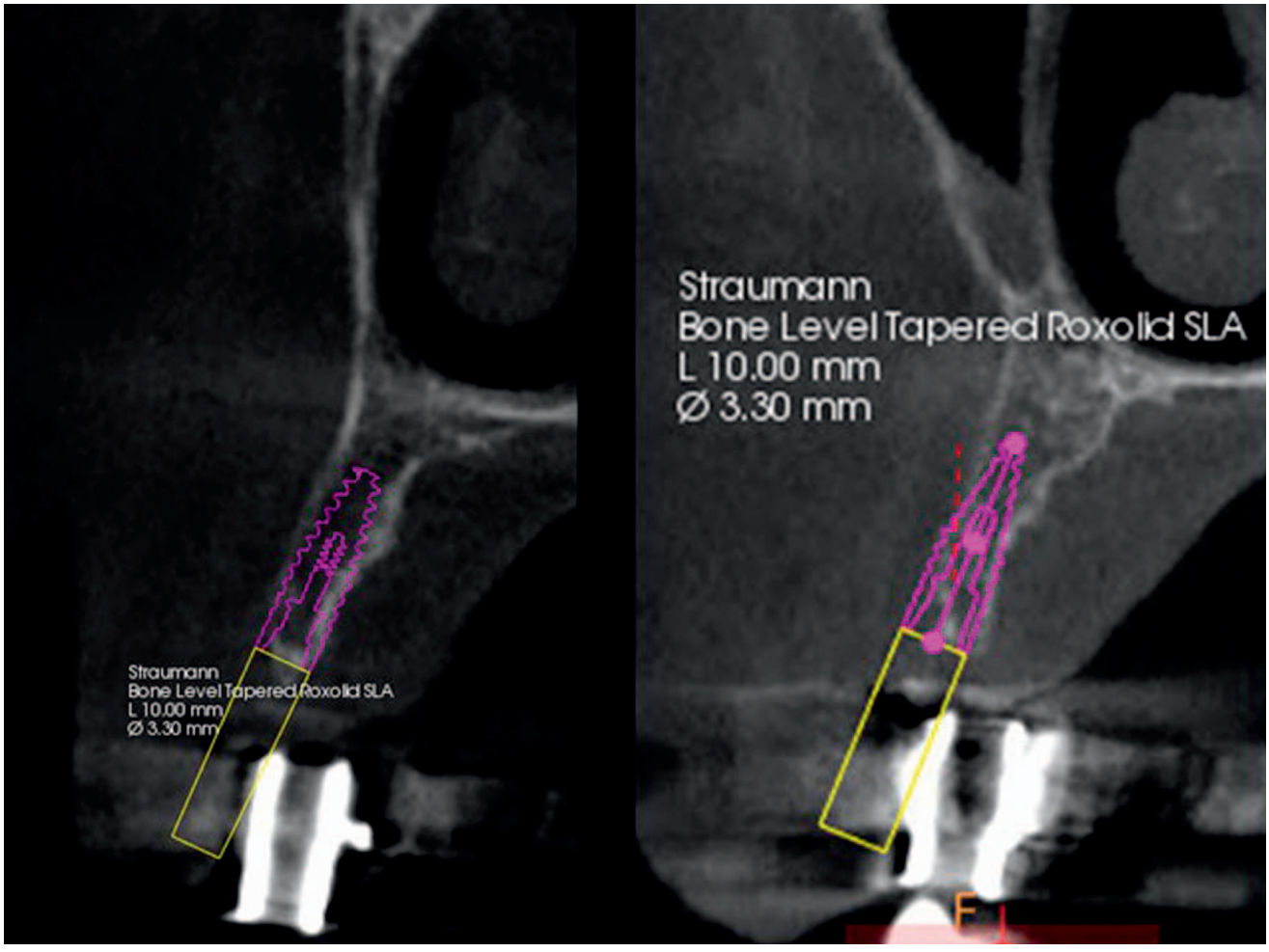

Figure 5. Virtual planning at site #11 of a 3.3-mm implant demonstrates inadequate width of the ridge, necessitating osseous augmentation to prepare the site for implant placement.

of the ridge between the teeth 7 and 14 and a titanium mesh (Impladent) was placed over the graft to tent the area, prevent displacement, and contain it until it could organize with the host bone. Fixations screws were placed to secure the titanium mesh and the flap was repositioned in a tension-free manner and closed with sutures. The current partial denture was modified to remove pressure on the ridge over the graft and accommodate the larger underlying ridge.

Tooth 14 became symptomatic and was extracted at 5 months post graft placement. At 6 months post-grafting, the patient returned and 2 impressions were made: one with the modified partial denture intraorally and the second without the partial present intraorally for fabrication of a new diagnostic guide. Casts were made from the 2 impressions. Black marks were made at the ideal prosthetic positions on the cast with the partial denture present to aid in positioning the marks at the center of the denture teeth numbers 11 and 13 (Figure 8 left). A Vacuform stent was then fabricated over the cast with a Biostar vacuum forming machine (Scheu Dental, Iserlohn, Germany) (Figure 8 middle). Holes were made through the stent at the previously placed black marks with a 3/32-inch drill and then removed from the cast (Figure 8 right). The Vacuform stent was placed on the cast of the arch without the partial denture present and used to guide the hole placement on the cast without the partial denture (Figure 9 left). Guideposts were placed into the 2 holes and a guide sleeve placed over them with the retentive element positioned to the lingual. Light-cure resin (Triad gel, Dentsply Sirona, York, PA) was flowed over the retentive elements of the guide sleeves. The resin was placed over the occlusal/incisal and lingual surfaces of the adjacent teeth (Figure 9 middle). The guideposts were removed, and the new diagnostic guide was removed from the cast to analyze virtual planning with the improved osseous dimensions (Figure 9 right).

When the patient returned, the new diagnostic guide was inserted intraorally after partial denture removal, and a CBCT scan was taken. The data was imported into Carestream implant planning software (Carestream Dental). Analysis of site #11 in a cross-section view demonstrated improved width of the ridge with the titanium mesh evident on the buccal aspect of the ridge (Figure 10). The guide sleeve was used to visualize the long axis through the sleeve that would be used to create the eventual osteotomy. The ridge was now of adequate width to accommodate implant placement; howev-

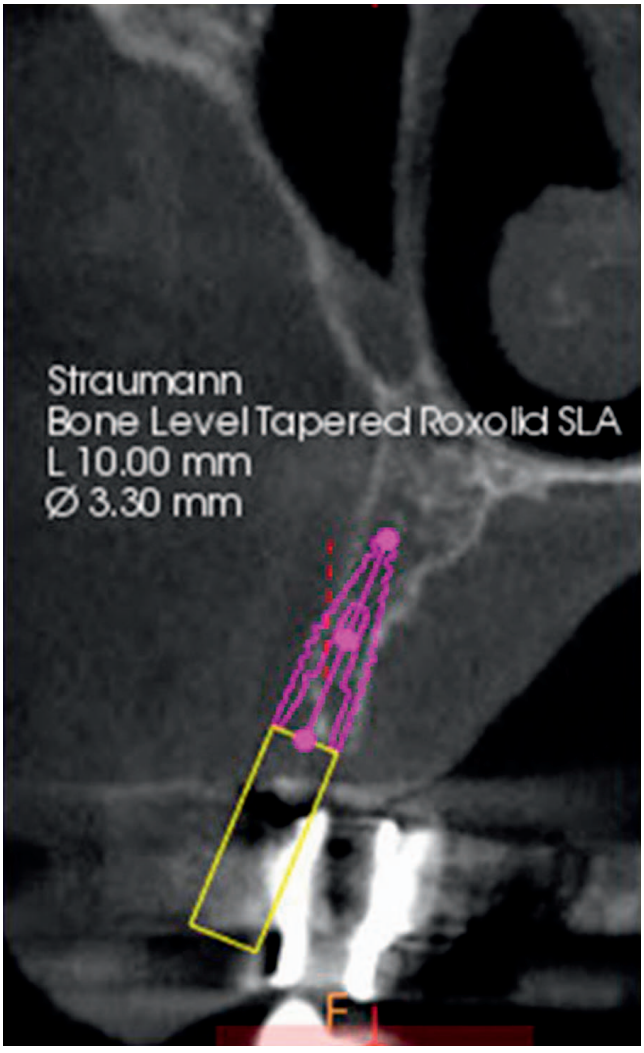

Figure 6. Virtual planning at site #13 of a 3.3-mm implant demonstrates inadequate width of the ridge, necessitating osseous augmentation to prepare the site for implant placement.

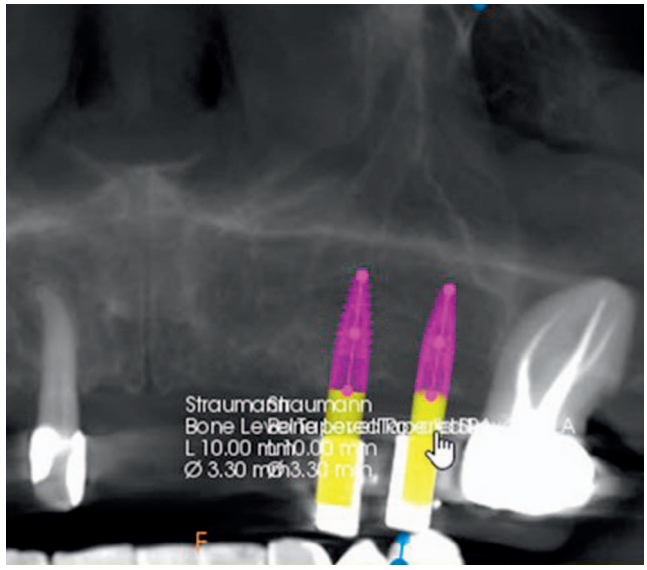

Figure 7. Virtual planning in the CBCT scan notes adequate height of available bone for implant placement at both sites.

er, a correction in the buccal-palatal dimension and in angulation were necessary to place the implant within the new osseous confines and proper prosthetic positioning. Analysis of site #11 required an offset to the buccal of 2.5 mm and an angle correction of 1°. A 2-piece offset post with the determined changes was modified using the Guide Right bending tool for site #11 (Figure 11). Virtual planning analysis of site #13 determined that an offset of 2.0 mm to the buccal and a 1° angle correction was necessary (Figure 12). The Guide Right bending tool was used to modify the 2-piece guidepost for the #13 site (Figure 13).

The lower portion of the 2-piece guideposts were placed into the appropriate hole on the cast (Figure 14a). The modified upper portion of the 2-piece guidepost was inserted over the appropriate post on the cast (Figure 14b). Then a guide sleeve was placed over the guidepost with the retentive element positioned to the lingual (Figure 14c). Light-cure resin (Triad gel, Dentsply Sirona) was placed over: (1) the retentive element on the sleeves, (2) the occlusal/incisal, and (3) lingual of the remaining teeth in the arch. The resin was then light cured (Figure 14d). The corrected surgical guide was ready for implant guided surgery (Figure 14e).

The patient returned and the consent forms were reviewed and signed by the patient. Local anesthetic was placed via infiltration into the buccal vestibule and supplemented on the palatal using 3 carpules of Orabloc articaine hydrochloride 4% with 1:100 000 epinephrine (Pierrel Research USA) was placed over the surgical area and an incision was again made in a similar fashion to that made at the graft placement appointment. The underlying titanium mesh was exposed (Figure 15 left). The fixation screws and titanium mesh were removed, exposing the mature osseous graft (Figure 15 right). The corrected surgical guide was inserted, and stability from the remaining dentition was verified. The osteotomies were performed though the surgical guide with 3.9-mm 2° tapered-depth stop drills (DePlaque) to accommodate a 4.0-mm wide implant with an 11.5-mm height (Anyridge, MegaGen, Englewood Cliffs, NJ) at both planned implant sites (Figure 16). The surgical guide was removed intraorally, and the implants were placed into the osteotomies. Cover screws were placed in the implants and the flap was closed with sutures (5-0 nylon, Henry Schein Dental, Melville, NY). The partial denture was reinserted and verified not to be impinging on the underlying soft tissue. A CBCT was taken to document implant positions in relation to the osseous dimensions and relevant anatomical considerations.

The prior CBCT scan cross-sections at both sites of the pretreatment, post-osseous grafting and implant placement, were compared (Figures 17 and 18). The virtually planned implant was overlayed on the CBCT cross-section to compare the planned and actual positions. Accuracy of the implant placement using the corrected surgical guide was confirmed to be satisfactory (Figure 19).

After a healing period of 3 months to allow osseointegration, the implants were uncovered, and impressions made for

Figure 8. Cast fabricated from an impression after grafting of the arch with current partial denture intraorally with a black mark made at ideal prosthetic position of the implants planned at site numbers 11 and 13 (left); a Vacuform stent was made of the cast (middle) and holes drilled in the stent at the black marks to allow transfer of the ideal positions to a cast of the arch post-grafting.

the planned prosthesis. An overdenture bar was fabricated with a VKS-SG attachment (Bredent USA, Miami, FL) on the mesial and distal terminal ends of the bar. A cast partial denture was then fabricated to fit over the overdenture bar and clasp to the remaining natural teeth on the opposing side of the arch (Figure 20 left). When the prosthetics returned from the lab, the bar was inserted intraorally (Figure 20 right). Tooth 14 was extracted under local anesthetic using infiltration with 2 carpules Orabloc articaine hydrochloride 4% with 1:100 000 epinephrine (Pierrel Research USA) and the overdenture was inserted intraorally. Occlusion was checked and adjusted as needed.

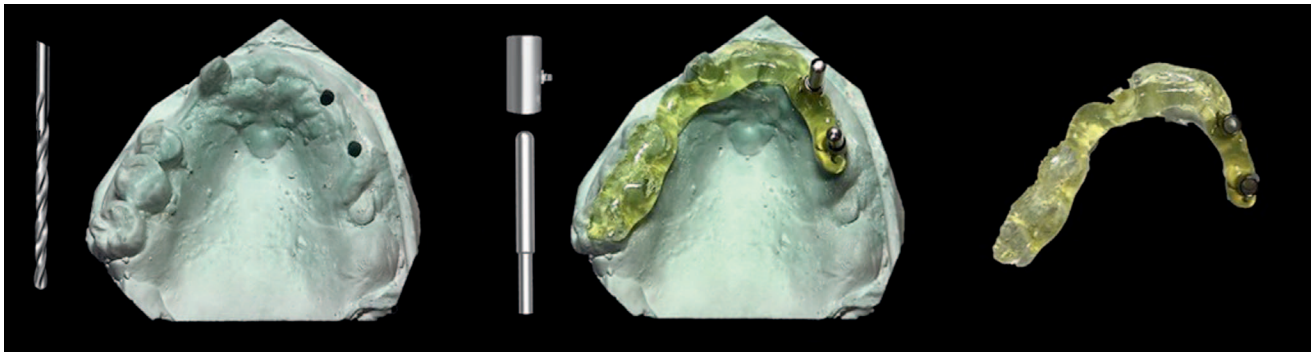

Figure 9. A cast fabricated of the arch without the partial denture intraorally after graft healing, with holes positioned using the Vacuform stent and drilled with the 3/32-inch drill (left). A new diagnostic guide is fabricated with light-cure resin and guide posts and guide sleeves (middle), yielding a new diagnostic guide ready to analyze the improved arch (right).

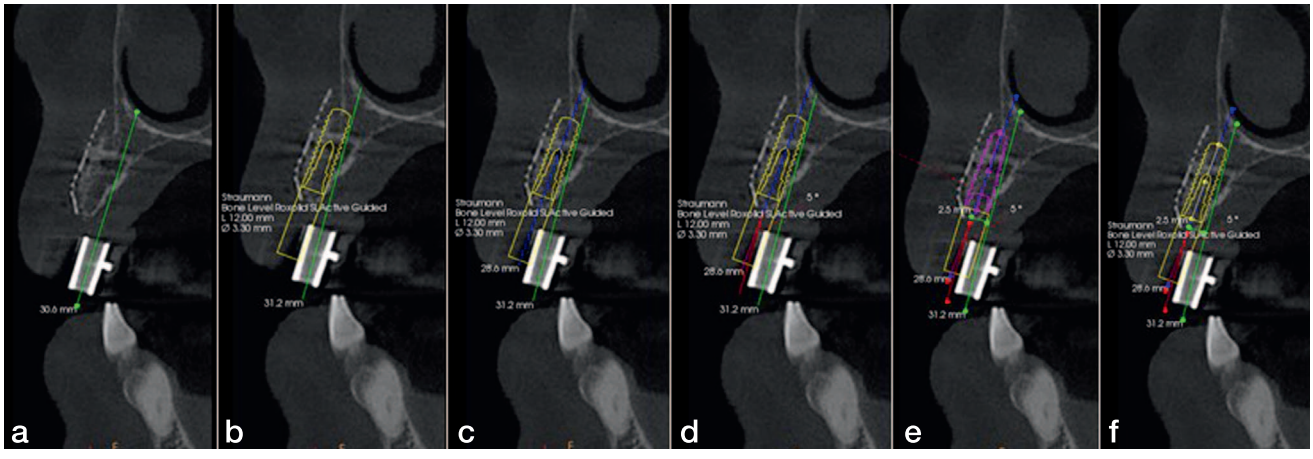

Figure 10. Virtual planning of site #11 after graft healing using the new diagnostic guide, indicating adequate width of ridge for implant placement.

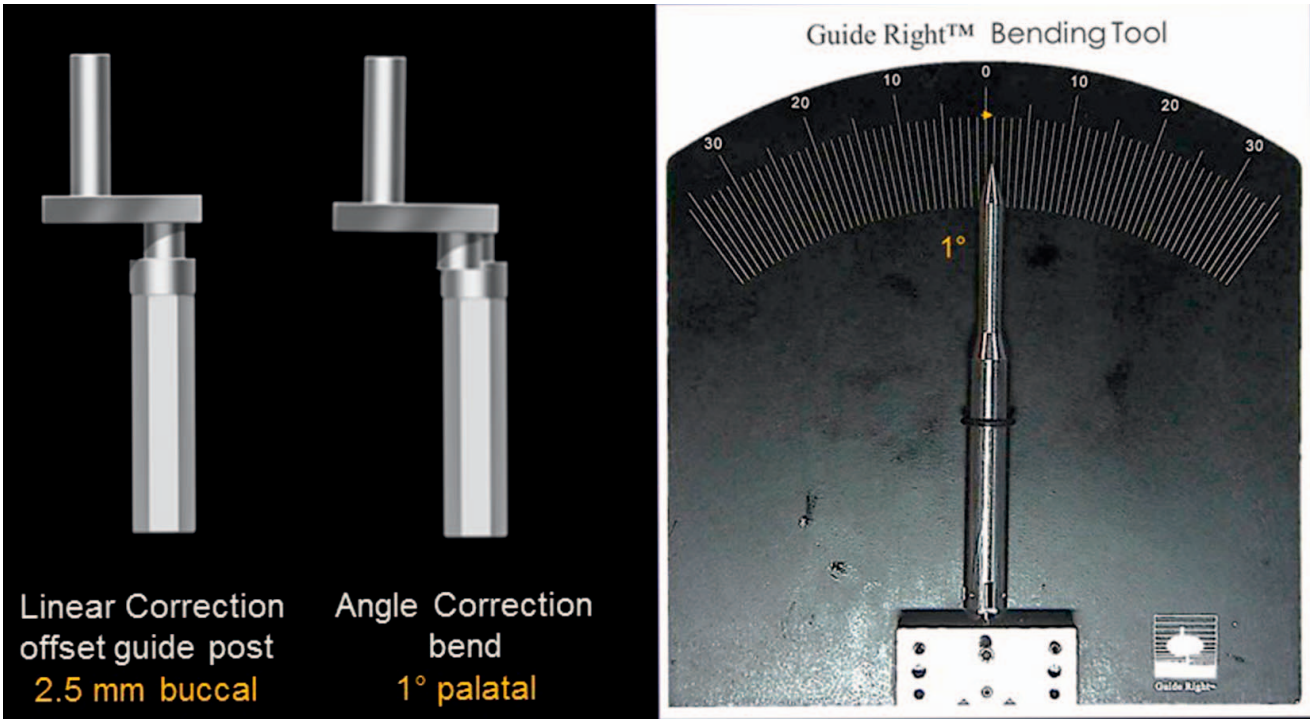

Figure 11. Virtual planning based on ideal prosthetic positioning determined a correction of implant position would be necessary on site #11 with a 2.5-mm buccal offset and a 1° angle correction.

Discussion

Surgical guides are well accepted to aid in ideal placement of implants, and CBCTs have become routine in the planning and fabrication of those surgical guides. CBCT scans provide valuable information when planning implant placement, but prosthetic positioning is not available with a typical scan. Information from a dental cast can be used to ideally position the implant prosthetically. This information can then be transferred to the data when the CBCT scan is taken by use of a diagnostic guide. By coordinating the cast and CBCT data this will allow prosthetic positioning to be used when virtual planning is done in the computer.

A prediagnostic guide fabricated on a cast of the pretreatment arch aids in guiding planning and analysis. A preliminary CBCT scan with the prediagnostic guide provides information to access the anatomical dimensions of the ridge at the planned sites when viewed in cross-section to access if osseous grafting will be needed to provide adequate bone for implant placement.[9] Block grafting has been advocated in the past, but this requires harvesting a block from a donor site in the patient, which may add complications to healing and patient comfort during the initial stages of treatment. But the success rate has been reported to be about 81%[10] and some complications may result, including failure of the block to integrate to the underlying with morbidity associated with donor and recipient sites.[11] With the availability of titanium mesh to support the osseous graft material and tent the area, this method has gained favorability as it eliminates the need for a donor site and does not have the issues that have been reported with block graft.

Various materials are available and have been advocated for osseous grafting to widen the ridge to allow implant placement, which provides different challenges compared to socket grafting. Ideally, the graft material selected should stimulate conversion of that graft material to host bone, shortening the time between graft placement and implant placement. Some graft materials currently available contain bone morphogenetic protein, a manufactured version of a protein already present in the body that promotes new bone growth.

Infuse bone graft is a recombinant human Bone Morphogenetic Protein-2 (rhBMP-2) placed on an absorbable collagen sponge. Although Infuse bone graft has a collagen carrier, mixing it with OsteoGen, a synthetic bioactive resorbable graft material (SBRG) consisting of calcium apatite with a bovine Achilles tendon collagen matrix, improves its properties as a graft material. Osteogen acts as a filler to maintain the volume of the graft during healing and host conversion to native bone. It has been reported that combining Infuse with a ceramic collagen containing sponge resulted in greater graft results than use of the Infuse alone.[12,13]

The particular case featured in this article required ridge augmentation to create dimensions that would accommodate implant placement. After healing of the grafted ridge, a new CBCT is taken with the diagnostic guide and implant planning in the software is then performed with the new osseous anatomy. Design of the diagnostic guide uses straight guideposts on the pretreatment cast. The offset guidepost is used when a correction to the osteotomy position is required, positioning the osteotomy to the facial/buccal or lingual based on the CBCT analysis. This allows use of the guide hole in the

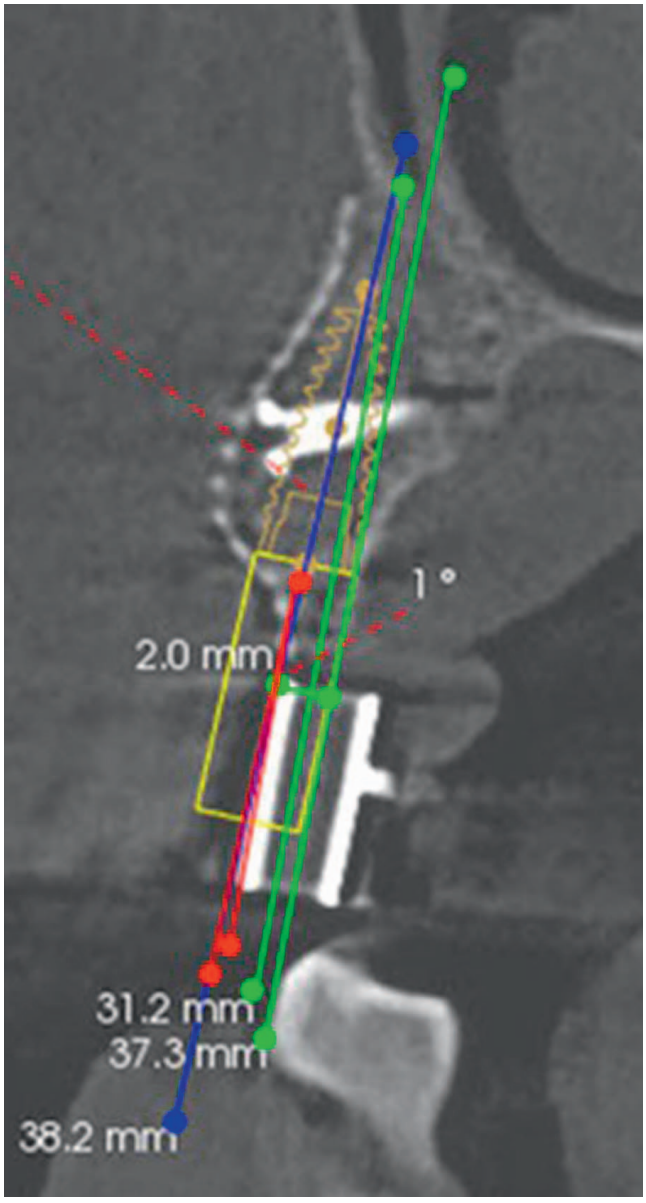

Figure 12. Virtual planning in the CBCT cross-section at site #13 determined that a 2.0-mm buccal offset would be necessary and a 1° palatal angle correction to ideally position the implant prosthetically.

initial cast to correct the position and angulation of the guided osteotomy when fabricating the corrected surgical guide.

Conclusion

When inadequate horizontal dimensions of a partially edentulous residual ridge are present, bone augmentation can be predictably performed to provide a suitable ridge for proper prosthetically driven dental implant placement. A new diagnostic guide matching the de novo bone ridge can be constructed, which can guide corrections to the previously

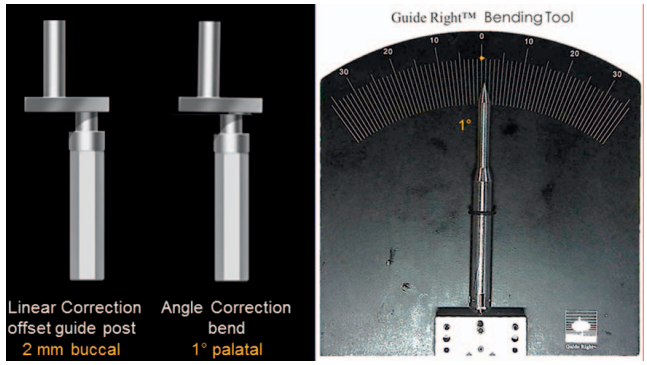

Figure 13. Virtual planning based on ideal prosthetic positioning determined a correction of implant position would be necessary on site #13 with a 2.0-mm buccal offset and a 1° angle correction.

planned surgical guide. The resulting corrected surgical guide can then be used to guide each osteotomy drill with depth stops to accurately replicate the virtual planning.

This technique allows for accurate surgical and prosthetic placement of the dental implants.

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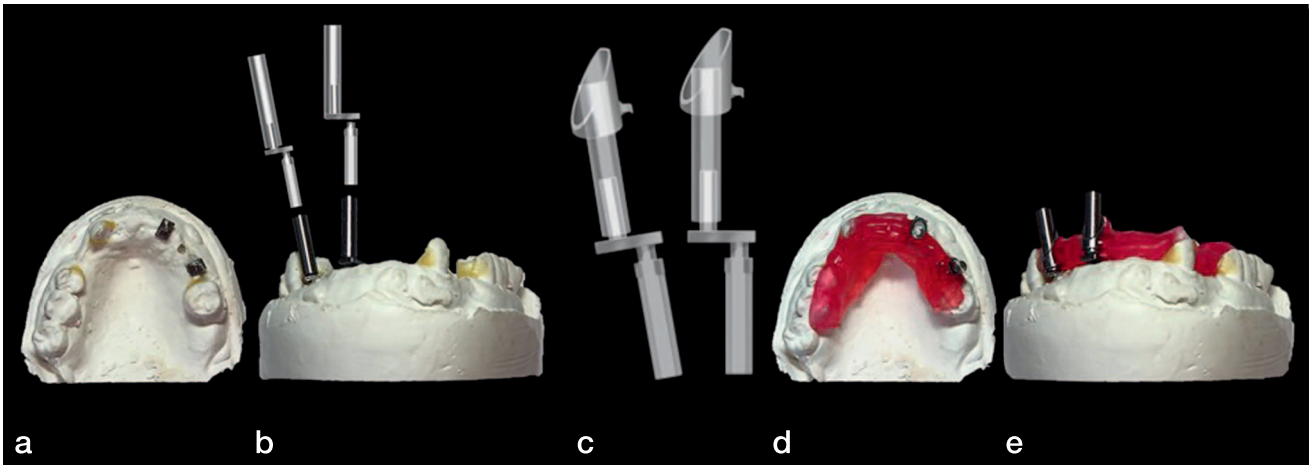

Figure 14. Fabrication of the corrected implant surgical guide consisted of placement of guide posts into the cast at the prior drilled holes (a), the upper portion of the modified 2-piece offset guide post was inserted over them (b), guide sleeves were then placed over the 2-piece offset guide posts with the retentive element at the lingual (c), light-cure resin was placed to capture the sleeves retentive element and cover the occlusal/incisal and lingual surfaces of the remaining teeth (d), and the corrected surgical guide was completed (e).

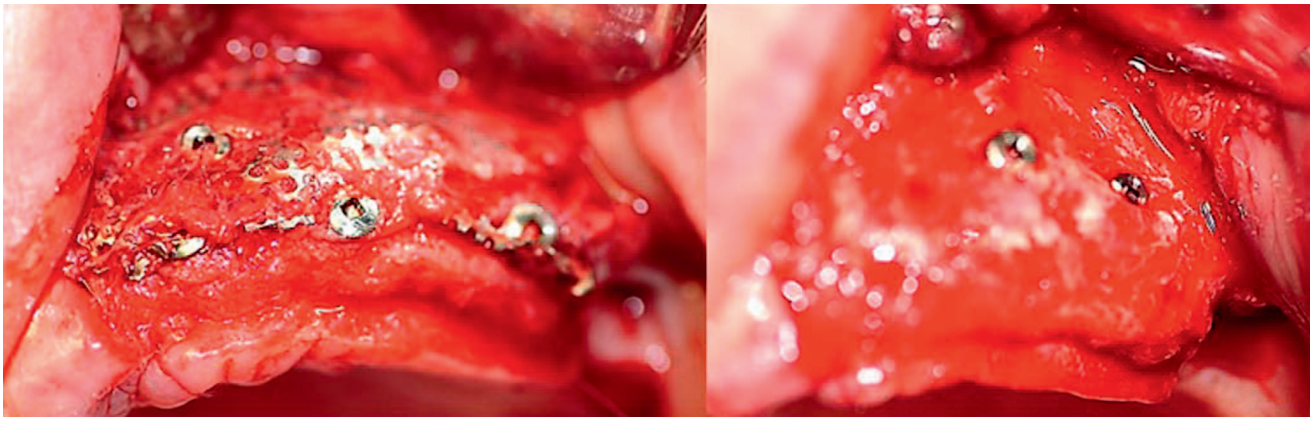

Figure 15. After 6 months of graft healing, an incision was made and a full-thickness flap elevated to expose the underlying titanium mesh and tenting/fixation screws (left) and after removal of the mesh to demonstrate an improved width of ridge to allow implant placement.

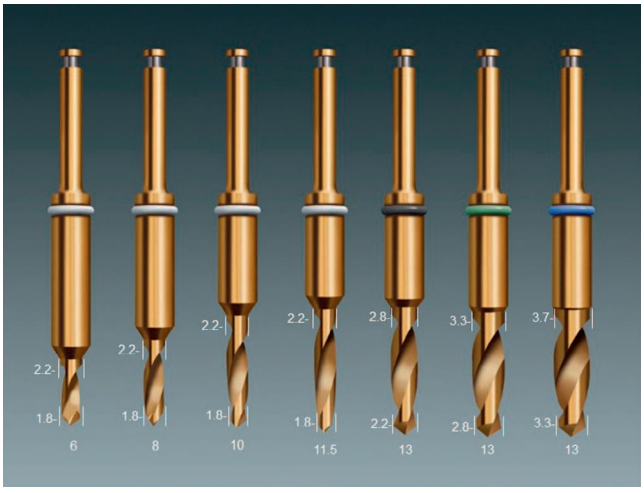

Figure 16. Guide Right drills for osteotomy preparation with the surgical guide.

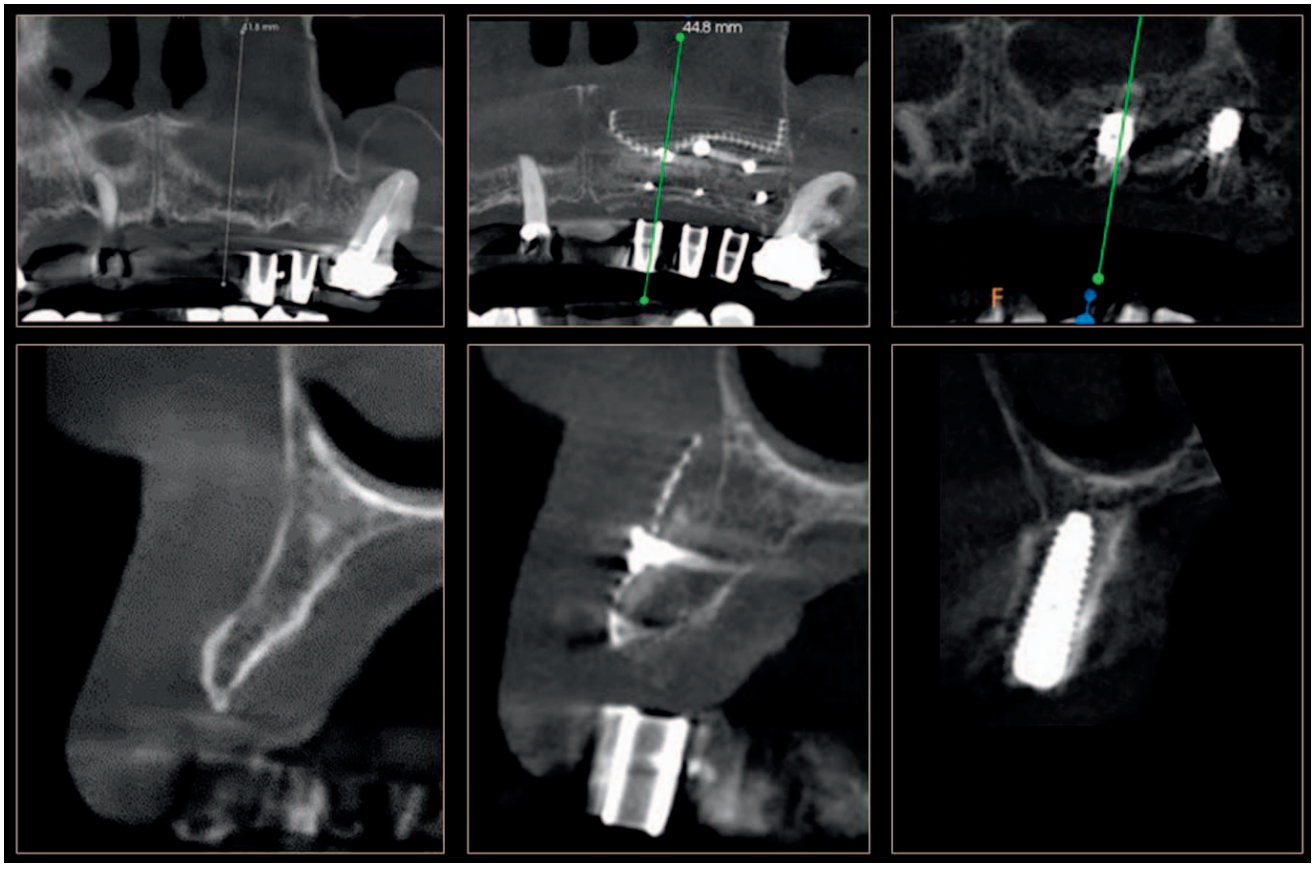

Figure 17. Comparison of site #11 of pretreatment (left), post osseous grafting (middle), and implant placed (right).

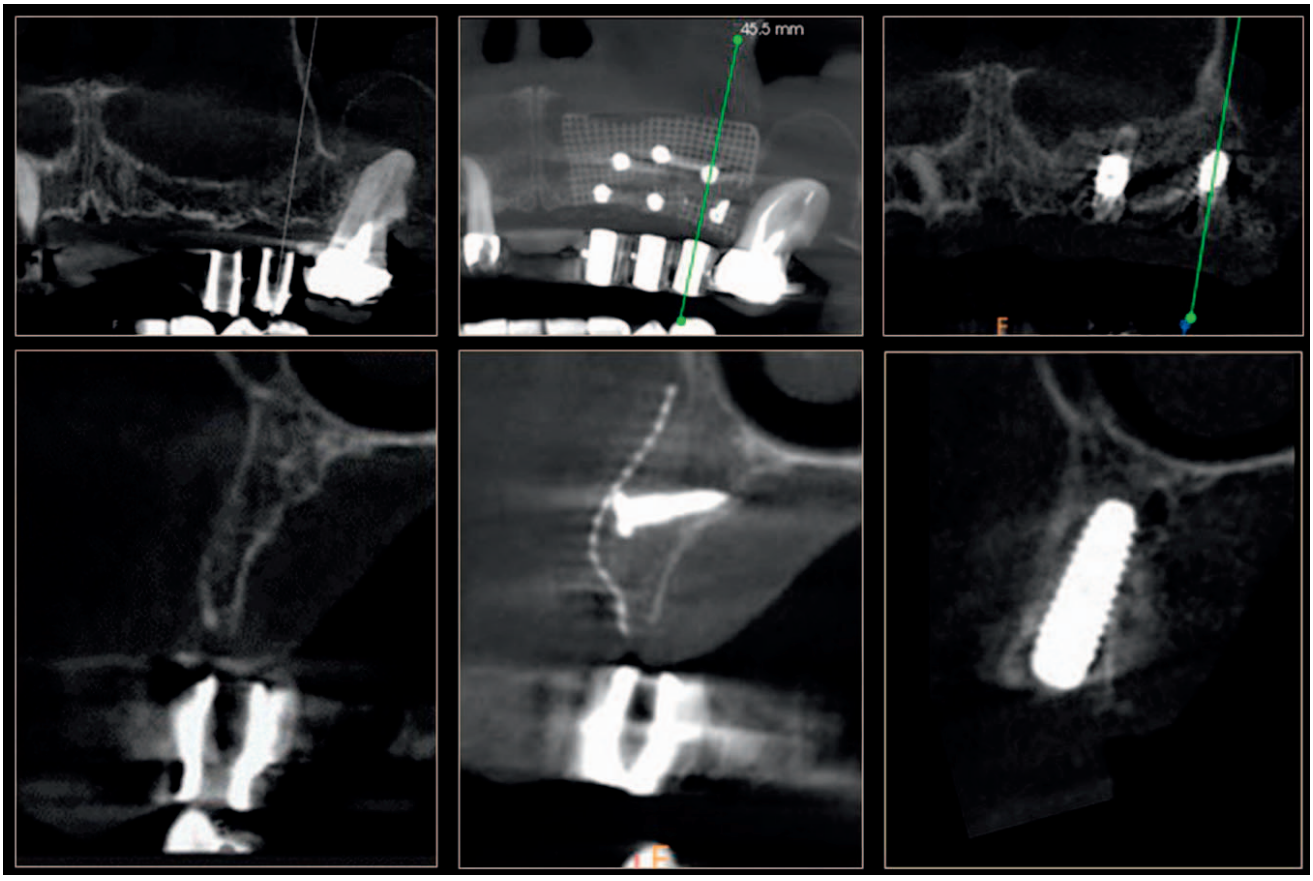

Figure 18. Comparison of site #13 of pretreatment (left), post osseous grafting (middle), and implant placed (right).

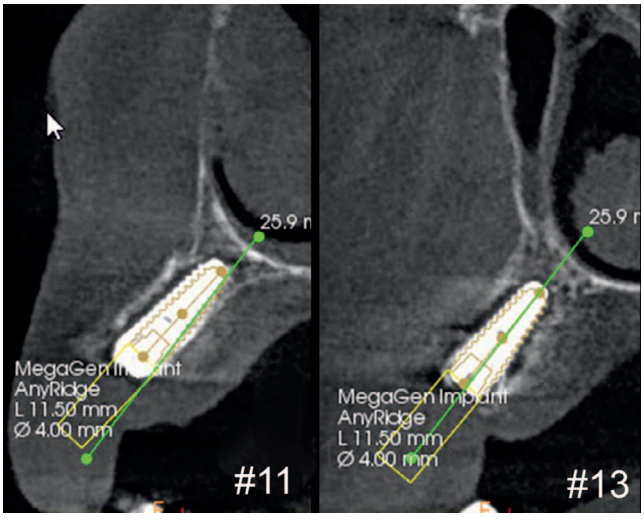

Figure 19. CBCT cross-sections after implant placement with virtual planning overlaid to demonstrate accuracy between planning, the corrected surgical guide, and achieved implant positions.

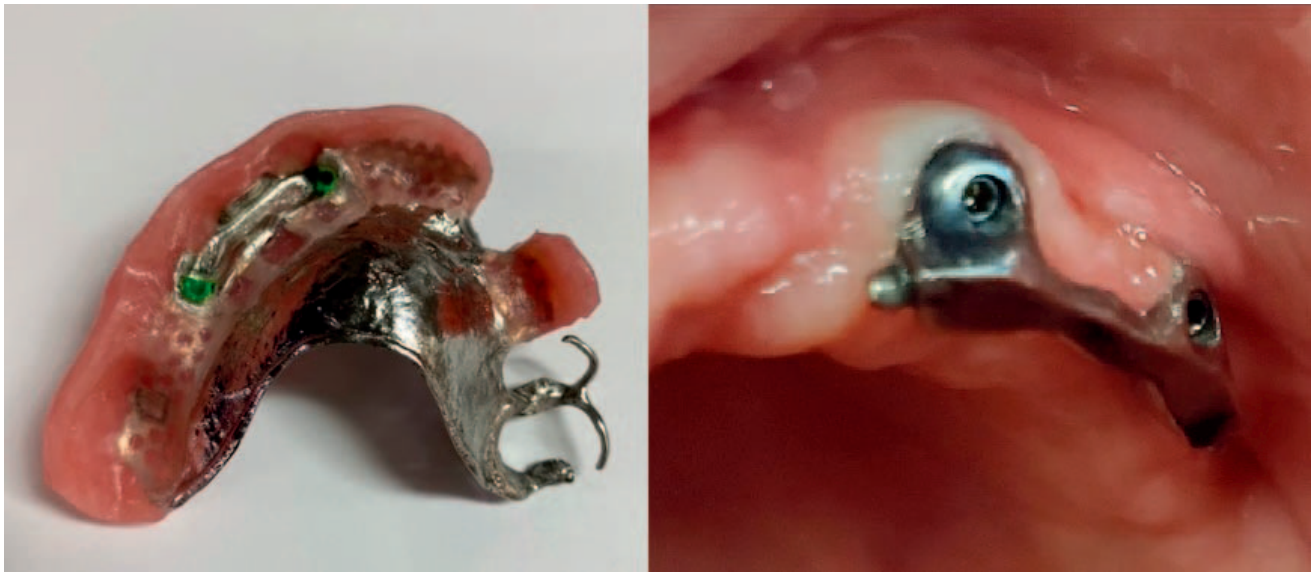

Figure 20. Completed prosthesis with the female portion of the attachments for the overdenture bar within the cast partial overdenture (left) and VKS-SG (Bredent) attachments on the terminal ends of the overdenture bar intraorally (right).