Full-arch implant surgical and restorative considerations

Utilising a full-template guidance technique

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Introduction

Full-arch dental implant reconstruction requires proper diagnosis and treatment planning to assess the existing patient anatomy, any pathologies, occlusion, soft-tissue volume, lip support, and aesthetics, and gain understanding of the desired outcome.1 A decision tree can be established based upon sound prosthodontics and surgical protocols to maximise success when a full-arch implant-supported reconstruction is contemplated. Technological innovations can only enhance the diagnostic, treatment planning, communication, surgical and restorative aspects for each patient. Three-dimensional imaging modalities afforded by current CBCT provide the foundation for all that follows (Fig. 1).2,3

The native DICOM data, once imported into interactive treatment planning software (R2GATE, MegaGen), allows for careful inspection of the existing anatomical presentation to identify potential implant receptor sites that will aid in realistic implant placement simulations and avoid potential complications (Fig. 2).4 Regardless of the eventual surgical protocol, the authors believe that the diagnostic phase must be based on a complete and thorough review of the CBCT scan data.5

Fig. 1: Three-dimensional imaging modalities afforded by current CBCT are essential for proper diagnosis and treatment planning. Fig. 2: Interactive treatment planning software, such as R2GATE, helps clinicians identify potential implant receptor sites to aid in realistic implant placement simulations.

Fig. 3: A failing maxillary and mandibular dentition exhibited mobile teeth, a poor occlusion, malaligned teeth and bone loss.
Case report

A failing maxillary and mandibular dentition exhibited mobile teeth, a poor occlusion, malaligned teeth and bone loss (Fig. 3). The CBCT data was analysed to determine the most appropriate treatment alternatives based upon bone quality, bone density and an appreciation of the patient’s desires. Utilising advanced software (Blue Sky Plan, Blue Sky Bio), the diagnostic information for implant planning can be fully appreciated in all of the necessary views, including cross-sectional, coronal, sagittal and axial, and in 3D reconstructed surface models. Implant receptor sites can be identified and virtual implants can be positioned with each of the previously mentioned views, as no single view can provide all of the necessary information to achieve success (Fig. 4a). Placing an implant into a cross-sectional slice is only the beginning of the process of helping to visualise the thickness and opacity of the buccal and palatal cortical plates and the quality of the intermedullary bone to determine whether an implant can be placed that has an appropriate length and diameter to fit the remaining alveolus, based upon the triangle of bone protocol (Figs. 4b & 4c). Additionally, virtual implant simulation plays a significant role in managing the desired restorative outcomes based upon tooth position and the choice of screw or cement retention. In the authors’

Figs. 4a–c: Implant receptor sites were identified, and virtual implants were positioned in the cross-sectional slices (a). The diagnostic process visualised the buccal and palatal cortical plates and the quality of the intermedullary bone (b). An appropriate length and diameter implant was positioned within the remaining alveolus based upon the triangle of bone protocol (c). Figs. 5a & b: Anchor pins were carefully positioned to avoid adjacent vital structures and engage dense cortical bone, helping to gain bicortical stabilisation when possible. They will often penetrate both buccal and lingual plates and avoid close proximity to implant receptor sites.

Figs. 6a & b: The stone cast was digitised using a desktop scanner (a). The resultant STL file was aligned to the opposing occlusion and merged to the CBCT DICOM data set (b). Figs. 7a & b: Through the process of segmentation, a surface model was reconstructed from the DICOM data based on bone density (a). Current software provides extremely accurate merging of the STL files of the pre-existing intra-oral occlusion and the DICOM data (b).
opinion, the most efficient manner of facilitating the process is to extend an abutment projection from the coronal aspect of the implant through the occlusal table, as visualised in yellow in Figures 4a and 4b. When a guided surgical approach is contemplated, the template can be designed to be tooth-borne, bone-borne or mucosal-borne. When appropriate, it is important that the drill guide be stabilised to prevent any movement during surgery. One aspect that is often under-estimated is the planning of fixation or anchor pins to help achieve the highest degree of surgical accuracy. Each potential anchor pin must be positioned to avoid adjacent vital structures and engage dense cortical bone, helping to gain bicortical stabilisation when possible. This will often penetrate both buccal and lingual plates and avoid close proximity to implant receptor sites (Figs. 5a & b).

The diagnostic phase is greatly enhanced when the existing intra-oral condition can be captured with either an analogue or a digital method. In a traditional analogue method, a physical impression records the teeth and soft tissue. A stone model can then be fabricated from the impression. To facilitate 3D planning, the stone cast can then be digitised using a desktop scanner. Alternatively, the impression itself can be scanned, resulting in an STL file that can be aligned to the opposing occlusion and then merged to the CBCT DICOM data set (Figs. 6a & b). The fully digital method utilises an intra-oral scanner to directly digitise the oral condition. Full-face and intra-oral retracted views and smiles (not shown) are often required to complete case planning. Through the process of segmentation, a surface model can be reconstructed from the DICOM data based on bone density (Fig. 7a). Often, this process is hindered by metal scatter artifacts from existing metal–ceramic restorations, making it difficult to adequately define the anatomy. Therefore, it is recommended that there be a space between the upper and lower jaws when the CBCT scan is acquired. As good segmentation is often very time-consuming, third-party companies, such as 3D Diagnostix, are available to manage this often essential aspect of implant planning. Current software allows for extremely accurate merging of STL files and DICOM data (Fig. 7b). To complete the planning process, a diagnostic wax-up or virtual tooth set-up of the desired prosthetic outcome can be designed to achieve true restoratively driven implant placement when applied to 3D surface DICOM data (Figs. 8a–c). The final plan often requires bone reduction to facilitate implant placement and the necessary restorative space for the prosthesis.

An innovative approach to full-template guidance utilises the existing dentition to position a metal fixation base to which everything else will be related (CHROME GuidedSMILE, ROE Dental Laboratory). Positioning the fixation base over the teeth is accomplished with a pin guide that orients the base in the proper position. A full-thickness mucoperiosteal flap reflects the tissue sufficiently within the vestibule to allow for positioning of the fixation pins (Fig. 9). Prior to seating over the teeth, the fixation base is securely attached to the pin guide with a series of Swiss locks and delivered over the teeth (Fig. 10a). This method allows for the metal frame to be correctly positioned. Proper fit of the pin guide over the teeth is essential and can be verified by visual inspection though the windows of the resin. In this case, four anchor pins were utilised to stabilise the metal guide (Fig. 10b). As previously stated, it should be noted that planning for the location of receptor sites for the anchor pins is as important as planning for the position of the implants—ensuring that they are all located in good-quality bone, often taking advantage of both buccal and lingual/palatal cortical plates.
After the fixation base had been secured to the bone, the pin guide was removed, leaving the maxillary teeth available for extraction (Fig. 11a). The teeth were all carefully removed, leaving the remaining alveoli exposed (Fig. 11b). It should be noted that the metal guide for this case example was designed to sit floating away from the bone. Planning for a full-arch restoration may require bone reduction to provide the restorative space required, which can be accomplished with rotary instruments, piezo-ultrasonic surgery or a reciprocating saw (Fig. 12a). The amount of bone reduction needed was determined after a careful evaluation of potential implant sites in relation to the desired prosthetic outcome (Fig. 12b). The outer aspect of the metal fixation base was used as a bone reduction guide as first defined by Ganz.9

The carrier guide serves several purposes. The translucent resin plate is first utilised to check whether adequate bone reduction has been accomplished. The carrier guide will not fit passively into the Swiss locks if the bone has not been properly levelled. The compressed area of bone can often be visualised through the resin (Fig. 12c).

Full-template guidance allows for the precise drilling of the implant osteotomies with or without the use of sleeves embedded within the surgical template or separate key inserts that match the drill diameters of the guided surgical kit that must be utilised. Innovative designs have allowed for the elimination of these separate components, simplifying the drilling protocol. The R2GATE guided surgery kit consists of a series of sequential drills to achieve full-template guidance in a keyless system. The wide drill core or barrel will engage the entire vertical height of the guide cylinder to ensure drilling accuracy and depth control. Starting with a short drill and gradually using longer drills within the initial osteotomy helps to maintain proper trajectory until final implant diameter and depth are achieved. The osteotomy drill guide was seated on

Figs. 10a & b: Prior to seating over the teeth, the fixation base was securely attached to the pin guide with a series of Swiss locks and delivered over the teeth (a). Proper fit of the pin guide was verified by inspection through the windows of the resin. In this case, four anchor pins were utilised to stabilise the metal guide (b). Figs. 11a & b: After the fixation base had been secured to the bone, the pin guide was removed, leaving the maxillary teeth available for extraction (a). The teeth were all carefully removed, leaving the remaining alveoli exposed (b).
to the fixation base and secured by the Swiss locks (Fig. 14a). Each osteotomy was carefully prepared with the R2GATE sequential surgical drills with the wide core or barrel that engaged the entire vertical height of the guide cylinder to ensure drilling accuracy and depth control (b). Each AnyRidge implant (integrated dental systems) was first attached to its matching implant carrier and then delivered to the site at the appropriate rotational speed and torque (c). Six AnyRidge implants were placed by first using the handpiece and then hand-torquing them until final depth was achieved (d).

Full-template guidance means the implant is delivered through the template after the osteotomies have been completed. In order to achieve full-template guidance, a manufacturer-specific implant carrier must be used to

Prior to inserting screw-receiving abutments, the carrier guide was once again seated on the fixation base. Depending upon the manufacturer, multi-unit abutments are generally available in various tissue cuff heights and angles that are established during the planning phase. The second purpose of the carrier guide is to help guide the placement of the multi-unit abutments through the predefined holes and on to each implant. The anterior implants received AnyRidge straight multi-unit abutments for the screw-retained prosthesis, and the posterior-most implants received 30° multi-unit abutments. The final purpose of the carrier guide is to orient the transitional prosthesis to the predetermined position of the implants by utilising the resin pillars (Fig. 15a). The right and left distal implants must be rotated so that the angled multi-unit abutments allow for the screw access hole to fit within the envelope of the prosthesis by utilising titanium sleeves and screws (Fig. 15b). The titanium sleeves will then be incorporated into the transitional prosthesis with a self-curing
acrylic (Quick Up, VOCO). Prior to inserting the acrylic, a small, oval-shaped piece of rubber dam is placed over each titanium sleeve to protect the underlying surgical site. An alternative method allows for the prosthesis to attach directly to the fixation guide (Fig. 15c). Once the acrylic had reached a final set, the prosthesis was then removed and examined for any acrylic deficiencies or gaps. These gaps were all filled, and the prosthesis was polished. While the prosthesis was adjusted, any bony defects were filled with cortico-cancellous allograft (Maxxeus Dental, Community Tissue Services), and the area was covered with layers of platelet-rich fibrin and sutured around the multi-unit abutments. The transitional prosthesis was delivered to the patient with minimal occlusal adjustments (Fig. 16). The mandibular full-arch implant-supported reconstruction was completed during the same visit (ROE Dental Laboratory).

Closing comments

The ability to incorporate 3D imaging modalities, when combined with interactive treatment planning software, has greatly enhanced the clinician’s ability to diagnose and plan treatment for single and multiple implants. As technology has advanced, guided surgery protocols have improved, offering innovative alternatives for partially and fully edentulous patients. While CT-derived surgical templates have been available for almost two decades, the focus has been on the surgical aspect of implant placement. Interactive treatment planning software has provided clinicians with an appreciation of the bony anatomy to assess implant receptor sites and even more. The evolution of guided applications has included the development of the bone reduction guide, the sinus lift guide and the harvest guide for guided bone grafting procedures. Software, such as R2GATE and Blue Sky Plan, allows for the planning of implants in relation to the desired prosthetic outcomes. However, the missing link has been the accurate orientation of the prosthesis at the time of surgery. The merging of CAD/CAM design with 3D DICOM data enables restoratively driven implant planning at a very high level. Implants can be predictably placed with the prosthetic outcome in mind—critical for immediate loading of full-arch restorations.

The case example presented here illustrates the use of a stackable system that provides a fixation base anchored to the bone to which a drill guide can be mounted for accurate osteotomies and a carrier guide can be oriented to the transitional prosthesis. This greatly facilitates the processes of immediate placement and immediate restoration. Further research will be required to validate the methods and long-term outcomes of this full-template guidance solution for full-arch implant reconstruction.

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