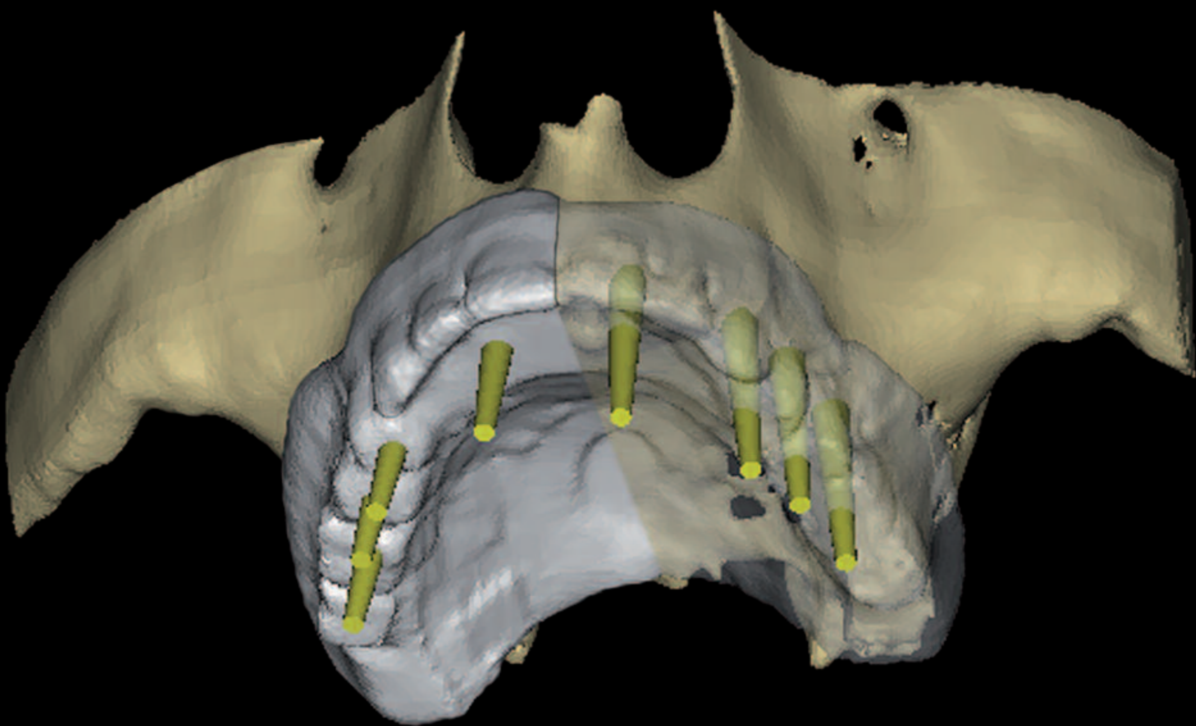
issn 2198-6762
Vol. 2 • Issue 2/2015

cone beam

international magazine of cone beam dentistry

2 2015



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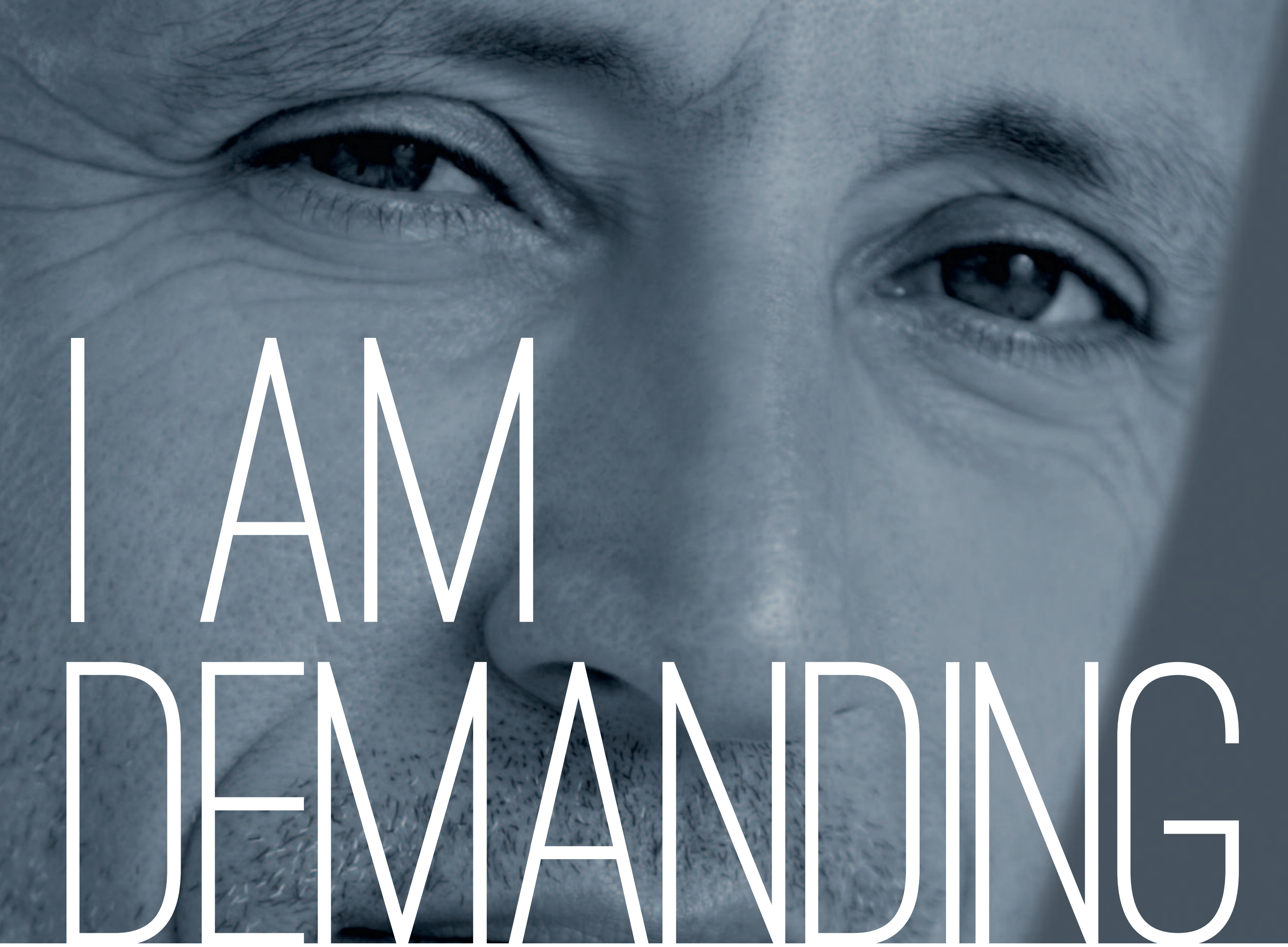

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Clarity of Vision

Dr Scott D. Ganz

_**Without questions,** Cone Beam Computed Tomography has provided clinicians with an amazing imaging modality to assess our patient's individual anatomy. In fact today, many clinicians will not place a dental implant without a CBCT scan prior to any surgical intervention. While this alone is a powerful statement, there are still questions that need to be asked with regard to how the technology is utilized. Are we seeing what we need to see? Having a CBCT scan does not in itself mean that clinicians are able to clearly visualize all aspects of the bone, soft tissue, teeth, and adjacent vital structures. The implication is that if clinicians can not see everything that we need to see, are we able to diagnose properly? In my opinion, diagnosis is a key..

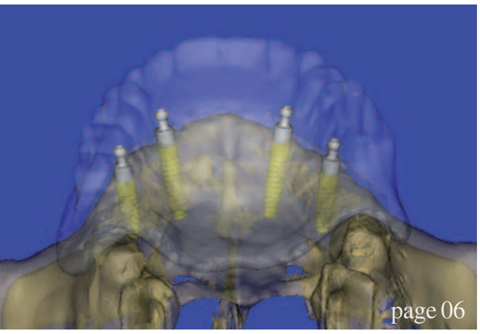
The data that is derived from a CBCT is invaluable for certain, but it does require software intervention to convert that data into information that can be used for diagnosis and treatment planning for a variety of different purposes. Managing the DICOM data from the CBCT device perhaps the most important consideration that can define the clinicians' ability to visualize everything necessary for proper diagnosis. One example of the impact of the software capabilities is how the data is revealed on our computer screen. The software should easily allow for each cross-sectional, axial, coronal, and 3-D reconstructed volume to be enlarged without distortion for careful inspection at highlevels of magnification. The ability to change the opacity of various anatomical structures, as I have previously termed, "selective transparency" is essential to provide clinicians with very powerful tools to visualize relationships between these structures.

When the software attempts to create beautiful and visually pleasing three-dimensional reconstructed volumes, problems often occur when there are existing crowns, or metal within the field of view resulting in scatter artifact. This scatter can mask underlying anatomy in critical regions that clinicians need to analyze, making the scan useless for diagnosis. Therefore, the software must have an ability to help remove or diminish scatter artifact, and this may require ancillary superimposition of intra-oral scans or optical scans of stone casts to improve surface accuracy, as an aid for planning and the eventual fabrication of surgical templates via stereolithography, 3-D printing, or CAD/CAM processes.

In the pages of CBCT International Magazine, we continue to strive to provide our readership with information that will help inform and educate about state-of-the-art tools as utilized by world-class authors who have taken the time to document their cases and concepts. The information will illustrate that there are vast differences in how data is used from various CBCT devices and software applications. The underlying and most important goal for our publication is to deliver the "clarity of vision" to help clinicians make the best decisions for our patients.

Please enjoy our latest issue!

Dr Scott D. Ganz
Editor-in-Chief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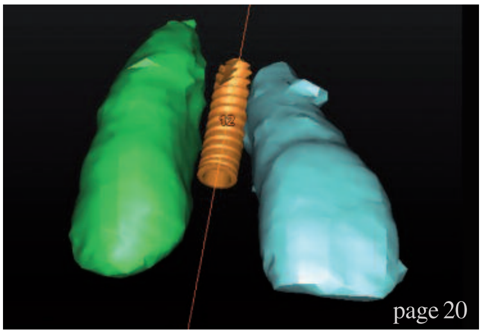
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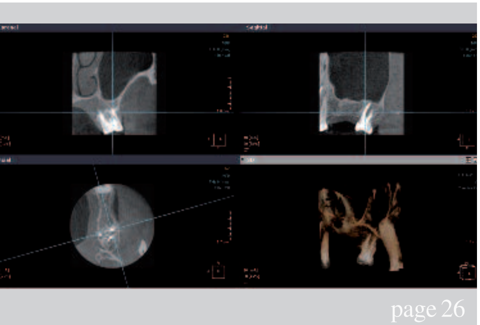
Cover image courtesy of Dr Scott D. Ganz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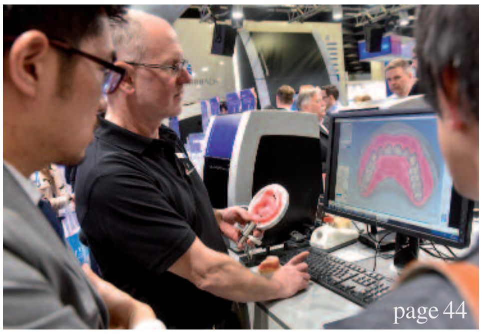
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3-D Virtual Planning Concepts: Maxillary Implant Supported Removable or Fixed Prostheses

Author_ Dr Scott D. Ganz, USA

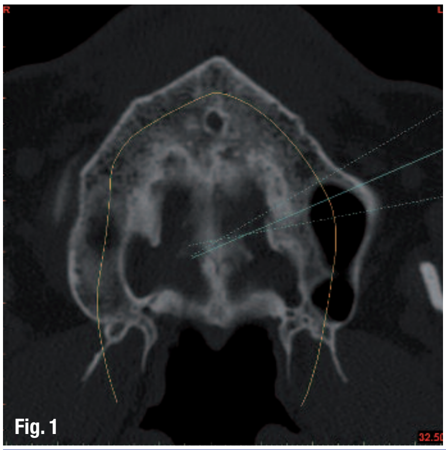


Fig. 1_The axial view provides insight into the global topography of the maxilla.

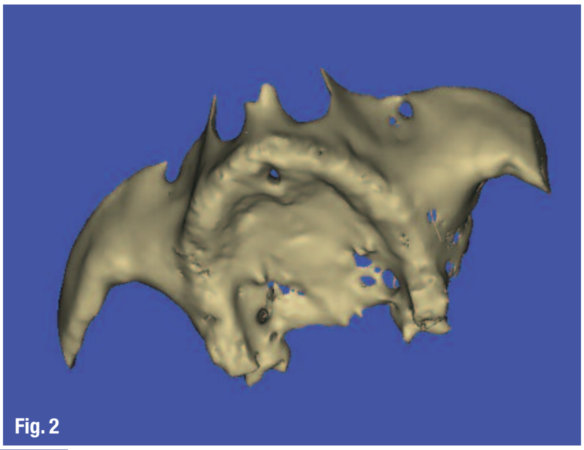
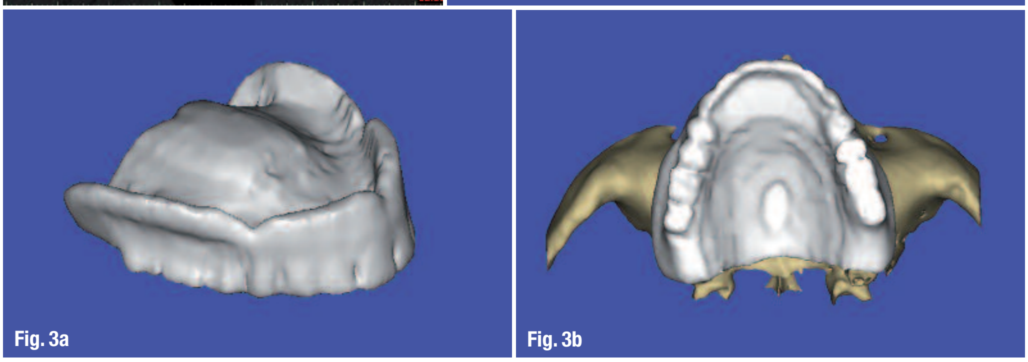


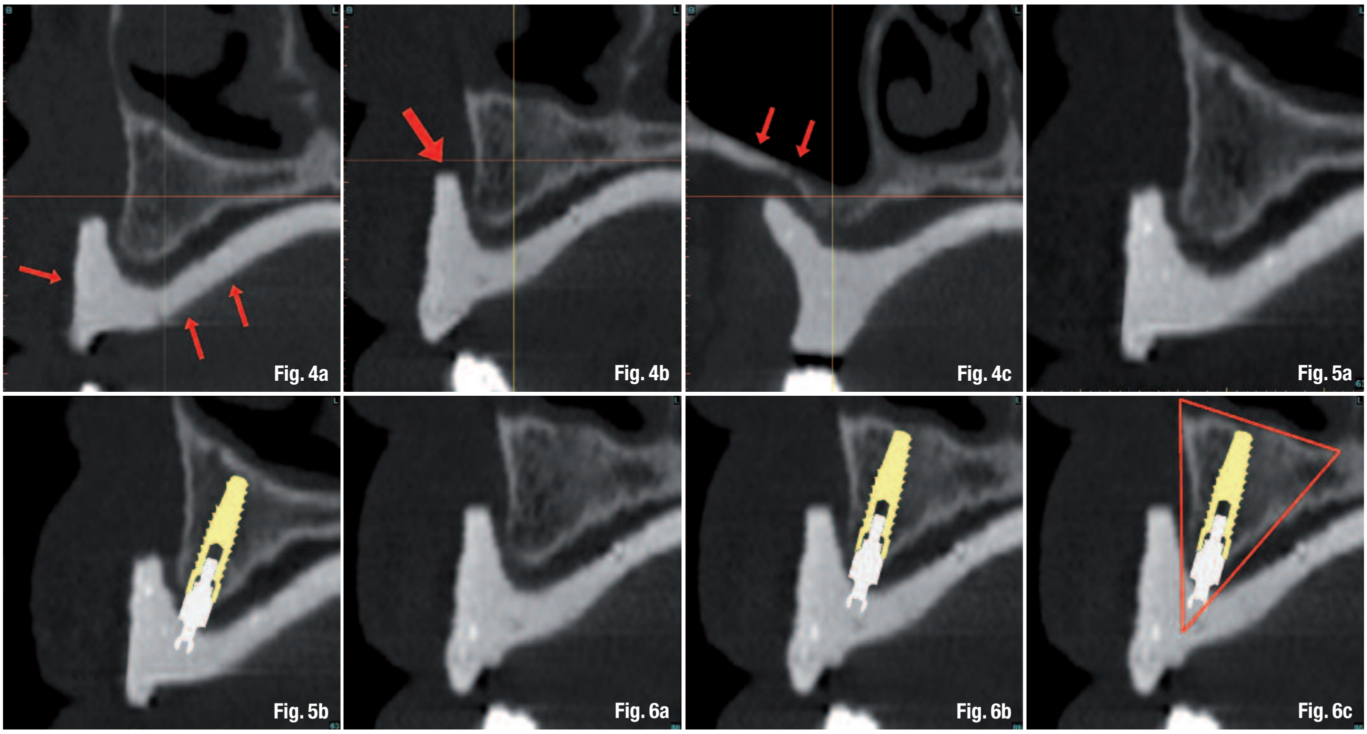
Fig. 2_The volumetric rendering aids in the inspection of the bone but does not the desired restorative position.



Figs. 3a & b_A radiopaque scanning appliance fabricated from a duplicate of a patient's existing well-fitting denture (a) allows inspection of tooth position in relation to the underlying bone (b).

_**"Pre-surgical prosthetic planning"** can be defined as the process of accumulating diagnostic information to determine which course of treatment should be considered for the fully edentate patient. The first step in patient evaluation should include conventional periapical radiographs, panoramic radiographs, oral examination, and mounted, articulated study casts. In the completely edentulous patient it is essential for the clinician to assess several important aspects of the individual anatomical presentation including vertical dimension of occlusion, lip support, phonetics, smile line, over-jet, overbite, ridge contours, and a basic understanding of the underlying bone structures. The accumulation of preliminary data afforded by conventional diagnostics provides a foundation to prepare a course of treatment for the patient. However, if the review of findings is based upon a two-dimensional panoramic radiograph, it may not be accurate in appreciating the true spatial positioning of vital structures such as the incisal canal, the floor of the nose, or the maxillary sinus. To fully understand each individual patient's actual bone anatomy, it is essential that clinicians adopt an innovative set of virtual, three-dimensional tools. Through the use of advanced imaging modalities new paradigms have been established that in the author's opinion will continue to redefine the process of diagnosis and treatment planning dental implant procedures for years to come. Without the application of computed tomography (CT) or lower radiation dosage cone beam computed tomography (CBCT), an understanding of the three-dimensional anatomic reality cannot be accurately determined, potentially increasing surgical and restorative complications.

The utilization of 3-D imaging modalities as part of pre-surgical prosthetic planning can take several paths. The first involves acquiring a three-dimensional scan directly, without any prior planning or ancillary appliances. The scan process can be accomplished at a local radiology centre, mobile imaging company, or via an in-office CBCT device. The scan itself can be completed within several minutes. Once the data is processed, it can be viewed on the native software of the CBCT machine itself, evaluated for potential implant receptor sites, followed by the surgical intervention, or with a third party interactive treatment planning software. A second path requires the fabrication of a radiopaque "scannographic" appliance that incor-

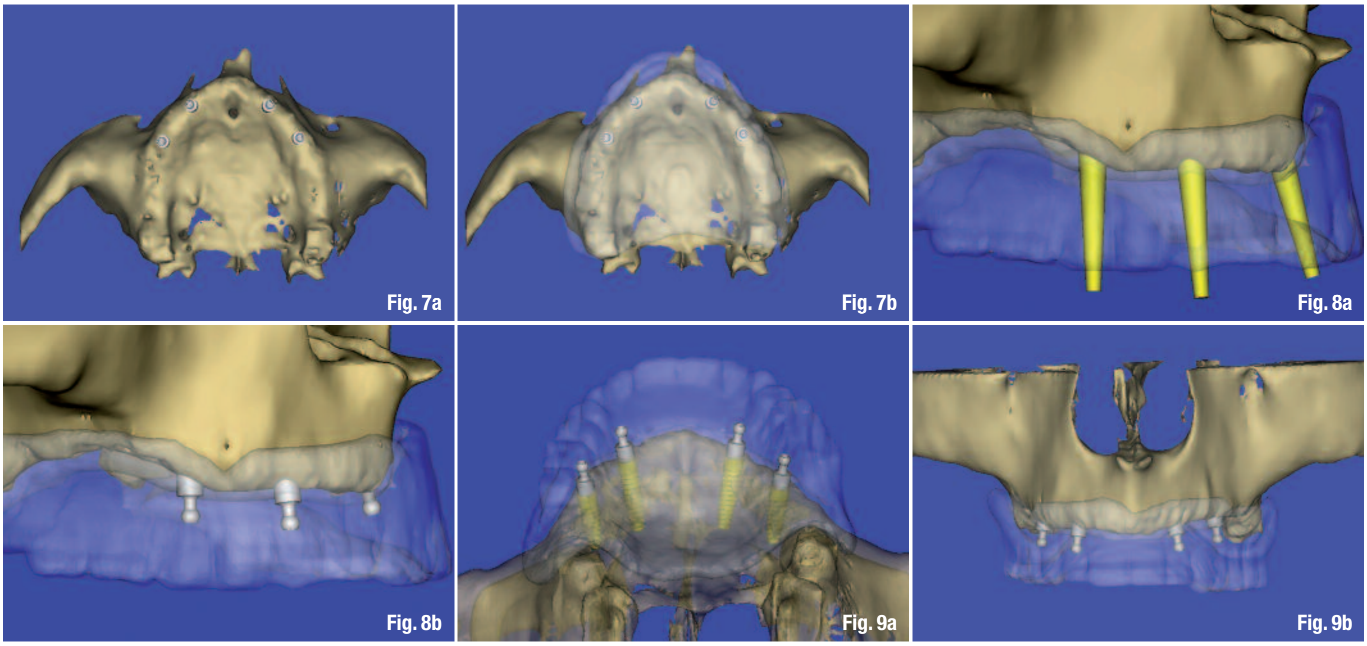


Figs. 4a–c_Cross-sectional slice reveals tooth position in relationship to the bone (a) and the extension of the labial vestibule (red arrow) (b). The relationship to the maxillary sinus is essential for planning in the posterior region, where thin cortical plate can be clearly visualized (arrow) (c).

Figs. 5a & b_Evaluating a potential receptor site within the cross-sectional view (Slice 63) (a). The positioning of the implant(s) need to fall within the envelope of the teeth (b).

porates vital restorative information that will be worn by the patient during the acquisition of the scan. In this manner, the desired tooth position can be evaluated in relation to the underlying bone and other important anatomic structures such as the maxillary sinus or the inferior alveolar nerve. Certain proprietary methods incorporate the use of fiducial markers to help with the registration process for planning based directly upon the restorative needs for the patient.

The use of interactive treatment planning has expanded dramatically in the past ten years as computing power has increased exponentially. As defined by the author, guided surgery can be divided into three distinct categories once a "virtual" plan has been established based on 3-D scan diagnosis (Ganz-Rinaldi Classification of Guided Implant Surgery Protocols). The first allows the information to be assessed, providing important information to the clinician who will perform the surgical intervention free-hand based upon the software plan, termed "Diagnostic-Freehand". The second category involves the fabrication of a surgical guide or template that is remotely constructed from the digital plan usually through rapid prototyping or



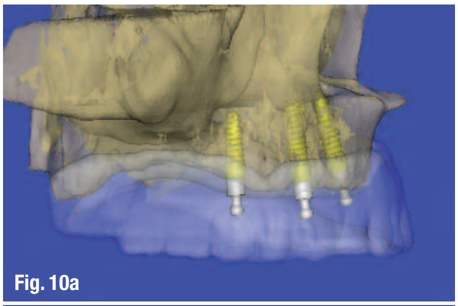


Fig. 10a

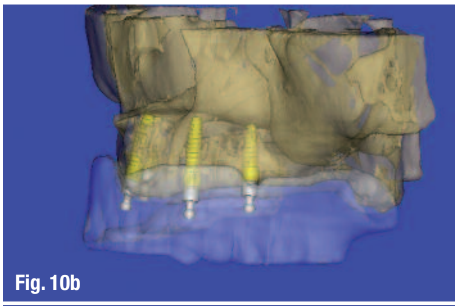


Fig. 10b

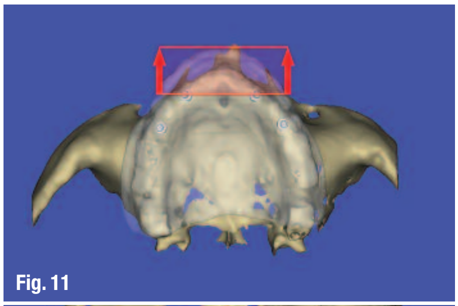


Fig. 11

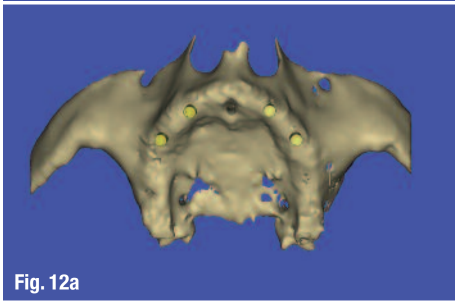


Fig. 12a

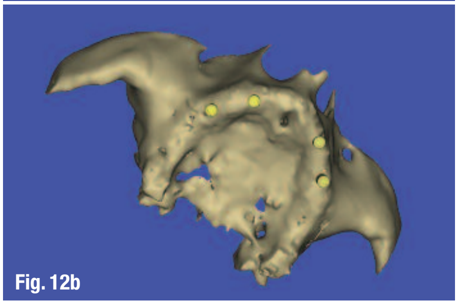


Fig. 12b

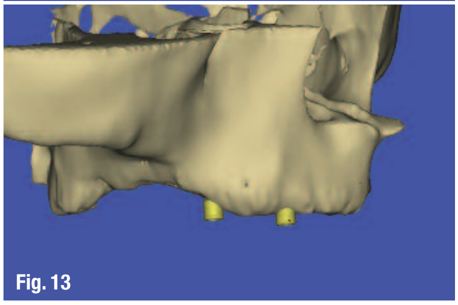


Fig. 13

Figs. 6a–c_The cross-sectional image reveals a potential receptor site (a); the realistic implant and abutment simulation (b); the author's preference places the implant within a defined zone of available bone defined as the "Triangle of Bone" (TOB) that also acts to relate implant position to the restorative outcome (c).
Figs. 7a & b_The occlusal view of the volumetric rendering aids in the implant-to-implant positioning within the bone (a). Superimposing a translucent scannographic template over the maxilla provides the information to position implants within the restorative envelope (b).
Figs. 8a & b_Use of "selective transparency" with abutment

stereolithography, CAD/CAM, or laboratory fabricated, termed CT-derived "Template-Assisted". The drilling process is started and can be completed within the template helping to control trajectory and depth with the proper instrumentation. The third category requires a specific template design that allows for accurate drilling and osteotomy preparation, and with the proper manufacturer-specific carriers the implants can then be accurately delivered through the template, termed, "Full Template Guidance." The use of advanced imaging modalities for pre-surgical prosthetic planning is essential for any type of implant surgical and restorative intervention, from the single tooth, multiple tooth restoration, full arch fixed and removable overdenture reconstruction. However, it is the correct use of three-dimensional tools that provides clinicians with the power to diagnose and treatment plan with the highest degree of acuity and accuracy.

_3-D Planning Concepts: Full Arch Maxillary Overdenture

Due to anatomical variations related to the maxillary sinus, the floor of the nose, the incisal canal, the facial trajectory of the anterior segment, thin cortical plates, and diminished overall bone density when compared to the mandible, the completely edentate maxilla offers additional diagnostic challenges for clinicians. The axial view provides insight into the global topography of the maxilla (Fig. 1). The position of the incisal canal can be visualized, along with thin facial and palatal cortical plates. The volumetric rendering aids in the inspection of the bone, but does not offer any information regarding tooth or ultimate restorative position (Fig. 2). In order to achieve the concept of "true restoratively driven implant dentistry" pre-surgical prosthetic planning should start prior to any scan being taken. A scanning appliance can be fabricated from a duplicate of a patient's existing well-fitting denture, or a new diagnostic set-up which positions the teeth at the ideal vertical dimension of occlusion, centric relation, and functional/aesthetic components (Fig. 3a). The patient wears the scannographic appliance during the scan, ideally held in place with a pre-determined bite registration to minimize movement. The scan reconstruction will then contain both the tooth position and the underlying bone (Fig. 3b).

The combination of the anatomical scan data with the radiopaque template allows unprecedented diagnostic potential. The template reveals the tooth position (red arrows) in relationship to the underlying

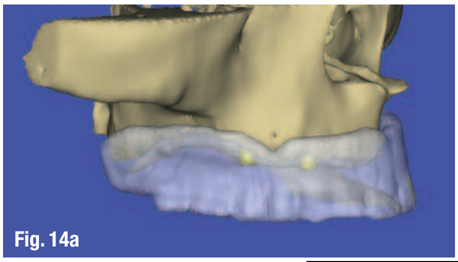


Fig. 14a

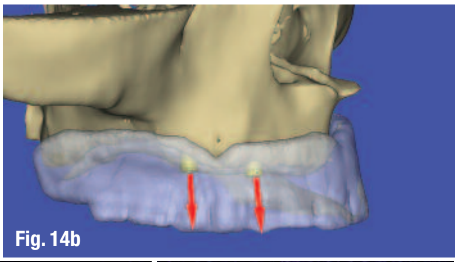


Fig. 14b

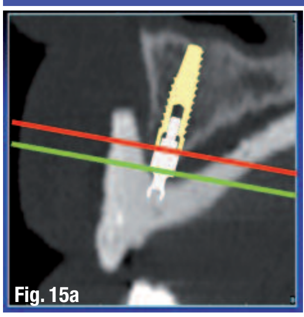


Fig. 15a

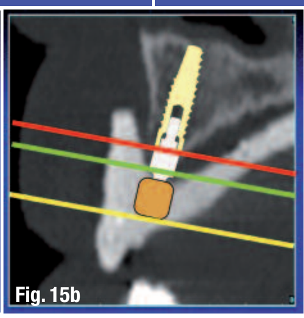


Fig. 15b

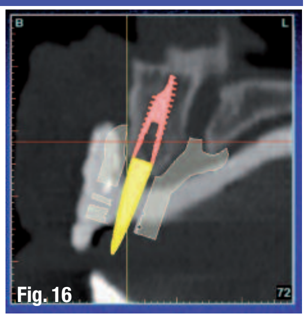


Fig. 16

bone in the cross-sectional slice (Fig. 4a). The thin cortical plates can be clearly visualized, along with the extension of the labial vestibule (red arrow, Fig. 4b). The relationship to the maxillary sinus is important when deciding if implants might be an option in the posterior region (Fig. 4c). In this example the pneumatisation of the sinus has resulted in extremely thin lateral cortical plate (see red arrows). The radiopaque template is helpful when evaluating other receptor sites, and positioning a simulated implant within the cross-sectional view (Slice 63, Fig. 5a). For an over-denture application the positioning of implants need to fall within the envelope of the teeth, and it is even more practical to visualize the abutments that might be utilized (Fig. 5b). For this example a realistic stock "ball type" abutment was utilized on the virtual realistic implant. In order to provide some guidance, it is the author's preference to place the implant within a defined zone of available bone (Figs. 6a & b). This zone has been previously defined as the "Triangle of Bone" (TOB) that also acts as a decision tree to connect the implant placement to the restorative outcome (Fig. 6c). Positioning the implant within the zone of the TOB, or actually bisecting the triangle, allows for the most bone volume to surround the implant. Following this formula, the implant and abutment will be positioned in a favourable restorative position.

Further inspection through the utilization of additional views can be extremely enlightening with regard to the final positioning of the implants. The occlusal view of the volumetric reconstruction aids in the implant-to-implant positioning within the bone (Fig 7a). However, without a complete understanding of the tooth position, the implants may not be ideally located based upon the prosthetic plan.

Superimposing a translucent scannographic template over the maxilla provides the important information to position the implants within the restorative envelope (Fig. 7b). The prosthesis design can be evaluated to determine whether to fabricate a complete denture that would extend to incorporate a conventional post-palatal seal, or an open-palate horseshoe type prosthesis. To aid in the final positioning, it is helpful to visualize the outline of the occlusion using the author's concept of "selective transparency", and extend the abutments above the occlusal plane (Fig. 8a). "Selective transparency" is a software tool which can help separate one anatomical structure from another by adjusting the opacity of the various objects. Once the implants are placed, the ball abutments can then be positioned at the proper tissue cuff height (Fig. 8b). Rotating the views can substantiate the plan to place the implants where they will be support the removable prosthesis (Figs. 9a & b).

It is important to assess the clearance within the denture to allow for sufficient thickness of acrylic within the over-denture abutment housing avoiding potential fracture of the prosthesis. This "prosthetic space" requirement may be different depending upon the type of attachment used. Using the power of digital technology and selective transparency, the realistic implant and ball abutment can be seen through the prosthesis and the underling bone (Figs. 10a & b). These illustrations reveal that the two right implants are parallel, while the left implants are seen to follow the natural

extensions above the occlusal plane (a). Ball abutments positioned at the proper tissue cuff height (b).
Figs. 9a & b_Rotating the views help position implants where they will best support the removable prosthesis.
Figs. 10a & b_Selective transparency allows the realistic implants and ball abutments to be seen through the prosthesis and the maxillary bone.
Fig. 11_The distance between the two anterior implants and the maxillary incisor teeth (red arrows) represents a cantilever that could result in tipping of the denture.
Figs. 12a & b_The use of realistic attachments allows for implant-to-implant positioning around the arch necessary to gain maximum retention and resistance of the prosthesis to dislodgement during mastication.
Fig. 13_Utilization of virtual abutments aids in determining the correct tissue cuff heights of the abutments above the bone, and through the soft tissue.
Figs. 14a & b_The vertical distance can be evaluated within the prosthetic design (a), crown-to-root ratios, and the trajectory of the implant-abutment complex can be visualized within the virtual plan.

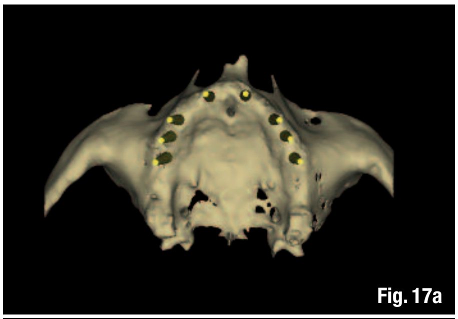


Fig. 17a

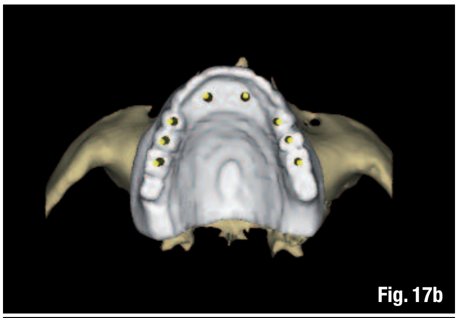


Fig. 17b

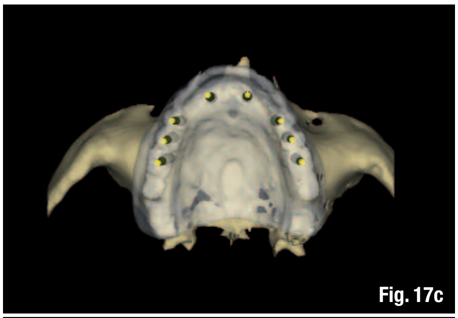


Fig. 17c

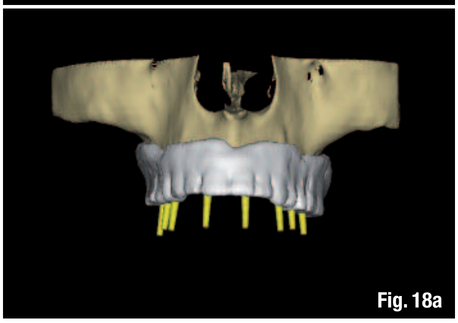


Fig. 18a

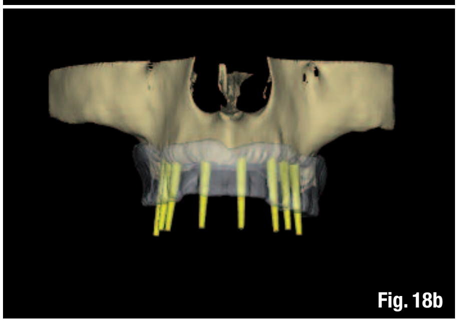


Fig. 18b

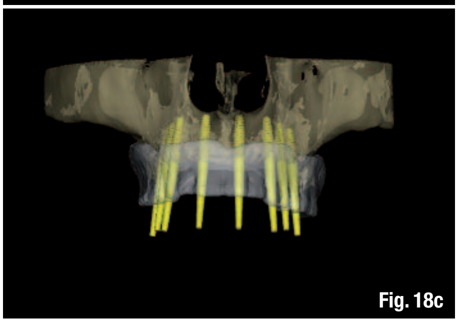


Fig. 18c