Use of Advanced Software in Implant Dentistry: An Update

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ABSTRACT

Three-dimensional imaging has revolutionized the field of implant dentistry. Cone beam computed tomography (CBCT) scans can accurately determine bone height, width and bone angulation. The new developments enable dentists to visualize the internal anatomy of the head and jaws with unparalleled accuracy and clarity. This quantum leap in imaging technology enables dentists to treatment plan with confidence and precision previously unknown in dentistry. Cone Beam three-dimensional Technology is vastly more accurate than prior attempts to scan and depict the internal anatomy. In fact, CBCT scans are so accurate that they can even be used for identifying missed canals in endodontic failures. The accuracy and resolution are that advanced. CBCT scans can also be used for identifying occult fractures of the crown or root that cannot be detected by any other means.

Keywords: Cone-beam three-dimensional technology, Triangle bone concept, Advanced imaging.


INTRODUCTION

During the past 20 years, advances in diagnosis and treatment planning software applications have evolved with the concomitant acceptance of computed tomography (CT) and cone beam CT (CBCT) technology. The CBCT has been widely utilized to understand and appreciate patient anatomy since its introduction and adoption. The use of native, pre packaged software can serve as an excellent aid to evaluate potential implant receptor sites or assess bone grafting procedures. However, it is the synergy between CBCT data and advanced interactive planning software that fully empowers clinicians with the tools to achieve true, restoratively driven implant dentistry. Through the presentation of a partially edentulous case, for a single missing maxillary lateral incisor we will illustrate concepts that can also be effective with multiple implants for partial or fully edentulous presentations. Additionally, the use of this technology affords clinicians with a powerful means of communication with all members of the implant team and an effective marketing tool to patients.

VISUALIZING THE POTENTIAL IMPLANT RECEPTOR SITE THROUGH CBCT

The CT scan data and its use within the proprietary software (i-CAT Vision software) is helpful in visualizing the potential implant receptor site in edentulous patient. However, to enhance the diagnostic information, the data is imported using SimPlant [Version 11 (Materialise Dental)], an interactive treatment planning software program with advanced features. For a missing lateral incisor, it is important to consider the available bone volume, the bone quality, and the proximity of the adjacent tooth roots. The cross-sectional views will aid in determining the available bone volume and the bone density. In order to connect the implant location to the desired tooth restoration, it is useful to have a radiopaque scanning appliance worn at the time that the scan is taken. Unfortunately is taken before the patient is seen for consultation. Therefore, the ability to connect the implant to the restorative position could not be established with great accuracy, even with a simulated abutment projection. However, new and innovative tools have been incorporated into the software that can facilitate the process. A Triangle of Bone (TOB) can be established over the cross-sectional image to aid in the planning process:

A realistic abutment placed within the schematic cross-sectional view allows the clinician to plan from within a library of virtual components (supplied by individual implant manufacturers), including most implants currently available with their stocked straight, angled, overdenture and screw-receiving abutments.

IMAGE FORMATION IN DENTAL IMPLANT PLANNING THROUGH CBCT

The CT scan data from the i-CAT CBCT machine is reconstructed within SimPlant software to create a virtual three-dimensional (3D) model of the patient’s...
maxilla. The ability to visualize the patient’s anatomy in 3 dimensions can become exponentially enhanced with proper interactive manipulation.\textsuperscript{9} Translucency provides an invaluable diagnostic aid when the outer bone can be made semitransparent to reveal the underlying surrounding tooth roots. The use of advanced masking allows for specific anatomical structures to be separated, and even colorized, thereby intensifying diagnostic capabilities. The occlusal view of the maxilla showing the edentulous receptor site and maxillary teeth colored individually and in groups, can be seen in. The improved features of the software have made it easier to remove the bone entirely to gain access to anatomy, which had been previously hidden from view.\textsuperscript{10} Accurate placement of another virtual realistic tapered implant [Tapered Internal Implant (BioHorizons)] from the manufacturers’ library was facilitated with these advanced modalities. The coronal position of the implant, as well as the apical position of the implant, can be evaluated easily with respect to the adjacent tooth roots and area that was suspect in the original periapical radiograph. The abutment projection (in yellow) is helpful in identifying the overall spatial position of the implant as it points toward the envelope of tooth.\textsuperscript{11}

The development of the virtual tooth is an important evolutionary step for virtual implant planning. The 3D maxilla, with the virtual lateral incisor tooth (in yellow) can be seen. The virtual tooth can be scaled to fit the space and allow inspection of the contact areas, the distance to the crest of the alveolar bone, and the esthetics. Removing the bone and adding translucency helps to finalize the position of the implant and abutment.\textsuperscript{12}

The 3D model can be rotated in any position, allowing for ultimate inspection and appreciation of the site. The body and thread design of the implant can be fully visualized. The assessment of apical proximity to the adjacent tooth roots is especially useful when planning implants near natural teeth. The occlusal view affords additional examination of the relationship of the implant, the abutment, and the virtual tooth to the surrounding structures. When the adjacent teeth, the virtual tooth, and the abutment are removed, the implant receptor site can be compared to the morphology of the neighboring alveolar housings. This type of assessment represents how these 3D tools can be used to define new paradigms for implant planning, and serves as an excellent educational opportunity for all members of the implant team. Once the plan has been reviewed in all available views, and the implant position finalized, the information can be shared with the patient, and if applicable, members of the implant team\textsuperscript{13} (Fig. 1).

\textbf{USE OF ADVANCED COMPUTERS IN IMPLANT PLANNING}

The widespread use of computers and high-speed Internet access allow for quick and easy exchange of this important information, within the constraints of HIPAA (Health Insurance Portability and Accountability Act of 1996). The incorporation of this technology into daily practice goes well beyond excellent diagnostic capability and empowers clinicians with a powerful communication and marketing tool. With a desktop or laptop computer, the images can be easily incorporated into an impressive presentation, helping patients understand the treatment recommendation. Once a patient accepts the treatment plan, the data is sent via e-mail for fabrication of a CT-derived template to link the virtual plan to the surgical intervention [SurgiGuide (Materialize Dental)]. The template can be bone-borne, tooth-borne, or soft-tissue-borne, depending upon the software application utilized. For this case, a tooth-borne template was necessitated by the partially edentulous condition.\textsuperscript{14}

\textbf{FABRICATION OF SURGICAL TEMPLATE}

A stereolithographic process fabricates the tooth-borne template. The 5.0 mm tall stainless steel cylinder supplies surgical guidance that can be of variable diameter based upon the drills to be used to create the osteotomy. Three different templates are used for the Surgi Guides, which represent the three different manufacturer-specific drills for sequential osteotomy preparation. A 3.75 mm diameter ×13 mm long implant [Tapered Screw-Vent (Zimmer Dental)] was chosen and placed according to the CT plan. Since the bone density and topography had been previously assessed from the CT data and, knowing the excellent fixation properties of the implant, it was determined that the implant could be
immediately restored. Based upon the use of the advanced planning features of the interactive software, the implant was rotated so that the flat of the internal hex connection was facing toward the buccal. A precontoured stock abutment, ready at the time of surgery, was placed for immediate temporization. The ability to assess the restorative requirements of the receptor site has been greatly enhanced with the development of the ‘virtual tooth’ and the realistic abutment that can be positioned within the envelope of the desired tooth position. The position of the real abutment intraorally matched the virtual plan, revealing an adequate distance between the premachined margins of the abutment and the adjacent teeth. This is important for papilla preservation.

VIRTUAL TEETH PLACEMENT THROUGH CBCT

As the apex of the maxillary right central incisor root is in close proximity to the implant, it was advisable to place the implant with the aid of a CT-derive template. Additional information can be obtained by slicing through the 3D model, with the virtual tooth. This highly diagnostic view provides clinicians with previously hidden information about the implant receptor site. While it may be difficult for clinicians unfamiliar with standard CT images to interpret the information, the 3D images are easily understood. The buccal and palatal cortical thickness surrounding the dense trabecular bone can be evaluated so that the implant can be properly positioned within the zone of the TOB. Note that the realistic abutment has been rotated so that the lower premachined margin has been placed toward the facial, and the higher margin toward the palate. The virtual implant library can aid clinicians in planning cases with a variety of different implants and prosthetic components\(^{15}\) (Fig. 2).

ABUTMENT PLACEMENT THROUGH CBCT

Removing the bone with the help of software reveals a virtual, realistic, straight-walled implant [OsseoSpeed (Astra Tech)], which was placed to avoid close proximity to the adjacent roots. Therefore, this technology can be utilized for most available implant systems currently available and presently incorporated into the software for planning and template fabrication. In the past, 2D imaging was inherently limiting. For single-tooth applications especially, clinicians do not feel the need for 3D volumetric imaging for diagnosis of available bone. However, the acceptance of CT and CBCT has helped clinicians expand beyond their conventional imaging modalities to understanding the 3D anatomical presentations of their patients and the importance of this technology, even for missing single teeth. Interactive treatment planning software can take the CBCT data and reprocess it in a manner that can be readily utilized for evaluating potential implant receptor sites. The continued development of software applications to incorporate realistic virtual implants, realistic abutments, and virtual teeth takes the technology to new levels of accuracy, allowing for true, restoratively driven implant dentistry. This type of assessment represents how these 3D tools can be used to define new paradigms for implant planning, and serves as an excellent educational opportunity for all members of the implant team. Simulating the placement of implants must then be transferred to the patient utilizing a CT-derived template, which aids in surgical accuracy and avoidance of vital anatomical structures. The ability to virtually plan the case, discuss the case with members of the implant team, present the case to the patient, and execute the plan with a high degree of accuracy through the use of surgical templates has, elevated the art of implant dentistry into the science of implant dentistry. Although available since the early 1990s, it has been only recently that clinicians worldwide have started to utilize this technology to define new paradigms in understanding anatomy and implant planning. Even the dental implant companies have recognized the importance of this modality for proper diagnosis and treatment planning as evidenced by new software and hardware product offerings. As the author states, ‘There is a danger when we are bound by 2D concepts when we live in a 3D world the evolution will be continue.’

CONCLUSION

The CBCT scanners represent a great advance in dentomaxillofacial (DMF) imaging. This technology, introduced into dental use in the late 1990s, has advanced dentistry significantly. The number of CBCT-related papers published each year has increased tremendously in the last years. The above systematic growth related to CBCT-imaging applications in dental practice was undertaken in order to summarize concisely the indications of this new image technique in different dental specialties. Cone-beam

Fig. 2: Virtual teeth using implant planning software
computed tomography in dentistry was used as key phrase in this systemic review. Other terminology encountered in the literature, such as cone-beam volumetric scanning, volumetric computed tomography, dental CT, dental 3D CT and cone-beam volumetric imaging, did not result in additional relevant papers. The clinical applications for CBCT imaging in dentistry are increasing. The clinically relevant and that the most common clinical applications are in the field of oral and maxillofacial surgery, implant dentistry, and endodontics. CBCT has limited use in operative dentistry owing to the high radiation dose required in relation to its diagnostic value. The literature on CBCT is promising and needs further research.

REFERENCES