Cone Beam Computed Tomography–assisted Treatment Planning Concepts

Scott D. Ganz, DMD\textsuperscript{a,b,*}

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- Cone beam computed tomography
- Dental implants
- Computed tomography
- Interactive treatment planning applications

Computed tomography (CT) and cone beam CT (CBCT) technology allows for an unprecedented three-dimensional (3D) evaluation of each patient’s individual anatomy. The advent of this technology has evolved into an indispensable diagnostic tool that can be used for a variety of different clinical applications that include, but are not limited to: dental implant receptor site evaluation; alveolar bone defect and bone augmentation procedures; impacted teeth; orthodontics; endodontics; temporomandibular (TM) joint diagnostics; sinus augmentation procedures; and orthognathic surgical interventions. The presurgical planning phase of these applications that benefit from CBCT technology starts with the accumulation of data for which educated treatment decisions can be accurately determined. Adapting to the ALARA (as low as reasonably achievable) principle, the radiation dosages from CBCT have been minimized through the process of collimation, and reduction in scan time, yet maintaining a high degree of diagnostic accuracy. The benefits versus the risks should be considered when determining the need for a scan. The purpose of this article is to show the benefits of using CBCT technology for dental implant applications.

A myriad of CBCT scanning machines are available in the United States and around the world that claim to deliver high-quality diagnostic images with machine-specific variations on how this can be achieved. In addition, each machine is driven by...
Fig. 1. i-CAT CBCT provides 4 important image views: cross-sectional, panoramic, axial, and 3D volume reconstruction.
proprietary software to obtain and visualize the 3D dataset. Once a scan has been taken, the interpretation process begins regardless of which software is used. Each manufacturer allows clinicians to visualize and interact with the data for the purposes of diagnosis and treatment planning. There are 4 important 3D views; (1) axial, (2) cross-sectional, (3) panoramic, and (4) 3D reconstructions (Fig. 1) (i-CAT Vision, Imaging Sciences Inc, Hatfield, PA). Each of these views is individually important, providing unique levels of detail. When assimilated in total as a result of the interactive nature of the CBCT native software, these views provide the ultimate overview of the patient’s anatomic presentation. The data can also be exported into DICOM (digital imaging and communications in medicine) files that can be visualized through third-party interactive treatment planning software applications that have innovative tools to enhance the diagnosis and treatment planning process. The author has long advocated the concept that “It’s not the scan, it’s the plan,” meaning that the clinician must evaluate and interpret the data provided by the CBCT machine to establish accurate treatment options using innovative state-of-the-art digital tools. Once the scan is taken, it can be viewed on the computer workstation using the native software (ie, i-CAT Vision), or the DICOM data can be exported into an interactive treatment planning software such as SimPlant (Materialise Dental, Glen Burnie, MD, USA), NobelGuide (Nobel Biocare, Göteborg, Sweden), Invivo5 (Anatomage, San Jose, CA, USA), (VIP Software, BioHorizons Inc, Birmingham, AL, USA), Straumann coDiagnostiX (Straumann USA, Andover, MA, USA), Blue Sky Plan (BlueSkyBio Grayslake, IL, USA), where all available images can be processed and manipulated interactively to create an excellent diagnostic environment (Fig. 2).

Fig. 2. The flow of information from the i-CAT CBCT scan data to the final treatment plan using interactive treatment planning software.

Fig. 3. Panoramic view revealing the maxillary-mandibular relationship, and 3 stages of implant reconstruction.
BENEFITS VERSUS RISKS

During the evolution of CT and CBCT, clinicians worldwide discovered what the author has labeled the “reality of anatomy” or the patient’s individual anatomic 3D presentation. When a preoperative scan is not performed, potential complications can occur, and issues are then discovered with a postoperative scan. A postsurgical, postreconstruction CBCT scan (i-CAT) was performed after the mandibular right paresthesia did not resolve. The panoramic reconstruction revealed implants placed in 3 quadrants, the right, left, and anterior maxilla, and right mandible (Fig. 3). The image can be enlarged to focus on the area of interest such as the path of the inferior nerve and

**Fig. 4.** (A) Focusing the field of view to the right mandible illustrates the proximity of the implants near the path of the inferior alveolar nerve (arrow). (B) The axial view reveals the break in the cortical bone that indicates the mental foramen (yellow arrow). The red arrows show an artifact known as beam hardening.

**Fig. 5.** (A–D) A series of cross-sectional slices reveal an implant that perforated into the inferior alveolar nerve, and mental nerve complex (red arrows).
the proximity of the previously placed implants (Fig. 4A). To gain a great appreciation of the local anatomy, the axial slice created perpendicular to the panoramic slice reveals the break in the facial cortical bone (see Fig. 4B, yellow arrow), which indicates the mental foramen. The radiolucent areas between the implants could represent the inferior alveolar nerve, or it could also be a phenomenon called beam hardening, which turns the pixels in proximity to dense objects radiolucent (see Fig. 4B, red arrows). To differentiate, it is necessary to review the cross-sectional slices. Cross-sectional slices revealed that the implant closest to the mental nerve penetrated into the inferior alveolar nerve canal (Fig. 5). If a CBCT scan had been taken before the implant placement either a shorter implant could have been used, or a different receptor site might have been used.

Fig. 6. (A, B) The axial view reveals an implant located in the area of the right central incisor tooth that seems to perforate the facial cortical plate (A, red arrow). The cross-sectional view was helpful in identifying the apical position of the implant invading the space of the incisal canal (B, red arrows).

Fig. 7. (A, B) This axial view reveals an implant located in the area of the left lateral incisor tooth that significantly perforates the facial cortical plate (A, yellow arrow). The cross-section further shows that 50% of the implant is not located within the bone (B, yellow arrow).
Another paresthesia case resulted from a perforation into the incisal canal. An axial view revealed an implant placed in the area of the right maxillary central incisor (Fig. 6A). The implant appeared to perforate through the facial cortical plate (see Fig. 6A, large red arrow). The cross-sectional slices clearly illustrated the apical extent of the implant that invaded the incisal canal space causing long-lasting postoperative complications (see Fig. 6A, arrows).

A third example of a malpositioned implant can be visualized in the axial slice of a left maxillary lateral incisor (Fig. 7A, yellow arrow). The implant significantly perforates through the facial cortical bone. The cross-sectional view further illustrates that 50% of the implant is not located within the alveolar housing (see Fig. 7B). The yellow arrow reveals the apical portion of the implant is located within the soft-tissue vestibule. When a preoperative scan is used, implants can be positioned where they are surrounded with a good volume of bone. A cross-sectional slice of an implant in function for 10 years can be visualized in Fig. 8A. The implant was positioned within the zone that the author has defined as the “triangle of bone,” providing the most volume of surrounding bone (see Fig. 8B). The maxillary topography reveals a typical pattern where the bone is higher on the palate or lingual, and lower on the buccal or facial (see Fig. 8C). This bone pattern and implant placement are defined as transitional placement. Therefore there are known risks in placing implants without 3D diagnosis and surgical guidance with CT-derived templates. Potential serious complications can be avoided when 3D imaging tools are used, as is shown later.

**CASE PRESENTATION: FAILING LONG-SPAN MANDIBULAR BRIDGE**

Treating failed long-span bridges presents unique challenges for the clinician and the patient. When anchor abutment teeth fail, it is recommended that the bridge be removed, often it can no longer be supported by natural teeth. The treatment option to replace the missing dentition consists of a removable-type prosthesis, or an implant retained restoration. Most patients do not want to be without teeth for an extended amount of time and desire the option that most closely replaces their missing teeth: a fixed prosthesis. Many patients are now aware of treatment options that allow for removal of the failing bridge and anchor teeth followed by the immediate placement of dental implants to maintain an immediate transitional restoration. However, in order to present this treatment option to the patient, proper diagnosis and treatment planning are essential for a complete understanding of the available bone, soft tissue, opposing occlusion, vertical dimension, and surrounding vital structures. Current
two-dimensional panoramic and periapical radiographs can no longer be considered the most accurate diagnostic imaging modalities available.

To properly assess the patient’s anatomy, the author recommends 3D assessment using CBCT technology, which empowers the clinician with new tools to make educated decisions regarding the plan of treatment.

A 61-year-old male patient presented with pain and mobility in an existing posterior right mandibular long-span fixed bridge. A routine diagnostic workup was completed, including periapical radiographs and study casts. The patient had a history of bruxism, which may have been contributory to the root fractures and mobility of the bridge. Radiographic loss of bone was evident around the mandibular second molar tooth, the terminal abutment for the fixed bridge, which showed a significant angular defect on the mesial (Fig. 9). The first bicuspid had previously been treated with root canal therapy, and appeared to be fractured from the stress of the restoration and/or recurrent decay along the margins. To determine the potential treatment alternatives a CBCT scan was ordered to allow complete inspection of the 3D bony topography, and the relationship of adjacent vital structures. Two-dimensional imaging modalities could not provide an adequate interpretation of the patient anatomy, raising the risk of treatment and potential injury to vital structures.

Fig. 9. Preoperative radiograph showing area of bone loss and decay.

Fig. 10. Panoramic reconstruction reveals the failing right fixed bridge, and the path of the inferior alveolar nerve.
3D PLANNING

The panoramic image reconstructed from the CBCT dataset differs substantially from a conventional panoramic radiograph. This nondistorted image can be viewed interactively using the incorporated viewing software to assess the broader aspects of the arches (Fig. 10). The cross-sectional image is excellent for defining a slice of the mandible where the height and width of the bone can be accurately evaluated. Within an individual slice, the spatial location of the tooth and root can be appreciated (Fig. 11A). The facial, lingual cortical, and intermedullary bone can be visualized based on their radiopacity or gray-scale density values. Nuances within the anatomic presentation can be assessed with greater accuracy than with any other imaging modality. Simulated implants can be placed in a position to effectively support the desired restoration, even with close proximity to the mental foramen (see Fig. 11B). The

![Fig. 11. (A, B) A cross-sectional image reveals the facial and lingual cortical bone, the intermedullary bone, and the relative density (A), and a simulated implant placed over the mental foramen (B).](image)

![Fig. 12. The cross-sectional slice of the molar reveals the extent of the bone defect, the lingual concavity, and the inferior alveolar nerve (orange).](image)
cross-sectional slice of the posterior molar reveals the significant bone defect surrounding the apical roots (Fig. 12). A significant lingual concavity was noted with the pattern of cortical bone visualized below the root apex (see Fig. 12, yellow arrows). The inferior alveolar nerve can be carefully traced through the mandible to determine proximity to the tooth roots and potential implant receptor sites (see Fig. 12, orange). Although there was good-quality bone above the location of the nerve, there was insufficient bone to adequately fixate an implant after immediate extraction. It was therefore elected to remove the molar tooth and fill the defect with grafting material in anticipation of placing an implant after the new bone had matured.

Creating a fully interactive 3D reconstruction from the CBCT scan data allows the clinician further insight into the patient’s existing anatomic presentation. Using advanced software masking or segmentation enables the various anatomic entities to be separated for improved diagnostic capabilities (SimPlant). The preexisting bridge has been colorized (Fig. 13, magenta), as have the adjacent molar and cuspid teeth (see Fig. 13, white). Simulated implants were positioned within the bone to support a new fixed restoration based on the abutment projections that extended above the occlusal table (Fig. 14). Note the planned parallelism of the 4 simulated implants. Using advances in interactive software, “selective transparency” as defined
by the author, can be applied to change the opacity of various structures to aid in the
diagnosis and planning phase. Accurate placement of realistic implants is enhanced
by masking the adjacent tooth roots. The path of the inferior alveolar nerve can also
be fully appreciated (Fig. 15). If the preexisting restoration could not be physically
removed before CT/CBCT imaging and the old occlusion was found to be unfavorable,
through further masking or segmentation, it is now possible to build a virtual occlusion
using interactive treatment planning software. Virtual teeth (seen in yellow in Fig. 15)
can correct discrepancies, and allow for an ideal simulated morphology fabrication.
The large defect around the molar was significant, and it was determined that it could
not be used as a receptor site initially. It was elected to graft this site, and return in 5
months to place a single implant in the molar site. Once the plan has been verified in all
4 available 3D views a virtual template can be fabricated based on the simulated
implant positions (Fig. 16). Therefore, the final surgical template is only as good as
the virtual plan, and therefore, it is advisable to check each view carefully.

Three basic CT-derived template types are available that can be fabricated for
dental implant placement: (1) bone borne, (2) tooth borne, and (3) soft-tissue/
mucosal borne. Based on the fact that there were adjacent teeth in the region it

Fig. 15. “Selective transparency” allows close inspection of the implants placed within the
virtual teeth, and the proximity to the nerve.

Fig. 16. The 3D plan allows for a virtual template, which is then fabricated by the process of
stereolithography.
was elected to use a tooth-borne template stabilized by the existing occlusion. The CBCT scan data were sent via email for fabrication of a stereolithographic model (Fig. 17) (Materialise Dental, Lueven, Belgium). This resin-type model is a replica of the patient’s anatomy at the time that the images were acquired. The preexisting bridge was virtually removed via the software before fabrication of the surgical guide. The ability to separate anatomic and other structures from the reconstruction is known as segmentation and is not available in all software applications. The template adapts well to the surrounding dentition and does not require further fixation to prevent movement. The stainless steel tubes are two-tenths of a millimeter wider than the manufacturers’ sequential osteotomy drills, allowing accurate guidance during the drilling process. For fully edentulous cases, either bone-borne or mucosal-borne applications, it is advisable to use fixation pins or screws to stabilize the surgical template.

A novel modality pioneered by the author uses a CT-derived stereolithographic model-based approach to link the implant placement and the eventual restoration. Implant replicas, or analogues, were placed in predesignated implant receptors on the stereolithographic partially edentate mandible (Fig. 18). To accommodate the immediate restoration, manufacturers’ specific abutments were placed on the implant replicas. Note the interimplant distances for proper embrasure design, and appreciation of biologic width. A diagnostic wax-up was accomplished and a clear matrix fabricated to facilitate the fabrication of a provisional prosthesis. Stock, 3inOne titanium

Fig. 17. The stereolithographic tooth-borne template and mandibular model of the patient’s anatomy.

Fig. 18. Implant replicas were placed in the mandibular stereolithographic model.
abutments (BioHorizons) were positioned on the implant replicas to support the temporary restoration (Fig. 19A). The processed 4-unit transitional acrylic bridge was supported by the implant abutments (see Fig. 19B). Because the molar site would not receive an implant immediately, a distal cantilever pontic was required. The actual implants as simulated in the virtual plan were chosen in advance, as well as how to best position the implants to take advantage of the reverse buttress thread design, coronal microchannels, and internal hexagonal connection design features. The manufacturer has indicated that the Tapered Internal implants (BioHorizons) with the Laser-Lok (BioHorizons) microchannels allow the implants to be vertically placed in 3 potential positions relative to the height of bone. As with most bone-level implants, the implant can be placed at the crest of the bone (Fig. 20A). Because of the specific properties of the Laser-Lok microchannels the implant can also be placed supracrestal, or in a transitional position where the lingual cortical plate is higher than the facial cortical plate of bone (see Fig. 20 B, C). As indicated earlier, receptor sites often show asymmetry in the bone topography, which cannot be determined with conventional two-dimensional imaging. Regardless of which company manufactured the implants, there are design considerations that can benefit from presurgical prosthetic 3D planning concepts.

SURGICAL INTERVENTION

The preoperative lateral view of the original failing fixed bridge illustrating the ridge-lap pontic design (Fig. 21A). The occlusal view of the long-span bridge can be seen in Fig. 21B. Once the failed restoration was removed, the underlying fractured tooth roots were assessed. The volumetric change in the pontic areas was assessed by

![Fig. 19. (A) Stock, 3inOne abutments positioned on the implant replicas to support the temporary bridge. (B) The processed 4-unit transitional acrylic bridge supported by the abutments.](image)

![Fig. 20. (A) Crestal placement of an implant within the mandibular bone. (B) If an implant is placed above the crest it is considered supracrestal placement. (C) If bone levels are not even, it is considered transitional placement.](image)
Fig. 21. (A) Preoperative lateral view of the original failing fixed bridge showing the ridge-lap design pontics (A, yellow arrow). (B) Preoperative occlusal view of the original failing fixed bridge. (C) Preoperative occlusal view after the bridge had been removed revealing the roots, and diminished bone volume.

Fig. 22. The full-thickness flap revealed the underlying deficient alveolar ridge.

Fig. 23. The tooth-borne template in position to guide the implants.
comparing the facial lingual dimensions of the molar and bicuspid with the pontic area with diminished keratinized tissue (see Fig. 21C). All of the planning decisions had been made before the surgical intervention except the design of the flap to expose the underlying alveolar ridge. To preserve the keratinized tissue, a full-thickness mucoperiosteal flap was required, followed by extraction of the 2 natural abutment teeth (Fig. 22). The tooth-borne template was then placed over the site and examined for fit (Fig. 23). As per the CBCT-derived plan and template, the first 3 implants were placed (Tapered Internal). The implants were well fixated, allowing for immediate restoration by aligning the internal hexagonal connection to the facial to allow for proper seating of the 3inOne abutments (Fig. 24). The posterior molar extraction socket was filled with a corticocancellous mineralized bone graft material (MinerOss, BioHorizons), and covered with a collagen membrane.

The prefabricated 4-unit provisional restoration was seated and relined to fit the 3 anterior implant fixtures. The distal-extension cantilever replaced the missing molar, with care taken not to place pressure on the underlying graft. The soft tissue was sutured to allow for near primary closure as they were wrapped around the abutment projection, helping to establish embrasures (Fig. 25). The postoperative periapical radiograph confirms the placement of the anterior 3 implants and the bone graft in the molar defect (Fig. 26). The transitional restoration was cemented retained, and left in place for more than 2 months. Once the posterior molar bone graft had matured, the fourth implant was placed according to the original CBCT plan. When the fourth implant had integrated after 8 weeks in function, an abutment was connected, and
**Fig. 26.** The postoperative radiograph showing 3 Tapered Internal implants with abutments to support the temporary.

**Fig. 27.** The final prepared abutments on the working cast after the final implant was loaded.

**Fig. 28.** The bisque bake try-in reveals the new soft-tissue contours and emergence profile established.
the existing transitional restoration was relined. Impressions were made and a soft-tissue working cast fabricated for the laboratory process. The favorable parallelism afforded by the CBCT-derived planning required only minor preparation of the implant abutments to allow for adequate clearance for the metal alloy and porcelain veneer (Fig. 27).

Because of the patient's bruxism, it was elected to splint the posterior 3 units within the framework of the ceramometal restoration, whereas the anterior, longer implant was fabricated as a single unit. The bisque-bake try-in revealed improved soft-tissue contours and emergence profile (Fig. 28).

The completed ceramometal units seen in the periapical radiographs show satisfactory parallelism and interimplant distances (Fig. 29). The emergence profile of each implant illustrates a smooth transition important to long-term maintenance. The final glaze and porcelain characteristics of the posterior 4 units blend in with the surrounding dentition and soft tissue (Fig. 30). Note the excellent adaptation of the embrasures.

**POSTOPERATIVE CBCT SCAN EVALUATION**

Approximately 2 years after the initial implants were placed in the mandible, the patient returned to the office with a fractured bridge in the left posterior maxilla. Extraction of
the necessary teeth would have resulted in a lack of support for a new fixed bridge. It was therefore determined that the area was unrestorable by conventional means. To further evaluate this area it was necessary to gain additional 3D data from a CBCT scan. During the image acquisition, and with the patient’s permission, a larger field of view was incorporated to help validate the previous placement of the 4 implants in the posterior right mandible. The results of the CBCT for the mandible helped to substantiate that the initial plan was well executed. Each of the 4 receptor sites was evaluated separately using axial and cross-sectional views. The postoperative CBCT scan axial view indicated the position of the 4 implants (Fig. 31A). Starting with the most anterior implant (see Fig. 31A, red arrow), a cross-sectional slice indicated an ideal position of the implant within the supporting bone (see Fig. 31B). Continuing to the second implant site, the axial and cross-sectional views showed that the implant was positioned with adequate clearance above the inferior alveolar nerve, avoiding potential complications that were reviewed earlier (Fig. 32).

Fig. 31. (A) The postoperative CBCT scan axial slice at cross-section of the anterior implant (red arrow). (B) The cross-sectional slice showing the ideal position of the implant within the bone supporting the tooth.

Fig. 32. (A) The postoperative CBCT scan axial slice at cross-section of the second implant (red arrow). (B) The cross-sectional slice showing the position of the implant above the mental nerve and foramen (orange).
Compare the original plan (see Fig. 11B) with the 2-year follow-up scan in Fig. 32B. The implants were placed according to the desired position of the restoration.

The postoperative location of the third implant in the series can be seen in the axial view (Fig. 33A). The cross-sectional slice (number 57) illustrated the ideal implant positioned to support the tooth and avoid proximity to the path of the inferior alveolar nerve (see Fig. 33B). The implant was placed based on the transitional topography of the crestal and cortical bone on the facial and lingual. It was also important to prevent perforation through the lingual concavity, and this was accomplished with the advanced 3D planning and use of the CT-derived template. The final implant had been placed in a delayed method after the large-diameter molar extraction socket was grafted with mineralized bone. The postoperative CBCT scan revealed total bone fill with sufficient volume to support the implant and the restoration (Fig. 34). The cross-sectional slice illustrated the vertical relationship between the implant,

Fig. 33. (A) The postoperative CBCT scan axial slice at cross-section of the third implant (red arrow). (B) The cross-sectional slice showing the ideal position of the implant well above the nerve, avoiding the lingual concavity.

Fig. 34. (A) The postoperative CBCT scan axial slice at cross-section of the posterior molar. (B) The cross-sectional slice showing the postgraft placement of the implant and the proximity to the lingual concavity (arrow).
the abutment, and the crown. The severe concavity was avoided with careful planning and the use of a tapered design implant body style (see Fig. 34B, red arrow).

The purpose of this clinical case example was to illustrate the enhanced diagnostic and treatment planning capabilities of CBCT data combined with interactive treatment planning software. The combination of careful diagnosis with proper planning aids the clinician in understanding existing bone topography, bone density, adjacent tooth roots, lingual concavities, occlusion, and the path of the inferior alveolar nerve. Once the information has been gathered, an accurate plan can be established. This plan is then transferred to a surgical guide, allowing for precise implant placement. In a phased approach, 3 initially placed implants were immediately loaded with a transitional cantilever restoration, avoiding the lingual concavity and within a zone of safety above the inferior alveolar nerve. The posterior molar tooth with resulting socket defect was found to be unfavorable for implant fixation, and therefore site development was accomplished with bone grafting. This situation was anticipated and documented preoperatively after interpretation of the CBCT data. Once matured, the molar area became an excellent implant receptor site. The patient was given a transitional restoration the day of surgery, although there was a staged approach and delayed implant placement in the molar area. This case represented one treatment alternative to replacing a failed long-span mandibular and bridge, which was made possible through CBCT scan technology, interactive treatment planning software, and CT-derived surgical templates to guide the placement of the implants based on the restorative needs of the patient. Postoperative CBCT scan data at 2 years validated that the plan had been successfully achieved.

SUMMARY

CT and CBCT scan technologies have played a major role in the evolution of diagnostic imaging for dental applications. The ability to visualize each individual patient’s anatomy with an interactive 3D assessment takes the guesswork out of the equation, and allows clinicians to make truly educated decisions regarding treatment. Using the ALARA principle, newer CBCT imaging machines have achieved the delivery of this information with a significant reduction in radiation, and smaller in-office machines that provide almost instant access to enhanced diagnostic imaging. The benefits versus the risks should be considered when determining the need for a scan. Several case examples illustrated complications that occurred when CBCT was not used presurgically. Postoperative scanning can also prove to be a useful application of this technology to help validate the 3D placement of implants, or to evaluate healing progress of bone grafts, or other procedures when warranted.

The advent of this technology has evolved into an indispensable diagnostic tool that can be used for a variety of different clinical applications which include, but are not limited to: dental implant receptor site evaluation; alveolar bone defect and bone augmentation procedures; impacted teeth; orthodontics; endodontics; TM joint diagnostics; sinus augmentation procedures; and orthognathic surgical interventions. The use of the CBCT native software, or when the DICOM dataset is imported and visualized through third-party interactive treatment planning software applications, enhance the diagnosis and treatment planning process. This article highlights the presurgical planning phase of dental implant applications that benefit from CBCT technology so that educated treatment decisions can be accurately determined through a careful evaluation of all 4 3D views: (1) axial, (2) cross-sectional, (3) panoramic, and (4) 3D reconstructions. It is important for clinicians to gain an understanding of how each of these views is individually significant, and how each slice can provide unique levels
of detail to provide a comprehensive overview of the patient’s anatomic presentation. The use of this technology will help clinicians to avoid potential complications and costly remakes and will result in decreased patient morbidity through improved presurgical planning. The digital world will continue to evolve with new and improved tools, with the ultimate goal of benefiting the patients we treat.

SUGGESTED READINGS


