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Cone-beam computed tomography ... What’s not to like?

First approved by the Food and Drug Administration in March 2001, cone-beam computed tomography (CBCT) is unlike other digital X-ray imaging technologies and has experienced rapid adoption in the past decade. This is because it improves the clinical decision-making across a wide variety of dental disciplines. It is dentistry’s newest disruptive technology. Dentists do not place an implant every day or even a three-unit fixed prosthetic bridge. Dentists and dental specialists perform different imaging examinations on almost every patient and certainly every day in their practices.

X-ray imaging procedures have the highest profit margin of any procedure in the dental office. Most clinicians are not aware of this because they could not perform the actual tasks of image acquisition. Dentists interpret the image data to help them make a treatment plan and to help decide what procedures are necessary. In this regard, CBCT provides more precise, more useful and more graphically detailed information to help clinicians with their diagnostic tasks. Whether one is imaging a prospective implant site, the condyles, the morphology of the tooth to be treated endodontically, an impacted tooth or orthodontic or airway analysis, CBCT data sets can provide thin slice, highly accurate, 2-D multiplanar grayscale images, or if necessary, full 3-D color reconstructed images to assess both anatomy and pathology. No other technology can provide this type of information at such a low dose to the patient. What’s not to like?

However, just as they must with any other newly introduced technology, dentists or dental specialists must navigate their way through myriad claims, sometimes inappropriate, made by manufacturers about the capability of the various machines that they are investigating to purchase. Stated simply, “the technology is always introduced ahead of the education.” Thus, the early adopters often make purchases based upon pretty images and manufacturers’ claims and are sometimes disappointed with the results of the technology. This happened with panoramic imaging many decades ago.

Before the understanding of simple positioning adjustments that could render almost any image useless for diagnosis, many clinicians would use panoramic images that were unacceptable for their clinical decisions. Thus, the modality was panned by many early critics as being inappropriate and too high a dose to use instead of using intraoral images for many of the dental tasks that the dentist wished to perform.

Today, thanks to decades of the training dental students, practicing clinicians and dental auxiliaries have received about panoramic positioning errors, the acceptability and use of panoramic X-ray imaging is universal. Because CBCT has many more applications, and because of the tremendous improvements in imaging and computer technology, this modality has been accepted much more rapidly than previous X-ray techniques. What’s not to like?

Therefore, we will continue to see manufacturers make improvements to their machines in their software. We will continue to see widespread adoption of the technology, and we will continue to see better decision-making arising from the use of this technology. Again, what’s not to like?

If clinicians, manufacturers and oral and maxillofacial radiologists worked together to provide the missing piece, genuine and robust education, CBCT technology will lead to a true and appropriate imaging revolution. Let’s all work together to make this happen. What’s not to like?

Sincerely,

Dale A. Miles BA, DDS, MS, FRCD (C), Dip. ABOMR, Dip. ABOM
Academy of Osseointegration

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Imaging solutions for professionals.
Clinical and diagnostic advantages of PreXion 3-D imaging system

Author_Dan McEowen, DDS

For nearly 100 years, dentists have relied on 2-D radiographic imaging for diagnosis and treatment planning. With the 1999 introduction of cone-beam computed tomography (CBCT), all dentists now have tools available for more accurate diagnosis and treatment.¹

The ability to look at a tooth in any direction and orientation, as well as in 3-D, eliminates much of the guesswork commonly experienced with 2-D radiographs.

We have been limited in most cases to only a buccal-lingual view provided by periapicals, bitewings and panoramic radiographs with the occasional axial view of an occlusal film. Medical CT scans and images began in the early 1970s and were sometimes used by dentists, offering our first multiplaner views.²

The adoption of 3-D cone-beam imaging is appropriate and has important advantages for all modalities of dentistry. From every specialist to the general dentist, the increased amount of radiographic information as well as increased accuracy will aid in the most sound diagnosis possible.

_CBCT description

CBCT is a single or partial rotation of an X-ray source around the head, capturing X-rays on various flat panel arrays and sensors. The information is converted to a series of axial slices by computed tomography and stored as virtual anatomy in the computer.

With the use of sophisticated software, the dentist is able to view information in several different views, including: axial slices (head-to-toe orientation), coronal slices (front-to-back orientation), sagittal slices (side-to-side orientation) all known as multiplaner reconstructions (MPR). The thickness of each slice can be varied to include more or less information.

Because the voxels (volumetric pixels 3-D) are isotropic, other MPR images can be generated by

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Fig. 4. The 3-D CBCT showing anatomy of the maxillary sinuses.

Fig. 5. Axial MPR showing mesial buccal roots in first, second and third molars.

slices drawn at any angle, curve or thickness through the scan to view areas critical to the final diagnosis.3,8

The final view offered by CBCT is a 3-D view that can be rotated and viewed in any direction.

Once again through software manipulation, 3-D images can be viewed as conventional radiographs, maximum intensity projections (MIP), soft-tissue projections and a variety other views.

This nearly endless ability to manipulate the data aids in the diagnosis and identification of disease, nerve canals, sinus morphology, dental caries, bone density, fractures, endodontic pathology, implant placement criteria, periodontal defects, bone pathology, fractured teeth, iatrogenic trauma, TMJ morphology and disease, third-molar position and many more healthy or diseased conditions.

Early CBCT adoption with implants

The first and primary use of CBCT for early adopters was implant placement. As the scope and the value of the information became better known, dentists of all branches began to see the value of MPRs and 3-D renderings including periodontics, endodontics, oral surgery, treatment of TMJ, orthodontics, implantology and general dentistry.1,2,8

Clinical periapical and panoramic radiographs for the placement of implants can be misleading with elongation, foreshortening, superimposition and geometrically incorrect data.7,8 A look at the implant in the periapical shows no obvious disease to an existing integrated implant. Clinically, a buccal fistula was present with exudate and slight pain. The CBCT scan (Fig. 1) reveals a more accurate view showing a buccal defect on a sagittal MPR. A surgical flap revealed a dehiscence of the coating of the implant. Removal of the foreign body resulted in an asymptomatic and healthy patient.

The evaluation of the available bone for the initial implant placement can be crucial for the long-term success of the case. If there is inadequate bone available, grafting may be a necessity. CBCT studies render the most accurate information available at a low radiation dose. The periapical shows an obvious lack of bone height, but does not show the buccal-lingual dimensions or an accurate view of the sinus morphology (Fig. 2).

The MPR view of the CBCT shows all necessary measurements to perform the sinus lift and grafting with the immediate placement of the implant fixture (Fig. 3). Three-dimensional views show the floor of the sinus and any soft-tissue pathology (Fig. 4). Having accurate measurements in all dimensions is an advantage of CBCT scanning.

CBCT and endodontics

Endodontics is a field that is rapidly adopting the use of CBCT and for good reason. The inherent geometric deficiencies of 2-D radiographs make the CBCT scan a valuable adjunct to investigate the root morphology in both 3-D and MPR. The typical periapical will show superimposed canals in the anteriors, bicuspsids and molars as well as unwanted bone densities both buccal and lingual to the affected tooth making the image quality poor.

The ability to view MPR slices in cross-section, long axis and oblique directions gives the ability to follow all canals in any direction and show their relationship and measurements from other known...
structures. This virtual tour of the root morphology is a great benefit to the final treatment outcome (Fig. 5).3,4

Post root-canal infection can be difficult to diagnose with the standard periapical. The endodontic fills may appear to be normal even though other clinical findings and symptoms are abnormal. The patient presents several months post root-canal treatment with pain on palpation and pressure and avoids this side of the mouth.

A periapical radiograph shows minimal pathology (Fig. 6). The roots appear to be filled and a small puff of sealer extends through the apex of the mesial roots. The distal root structure and fill appear normal. There is little indication of periapical radiolucency only a widening of the periodontal ligaments of the mesial roots.

A CBCT scan reveals a completely different picture. The coronal MPR reveals a short fill near the apex of the mesial lingual root and a large radiolucency (Figs. 7, 8) not visible on the periapical radiograph (Fig. 6).

Missed canals are difficult to see in a buccal-lingual projection of the periapical radiograph as one canal is superimposed on the other (Fig. 9). Often, as viewed in this radiograph, we see periapical pathology with an apparent normally filled canal. CBCT scans allow dentists to look for pathology in MPR planes to identify the actual problem before invasive procedures are performed on the patient. The axial view shows a lingual canal exists and is untreated. The coronal view confirms the diagnosis and treatment can be completed (Fig. 10).

Today’s endodontists, as well as general dentists, are benefiting from the diagnostic capabilities of the high-resolution CBCT scanners available over conventional 2-D periapical.5,6

**Oral surgery**

Oral surgery, with its inherent invasive nature, can be better served using CBCT with MPR as well as 3-D images. The ability to perform virtual surgery is a benefit to both the doctor and the patient. Doctors have the advantage of seeing morphology and landmarks in real time and space with accurate measurements, and patients will gain a better understanding of the problems and the solutions their doctors are offering them.

Third-molar extractions can be risky based on 2-D and panoramic radiographs. These radiographs
can often superimpose nerves and sinuses over root structures. Dentists using 2-D radiographs must often rely on experience to assess the risks of iatrogenic trauma. The use of CBCT with MPRs and 3-D images reduces any guessing as well as the chance for any permanent damage to the patient. With the adoption of CBCT, the judgment is based on solid evidence and the risk will decrease.

A panorex of the superimposed third molars gave no solid evidence the canal lies between the roots. It is only with the use of CBCT and the MPRs that the nerve can accurately be seen traversing between the mesial buccal and mesial lingual root (Fig. 11).4,5

Other surgical advantages include the identification and the position of supernumerary or impacted teeth. The images show accurate positions and show definitive morphology that will aid in removal of the proper teeth (Fig. 12). Knowing the exact position of many of these teeth is a benefit to both the doctor and patient. It will lead to the most precise surgical path and the least invasive procedure.

**Periodontics**

The explanation of periodontal problems are often misunderstood by the patient. As doctors we talk about pockets, point to X-rays and propose treatment only to have patients refuse treatment because they do not understand what we are clinically describing. Using the 3-D portion of the CBCT scan can improve the understanding and acceptance of treatment plans. The images are a picture of the problem that is owned by that patient and much easier to understand by the layperson. Illustrating periodontal defects and pockets allows the patient to better participate in the process (Fig. 13).

The MPRs and the 3-D projections aid in surgical planning for periodontists, allowing for accurate measurements and bone analysis prior to osseous surgery that doctors cannot get using the periapicals or panoramics. Studies have shown that CBCT images are more accurate than panoramic radiographs. For the periodontist placing implants, the ability to measure bone density and avoid important anatomy is important.4,5

**Orthodontics**

Orthodontists are beginning to adopt large field-of-view CBCT. Recent studies show that linear measurements of bony structures are more accurate using CBCT and have less distortion than currently used methods of measurement: lateral cephalometric, posteroanterior (PA) and submentovertex (SMVT).5 Accurate measurements of tooth volume and tooth position can aid in accelerated treatment times and more precise treatment.

Along with tooth position, density of bone and size of arches, the orthodontist also has an accurate evaluation of the temporomandibular joint and position of the condyles. Impacted teeth are easily identified and position either buccal or lingual can be confirmed prior to movement or removal. Both MPRs and 3-D projections give the clinician a complete picture of the problems and the treatment course.

With a single CBCT scan, orthodontists can produce all of the information they need: panoramic, cephalometric, PA, SMVT, tooth size and volume,
crowding evaluation in any plane, TMJ evaluation and airway analysis, all with both soft-tissue and skeletal information.5,7

Conclusion

We treat our patients in 3-D, and now, with cone-beam computed tomography, we are changing the way we diagnose from 2-D to 3-D. The addition of this technology will increase your diagnostic skills with better and more complete information at your disposal. As with any type of invasive diagnostic tool, clinicians should weigh the risk to benefit in using CBCT scans.

Judicious use of CBCT and knowledge of patient’s lifetime doses should always be a consideration as well as the availability of other diagnostic tests appropriate for the problems of the patient. When adopting new technology, training is paramount. Along with training comes the responsibility of the doctor to read and diagnose information from CBCT scans.

Do not avoid CBCT from lack of knowledge; instead, take this opportunity to become a better diagnostician and radiologist. As you review radiology and pathology, your use of CBCT will aid in making the most accurate diagnosis and the most complete treatment plans._

Editorial Note: A complete list of references is available from the publisher.

About the Author

Dan McEowen, DDS, is a 1982 graduate of Loma Linda School of Dentistry and has been in private practice for 26 years. He is a founding member of the World Clinical Laser Institute, achieving a mastership level of proficiency. He has been active in FDA approval of oral surgery techniques using Erbium lasers. McEowen has lectured and trained internationally in techniques using lasers in general and specialty dental fields. He is a member of the ICOI and is active in implantology. McEowen has been involved in cone-beam technology for more than five years and owns 3D Imaging Center in Maryland.
Full arch reconstruction of the edentulous maxilla

Using the CAMLOG Guide System Prosthetics

Author: Claudio Cacaci, DMD

Information on patient and treatment

The male patient, aged 59, was looking for a new fixed restoration for his maxilla. His case history showed no general disease. The patient had been fitted with telescopic model casting prostheses in the maxilla and mandible.

Due to the periodontally insufficient anterior residual teeth in the maxilla (teeth 11, 12, 21, 22), the prosthesis could no longer be supported. After losing the residual teeth, the patient wanted a fixed implant-based restoration of the maxilla.

The residual teeth of the mandible showed the following findings: tooth 48 was impacted and displaced, tooth 45 showed mobility grade 3 and was periodontally insufficient. The anterior residual teeth 33–43 presented with increased probing depths on the canine teeth and increased mobility (grade 2).

The treatment strategy for the maxilla included as a first step a conservative periodontal therapy of the anterior residual teeth for strategic preservation and fixation of the existing prosthesis until implant insertion.

Afterwards, the residual teeth were removed and a bilateral sinus floor augmentation was performed in a two-stage procedure. Following a 3-D planning, eight endosseous implants were inserted with the CAMLOG Guide System in a flapless procedure, and the prosthetic restoration was realized using a telescopic bridge. In the mandible, tooth 45 was removed while the other teeth were treated with conservative periodontal therapy. The mandibular posterior teeth were replaced and realigned. Teeth 43–33 received reenveering of the removable denture.

Conclusions

The original goal of the prosthetic reconstruction was a fixed bridge restoration. Due to the hygienic and functional training phase with the long-term temporary appliance, the patient decided for a removable bridge.

The accuracy and simplicity with which the implants can be inserted in prosthetically correct or anatomically difficult situations is increased significantly by virtual 3-D implant planning in the cone-beam CT or CT in combination with the guided implant bed preparation and implant insertion. Implant therapy is thus facilitated.

The drilling sequence in the CAMLOG Guide System is different from other systems. While in a conventional drilling sequence the pilot drill is advanced to the final implant length, the drilling sequence guided by the CAMLOG Guide first starts with the shorter pilot drill (length 6 mm). So that all drills are guided by the sleeve geometry from the start, the drilling sequence I performed in succession from the 9 mm drill to the 11 mm drill and finally...
Sinus floor augmentation

Fig. 3. The facial maxillary sinus wall is moved inwards and becomes the neurocranial floor of the maxillary sinus. On the left side, a vertical bone septum (visible on Fig. 1) requires two separate lateral approaches.

Insertion of interim implants

The planned minimally invasive flapless procedure for implant insertion requires a unique fixation for the preparation of radiological materials. The fixation is facilitated by temporary implants in a suitable position.

In order to ensure accurate transferability, the fixation must be performed under radiological control in the identical position as the one of the implantation.

Fig. 4. Filling of the right sinus cavity with blood and xenogenic bone substitute material. Coverage of the lateral window with a resorbable collagen membrane to avoid displacement of the bone substitute material.

Fig. 5. Postoperative panoramic radiograph shows filling of both maxillary sinus cavities.

Fig. 6. Panoramic radiograph with scan prosthesis for determining the fixation positions using the four interim implants.

Implant placement

Fig. 7. Two-part temporary implants fitted with ball abutments in positions 11 and 21. Posterior anchorages in positions 15 and 25.

Fig. 8. The system-specific matrices are placed and secured in the scan template with plastic.

Fig. 9. Fixed ball abutment matrices in scan template. The DVT image is taken immediately with the radiology template mounted.

to the 13 mm drill (maximum implant length). The CAMLOG Guide offers a sleeve system. As opposed to multi-sleeve systems, a single sleeve inserted into the surgical template is adequate for guidance during all drilling sequences and implantation procedures. The implants can be inserted through the sleeves.

References


Cone-beam diagnostics

The scan template is fabricated based on prosthetic requirements (functional, esthetic). A bone-anchored and prosthetic-oriented scan can be taken under radiological control due to the unique fixation of the scan template using the interim implants.

The thickness of the mucous membrane can be measured by fitting the radio-opaque tooth on the plaster surface. The distance from holding sleeve to bone surface must not exceed 3.5 mm.

Fig. 10. Transversal view at region 26. The central axial borehole is clearly visible. Good ossification in the sinus.

Fig. 11. All views at implant region 27. From left to right: Lateral view with projection of the temporary implant in region 25, transversal view, panoramic anatomic view, occlusal view.

Fig. 12. Transversal view at 24.

Fig. 13. Transversal view at 23.

Fig. 14. Transversal view at 17.

Fig. 15. All views at implant region 16. From left to right: Lateral view with projection of the temporary implant in region 15, transversal view, panoramic anatomic view, occlusal view.

Fig. 16. Transversal view at 14.

Fig. 17. Transversal view at 13.

Fig. 18. Transversal view at 12.
**_CAMLOG Guide Surgery_**

**Fig. 19.** Surgical template with ball retention elements at positions 21, 15, 25 for stable positioning of the template during drilling procedures. Before placement, careful cleaning and disinfection (please see previous page for image).

**Fig. 20.** Ball retentions on temporary implants for stabilization of the temporary prosthesis, fixation of the scan template during cone-beam scan and positioning of the surgical template during the drill procedure.

**Fig. 21.** The gingival punch is guided through the sleeves onto the mucous membrane. The punch has no depth stop.

**Fig. 22.** A scalpel is used to cut out and remove the punched gingival islands after removing the template.

**Fig. 23.** Resected implant locations 26 and 27.

**Fig. 24.** The template is mounted again. Start of the Camlog Guide drilling sequence with pilot drill followed by drills of the appropriate lengths depending on the implant length (region 23).

**Fig. 25.** Guided insertion through the sleeves utilising special Camlog Guide inserting tool.

**Fig. 26.** The sleeve dimension allows bone condensing and bone spreading procedures through the sleeve (here, osteotome for vertical bone condensation).

**Fig. 27.** Implants in first quadrant in situ. Depth stops on the surface of the sleeves.

**Fig. 28.** Postoperative panoramic radiograph.
Fig. 29. Healing after one week postoperatively. The patient had neither complaints nor postoperative swelling (please see previous page for image).

Preparation for provisional

Fig. 30. The surgical template is set back on its fabrication model. The analog plaster reamers are used to create the cavity for the lab analog through the sleeve.

Fig. 31. Implant positions on the plaster cast.

Fig. 32. Mounted lab analogs together with the inserting posts are secured to the sleeves with wax. The lab analogs are fixed into the plaster cast.

Fig. 33. Cast with lab analogs in place. The transfer of the analog into the correct position through the sleeve of the surgical stent.

Fig. 34. A 0.5 mm thick thermoformed splint is drawn over the abutments. The thermoformed copings perform the space-making task for passivation when cementing the interim restoration.

Fig. 35. Long-term temporary appliance in the articulator.

Fig. 36. PEEK abutments in situ.

Fig. 37. Long-term temporary appliance cemented in situ in terms of early treatment eight weeks postoperatively.
The final prosthetic was fabricated using CAD/CAM technology. The bridge framework was made of a fiber composite (KaVo C-Temp) and veneered with acrylic material. For passivation, electroplating was used. Custom CAD/CAM-fabricated zirconia abutments were selected.

**Fig. 38** Impression with closed impression posts.

**Fig. 39** CAD/CAM-fabricated zirconia abutments bonded to CAMLOG Esthomic inset abutments.

**Fig. 40** CAD/CAM-fabricated zirconia abutments after one year.

**Fig. 41** Veneering work.

**Fig. 42** Occlusal view before treatment.

**Fig. 43** Radiological situation before treatment.

**Fig. 44** Occlusal view two years after final prosthetic restoration.

**Fig. 45** Radiological situation two years after loading.

Claudio Cacaci, DMD, is a specialist in oral surgery and implant dentistry. He studied at the Munich dental school and worked in the department of maxillofacial surgery (Prof. Dr. mult. D. Schlegel) in Munich and in the department of oral surgery and implant dentistry (Prof. Dr G.H. Nentwig).

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Table I: Implants used

Implants used are noted in the table. There were no implants used for teeth #41–48 and #31–38.

Implant type as noted in the table includes:

- ROOT LINE (RL)/SCREW-LINE (SL) Implant Surface:
  - Promote® (P)/Promote® Plus (PP)
Treatment options for restoring missing mandibular incisors

Author: Dov Almog, DMD

To date, the treatment options for restoring missing mandibular incisors have been frequently reviewed and researched. Historically, the conventional approach for replacing mandibular incisors was the utilization of a fixed partial denture (FPD) or removable partial denture (RPD), depending on the number of missing teeth that determined the extent of the prosthesis.

At present, given the fact that the growth in dental implants and implant-based dental reconstruction products and services outstripped all other areas in dentistry, the No. 1 treatment choice for restoring missing mandibular incisors would be an implant-supported FPD.

Yet, there are situations where the treatment options associated with the restoration of missing mandibular incisors is not as clear. This case report represents a patient in his 30s who lost all four mandibular incisors subsequent to a sports injury that took place several years ago (Figs. 1a, b).

Ultimately, the intent of this case report is to explore the various treatment options for replacing mandibular incisors. Given the specific anatomical complexity, the future esthetics, phonetics, occlusion...
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Fig. 1b. As observed in this clinical intraoral image, all four mandibular incisor teeth are missing. Note the knife-edge shape of the gingival tissue in the area of the missing teeth.

Fig. 2a. Three-dimensional CBCT based cross-sectional slices revealed the edentulous anterior section of the mandible from an entirely different perspective. Note the knife-edge shape of the alveolar crest.

Fig. 2b. A closer look at the 3-D CBCT based cross-sectional slice revealed a very slim knife-edge shape, measuring infinitesimal bucco-lingually in the gingival region of the alveolar crest.

Fig. 2c. The 3-D CBCT based cross-sectional slices also revealed anatomical variances in the lingual aspect of the anterior region of the mandible.

and long-term prognosis, and not to mention the associated future clinical consequences, the ultimate treatment options will be discussed.

_Treatment options_

_CASE NO. 1_

A removable partial denture with cast framework. This option is considered amongst the most conservative and reasonable options with the least amount of risks to the patient and/or with the least amount of long-term associated clinical consequences.

As described in a recent publication in the British Dental Journal, when defining the need for a RPD, dentists focused on the anatomical and physical properties whereas patients focused on cost and social sense. The article concludes with the notion that further research on the relationship between denture use and social identity could be beneficial.

Nevertheless, considering the age of the patient and the associated social sense, plus the fact that the price tag in this case was irrelevant, other options were considered.

_CASE NO. 2_

A fixed partial denture extending from tooth #22 to tooth #27. Again, historically speaking this option was considered less conservative than a RPD and much more expensive. Furthermore, the long-term prognosis and the associated clinical consequences were substantially different.

As recent as 2008, Dr. Gordon J. Christensen reported that patients are interested to know how long a FPD is expected to last. According to Christensen, while studies’ estimates for service longevity vary from a few years to 20 years, recurrent caries was the most reported reason for failure.

Now, that plus the fact that a FPD extending from tooth #22 to tooth #27 is considered a long span bridge, further compromises the long-term prognosis and the potential for associated future clinical consequences.

_CASE NO. 3_

Implants-supported fixed partial denture extending from tooth #21 to tooth #26. In this option the specific anatomical complexity and condition is very relevant.

As can be seen in the 3-D CBCT-based cross-sectional slices in Figure 2a, the edentulous section of the alveolar crest in the anterior region of the mandible had a sharp knife-edge shaped ridge.

Interestingly, the 3-D CBCT based cross-sectional slices also revealed anatomical variances in the lin-
gual aspect of the anterior region of the mandible. These variances were reported in the Journal of Oral Implantology in 2007. While no biopsies were performed in that study in order to obtain histological data on these anatomic variances, it was assumed that they are most likely developmental rarefactions (regions of decreased particle density) and radiopacities (regions of increased particle density).

The mere fact that the associated mean bone radiodensity within the anatomic variance measured above the mean bone radiodensity observed in adjacent sites suggested that there were no limitations from a bone quality and implant fixation perspective in these regions.

Furthermore, while the overall success rate of dental implants is high, accomplishing predictable reconstruction and esthetic results for single or multiple teeth replacements with dental implants is challenging, and as dental implants become an increasingly viable treatment for replacing missing teeth, we may encounter more random maxillofacial anatomic conditions.

Therefore, and as seen in this case, with the use of CBCT three-dimensional based dental imaging, we captured a volume of data and through a reconstruction process we constructed images that took the guesswork out of our treatment planning and made us more proficient.

Given the unique slim knife-edge shape, measuring infinitesimal bucco-lingually in the gingival region of the alveolar crest as seen in the 3-D CBCT-based cross-sectional slice in Figure 2b, and the eminent buccal concavity in the alveolar crest as seen in the 3DVR in Figure 3a, the following alveolar bone surgical approaches were considered in preparation for the implants-supported FPD treatment option:

3a) A variety of techniques and materials are used to expand the buccal-lingual dimension of the alveolar crest support for dental implants. Alveolar crest augmentation techniques include several surgical approaches, such as onlay grafting and ridge splitting, to name a few. In this particular case, in order to gain an increase in the buccal-lingual dimension of the alveolar crest, a bone ridge splitting technique was considered.4

3b) A different technique used to achieve the buccal-lingual dimension necessary to support dental implants is to flatten the alveolar crest. This technique is also referred to as "tabling" the alveolar crest. However, due to the very slim knife-edge alveolar crest, considerable vertical tabling will be necessitated.

Following an interdisciplinary professional consult between the restoring dentist and the oral surgeon, a decision was made to consider tabling of the alveolar crest in the middle region where teeth #24 and #25 used to be. This surgical approach would increase the buccal-lingual dimension of the alveolar crest and allow placement of two implants-supported four-unit fixed partial denture.

As seen in Figure 4, a computer-generated image represents a four-unit fixed partial denture supported by two implants. This surgical approach would prevent the tabling of the alveolar crest in the regions close to teeth #22 and #27, avoiding future supporting bone loss, thus significantly improving their long-term life span.

Conclusions

The specific goal of this case report was to review the notion of removable partial denture vs. fixed par-
Fig. 4. A computer-generated simulation representing a four-unit fixed partial denture supported by two implants. As illustrated by the dotted line, the tabling procedure is kept away from teeth #22 and #27.

tial denture vs. implant supported fixed partial denture in the case of missing four lower anterior teeth.

Scientifically speaking, given the diversity in our patient population, with all due respect to our expertise and experience, the quantitative relationship between successful outcomes in the treatment options discussed in this case report is unknown and awaits discovery through large prospective clinical trials.

Therefore, the decision-making is not easy. The restoring dentists face the difficult task of judging the associated risk factors related to each treatment option that can affect the long-term prognosis of a chosen treatment plan.

As a side note and as mentioned indirectly earlier, oral implantology has become the fastest growing segment in dentistry, and therefore, accurate understanding of critical anatomical information may avoid future failure outcomes with dental implants. While researchers studying these CBCT three-dimensional based dental imaging platforms’ methodologies agree that more outcomes assessment research has a long term value, in the meantime we must work together to optimize our patients’ health.

To that effect, recent introduction of numerous associated cone-beam CT-based imaging systems and surgical guidance platforms are gradually taking our profession through key changes that have major impact on the way we view and practice oral implantology, ultimately yielding substantial public health benefits, translating into more predictable outcomes, preservation of adjacent teeth, protection of critical anatomical landmarks, and improved esthetics and function.

References
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CBCT-assisted implant therapy

Author_Nilesh R. Parmar, BDS (Lond), Msc (ProsthDent), Msc (ImpDent)

Implant treatment in the anterior mandible has favourable long-term success rates when compared with other areas of the mouth (Gokcen-Rohlig et al. 2009). Placement of dental implants in the interforaminal area is considered a safe and predictable procedure.

However, perforation of the lingual cortical plate can result in a profound and potentially life threatening sublingual bleed (Bucal 2008). The blood supply to this area is provided by the submental, sublingual and mylohyoid arteries, which if perforated, may set off a massive internal haemorrhage in the floor of the mouth.

Although rare, this can ultimately cause protrusion of the tongue, resulting in airway obstruction and necessitate surgical intervention. It has been recommended by Tepper et al. (2001) that CT imaging of this area is warranted to visualize 3-D bone anatomy prior to surgery, thereby reducing the possibility of surgical instrumentation of this sensitive area.

This case report shall show how CBCT, coupled with chairside diagnostic imaging, has helped plan, simplify and execute implant placement in the anterior mandible.

Patient history

A 44-year-old female who has been undergoing long term periodontal treatment presented with mobile and painful lower incisors. She exhibited very good oral hygiene but with a periapical area and mobility associated with the UR4 and grade 2 mobility of her lower incisors. The patient described difficulty and embarrassment when eating due to the movement of her lower teeth and wanted a fixed solution.

Clinical examination

The patient had a lightly restored dentition with a thin gingival biotype. As previously mentioned, her oral hygiene was good and she was a non-smoker (gave up 11 years previously). She exhibited bilateral canine guidance with no evidence of any parafunction. Her BPE scores were 312/231.

Treatment options

Due to the patient’s history of periodontal disease and associated mobility, she was aware that some...
form of replacement was necessary. The patient did not want a removable restoration and preferred a fixed solution. In this area of the mouth either fixed bridgework or an implant-retained prosthesis were possible.

After learning about the options, and with the understanding of the increased risk of peri-implantitis of implants in patients with previous periodontal disease, (Esposito 2006) the patient opted for a fixed implant-retained solution.

The treatment was to be planned in such a way that if she lost her posterior molars in the future, a full arch fixed prosthesis could be made after subsequent implant placement.

_Treatment plan_

*Step 1:* Continuation of periodontal treatment and oral hygiene advice.
*Step 2:* CBCT Sirona Galileos scan to assess bone height, bone profile and associated anatomy.
*Step 3:* Extraction of all four lower incisors and the UR4.
*Step 4:* Placement of two Straumann SLA active implants.
*Step 5:* Restoration with a screw-retained four-unit PFM bridge.

_CBCT_

It was decided to take a full volume CBCT to further assess the upper teeth and the UR4 for future implant replacement. The CBCT showed excessive bone loss around the anterior incisors with a small area of periapical radiolucency around the LL1. A cross-sectional view showed thick, well-developed cortical plates with very little lingual concavity. Due to the good bone height and minimal pathology, immediate implant placement was planned.

Due to the patients bone loss, the lower incisors had drifted, giving a less than desirable tooth position. Among the patient’s main complaints were the gaps that had appeared between the lower incisors and the uneven appearance of the incisal edges.

To aid implant placement in the correct angulation, a CEREC Blu-Cam image was taken and manipulated so that the lower tooth positions were in harmony with the rest of the dentition. This proposal was then overlaid onto the CBCT scan and was used to facilitate implant planning. The aim was to provide the patient with a screw-retained bridge with access holes through the lingual aspects of the lower incisors, whilst maintaining a sound margin of safety from the lingual cortical plate.

Due to the patient’s previous periodontal history, it was decided to use Straumann Standard Plus implants in this case. The design of this implant incorporates a 1.8 mm polished collar above the active surface of the implant. This results in the implant-to-abutment junction being located 1.8 mm superiorly to the bone crest.

_Surgical procedure_

The patient was given 400 mg ibuprofen and a Chlorhexidine mouth rinse before the surgery began.
The procedure was carried out under intravenous sedation using Midazolam. The lower incisors were removed using periotomes and forceps. The sockets were curetted and thoroughly irrigated. A crestal incision with distal relieving incisions was made. Due to the CBCT and surgical stent, only a small lingual reflection was necessary.

Implant placement was carried out using standard ITI protocols. Two Straumann SLA-Active Standard Plus implants of 4.1 x 10 mm were placed. The implants exhibited excellent primary stability with an insertion torque of greater than 35 Ncm. The patient’s bone quality was estimated to be type D1-2 (Lekholm and Zarb 1985).

Due to the high primary stability and good bone quality, it was decided to adopt a single-stage surgical protocol, thereby placing healing abutments over the implants.

The site was closed using 5.0 PGA sutures and a tooth supported denture replacing the lower incisors was fitted. Careful examination of the denture was carried out to ensure there was no contact, or transfer of occlusal load onto the implants from the denture. The patient was seen seven days after surgery for suture removal and review.

The patient healed without incident and due to the favourable lingual undercuts of the lower teeth was able to comfortably wear the denture during the healing process. Due to financial reasons, the planned implant placement for the UR4 site was deferred until a later date.

After eight weeks of healing, fixture level open-tray impressions were taken in Impregum (3M ESPE), and a four-unit screw-retained bridge was fabricated. The tooth set of the denture was duplicated on the final bridge because the patient was happy with the tooth size and shape. Due to the previous bone loss, pink porcelain was added to the bridge to improve the emergence and reduce the crown lengths of the lower incisors.

The bridge was seated and torqued to 35 Ncm and composite placed in the access holes; a baseline long cone periapical radiograph was taken to serve as a baseline for bone-level measurements.

The occlusion was checked, with the patient exhibiting canine guidance in excursive movements. The patient was shown how to clean under the bridge using super floss and tepe brushes and placed on a long-term maintenance programme.

**_Prognosis_**

The bridge has a good long-term prognosis because this patient is highly motivated and exhibits

‘CBCT has helped plan, simplify and execute implant placement in the anterior mandible.’

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**Case Study**

**Anterior Mandible**

**Figs. 8, 9** Laboratory made screw-retained porcelain bridge on Straumann Sync Octa abutments.

**Fig. 10** The bridge.

**Fig. 11** Appearance at fit.

**Fig. 12** Pre-op presentation.

**Fig. 13** CBCT with CEREC integration.
excellent oral hygiene. She is aware of the increased risk of complications and the possibility of losing more teeth in the long run, but after having worn a denture for three months, she is determined to avoid becoming a long-term denture wearer.

The patient will visit at six-month intervals and see a hygienist every three months for maintenance.


Nilesh R. Parmar, BDS (Lond), Msc (ProsthDent), Msc (ImpDent), was voted Best Young Dentist in East of England in 2009 and runner-up in 2010. He is one of the few dentists to hold a University of London degree from all three London dental schools and has started his third Msc in orthodontics at Warwick University.

Parmar is an Astra Tech clinical coach and has his own practice in Southend on Sea, Essex. He also works as a visiting implantologist at Sparkly Smiles in Blackheath and the London Bridge Dental Practice.

You may contact Parmar through his website at www.drnileshparmar.com

Fig. 14. After eight weeks of healing.

Fig. 15. Insertion of final bridge.

Figs. 16, 17. Appearance at one month review.
Volumetric cone-beam computed tomography in neuromuscular dentistry

Author: Richard W. Greenan

Three-dimensional imaging for dentistry is here and has already proven to be the practical alternative to traditional 2-D radiodontics, as expected. A single volumetric cone-beam computed tomography (CBCT) scan can now replace the conventional cephalogram, panoramic, PA skull and tomograms of the TMJs, implant sites and paranasal sinuses in one 10–20 second scan. The advent of volumetric CBCT has overtaken conventional medical CT in both its reduction of radiation, significant increase in restorative detail and at a lower cost to both the clinician and patient. This new technology is already redefining cephalometrics.

History

CT was invented in 1972 by British engineer Sir Godfrey N. Hounsfield of EMI Laboratories, England, with the first "CAT-Scans" patent granted to Robert S. Ledley on Nov. 25, 1975. Most conventional medical MDCT's incorporate a fan shaped beam (Fig. 1) whereas dental CBCT systems today utilize a cone shape beam (Fig. 2). With conventional CT, X-ray is produced as the gantry rotates the X-ray tube and detector around the patient (Fig. 2) producing an image or "slice" with each 360 degree rotation and then stacks the multiple scans and slices.

In a cone-beam CT (CBCT) geometry, the entire subject is exposed just once from a single point source using an amorphous silicon (aSi:H) flat-panel sensor, CsI, CMOS or CCD as its detector. A single rotation CBCT scan results in a volumetric scan of the entire subject with complete data acquisition in just two to three minutes.

In March 2001, the NewTom™ QR-DVT 9000 became the first CBCT system to receive FDA approval in the United States (Fig. 3). Followed in 2003 by the Imaging Sciences International i-CAT™ incorporating similar CBCT technology but in a sit-down and relatively affordable system (Fig. 4).

In 2008, NewTom introduced the upright VG system (Fig. 5) utilizing its exclusive Smart Beam Technology with significant reduction in radiation dosage.
With a single 10–20 second CBCT scan and a large FOV (field of view), we now have the full 3-D volume of the head and neck from Nasion down to C4 including a panoramic, TMJ’s, pharyngeal airway, paranasal and maxillary sinuses, etc., with a single scan. Three-dimensional rendering and the MIP (maximum intensity projection) in Figure 6 will undoubtedly demand new cephalometric landmarks and analyses (Fig. 7) in addition to enhancing patient understanding and acceptance.

Three-dimensional data will continue to enhance our existing knowledge with:

1) A measurable assessment of bone quality and density (Hounsfield units).
2) The ability to measure arch widths before and after treatment (Fig. 8).
3) Actual impacted dentition orientation in three-dimensions (Fig. 9).
4) Upper airway evaluation (Fig. 10).
5) Pharyngeal volumetric airway evaluation before and after treatment (Fig. 11).
6) TMJ morphology and condylar position (Fig. 12).

Yet, with this new technology comes the personal responsibility to further one’s education on 3-D anatomy — an absolute necessity for a proper, comprehensive neuromuscular diagnosis. We must also learn how to accurately create the necessary images from this single scan.

For example with 3-D pans, we must increase the reconstructed cut-plane width to incorporate the coronoid processes to assess potential hyperplasia and impingement and to incorporate maxillary bone as well as basal bone for potential ossifications of the stylohyoid ligament (Eagles syndrome). Failure to do so will result in a myriad of false negatives and potential misdiagnoses.

Proper mapping of the anatomy is no more critical than for the temporal mandibular joints, best illustrated in the below axial views. The three axial images [Submental view] in Figures 13–15 are actually on the same patient, but demonstrate three different and distinct condylar morphologies. Which one would you map for your TMJ study?

The answer is Figure 13. Figure 13 demonstrates bilateral kidney shaped condyles, while both Figures 14 and 15 are indicative of potential osteogenic degeneration.

Too often, Figure 14 is mapped with the straight TMJ tool (Fig. 16), creating the false positive of bilateral avascular necrosis, as seen here in the bilateral coronal views (Fig. 16), an artifact with invasive consequences!

The operator should have continued to Figure 13, and using the oblique or panoramic tool, drawn the necessary Bezier curve incorporating both lateral and medial poles (Fig. 17).

_Soft-tissue legalities_

There has been a great deal of discussion and unwarranted fear being disseminated by a few self-serving oral and maxillofacial radiologists in addition to the manufacturers of smaller FOV systems. Implying that we are now responsible for diagnosing brain tissue!

Three-dimensions do not change the fact that brain tissue maladies and diagnoses are not taught in dental school and that CBCT systems by their very nature are not to be used in lieu of a medical CT or MRI for soft-tissue diagnoses.

With the cephalograms I read, an image encompassing more cranial anatomy than the typical large FOV CBCT scan, I see one or two fibrosarcomas in sella and the thyroid every month because I look for them. But I see few articles in our dental journals that address these very issues, and I suspect that our medical radiology journals also devote little ink to periodontal disease.
A review of the current literature suggests: “In comparing cone-beam technology with conventional CT, it should be kept in mind that cone-beam systems dedicated to maxillofacial diagnostics by their physical nature do not provide enough low-contrast resolution to discriminate soft tissue structures.”

“Where it is likely that evaluation of soft tissues will be required as part of the patient’s radiological assessment, the appropriate imaging should be conventional medical CT or MR, rather than CBCT.” Statement 8 comes close to this in recommending that CBCT not be used where soft tissue assessment is a significant aspect of the need for imaging.

**Conclusions**

CBCT has been responsible for a significant reduction in radiation as compared to medical CT (68 μSv vs. 1200-3300 μSv). One CBCT scan is equivalent to approximately five plain film panoramic radiographs, significantly less than a full-mouth series.

CBCT images can be saved and viewed as native DICOM, PDF and JPEG compressed files and imported into most third-party patient management software programs.

As a result of this evolution, there are now numerous free DICOM 3-D multiview readers available for both PC and Mac platforms, yet this author prefers the Anatomage Invivo™3-D software for its ease of use and options. CBCT has also been responsible for making CT technology affordable while opening up paths for future research and innovation, particularly in neuromuscular orthopedics.

**References**

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Figs. 13–17. See text on page 35 for complete explanation.

Fig. 18. CT brain CBCT axial scan.

Fig. 19. Normal axial medical CAT scan.

Fig. 18. Stereograms.
Cone Beam magazine seeks to provide its readership with pertinent information of all things cone beam, including its historical origins by those who pioneered the development in dentistry from an imaging standpoint. Bruce Lipsig, who is the director of imaging for Henry Schein Dental, is one of the innovators who brought 2-D and 3-D imaging to dentistry.

To give our readers a perspective and evolutionary look at where we’ve been and where we are in dental imaging, would you take us through your involvement and the innovations you’ve been involved with?

For me it began in 1991. While working in the music industry I learned how sound changes were not only related to what effects were used on those sounds, but also in what order those effects were applied. For example, if distortion was added to the guitar first and then echo was added you would be echoing a bunch of distortion, whereas if you placed the echo first in the chain then you could distort your echo — so these are two completely different outcomes. This started my interest in “perfect pairings” as we would combine different elements to create a superior outcome.

From that point, a friend who had been watching requested that I come to his company and perform similar fine tuning of their video. They were perfecting one of the first intraoral cameras called the AcuCam, and from the moment I got involved, I was hooked.

Building the early AcuCam for New Image Industries, I made two lifelong friends with whom I helped design and developed products. Together we created the first dental imaging products called AcuCam PC — running on DOS and early Windows 3.11 — as well as the cosmetic imaging application called AcuView, which provided the ability to morph patient images to show potential before and after images of planned procedures, such as bleaching and bonding.

These products changed the profession in many ways, bringing about a period of co-diagnosis whereby the patient was actually able to see not only what the clinician was viewing, but also what the clinician was planning as a final outcome.

We also investigated early digital radiography through a company in Sweden called Regan, as well as many others. This technology was still in its earliest stages of testing, something called “direct detection” whereby the energy from the X-ray head was captured on a sensor/chip. Unfortunately, at that time, we were just learning that with direct detection the energy from the X-ray head was too powerful and would damage the chip as well as the components on the back of the chip very quickly.

Thus, indirect detection, whereby a scintillator would convert the energy from the X-ray photons to visible light that the sensor/chip could then image, would be needed if digital X-ray were to succeed. It was from those early days that the groundwork was laid for the future of digital radiography.

Some readers may remember those products from the early days of technology. Where did it go from there?

My team and I left New Image in 1995 and founded a company called Integra Medical where we created the award-winning Vipersoft suite of imaging software and ViperCam intraoral camera. This suite of imaging software also included a morphing software application for cosmetic imaging.

This application actually allowed the clinician to show a patient not only what they were seeing, but what they were thinking in terms of potential treatment options by allowing the clinician to modify/morph the image to show the potential outcome of certain proposed treatments, such as bleaching and bonding.

Henry Schein acquired Integra Medical in 2000 and paired our Vipersoft imaging software with the industry leading Dentrix practice management software, rebranding our Vipersoft imaging software as Dentrix Image and creating the first digital dental office [DDO]. Finally, the dental office was computerized in the front office and the operatory with all
systems linked together. Along with the relationship to these desktops came the opportunity to provide peripherals that the clinician needs, such as digital radiography.

Digital radiography had quickly become the buzz words of the industry. It was the thought of having X-rays appear on your computer screen instantly for diagnosis, archiving and transmission, and the thought of these reusable X-ray chips not only replacing standard film and developing chemicals, but also accomplishing this task with as much as 90 percent less radiation than film.

Safer for the patient, safer for the staff, better for the environment and already digital for transmission to insurance companies, this product had so many advantages it was guaranteed to change the industry.

As we can see today, more than 60 percent of offices now use digital radiography, and that is only one way that the move to digital has changed the dental industry, and many other industries, forever.

From that point, we set out developing digital radiography, the intraoral camera and dental imaging technology for Henry Schein. When we started this journey, there were no computers in the operatories, and even very few computers at the front desk. Today computers are essential. The dental office relies on computers and would be hard pressed to survive without them. Two-dimensional imaging had found a home in dentistry, but this was just the start.

With the introduction of the CT scanner in the medical world, it was quickly understood that 3-D imaging would be the next wave of technology. In addition, that it could have incredible opportunities in the dental industry, from understanding bone density for placing implants to viewing bone and airway abnormalities, orthodontics, sleep apnea and a world of other opportunities found in the dental

Lipsig’s top 5 cone-beam units (alphabetically by unit name)

Fig. 1. GXDP-700 (Gendex)
Fig. 2. i-CAT (Imaging Sciences International)
Fig. 3. OP300 (Instrumentarium Dental)
Fig. 4. ProMax 3D (Planmeca)
Fig. 5. Scanora 3D (Soredex)

(Photos/Provided by the companies noted)
Three-dimensional imaging is the future of dentistry in many ways, and the sooner it is embraced, the sooner we will reap the benefits.’

This has sparked a new theory that has truly excited the dental community. Finally, we have a practical solution, restorative driven implant therapy, which refers to planning implant therapy from the restorative point of view. Simply put, this means placing an implant while being sure to take into account the requirements for the placement of the restoration.

This theory offers the general practitioner more control over the treatment from planning through completion and assures a more confident restorative result for the patient.

Speaking of perfect pairing, you’re also known as a wine connoisseur/collection. Please tell us about this passion and how it relates to what you see happening in dentistry with cone beam.

I developed a passion for wine collecting in 2000 and found that wine is another opportunity to pair two things together and achieve a higher level of value/satisfaction than either part was capable of alone. There are some wines that are bursting with flavor, yet pair them with a particular food and along with the bursting flavor you can suddenly decipher nuances that you never noticed before.

Flavors that seemed hidden before but are brought to a new level due to the pairing. This started me on a quest to test different pairings and find out for myself how incredible some of these flavors could be.

There is no one universal wine, although good arguments could be made, but rather there are different wines for different occasions; different wines match more properly with different flavors. It is a never-ending learning, testing and tasting opportunity. There are some rules, but they are more like guidelines.

I continue to find things that together raise an evening to a new level. Such as a fine Bordeaux paired with the strong flavors of lamb, or the way a fabulous sauténe such as a Chateau d’Yquem can pair perfectly with chocolate and dessert, as well as blue cheese and Foie gras. The possibilities are endless.

This also relates for me to the aspect that not all technologies can be or should be paired. There are optimal pairing partners. Manufactures of cone beam and CAD/CAM have worked to optimize their systems with either a particular proprietary system [CEREC and Galileos] or more of an open selection [E4D and i-CAT, Gendex, OP-300 and Scanora] providing clinicians a wide variety to choose from.

In the wine world we call this a broad pairing opportunity, where a wine pairs perfectly with several varieties, thus giving you more options.

Two elements elevating each other to heights that neither one could achieve alone. This is also shown in the growth of technology itself. Technology is rapidly changing and creating paradigm shifts in our
industry, assisting users in doing things that they could not do before.

*What have been the major developments over the years in imaging technology and how do you see it progressing?*

The power found in today’s computers is one of the major developments that allow us to do more. It takes minimal computer power to handle practice management, which are mostly text driven files that are not very large and do not take much power to render to the screen. Imaging is quite different. Two-dimensional images can take much more computing power. X-rays are actually single images displayed in grayscale, although they can be high resolution, which makes them a bit larger and harder to deal with.

Yet, full-color images from intraoral cameras and digital cameras take a bit more processing power; especially if you realize that the live previews found in intraoral cameras are actually rendering many full color images/frames per second on the screen. The current CAD/CAM and CBCT files are so large that it would have been nearly impossible to move/render the image files that we use today.

While the power of the computer has made most of this technology usable, other technological advances make some of these systems function better than others. New laser scanning in some CAD/CAM systems allows you to avoid the need to prepare the subject with powder, which is often used as a contrast agent to avoid reflection when scanning images. And some of the new CBCT systems offer adjustable fields of view to avoid higher radiation doses that are unnecessary for certain focused procedures.

It was the combination of such new advancements that led us to some of the best pairings in technology whereby the industry leaders in CBCT and CAD/CAM paired together the best of the best technologies to create the best solutions in the marketplace today. E4D Compass [D4D Technologies, Richardson, Texas] is a great example of this. This is technology that assists clinicians to do more.

*Any additional thoughts on the future?*

The future will be incredible. Computing power that originally needed a room the size of a gymnasium is now available in your watch. They say that if the automobile industry had progressed as much and as quickly as the computer industry that we would all be driving in cars that could travel at the speed of sound and cost a nickel.

I still remember the first time I had a picture in my mind of what videoconferencing might look like. I pictured a standard touch-tone phone hanging from the wall with the chord hanging down and a small viewing screen attached to it on the side; much more like an intercom system from a gate where you could see someone on the other end.

I never would have anticipated how quickly we would have face time conversations on full color screens the size of a few credit cards, such as the iPhone.

The rate of progress has been amazing. Technology such as cone beam gives us more data than ever before and the uses of this data are just beginning to come to light. Three-dimensional imaging is the future of dentistry in many ways, and the sooner it is embraced, the sooner we will reap the benefits. I personally can’t wait to show you what is coming next!
Better together

‘The whole is greater than the sum of its parts.’ ~Aristotle

Author: Gary Severance, DDS

Synergy has been described as two or more things functioning together to produce a result not obtainable independently. On a daily basis, we find examples of items that when combined provide synergy or a better effect than either could alone, whether in the edible world (e.g., peanut butter and chocolate in a Reese’s Peanut Butter Cup, see also the “Perfect pairing” article on page 38) in the superhero field (e.g., Batman and Robin) or now, in dentistry (cone beam and digital impressions).

The combining of virtual patient information captured via different sources but then combined, serves to provide even more information and capabilities than either source alone. Specifically, every practitioner can experience that by combining 3-D cone-beam information (DICOM data) and intraoral scanning images; diagnostics and implant and restorative planning can be completed with more proficiency, efficiency and confidence than ever before.

In the world of digital impressions and chairside design, there are only two systems currently on the market that capture the intraoral scan and are immediately able to generate (and fabricate/mill if desired) a proposed restorative solution (design the restoration), the CEREC system (Sirona Dental Systems) (Fig. 1) and the E4D Dentist System (D4D Technologies) (Fig. 2).

Both of these systems also offer the ability to combine the proposed and planned restorative information (information above the tissue) with the surgical information and planned implant therapy (information below the tissue) to complete and demonstrate the planned treatment before initiating any treatment.

The CEREC system completes this solution by exporting a fixed restorative scan/file into GALAXIS (implant planning software) where it is joined with the DICOM data from the Galileo’s cone-beam scan. Most often this combining of data files occurs on the computer associated with the Galileo/GALAXIS system, typically away from the clinical operatory.

The E4D System (D4D Technologies) has taken a different and more open approach and imports the DICOM data from one of several cone-beam systems (i-CAT (ISI), Gendex GXDP-700 (Gendex), OP-300 (Instrumentarium) or Scanora (Soredex) into the chairside restorative system E4D Dentist. Proprietary software called E4D Compass™ (D4D Technologies) can then link with an “active” restorative file and design. E4D Compass software that combines the data of the intraoral condition with that of the corresponding DICOM data chairside — all right in the operatory or wherever the mobile cart is.

The E4D Compass software provides restoratively driven implant therapy planning in an easy-to-use and intuitive format: E4D Compass is an acronym for Cone Beam Pairing Software Solution.

While survey estimates vary greatly on the percentage of general dental practitioners who are actually placing their own implants,1–3 it is safe to say and readily acknowledged that nearly all general practitioners and their teams discuss and offer implant therapy as an option in treatment plans dealing with edentulous areas.

In fact, there continues to be a high annual growth rate predicted, not only for implants and their accompanying parts and procedures4, but also for single crown restorations — with a much slower growth in fixed partial restorations (bridges).5

In fact, according to the ADA Key Facts, full coverage restoration is the third most common procedure a general practice completes behind prophylaxis and oral exams.6 So the future direction is clear: more single tooth implants and more single tooth restorations.
Software solutions

The software that typically accompanies or is suggested for use with the actual cone-beam system (e.g., Invivo (Anatomage), Cliniview (Instrumentarium), SimPlant (Materialise)) is typically feature-rich with levels upon levels of diagnostic fields, measurement capabilities and visual markers.

The intent of the E4D Compass software is to combine the accuracy and the simplicity associated with its chairside restorative counterpart (E4D DentalLogic) in a format understood and valuable to the restorative clinician educating (and selling) their patients on the option of implant therapy.

But most important is the ability to plan the restorative placement first, as the ideal, providing guidelines for the surgical team — whether it is the practice itself or if the procedure is referred out.

There are numerous associated companies and dental laboratories that provide support, cone-beam readings and associated surgical guides (e.g. 3-D Diagnostics, 360i/imaging) in order for the final treatment to be completed, but E4D Compass provides the restorative clinician, the capability to preliminarily plan, educate, communicate and then collaborate through the restorative cycle — providing a clear concise and confident plan for the surgical team/referral.

The planning process

Patients don’t regularly enter a practice with a demand for placement of a dental implant, instead, more commonly, the complaint is lost function or the presence of a food trap in an edentulous area. It is up to the dental professional to gather the relevant data and then suggest the options for treatment, based on a number of clinical parameters that could include one or more of the following: fixed partial bridge, removable partial bridge (partial), implant therapy, orthodontic movement or nothing at all.

Only when the restorative clinician has more information via study models (either stone or virtual), 2-D or 3-D data (X-rays or cone-beam scan), clinical observation and functional requirements can he/she properly recommend or treatment plan the functional restorative options.

Having a digital scanner that can proceed directly to a restorative outcome (i.e., Function First) allows the clinician or clinical team to scan the edentulous (Fig. 3) and functional area and then design the ideal restoration, regardless of the manner that will eventually hold it in place (Fig. 4).

Another consideration is if the digital scanner selected uses technology that doesn’t require a contrast agent (i.e., powders or sprays) scans of the oral environment can take place at any stage pre- or postsurgical without the concern of residual powder or disturbance of the healing process. The E4D Dentist system uses a laser to capture the 3-D environment whether soft tissue, hard tissue, impressions or models and without the use of a contrast agent.

By using digital scanning one is able to show the patient immediately the restorative plan, which means the process can continue through to the next steps more smoothly, which if implant therapy is being considered, could include a work authorization for a cone-beam scan.

Once you have a compatible cone-beam scan, (iCAT, Gendex, Instrumentarium, Soredex) you can simply import the cone beam scan and through proprietary visualization within the E4D Compass software you can align the two data sets (Fig. 5). Then the treatment planning and education can begin.

After confirming the proper data sets by seeing the intraoral scan data and the cone-beam data, nerve identification can begin if it is a mandibular case. With a click of a mouse, data sets are moved to arch form and visualize the area of interest.

Once the mandibular canal in the surgical area is identified, and the areas can be viewed in all planes, the nerve is visually depicted similarly to the method use to draw the margin on a restoration, clicking the mouse and following the line.

Once the nerve has been drawn, it can be enlarged to provide a visual safety factor, and even carried out through the mental foramen (Fig. 6).
Fig. 6. Drawing of mandibular nerve with the E4D Compass Software.

Fig. 7. Final screen with abutment, bone density, implant and restoration.

Fig. 8. Report providing details of the planned treatment.

Alignment of the data sets

Unlike other software alignment procedures, E4D Compass allows the operator full control — although initially the alignment is proposed along the best possible case, with E4D Compass the operator has visual clues and complete control to adjust the alignment of the two data sets. Again, intuitive controls and visualization within E4D Compass make this an easy task.

Once the nerve(s) are marked and the models are aligned, the clinician can go through placement procedures of the preferred implant (manufacturer, type and size), location as well as the measurement details of a standard abutment selection, including angled abutments. The abutment view provides the clinical team the ability to adjust several parameters of the abutment, the wall height, the collar radius, collar height and even an angled parameter showing 5, 10 and 15 degrees of angulation.

Each pane of the E4D Compass software can be expanded to full view for better visualization or realization. The density of the surrounding bone (in contact with the implant and/or within 1 to 2 mm of the implant) is depicted visually in a color-coded scale matched to Hounsfield units for representation of proper bone quality (Fig. 7).

All of this provides the clinician and the patient with confidence, more information and a better case acceptance experience knowing that the procedure has been planned and correctly predicted prior to any surgical or restorative procedure or expense (other than diagnostic) has been completed.

Once the general plan has been approved, E4D Compass provides an easy method to communicate the intended plan to the surgical team. Clicking on the report icon will produce an html file consisting of the images of the last screen, the details of the implant selected as well as the outline of the intended restorative solution. This can all aid the surgical team in placing the implant according to the intended restorative position.

As always, the surgical guidelines/quality of the bone may dictate the final location and placement, however, providing a blueprint of sorts through the use of planning software will certainly set forth an ideal target area and eliminate restorative complications and surprises (as well as minimize expenses) should it be followed (Fig. 8).

Synergy amongst various dental technologies will continue to improve the communication between dental professionals and patients as well as the teamwork and collaboration involved when providing excellence in dentistry.

References

1) Dental Implants facts and figures; American Academy of Implant Dentistry (10 percent).
2) The Wealthy Dentist Survey (53 percent) www.thewealthydentist.com
4) Millennium research, 2010.
5) ADA Key Dental Facts.
6) DATA research 2010.
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The best in implant dentistry


Every day we are faced with various options to provide the best treatment for our patients. As the practice of implant dentistry continues to evolve, various tools, technologies, and treatment approaches are available to the clinical dentist which often present challenging decisions.

This meeting is designed to bring together the world’s experts in implant dentistry to debate several options of treating a similar situation allowing you to develop practical solutions. Examples of some of the options that will be debated include:

- Should comprehensive reconstruction be the goal or can we settle for conformative Implant restorations?
- Should length matter? Can short implants be a solution to circumvent grafting or does length ensure longevity?
- Is autogenous bone the gold standard? Can allogenic particulate grafts get the same results as autogenous block grafts?
- Connective tissue grafts: How much should we stretch to achieve perfection? Or should we resort to prosthetic solutions for soft tissue limitations?

The American Academy of Implant Dentistry’s (AAID) 2012 scientific program will give side-by-side comparisons of various treatment options, challenging you to think about the choices you make.

They will start Wednesday, Oct. 3 at 1:30 p.m. following a morning of new trends, techniques, and technology presentations and a “Dine and Discuss” session.

In addition, hands-on workshops will be offered throughout the meeting. A session featuring thought leaders in the field of implant dentistry from different parts of the world will be offered.

The best in today’s implant dentistry will be featured in several ways during the meeting, including poster presentations, expert clinicians at table clinics, and research foundation grant investigators’ presentations of their current implant research.
AAID’s annual meeting is well known for camaraderie and networking. Interact with the best and brightest in implant dentistry at two cocktail receptions, two “Implant Expo” lunches, multiple breaks throughout the meeting, and the always enjoyable President’s Celebration. Here are a few of the main podium programs that will compare options:

- Wisdom from Implant Treatment Planning Through the Last Five Decades, by Leonard Linkow
- Soft Tissue vs. Prosthetics: Esthetic and Functional Considerations — What is Predictable?, by Sonia Leziy, DDS, and Brahm Miller, DDS
- Key Implant Position or Biomechanics: What Are the Ideal Parameters?, by Carl Misch, DDS, MDS, PhD (h.c.) and Palo Malo
- Guided Surgery vs. Skilled Surgeries — Scan and Plan or Visualize and Verify: The Utilization of Technology for Implant Surgical Procedures, by Scott Ganz, DMD, and David Vassos, DDS
- Short vs. Long Implants: Does Size Matter?, by Mark Esposito and Michael Pikos, DDS
- Bone Enhancements — Realities of Additives: Do Materials Make a Difference?, by Alfred “Duke” Heller, DDS, MS, and Edgard El Chaar, DDS, MS
- Soft Tissue: Classical Guidelines or Revised Biological Guidelines: The Realities of Implant Abutment Junction, by Michael Sonick, DMD, and Marius Steigmann, DMD
- Autogenous vs. Allogenic: The Gold Standard or the New Standard?, by Fouad Khoury, DMD, PhD, and John Russo, DDS

For more information about the event and to register, please visit www.aaid.com.
Get to know Dental Tribune Study Club

The Dental Tribune Study Club (DTSC) is an education-based online community that inspires new possibilities while creating higher expectations in online learning.

Study clubs provide a quintessential opportunity for dentists to “meet with” other dentists and their team members and to learn in a friendly, non-threatening environment. Dental Tribune is taking this concept to the next level through www.DTStudyClub.com.

Bringing the study club online allows interaction to occur across the globe. Suddenly, various cultures and fresh perspectives enhance the educational mix.

Online learning allows everyone to benefit from C.E. courses without incurring the usual travel costs or without the down time away from the practice. DTSC offers dentists an entire online community, including an exciting mix of possibilities:

- C.E. lectures that are live and interactive, as well as archived ones, bringing local events to national audiences.
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- Product reviews with recordings of opinion leaders’ first impressions.
- A growing database of case studies and articles featuring topics that are important to today’s practitioners.
- Networking possibilities that go beyond borders to create a “Global Dental Village.”
- Contests with chances to win free tuition for ADA CERP C.E.-accredited webinars.
- And much more.

The goal of Dental Tribune Study Club is to become the standard practice for dentists worldwide, not only in continuing education but in communications of all kinds.

Through its membership, the club seeks to inspire new possibilities and create higher expectations. Join DTSC to expand your networking possibilities on a global basis; and given the extensive archive, you also gain access to local and global events at a time that is convenient for you.

Considering all the new concepts emerging in dentistry, it is not surprising that many practi-
Scenes from Dental Tribune Study Club Symposium at the Greater New York Dental Meeting.

Fig. 3. Dr. Fay Goldstep and Dr. George Freedman
Fig. 4. Dr. Howard Glazer
Fig. 5. A full house in the DTSC Symposium room.
Fig. 6. Dr. Paul Goodman
Fig. 7. Dr. Shamshudin Kherani
Fig. 8. Dr. Gregori Kurtzman
Fig. 9. Viewing a C.E. article at www.DTStudyClub.com.
Fig. 10. Printing the C.E. certificate at www.DTStudyClub.com.

Dentists are finding it difficult to stay up to date. The assessment of new products and techniques is a major challenge facing dentists. This may be especially true for those in a single dentist practice, with time for only occasional communication with other practitioners.

Study clubs can help increase this interaction, thus providing you with the opportunity to gain knowledge about such products through your colleagues’ experimentation and analysis, or even from respected opinion leaders directly.

The C.E. quiz for the article in this magazine is accessed through the DTSC website. You can take the quiz and print your C.E. certificate from the website in the same day. Please visit www.DTStudyClub.com to explore the many additional courses in the area of cone-beam education.
Cone beam’s role in the rising demand for implants

According to information released in February 2011 by the Millennium Research Group (MRG), a medical technology market intelligence company, dental implants are going to be among the “standouts” in terms of growth over the next five years.

“The esthetic and dental areas have consistently shown greater than average growth,” says April Chan, publications manager at MRG, who added that dental implants are expected to show a growth of nine percent.

The American Association of Oral and Maxillofacial Surgeons (AAOMS) notes that a successful implant experience takes cooperation and coordination between all parties involved — including the patient, the restorative dentist and the oral and maxillofacial surgeon.

Close communication between all members of the implant team results in better understanding and implementation of the proper protocols during the process, and the precise details for accurate implant diagnosis and treatment planning can be gained through cone beam computed tomography (CBCT). High-resolution, volumetric images and measurement tools provided by 3-D views facilitate thorough analysis of bone structure and tooth orientation, exact buccolingual dimensions, concavities and bone height.

Oral and maxillofacial surgeon, Dr. Steven Guttenberg, noted, “As an early adopter of CBCT, I have found it is indispensable for me as a surgeon to use this treatment tool for my patients. I cannot imagine placing an implant without the use of CBCT, especially when the case involves the extraction of difficult teeth that are close to the sinus, the inferior alveolar or mental nerve; the i-CAT scan is invaluable in terms of location to those anatomic entities.”

Guttenberg said that the 3-D scans give him the details that are needed to treat the patient more efficiently: “When it comes to the diagnosis and treatment of maxillofacial trauma, whether a fractured tooth, fractured maxilla or mandible, zygoma or nose, the CBCT offers a tremendous amount of information so that I can do a better job for my patients.”

He added that technologies such as CAD/CAM and guided surgery techniques allow for even more effective treatment, and having a 3-D system with those
Control over radiation dosage and scan settings gives clinicians the ability to tailor each scan to the patient. Through advancements in software and collimation technology, in-office cone-beam 3-D machines can "expose patients to minimal radiation, especially in comparison to medical grade CTs that we have used in the past," said Guttenberg.

Orthodontist Dr. Juan-Carlos Quintero noted, "Since I have had my CBCT, the results of making even the simplest treatment decisions based on anatomic truth, finally, have been increasingly surprising. It comes down to the difference between estimating and knowing." Regarding radiation risks, he added, "The recent position statement issued on December 13, 2011, by the American Association of Physicists in Medicine [AAPM] on radiation risks from medical imaging procedures, hopefully will put much of the unnecessary and unfounded hysteria to rest, at least for the scientifically inquisitive mind."

He said that with the imaging dose, especially taking into account the opportunity to capture scans in as few as 4.8 seconds, makes concerns "superfluous ... the levels are so low, almost nonexistent, compared to the 50,000–100,000 microsievert levels that the AAPM marks as beginning cause for concern." Moody concurred: "Collimation and the ability to control the dose is really important to me as I only want to expose the patient to a minimum of radiation while giving myself the very best diagnostic information. i-CAT provides that for me."

For diagnosis, planning and treatment implementation, cone-beam scanning provides many of the elements of an efficient implant planning process — from surgical accuracy to communication with referring colleagues and patients. Guttenberg summed up by saying, "When weighing the benefits and the risks, 3-D scanning virtually always comes out on the positive side of benefits in regards to patient care."
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