Dolphin 3D and Oral and Maxillofacial Radiology Practice

By Allan G. Farman and William C. Scarfe
Division of Radiology and Imaging Science,
The University of Louisville Department of Surgical and Hospital Dentistry

Frequently, Dolphin users are orthodontists and orthognathic surgeons primarily interested in its superb craniofacial and cephalometric analyses. The authors (AGF and WCS) are Oral and Maxillofacial Radiologists, a distinct specialty of dentistry recognized by the American Dental Association. While we too do use Dolphin 3D for craniofacial and cephalometric analyses, we also use it for a variety of other purposes. The aim of this short communication is to explain why Dolphin 3D is such a useful software application for Oral and Maxillofacial Radiology practice.

Background

Oral and Maxillofacial Radiology (OMR) is concerned with the production and interpretation of images and data produced by all modalities of radiant energy that are used for the diagnosis and management of diseases, disorders, and conditions of the oral and maxillofacial region.[1] Oral and Maxillofacial Radiologists assist the healthcare professions by providing consultation services in the interpretation of radiographs and advanced imaging studies of the oral and maxillofacial structures. To be able to read images from a variety of systems—including the relatively widely deployed cone beam computed tomography (CBCT) systems—requires that the exported images are in a form that is interoperable. The image data format that is internationally recognized for this purpose is the ISO-referenced DICOM (Digital Imaging and Communications in Medicine) Standard.[2] This is the Standard endorsed by the American Dental Association (ADA).[3] Image datasets using either the DICOM single file or multifile formats can be read by Dolphin 3D software. Indeed Dolphin Imaging has been a very active participant within Working Group 12.1 of the ADA Standards Committee on Dental Informatics and has participated in DICOM WG 22 (Dentistry) to refine, test and demonstrate interoperability. Dolphin 3D participated in the 2007 "Education in the Round" and 2008 "Live Operatory" associated activities involving successful live demonstrations of interoperability with image data outputs from a number of commercially available CBCT systems.[4,5]

The role of CBCT in OMR

The American Academy of Oral and Maxillofacial Radiology (AAOMR) has embraced the introduction of cone beam computed tomography (CBCT) as a major advancement in the imaging armamentarium available to the dental profession.[6] However, it believes that dentists utilizing CBCT should be held to the same standards as board-certified OMF radiologists, just as dentists excising oral and maxillofacial lesions are held to the same standards as OMF surgeons. It is the responsibility of the practitioner obtaining the CBCT images to interpret the findings of the examination. Just as a pathology report accompanies a biopsy, an imaging report must accompany a CBCT scan. The practitioner who operates a CBCT unit, or requests a CBCT study, must examine the entire image dataset. This is predicated on a thorough knowledge of CT anatomy for the entire acquired image volume, anatomic variations, and observation of abnormalities. It is imperative that all image data be systematically reviewed for disease. The field of view will vary with the system employed, positioning and collimation, and can include intracranial structures, the base of the skull, the paranasal sinuses, the cervical spine, the neck and the airway spaces. Qualified specialist OMFRs may be able to assist diagnostically when practitioners are unwilling to accept the responsibility to review the entire exposed tissue volume. There may be a misconception on the part of some practitioners that the user has no responsibility for radiologic findings beyond those needed for a specific task, (e.g. implant treatment planning). This assumption, according to the executive statement from the AAOMR, is erroneous.[6]

Working with CBCT data

To facilitate image retrieval, the dataset itself should be stored in compliance with relevant legal and regional stipulations and should be exportable in a format compatible with the ISO referenced DICOM Standard. Distributed images are a component of the permanent record and should be stored in a suitable archival format. An interpretation report of the imaging findings should also be included in the patient's record.

Dolphin 3D provides an excellent DICOM reading software that can be used to read DICOM format

image datasets from CBCT systems from different manufacturers. It also provides significant advantages in providing more advanced segmentation and viewing protocols than are generally provided by the manufacturers of CBCT systems. Further, there are refined analytic tools for cephalometric analysis and for accurate measurement of the airway. In other words, Dolphin 3D is a very valuable software for all professionals who are likely to receive image datasets from CBCT systems and other advanced imaging modalities made by a variety of manufacturers. It is a useful tool for Oral and Maxillofacial radiologists who desire to provide reading services to evaluate image volumes for unsuspected pathoses.

In private practice, the authors use four different CBCT systems from three different vendors (i-CAT classic and i-CAT next generation – Imaging Sciences International, Hatfield, PA; Kodak 9000 – Practiceworks, Atlanta, GA; Skyview – MyRay/Cefla, Imola, Italy), but the image datasets that are exported can all be viewed using Dolphin 3D with importing taking only a few seconds in each case. Patients are referred from practitioners representing most of the various specialties of dentistry as well as general practitioners who perform advanced procedures. The i-CAT systems are our major workhorses with the Kodak 9000 being used principally for high resolution small FOV tasks, primarily in the service of endodontics. We will be embarking on sleep apnea trials using the Skyview to determine whether there are advantages in having such patients supine during imaging.

Further advantages of 3D software

In addition to our own local production, we have read image datasets from centers geographically remote to our location, and these image datasets have been generated from a wide range of CBCT systems including those previously mentioned and also various generations of the NewTom (QR/AFP, Verona, Italy), Iluma (Imtec/3M, Ardmore, OK), 3D Accuitomo (J. Morita Corp., Kyoto, Japan), Galileos (Sirona Corp, Bensheim, Germany), Scanora 3D (Soredex/Palodex, Helsinki, Finland) and Promax 3D (Planmeca Oy, Helsinki, Finland). This is where Dolphin 3D is a very useful software as it can be used to open the datasets from all of these companies among others.

For all of these CBCT datasets, Dolphin 3D permits the display and report output of contiguous sections through the jaws and also permits the color coding

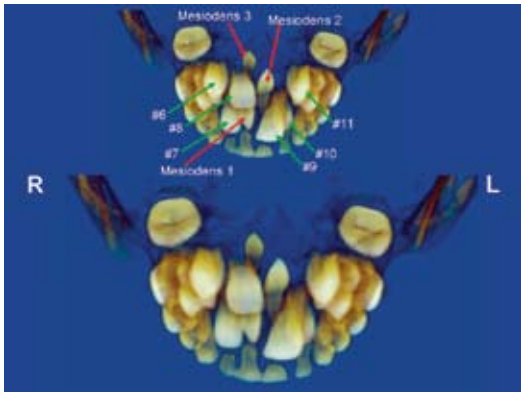

Fig. 1. This case of multiple mesiodens was provided to the clinician as an image dataset with a viewer that did not have 3D functions. When the DICOM files were extracted and viewed in 3D using Dolphin 3D, the relationship of the supernumerary teeth to the regular teeth and surrounding anatomy became clear to the clinician who was then better informed to perform the necessary operation.

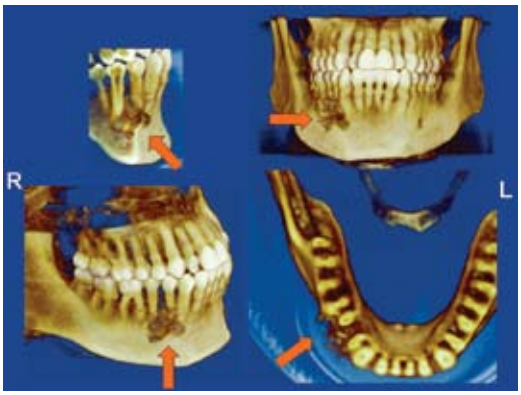

Fig. 2. An incidental radiographic at dental examination finding of a 47 year old male patient led to referral for CBCT. Dolphin 3D reconstructions clearly demonstrate the position of this multilocular lesion that has breached the buccal cortical plate. This proved on histopathology to be ameloblastoma.

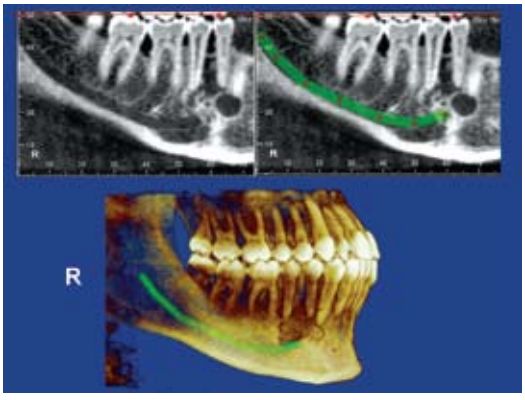

Fig. 3. Further examination of the case illustrated in Fig. 2 (again using Dolphin 3D) demonstrated the intimate association between the tumor and the mandibular canal in the region of the right mental foramen.

of the mandibular canals. This is very valuable for planning dental implant placement and also for planning extraction of impacted mandibular third molar teeth. This can be combined with video clips of the same structures in 3D gradually clipping the jaw structures to demonstrate relationships between structures that the surgeon will face at operation. We have also had clinicians visiting with DICOM datasets on CD removable media containing suboptimal at best and unusable at worst image viewers. Taking the DICOM file(s) from the CD and uploading the images in Dolphin 3D provides excellent anatomically correct views of the condition to be treated (Fig.1). The images can also be displayed as traditional CT slices in all three orthogonal planes and it is this format that is used for the careful review of the full image data for unsuspected pathoses that can have great health consequences for the patient, and can potentially lead to liability on the part of the dentist if not detected. Such findings then can be displayed using the special segmentation tools of Dolphin 3D (Fig. 2-4). Of eight subjects' images in San Francisco in the 2007 "Education in the Round" session, seven had significant reportable incidental findings.[4] In the population imaged in our private practice, the detection of carotid area calcifications consistent with atherosclerotic plaque exceeds 10 per cent of those imaged.

How accurate is Dolphin 3D? At the University of Louisville School of Dentistry, we have conducted a number of basic studies with our students and these have shown that measurements with CBCT images reconstructed through Dolphin 3D are likely to be no more unreliable that repeat direct measurements of anatomic specimens (Fig. 5).[7-10] Dolphin Imaging also followed our request for certain specifications for measurement of the upper airway, specifically the determination of the narrowest point and the determination of the cross-sectional area (Fig. 6). This could then be used to determine the effects of mandibular advancement devices on opening the airway in patients with known sleep apnea.[11] This tool is now part of the released Dolphin 3D v11.

In conclusion, Dolphin 3D has universal applications for examination of DICOM image datasets from CBCT systems. It is an enabling tool for Oral and Maxillofacial Radiologists and for all individuals who need to read images from diverse CBCT systems.

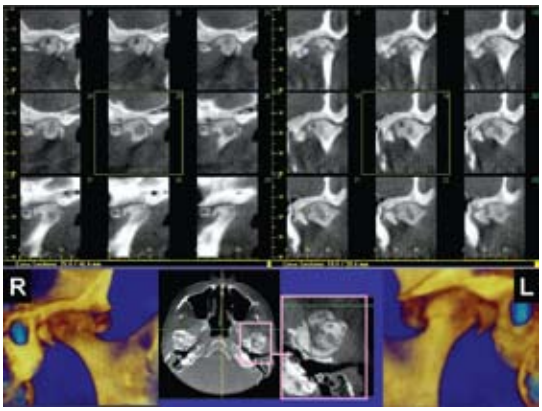

Fig. 4. Asymptomatic severe bilateral degenerative disease of the temporomandibular canals was clearly shown by the i-CAT XoranCAT proprietary software (upper views showing parasagittal slices of the TMJ); however, Dolphin 3D provided excellent 3D renditions of the situation that were helpful to the surgeon. This was an incidental finding in a patient imaged for dental implant planning.

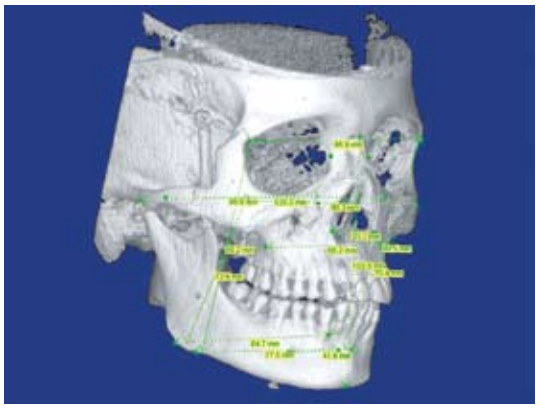

Fig. 5. Dolphin 3D rendition of a dried skull used by Brown et al.[10] for establishing the accuracy of i-CAT CBCT using this software application.

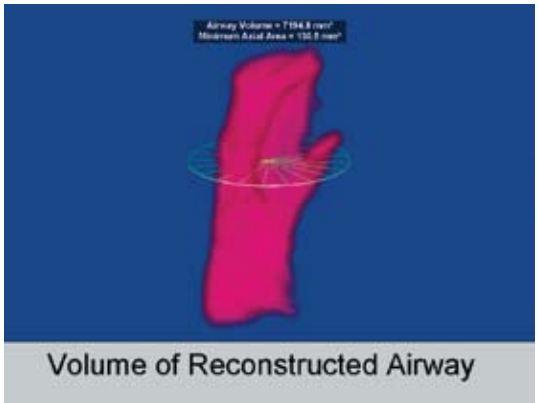

Fig. 6. Airway segmentation using Dolphin 3D v.11 to automatically determine the narrowest cross-sectional dimension. This approach has been used for evaluation of the effectiveness of mandibular advancement devices in the treatment of sleep apnea patients.[11]

Allan G. Farman, BDS, PhD, MBA, DSc

Dr. Farman is Professor of Radiology and Imaging Science, Department of Surgical and Hospital Dentistry, The University of Louisville School of Dentistry. He is a Diplomate both of the American and Japanese Boards in Oral and Maxillofacial Radiology and has Certification in that Specialty in the Commonwealth of Kentucky, practicing in partnership with the second author as Associates in Oral and Maxillofacial Radiology. Dr. Farman is ADA Representative to the international DICOM Standards Committee, both President Elect and Scientific Editor for the American Academy of Oral and Maxillofacial Radiology and Founder and Organizer of the International Congress on Computed Maxillofacial Imaging.

William C. Scarfe, BDS, FRACDS, MS

Dr. Scarfe is Professor of Radiology and Imaging Science, Department of Surgical and Hospital Dentistry, The University of Louisville School of Dentistry. He is a Diplomate of the American Board in Oral and Maxillofacial Radiology and has Certification in that Specialty in the Commonwealth of Kentucky, practicing in partnership with the first author as Associates in Oral and Maxillofacial Radiology. Dr. Scarfe is Treasurer for the American Academy of Oral and Maxillofacial Radiology and North American Representative to the International Association of DentoMaxilloFacial Radiology.

References

1. *http://www.ada.org/prof/ed/specialties/definitions.asp*
2. *Farman AG. Raising standards: digital interoperability and DICOM. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005;99:525-526.*
3. *American Dental Association. B-164-2000 and B-165-2000. Transactions. 141st Annual Session. Chicago: American Dental Association; 2000:408.*
4. *Farman AG, Levato CM, Scarfe WC, Mah J. Education in the round: multidimensional imaging in dentistry. Inside Dentistry. 2008;(1):39-41.*
5. *Farman AG, Levato C, Scarfe WC. Chenin D. Cone beam CT trends towards hybrid systems and third party software utilization. Inside Dentistry 2008;4(9):102-105.*
6. *Carter L, Farman AG, Geist J, Scarfe WC, Angelopoulos C, Nair MK, Hildebolt CF, Tyndall D, Shrout MK. [Exective Statement] American Academy of Oral and Maxillofacial Executive Statement on performing and interpreting diagnostic cone beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008:106:561-562.*
7. *Honey OB, Scarfe WC, Hilgers ML, Klueber K, Silveira AM, Haskell BS, Farman AG. Cone beam computed tomography accuracy in imaging the TMJ: comparison with panoramic radiology and linear tomography. Am J Orthod Dentofac Orthop 2007;132:429-438.*
8. *Moshiri M, Scarfe WC, Farman AG, et al. Accuracy of linear measurements from imaging plate and CBCT-derived lateral cephalometric images. Am J Orthod Dentofac Orthop 2007;132:550-560.*
9. *Periago DR, Scarfe WC, Moshiri M, Scheetz JP, Silveira AM, Farman AG. Linear accuracy and reliability of cone beam CT derived 3-dimensional images constructed using an orthodontic volumetric rendering program. Angle Orthod 2008;78:387-395.*
10. *Brown AA, Scarfe WC, Scheetz JP, Silveira AM, Farman AG. Linear accuracy of cone beam CT derived images. Angle Orthod 2009;79:150-157.*
11. *McCrillis J, Farman A, Scarfe W, Haskell J, Brammer M, Chenin D. Segmentation of the airway using CBCT in obstructive sleep apnea with and without placement of mandibular advancement device. Int J CARS 2008;3(Suppl 1):S208-S210.*