From the Students’ Corner

Student-Led Courses to Teach Cone Beam CT in the Predoctoral Dental Curriculum


Abstract: Cone beam computed tomography (CBCT) provides a new method to evaluate the craniofacial region. The goal of our project was to introduce into the predoctoral dental curriculum a student-initiated, student-led introduction to CBCT and how to use it, with minimal expenditure of financial resources. A third-year student worked with two faculty members to design a course in which a small number of third-year students would lead a small group of second-year students. The first approach involved each small group of second-year dental students discussing one clinical case in which the patient’s CBCT record was included. Representatives of each of the ten small groups presented the patient and that patient’s clinical problem (e.g., an impacted tooth) to the entire class as well as demonstrating the superiority and limitations of using CBCT in clinical dentistry. The second approach also used small-group meetings led by third-year dental students, but paired two second-year dental students as a team to present the patient’s CBCT data in the small-group setting. There were five teams each presenting a different type of patient as assessed only from the CBCT data. The first model focused on the problem (e.g., an impacted tooth), while the second model focused on how to evaluate and use CBCT scans to determine the patient’s primary problem. Based on surveys conducted at the end of each course, the majority of students felt they had gained a better understanding of CBCT.

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Cone beam computed tomography (CBCT) has become one of the new imaging tools in the dental field.1-6 It has become an important radiographic imaging approach for dentists who treat patients who need a dental implant7,8 or orthognathic surgery9,10 or have impacted dentition11 as it provides multiple planar views and three-dimensional images.12,13 CBCT is also being developed to evaluate the airway, which can assist orthodontists and oral and maxillofacial surgeons to evaluate airway restriction.14,15 CBCT is effective in determining the presence and extent of bony lesions as well.16 As CBCT develops, more companies are marketing the instrumentation, which makes it lower both in price and in radiographic radiation.17,18

Radiation dosage as defined by microsieverts (uSv) ranges from 100 to 800 depending on the scanner.19 A bite wing uses 1 to 4 uSv, a full mouth x-ray series uses 30 to 110 uSv, and a panoramic view uses 3 to 11 uSv.19,20 The software that accompanies the radiographic units provides the capability in a full head scan to look at individual teeth, depict a full lateral head x-ray used in cephalometric analysis, show a panoramic view to evaluate the temporomandibular joints,21 depict the airway with cross-sectional and volumetric views,14,22,23 and exhibit any section or plane as well as a three-dimensional view of the bone like the mandible and cervical vertebrae.

Experts in oral radiology have argued that dentists who use CBCT need to be able to evaluate the entire patient data in the CBCT scan, which requires using dental training in head and neck anatomy, oral pathology, and advanced training in oral radiology on how to interpret CBCT scans.24 Several dental schools have begun to develop ways to train predoctoral or advanced dental students on how to evaluate CBCT scans, particularly using web-based material (personal comments from Dr. Joseph Caruso, Loma
Early in the development of our CBCT course at the University of California, San Francisco, some dental students distributed a brief, informal e-mail survey to dental schools in the United States to get some preliminary idea of whether and how this subject is currently being taught; those results indicate that most dental schools are doing some form of teaching about CBCT but they vary regarding what should be taught and how much dental students should be expected to know.

The purpose of this article is to describe how we developed an approach to teaching CBCT using two different methods, both based on the idea that students would teach the material under guidance of the faculty. The two versions of this course involving active student learning were delivered to second-year students in successive years.

Materials and Methods

In 2005, two faculty members initiated a program to introduce cone beam computed tomography into the predoctoral dental curriculum. The purpose was to have dental students learn about what CBCT could offer and begin to appreciate the accurate anatomical data that could be defined in multiple planes and in the volumetric three-dimensional mode. An actively involved third-year dental student leader (J.H.) accepted the assignment of organizing the course. The faculty members provided the software, which was an open and free computer software (AVIA, Hitachi Medical Technology, Tokyo, Japan) developed by Hitachi Corporation to be used as a reader of Digital Imaging and Communication in Medicine (DICOM) data. The faculty members then selected several patients from the postdoctoral clinic for the predoctoral teaching and introduced the program and patients to the small group of third-year student leaders who would lead small groups of second-year students. The third-year dental student leader organized a group of ten to twelve students in his class to meet and develop the small groups of second-year dental students to learn about CBCT. The primary student course director developed the syllabus with the faculty members to accompany the use of the software and then met with the third-year students in his class to plan the small-group meetings around five individual cases.

The subjects were patients who sought treatment in one of the postdoctoral clinics and had one CBCT in their diagnostic analysis. Each patient seeking treatment had a scan with the Hitachi CB MercuRay (9.6 second scan, 10 ma and 110 KVp). The Division of Orthodontics at the university purchased the Hitachi CB MercuRay (Hitachi Medical Systems America, Inc., Twinsburg, OH) in 2002 as part of its interest in using CBCT in diagnostic evaluation of patients. All identifiers including the patient’s name, age, and gender were removed (DICOM Anonymizer Pro, NeoLogica Medical, Italy). Approval was requested and received from the university’s Institutional Review Board.

The scan from each patient was placed into a DICOM format, and the radiographic data were included with a program provided by Hitachi Medical Systems America, Inc., entitled CB MercuRay Referring Physician Lite Viewer, which had a manual introducing all of its functions. Initially, five patients were chosen: one patient with an impacted canine, a second patient with a mandibular lesion, a third patient with a unilateral cleft of the palate and lip, a fourth patient with a flattened condyle secondary to a temporomandibular disorder, and a fifth patient with partial edentulism requiring endosseous implant reconstruction.

Dental students in the second year of the predoctoral program were taught by a small group of volunteers from the third-year class using two different models for two consecutive years (Table 1). A syllabus was developed to introduce AVIA, which was loaded with a given patient DICOM set of images. In the first part of the syllabus, the subroutines were introduced. These included multi-planar reformatting (MPR), maximum intensity projection (MIP), and surface rendered volumetric images (Figure 1). In the second part of the syllabus, the students were asked to systematically evaluate the condyles, airway, occlusion, and mandibular bone (Figure 2). The students were instructed to systematically review the axial, coronal, and sagittal sections and take notes as to unusual findings. Students were led through the syllabus to use various tools including making linear measures of the lateral view of the airway. The students were then asked to answer clinically relevant questions pertaining to the patient’s chief complaint. An example of one set of questions is shown for a patient with impacted canines (Figure 3).

Results

Two different approaches or models were developed to teach second-year dental students about
### Table 1. Timeline of CBCT course in the pilot year and second year

<table>
<thead>
<tr>
<th></th>
<th>Summer Quarter</th>
<th>Fall Quarter</th>
<th>Winter Quarter</th>
<th>Spring Quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot Year/Model 1</td>
<td>Ten volunteer third-year students take the pilot CBCT course prior to teaching the course to the incoming second-year students in winter quarter.</td>
<td>The ten volunteers become small-group leaders. Their feedback helped improve the course and organize its structure better.</td>
<td>Pilot CBCT course taught to all second-year students as part of core UCSF curriculum.</td>
<td>Evaluated the course based upon surveys. Recruit students who would teach CBCT the following year (Model 2).</td>
</tr>
<tr>
<td>Year 2/Model 2</td>
<td>Student volunteers from the pilot year convene to discuss ways to improve the CBCT course.</td>
<td>Model 2 CBCT course ensues as part of UCSF core curriculum.</td>
<td>Same as the pilot year.</td>
<td>-</td>
</tr>
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![Figure 1. Example of how a patient is seen in a DICOM formatted file displayed by the AVIA program to show three different planes and one volumetric image](image)

**Note:** Upper left: frontal view; lower left: horizontal or axial view; upper right: sagittal view; lower right: volumetric image. Icons are displayed below the images to provide adjusting the image.
CBCT. Teaching Model One was used in the first year of this course and concentrated on a particular patient problem, pathology, or anomaly. Teaching Model Two was used in the second year of this course and focused on how students would use a CBCT set of scans to evaluate a patient’s unknown problem with no additional supporting information.

This student-led course could be improved year by year because the students who took the course during their second year were able to teach the course the next year. Having been a student in the CBCT course, the student teachers were able to improve the previous year’s teaching model. These models of a student-led course were cost-effective in terms of not requiring any additional resources.
Model One: Patient Pathology and Anomaly Complemented with CBCT Scans

In this first model, the small group of third-year dental students met and discussed the five patient cases as shown on AVIA (see Appendix). The third-year student leader (J.H.) met a few times with the group of third-year dental students to discuss logistics and the type of patients to be evaluated. In the winter quarter, the second-year dental students who attended a general course in comprehensive patient care were divided into ten groups with eight to ten students in each group. Each small group of second-year dental students met for one hour on several occasions in which the patient case was presented; the students then discussed the case (cleft palate, flattened condyle, or impacted tooth) and questions about this type of problem. Next, each group of second-year dental students prepared a presentation for the entire class, so that ten groups presented their cases over two hours, each discussing the type of problem its patient exhibited using the AVIA CBCT images and an introduction to the patient’s problem. During each presentation, the group discussed the value and limitations of using CBCT in evaluating a patient’s chief complaint.

Student feedback was solicited through a survey using an ordinal scale of 1 to 5 to determine strengths and weaknesses of the course (Table 2). Student feedback (N=61) collected from Model/Year 1 showed that students became more familiar with CBCT. The mode of students’ responses concerning their level of familiarity with CBCT was 1 prior to taking the CBCT course; it increased to 4 after the teaching.

Model Two: Using CBCT Scans to Determine Patient’s Pathology and/or Anomaly

In the second year, Model Two of teaching CBCT in the predoctoral dental curriculum was introduced. Again, a small group of third-year dental students (n=10) met and organized their five patients purchases of multiple license keys nor requiring additional faculty or staff to teach the course.

Patient: Impacted Canines __________________________________________ (print file name here)

1. Evaluation write-up: Imagine that you are a dental radiologist. Please write, in detail, the radiographic findings that you see in this patient’s craniofacial region. (helpful keywords: orientation, dimension, position of)

2. Identify the types of specialists that would typically work together on this patient. What is the name of the procedure? Describe, in layman’s terms, what the specialists would do during this procedure.

3. List the percentages and locations of the impacted canines in relation to the dental arch. Please cite your scientific resources.

4. List other commonly impacted teeth and their prevalence.

5. What do you think is the referring doctor’s primary or chief concern during the course of the treatment? List the importance of treating patients with impacted canines.

Extra credit question: Why is it that maxillary canines are more impacted than any other anterior teeth? What are some of the contributing factors?
to present to their small groups. These ten students had taken part in the Model One pilot year’s CBCT course and had expressed interest in teaching the course.

In Model Two, the second-year dental students were advised to bring their laptop computers to the small-group session and assigned as pairs to review and present one patient so that a total of five patients would be presented (see Appendix). Each team had to present the CBCT DICOM data suggesting the patient’s chief complaint, the referring doctor or dentist’s primary concern, and the images that demonstrated these radiographic findings (Figure 4). Student feedback was solicited using an ordinal scale of 1 to 5 to determine the strengths and weaknesses of this model (Table 3).

### Table 2. Student feedback on Model One/pilot year (N=61)

<table>
<thead>
<tr>
<th>Question</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Integrated well with overall course of Patient Center Care (PCC)</td>
<td>4</td>
</tr>
<tr>
<td>2. Helped me become familiar with CBCT and CBCT software.</td>
<td>4</td>
</tr>
<tr>
<td>2a. Before taking this course, I was already familiar with CBCT and CBCT</td>
<td>1</td>
</tr>
<tr>
<td>software.</td>
<td></td>
</tr>
<tr>
<td>3. Had a course manual that was clear and organized.</td>
<td>3</td>
</tr>
<tr>
<td>4. Had an assigned third-year student coordinator who led the discussion</td>
<td>4</td>
</tr>
<tr>
<td>effectively and answered my questions adequately.</td>
<td></td>
</tr>
<tr>
<td>5. Had homework assignment that enhanced my learning experience.</td>
<td>4</td>
</tr>
<tr>
<td>6. Had a student group presentation that helped me learn more about my</td>
<td>4</td>
</tr>
<tr>
<td>patient case and that of other groups.</td>
<td></td>
</tr>
<tr>
<td>7. Interested me in doing a research project that relates to and/or uses</td>
<td>3</td>
</tr>
<tr>
<td>CBCT technology.</td>
<td></td>
</tr>
<tr>
<td>8. Interested me in learning about more advanced CBCT software (e.g.,</td>
<td>3</td>
</tr>
<tr>
<td>InVivo, Dolphin).</td>
<td></td>
</tr>
<tr>
<td>9. Interested me in participating in a student-organized, student-led</td>
<td>3</td>
</tr>
<tr>
<td>teaching course such as this one.</td>
<td></td>
</tr>
</tbody>
</table>

1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree

### Discussion

The primary difference between the two approaches to teaching second-year dental students was that each small-group meeting in the first model discussed one patient and presented that patient to the entire class using the CBCT data to complement a more comprehensive understanding of the primary problem. The small-group meeting in the second model, on the other hand, had students work in pairs and present one of five patients on their own computer to the small group so that all five patients were presented in the small group. This approach focused on how to view the CBCT data.

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**Patient #1:**

1. List the images that show potential medical and dental problems of this patient.

2. List what you think is the patient’s primary or chief complaint.

3. List what you think is the referring doctor’s primary or chief concern and the treatment he/she is considering.

**Figure 4. Example of three questions that students answered for each CBCT patient presentation**
Table 3. Student feedback on Model Two (N=44)

<table>
<thead>
<tr>
<th>Question</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The CBCT course integrated well with the main course labeled PCC 139.</td>
<td>3</td>
</tr>
<tr>
<td>2. I became familiar with CBCT and its software.</td>
<td>4</td>
</tr>
<tr>
<td>3. I was familiar with CBCT software before this course.</td>
<td>1</td>
</tr>
<tr>
<td>4. The course manual was clear and organized.</td>
<td>3</td>
</tr>
<tr>
<td>5. I had a good third-year dental student coordinator.</td>
<td>4</td>
</tr>
<tr>
<td>6. The student coordinator gave a useful tutorial session.</td>
<td>4</td>
</tr>
<tr>
<td>7. The homework assignments enhanced the learning experience.</td>
<td>4</td>
</tr>
<tr>
<td>8. The group presentation helped me learn more about my patient case and that of other groups.</td>
<td>4</td>
</tr>
<tr>
<td>9. This experience motivated me in doing a research project with CBCT.</td>
<td>4</td>
</tr>
<tr>
<td>10. This experience motivated me to learn more about advanced CBCT software.</td>
<td>4</td>
</tr>
<tr>
<td>11. This experience motivated me to participate in a student-organized and student-run course.</td>
<td>3</td>
</tr>
</tbody>
</table>

1=absolutely disagree, 2=disagree, 3=neutral, 4=agree, 5=absolutely agree

Experts in oral radiology have developed guidelines for what the general dentist should be able to do with CBCT. It is evident, and of primary concern, that the dentist have enough skills and background to review a CBCT of his or her patient to identify the problem and to know when to refer the CBCT scan to a specialist and/or a certified oral radiologist.24 These guidelines also suggest that the general dentist using a CBCT system should use the least amount of radiation possible to achieve the goal of the imaging mode selected. Orthodontists typically want a full head x-ray, while experts in temporomandibular disorders often require a panoramic view and a corrected tomogram of the temporomandibular joint.

At this stage of development in CBCT, the systems available are becoming lower in radiation, approaching traditional radiographic records and providing much more information about the patient.17,18,26

Dental schools presently teach predoctoral students how to read intraoral and extraoral radiographs. However, it seems that it is now time for all dental curricula to include CBCT. As CBCT becomes more useful in dental applications such as implantation, correction of impacted teeth, or planning orthognathic surgery and as CBCT units become more common in dental schools, schools need to include some of the fundamentals of CBCT not only in postdoctoral programs but also in predoctoral curricula. Teaching CBCT builds on fundamental principles of three-dimensional anatomy such as understanding the route for the inferior alveolar nerve and integrates pathology for understanding such concepts as morphological changes in the condyles.27,31 In addition, many software programs take the DICOM data and develop multiple modes to evaluate the anatomy including three-dimensional volumetric images (e.g., Dolphin 3D, InVivoDental, CB Works, V Works, Quick Ceph Studio).

The question as to where to implement the teaching of CBCT imaging in the dental curriculum is important. It could complement a first-year anatomic course or follow an introductory oral radiology course that begins with dental x-rays and leads to panoramic views and CBCT images. It could also be included in an advanced course that evaluates selected cases in impacted teeth, placing dental implants, determining cleft palates, evaluating condylar shapes, determining asymmetry in the craniofacial skeleton, and defining restrictions in the airway.

It is evident that a course depending on students teaching each other relies on self-motivation and interest, as well as strong student leadership in which both the upper class leaders and the participating lower class students must contribute time and effort to learning CBCT. Class participation and individual contributions to our course reflected a level commensurate with that in postdoctoral dental education.

With faculty members from such departments as orthodontics, oral pathology, oral radiology, and oral and maxillofacial surgery contributing, predoctoral students are able to obtain valuable information in using CBCT with various clinical problems. The third-year students who led the teaching expressed a strong desire to have faculty members who were experts in the individual areas of pathologies and anomalies evaluate their findings in defining the patient’s condition for the first teaching model. This faculty input was essential for screening the wide
range of information readily available without requiring the student to have sufficient professional skills to ascertain if the information was accurate.

At the same time, the students’ contribution to this course was also substantial and was driven by their own desire to pursue knowledge and learn about a new radiographic approach. The student-led model has potential in a curriculum that provides the foundation of anatomy and pathology as well as lectures by oral radiologists who can provide a perspective about CBCT. Our student-led course was completed with minimal funds, and the cost of developing such a course should remain relatively low considering the extensive number of student hours contributed by student leaders and then students participating in teaching each other. However, such a program requires appropriate faculty advisors committed to using this mode of teaching for some topics like CBCT for such a student-led program to be possible.

Conclusion

This article has described two different approaches to teaching basic concepts of how CBCT can be used to evaluate patients in a dental school. It relies on a partnership between faculty and students with upper class students taking the initiative to lead small-group sessions of first- or second-year dental students. Our university’s experience with student-led CBCT instruction for predoctoral students expands the possibilities for adding a valuable course that is conducted cost-efficiently when guided by faculty advisors.

REFERENCES

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Teaching Model One

**Summer Quarter:** A Student Coordinator (J.H.) organizes a summer course for the incoming third-year dental students who are interested in facilitating small-group discussions for the second-year students who will be taking the course the following winter quarter. The incoming third-year Group Facilitators take the CBCT course and provide valuable feedback to improve the course. Improvements in areas such as better case selections and better questionnaires per clinical case were developed.

**Fall Quarter:** The Student Coordinator and the Group Facilitators convene with the dental radiology faculty member (L.A.) and course director (A.M.) and discuss ways to approach the CBCT course for the following winter quarter. Scheduling issues are discussed at this time.

**Winter Quarter:** The Student Coordinator gives an overview of the course to the entire second-year class as well as an introduction to the CBCT software (AVIA). Afterwards, students are divided into groups of 8-10 students.

The second-year students are organized to meet with one specific third-year Group Facilitator throughout the winter quarter during an elective studying period when they are not in class. The students discuss the following with the Group Facilitator:

1. How to use advanced features of CBCT software, AVIA.
2. Reviewing CBCT DICOM images per each clinical case, including anatomical landmarks.
3. Questions pertaining to each clinical case.
4. Preparing group presentations to the entire second-year class in regards to one particular clinical case (cleft lip/palate patient, TMD patient, etc.). Their presentations consist of explaining the superiority and limitations of CBCT use in creating a treatment plan for that particular patient’s clinical problem.
5. Ways to improve the course for the following year.

The small-group discussion lasts about an hour, and the students meet 5-6 times throughout the winter quarter.

Each small group is presented with DICOM formatted data that show five prototypical patients with the following chief complaints:

1. Temporomandibular disorder
2. Cleft palate/lip repair (prior to alveolar grafting surgery)
3. Implant consult
4. Mandibular lesion or cyst
5. Impacted teeth

At the end of the winter quarter each small group of second-year students develops an oral presentation (20 minutes long) in which they present the primary problem of the patient with the CBCT data and background information on the problem to the entire class of 84 students. The entire second-year class meets, and five oral presentations are presented, with each group presenting a patient and the primary problem of that patient with background information and CBCT scans.

At the end of the course, students have an opportunity to fill out an evaluation form, which helps the following year’s Student Coordinator and Group Facilitators to formulate a plan to improve the course.

Teaching Model Two

**Summer Quarter:** The Student Coordinator (M.L.) organizes a group of Group Facilitators (third-year dental students) who are interested in facilitating small-group discussions for the second-year dental students who will be taking the course the following winter quarter. The student coordinator collects feedback as to how the course went for them as second-year dental students and what suggestions they offered to improve the experience.
APPENDIX (continued)

Fall Quarter: The Student Coordinator and the Group Facilitators convene with the dental radiology faculty member (L.A.) and course director (A.M.) to discuss the organization of the CBCT course for the following winter quarter. The types of patients that the students will investigate as well as scheduling issues are discussed at this time. We select the following patient cases:

1. Asymmetrical airway
2. Calcified stylohyoid ligament
3. Impacted canine
4. Dental implant
5. Mandibular bony mass

Winter Quarter: The Student Coordinator gives an overview of the course to the entire second-year dental class as well as introduction to the CBCT software, AVIA. Afterwards, students are divided into groups of 8-10 students.

The second-year students meet with one specific third-year Group Facilitator within a week of the introduction lecture. This meeting not only introduces the students to their facilitator, but also allows them to use the CBCT software first-hand and have their questions answered about using the software. At the end of this meeting, the students pair to receive a particular patient case they are to investigate.

The students are then given one month to look at the patient case and to determine the anomaly as observed by CBCT. They are given several questions to guide them in their case presentation. Some of these questions require them to do some background research for the particular problem.

In their second meeting, the groups meet again with their Group Facilitator to present their cases to everyone in the group. This gives the students the opportunity to see all the cases and to ask questions from each presenting group. The group is then asked to submit a report within a month of the second meeting that includes the following: describe what CBCT identifies; describe all the findings found in each of the patient cases; and present your opinion as to the role CBCT contributes in dentistry.

At the end of the course, students have the opportunity to fill out an evaluation form of the course, which helps the following year’s Student Coordinator and Group Facilitators to formulate a plan to improve the CBCT course.