

A Case-Based and Team-Based Learning Model in Oral and Maxillofacial Radiology

Vandana Kumar, D.D.S., M.S.; Cynthia C. Gadbury-Amyot, M.S.D.H., Ed.D.

Abstract: The purpose of this article is to describe the process of transitioning a traditional face-to-face oral and maxillofacial radiology (OMR) lecture course to a case-based, team-based learning model for students ready to enter their fourth and final year of dental school. Data were collected from 294 new fourth-year students (Classes of 2009, 2010, and 2011) who participated in the newly formatted OMR course. At the time the course was taken, students had completed one year of clinical experience in taking and evaluating radiographic images on patients with various clinical conditions. Each class of approximately 100 students was divided into ten teams of ten each, and a topic on oral and maxillofacial lesions was assigned to each team. The teams researched their assigned topics, created PowerPoint presentations, and posted them on the course management system Blackboard site. The instructor posted on Blackboard eight to ten cases representing various lesions on that topic. Minimal clinical history was released at that point. Students reviewed the teams' PowerPoint presentations and the cases, answered the questions for each case, and turned in written assignments to be graded. The diagnoses were discussed in class. An end-of-course survey found that 71 percent of the students felt the case-based instruction helped them learn the content in a more comprehensive manner and 77 percent felt the in-class discussion increased their knowledge of radiographic interpretation. Some students said they felt uncomfortable being called on randomly during the class discussion. National Board Dental Examination results for the classes of 2009 and 2010 showed slight improvement when compared to national scores. As a result of student feedback, the course continues to be offered in the case-based, team-based format.

Dr. Kumar is Assistant Professor, Department of Oral Pathology, Medicine, and Oral Radiology, School of Dentistry, University of Missouri-Kansas City; and Dr. Gadbury-Amyot is Professor and Director, Distance Education and Faculty Development, School of Dentistry, and Interim Associate Vice Provost of Online Education, University of Missouri-Kansas City. Direct correspondence and requests for reprints to Dr. Vandana Kumar, School of Dentistry, University of Missouri-Kansas City, 650 East 25th Street, Kansas City, MO 64108; kumarva@umkc.edu.

Keywords: dental education, educational methodology, oral radiology, teaching methods, team-based learning, case-based teaching

Submitted for publication 3/22/11; accepted 6/29/11

Dental faculty members struggle to balance an enormous amount of information to convey to students in preparing them to perform in a clinical setting. Dental students have typically been accustomed to the traditional lecture style of courses, in which they participate passively by listening to the instructor, viewing PowerPoint presentations and handouts, and perhaps taking notes.^{1,2} Such large lecture-based classes are not conducive to creating deep and enduring understanding in students. Hendricson et al., in an article commissioned by the American Dental Education Association Commission on Change and Innovation in Dental Education (ADEA CCI), pointed out that students require more than memorization skills; they need to acquire skills such as team performance, the ability to listen and communicate, the willingness and ability to learn throughout life, and the capacity to think critically, evaluate situations, and solve problems.¹ The ADEA CCI endorsed eight guiding principles to create the ideal dental education experience for students and faculty. Two of those are pertinent to this study: “the importance of dental education operating in

an environment that promotes critical thinking and problem-solving by developing self-directed, self-disciplined, self-aware, and self-corrective learners”; and “the importance of dental education promoting self-assessment, as this has been shown to lead to critical thinking and problem-solving.”²

In the field of medicine, the Accreditation Council for Graduate Medical Education has endorsed practice-based learning and improvement (PBLI) as a core competence for residents.³ Building this competence requires more emphasis on experiential learning and resident participation in health care improvement projects.⁴ To start to gain some of these experiential learning experiences while still in a classroom setting, there has been a shift from pure lecture environments to active learning that requires participation by students as they wrestle with “real-world” scenarios. The goal is to shift to a problem- and case-based learning methodology and student-centered instructional models to achieve the kind of learning that requires the critical thinking and problem-solving skills needed for professional practice.^{5,6}

The purpose of this article is to describe how a traditional radiology lecture course was redesigned using a new case-based and team-based teaching and learning model. Radiographic imaging is a valuable diagnostic tool for patient assessment and treatment planning and forms the backbone of all clinical specialties of dentistry. A thorough knowledge of various available radiographic modalities, their applications, and accurate interpretation of the images and data created is necessary for the ethical and efficient practice of dentistry. A case-based, team-based, student-centered instructional model was introduced to prepare students to evaluate radiographic images and frame appropriate clinical questions to ask the patient or a referring clinician to reach a provisional diagnosis. Student perceptions of the course were sought,⁷ along with analysis of other outcomes measures including National Board Dental Examination scores.

Methods

This case-based, team-based teaching and learning model was introduced in the oral and maxillofacial radiology course in the summer semester of 2008 for new fourth-year dental students who had had one year of clinical experience in taking and evaluating radiographic images on patients with various clinical conditions. The major objective of this course was to introduce the principles of radiographic interpretation that would enhance students' experience in describing the radiographic findings and, based on those findings, developing a provisional diagnosis of the pathological entity. Another critical component of this course was to discuss the guidelines for prescribing appropriate radiographs for various pathological entities.

A wide spectrum of pathological entities was discussed in the course. Major topics covered included cysts and benign tumors of jaws, malignant lesions of jaws, bone diseases manifested in jaws, systemic and metabolic diseases manifested in jaws, soft tissue calcifications, inflammatory lesions of jaws and sinuses, and temporomandibular joint diseases. An example of ten subtopics of the major topic "Cysts of jaws" included general radiographic features and classifications of cysts, radicular cysts, dentigerous cyst, buccal bifurcation cyst, odontogenic keratocyst and basal cell nevus syndrome, lateral periodontal cyst, calcifying odontogenic cyst, simple bone cyst, and nasopalatine and nasolabial cyst. Students were instructed to discuss mainly the radiographic features and important clinical features of the cysts.

Historically, PowerPoint-supported lectures had been delivered on all of these topics by the instructor. The students were evaluated on the basis of a midterm and final exam that consisted of multiple-choice and true/false questions. The final grade was based on the results of the two exams.

In the new case-based, team-based learning format, the focus was shifted from an instructor-taught, passive learning model to an active learning model with students expected to actively participate in their own learning. Another component of the course redesign was its transition from a letter grade course to pass/fail. Students were required to achieve course requirements at 75 percent or greater for successful completion of the course. Course requirements consisted of the following: team project (40 percent), class participation (20 percent), team participation (20 percent), and class attendance (20 percent). Students receiving less than 75 percent earned a failing grade and were required to undergo a short remediation with the instructor followed by a written makeup assignment. The makeup assignment consisted of answering a series of questions on the findings of radiographs of eighteen to twenty cases depicting various oral and maxillofacial lesions. The successful completion of the makeup assignment would result in a passing grade. In the three years of this course redesign, no students have failed the course.

A description of course requirements and expectations for the team project, class participation, team participation, and class attendance appears in Appendix A. An example of one of the cases used in this course appears in Appendix B.

A survey was developed by the principal investigator to determine student perceptions of the redesigned course. The survey consisted of four Likert-scale questions ranging from 1 to 5 with 1=strongly disagree and 5=strongly agree. The study was found to be exempt by the University of Missouri-Kansas City Institutional Review Board.

Results

Participants in the study were a convenience sample of fourth-year dental students for three consecutive years following implementation of the redesigned course (Classes of 2009, 2010, and 2011). The survey was administered on the last day of the course. Survey responses were anonymous, and results are reported as aggregate data. The overall response rate was 79 percent (232 out of 294). The demographic results show a predominantly white,

male student body between the ages of twenty-three and twenty-five (Table 1).

Because the level of measurement for the survey data was ordinal, medians and interquartile ranges are reported as measures of central tendency and dispersion. The average median scores (and interquartile ranges) for each of the four survey questions (Table 2) were as follows: learning format=4 (1); cases covered assigned topics and objective=4 (1); discussion increased knowledge=4 (0); and comfortable learning environment=4 (1). In addition to the four survey questions, students were given an opportunity on the instrument to provide comments. Of the 232 students who completed the survey, sixty (26 percent) provided comments. Qualitative analysis of these comments⁷ resulted in five emergent themes (Table 3). The themes with the greatest number of comments were comprehensive coverage of course content, uncomfortable with being called on, and would have liked more information on the cases.

The National Board Dental Examination (NBDE) Part II is developed and conducted by the Joint Commission on National Dental Examinations (JCNDE) to assist regulatory agencies in making valid decisions regarding licensure of oral health care professionals.⁸ This examination is taken by fourth-year dental students before graduation. The results of this examination for the Classes of 2009 and 2010 were available and are reported here, whereas scores for the Class of 2011 were not available at the time this article was written. Because oral pathology and

radiology are reported as a combined score, this exam is not an ideal measure as it is impossible to separate out individual results for radiology. However, because it is a standard outcome measure used by all dental schools across the United States, it is useful to consider when examining the impact of a course redesign on student outcomes. Likewise, it provides a consistent data point for comparison before and after course restructuring.

For the Class of 2009, the average score in oral pathology/radiology on the NBDE Part II was 40.2 compared to a national average of 39.2. For the Class of 2010, the average score in oral pathology/radiology on the NBDE Part II was 40.6 compared to a national average of 41.6. Prior to the restructuring of this course, the Class of 2008's average score in oral pathology/radiology on the NBDE Part II was 36.9 compared to a national average of 37.2. Average scores on the case-based section of the NBDE Part II for the Classes of 2009 and 2010 were 68.9 and 71.2, respectively, compared to national averages of 64.5 and 70.0. Prior to the restructuring of the course, the average score on the case-based section for the Class of 2008 was 63.3 compared to a 62.3 national average.

Discussion

The results of our evaluation revealed that the case-based, team-based oral and maxillofacial radiology (OMR) courses were well received by students. The responses to the survey indicate that students perceived the discussion of cases increased their knowledge of interpretation of radiographic images and description of various diseases manifested in the jaw. These findings support the ADEA CCI-endorsed argument that cases in which students compare decisions and outcomes with those of expert practitioners who work through the scenarios with them help the students develop critical thinking and problem-solving skills.⁹

In our study, the students seemed to enjoy the challenge of interpreting the radiographic images with minimal clinical history available and then working up a different provisional diagnosis when the demographic data or medical or dental histories were changed during discussion of the case. The altering of demographic data or clinical symptoms for the same radiographic picture provoked thought and forced the students to come up with different provisional diagnoses of the same case. This emphasized the importance of collecting the patient's detailed

Table 1. Demographics of students in study (total enrollment for classes of 2009, 2010, and 2011; N=294)

	Number (percentage)
Gender	
Male	176 (60%)
Female	118 (40%)
Age in years	
20-22	66 (22%)
23-25	160 (54%)
26-30	50 (17%)
Over 30	18 (6%)
Race/ethnicity	
Caucasian	249 (85%)
Black	6 (2%)
Hispanic	5 (2%)
Native American	3 (1%)
Asian American	20 (7%)
Not reported	11 (4%)

Note: Percentages may not total 100% because of rounding.

Table 2. Student perceptions, by number and percentage of total respondents to survey (n=232)

Question	Strongly Disagree	Disagree	No Opinion	Agree	Strongly Agree
1. Did you feel the learning format using case-based seminars helped you learn the content in a more comprehensive way?	2 (1%)	23 (10%)	43 (19%)	113 (49%)	51 (22%)
2. The cases posted in the seminar thoroughly covered the assigned topics and objectives.	0	12 (5%)	34 (15%)	124 (53%)	62 (27%)
3. Discussion of cases increased my knowledge of interpretation of radiographs and description of various diseases manifested in the jaw.	4 (2%)	15 (7%)	34 (15%)	127 (55%)	52 (22%)
4. A comfortable learning environment was provided.	3 (1%)	46 (20%)	44 (19%)	96 (41%)	42 (18%)

Note: Percentages may not total 100% because of rounding.

Table 3. Qualitative analysis of student comments on survey

Emergent Themes	Representative Comments
Comprehensive coverage of course content	<ul style="list-style-type: none"> • Very comprehensive course. This has increased my knowledge and skills to interpret the radiograph. Thank you. • Lots of information provided, which was helpful. • It's excellent! Very organized. • This course was well organized and presented.
Uncomfortable with being called on	<ul style="list-style-type: none"> • Didn't like the random calling on people. • I get uncomfortable being put on the spot and called on at random, but it does make you come to class prepared. • Being put on the spot is never comfortable, even when one has to come to class prepared; however, I understand that if participation [relies on volunteering], silence will usually ensue, so I understand why the class is formatted in this fashion.
Would have liked more information on the cases; did not like the ambiguity created by not having full information	<ul style="list-style-type: none"> • It would improve the students' ability to correctly diagnose the cases if slightly more information was provided. • I like the way we had to try to figure out what each case was, but I think it would be nice to go through each disorder and describe its main characters and show several examples at the end of the lecture. • More patient history with diagnosis would be helpful. • I would like to have more clinical descriptions such as demographics and patient history along with symptoms. • Not enough info provided w/ cases to make thorough dx eval. Discussions often created more confusion because sometimes a definitive diagnosis was never given.
Would like class to be at least part lecture	<ul style="list-style-type: none"> • I would have like half lecture, half cases. • Would like a short lecture presenting the material to help learn better. • I believe this class should be more lecture-based than case-based. • I do not think the information was presented in a manner that allowed effective learning. More lecture vs cases would have allowed better understanding.
Not well prepared from previous radiology course, so seemed over head at times	<ul style="list-style-type: none"> • Our background in radiology is weak, as you can probably gather. This class was helpful. • It was a good class. The problem is the previous radiology classes didn't teach us much. If all the classes were like this one, it would be much better. • Our background to this point in radiology has not been very thorough. At times the cases seemed a little too advanced only because we have not been well prepared to this point.

Note: Sixty students (20 percent of the total) provided comments.

clinical history before evaluating radiographs since a slight change in patient demographics or medical history could significantly impact interpretation of the lesion and alter the treatment plan. It also helped the students to recognize the benefit of each intraoral and extraoral radiograph and establish proper grounds for prescribing radiographs. The discussions about each radiograph provided for the case made it clear that a radiographic examination is necessary when the history and clinical examination have not provided enough information for complete evaluation of a patient's condition and formulation of an appropriate treatment plan. The radiographs that do not contribute any pertinent information about certain disease entities should not be prescribed as part of set protocol followed in some dental practices. Though case-based, team-based learning required students to do more work than in the traditional lecture-based course, they felt that relevant and meaningful learning took place.

The results of the oral pathology/radiology and case-based sections of the NBDE Part II for the classes who took the older, traditional course format were compared with those who experienced the new active learning style. No real difference in scores between the two cohorts was found. Small differences in scores (one or two points) indicate that the new format of the course did not have any negative impact on the numerical score, providing confidence that this teaching and learning strategy does not adversely affect national exam outcomes such as NBDE scores.

The team projects encouraged students to interact with each other. They explored educational sources beyond the required textbook to develop their presentation, and all the teams developed impressive products. This process expanded their clinical knowledge and improved their interpretation skills for making better provisional diagnoses. In this student-centered, team-based learning environment, the students had the opportunity to play an active and participatory role in their own learning with the responsibility of keeping the team on schedule, collecting everyone's work, and giving final shape to the project for posting on a timely basis. Displaying their final project in the Blackboard course management system for their classmates' review provided added incentive to develop a quality project. Additionally, the peer evaluation process gave teammates the opportunity to evaluate each other, thereby creating additional responsibility and accountability for each team member to contribute his or her part. In this

process, teams were asked to complete a form on which they assessed the contributions each member made to the team's product. The form directed them to assess the team members' preparation (were they prepared when they came to class?), contribution (did they contribute productively to group discussion and work?), respect for others' ideas (did they encourage others to contribute their ideas?), and flexibility (were they flexible when disagreements occurred?). Considering these factors, the students were asked to distribute 100 points among the team members, excluding themselves, and to include comments for each person. (The form is available from the corresponding author.) Finally, the Clinical Radiology Conference (CRC) seminars were conducted in roundtable style, requiring students to be prepared thoroughly for each case; these provided a good foundation for discussion of each case.

The majority of students indicated on their survey responses that the case-based learning format helped them learn the content in a more comprehensive way and that the cases posted on Blackboard covered the assigned topic and objective thoroughly. The small-group setting for the team project and the immediate faculty feedback seemed to encourage students' attention and interest in class.

The first author, who also served as the course director, found this educational format to be much more dynamic than the traditional lecture format previously used. Ensuring there were several radiographic examples of the same lesion and preparing new cases every year for each topic did require extra effort. In addition, this instructor's evaluation of team projects (Table 4) required more effort than the previous lecture format, which did not include any team-based learning. However, it was her experience that the close interactions with students made the teaching experience more enjoyable and the students' enthusiasm and sharp clinical reasoning made it an interesting and rewarding experience. Student-faculty discussion of cases stimulated learning and uncovered prospective issues for research investigations.

In the analysis of student comments, the issue of students' feeling uncomfortable being called upon was clearly articulated. Those who commented about this on the survey indicated that they found this "on the spot environment" uncomfortable. In relation to the emergent theme of "would have liked more information on the cases," other research has found that while some students do not care for the ambiguity inherent in case-based instruction, the pedagogical

Table 4. Criteria for evaluation of the presentation as the team project

Criteria	Possible Points
Presentation prepared according to the guidelines provided.	10 points
Presentation shows in-depth knowledge of the topic and includes all the salient features of the lesions included in each topic.	10 points
Appropriate clinical pictures and radiographs included, and the referring sources identified.	10 points
Posted on Blackboard 24 hours prior to class session.	10 points

approach is to make them think beyond just black and white.¹⁰⁻¹⁴

Research endorsed by the ADEA CCI has drawn attention to the prevalence of teaching pedagogies that result in students' being passive learners rather than actively involved in their education.¹ Therefore, it was not a surprise to find in our project that the students were uncomfortable with what was new for them: a very active learning environment in which they were expected to come to class prepared and with the background to meaningfully engage in discussion. Case-based learning is a different way of teaching from the usual in dental schools, and many if not most students have had little exposure to such learning methodologies. Developing ways to assist students in adjusting to this methodology, including helping them understand its ultimate value, should become part of the next stage of improving this course.

Conclusions

This article reported on the redesign of a traditional lecture-based course into a case-based, team-based, active learning format that emphasizes the development of students' clinical problem-solving and decision making skills that are routinely applied in dental practice. This is in accordance with ADEA CCI guiding principles regarding critical thinking and self-assessment. The revised course mimics actual clinical situations and instills a sense of responsibility in students regarding ordering appropriate radiographs based on the patient's clinical history and examination and then evaluating and interpreting those radiographs properly to form a treatment plan. It may be that such methodologies could be applied in other aspects of clinical education to enhance the development of students' diagnostic and treatment-planning skills.

REFERENCES

1. Hendricson WD, Andrieu SC, Chadwick DG, Chmar JE, Cole JR, George MC, et al. Educational strategies associated with development of problem-solving, critical thinking, and self-directed learning. *J Dent Educ* 2006;70(9):925-36.
2. Haden NK, Andrieu SC, Chadwick DG, Chmar JE, Cole JR, George MC, et al. The dental education environment. *J Dent Educ* 2006;70(12):1265-70.
3. Ogrinc G, West A, Eliassen MS, Liuw S, Schiffman J, Cochran N. Integrating practice-based learning and improvement into medical student learning: evaluating complex curricular innovations. *Teach Learn Med* 2007;19(3):221-9.
4. Morrison LJ, Headrick LA. Teaching residents about practice-based learning and improvement. *Jt Comm J Qual Patient Saf* 2008;34(8):453-9.
5. Engel FE, Hendricson WD. A case-based learning model in orthodontics. *J Dent Educ* 1994;58(10):762-7.
6. Moore TS. Implementation of problem-based learning in a baccalaureate dental hygiene program. *J Dent Educ* 2007;71(8):1058-69.
7. Miles MB, Huberman AM. *Qualitative data analysis: an expanded sourcebook*. 2nd ed. Thousand Oaks, CA: Sage, 1994.
8. Joint Commission on National Dental Examinations. National board dental examination. At: www.ada.org/110.aspx. Accessed: June 2, 2011.
9. Hendricson W, Eisenberg E, Guest G, Jones P, Johnson L, Panagakos F, et al. What do dental students think about mandatory laptop programs? *J Dent Educ* 2006;70(5):480-99.
10. Barrows HS. A taxonomy of problem-based learning methods. *Med Educ* 1986;20(6):481-6.
11. Demarco R, Hayward L, Lynch M. Nursing students' experiences with and strategic approaches to case-based instruction: a replication and comparison study between two disciplines. *J Nurs Educ* 2002;41(4):165-74.
12. Distlehorst LH, Dawson E, Robbs RS, Barrows HS. Problem-based learning outcomes: the glass half-full. *Acad Med* 2005;80(3):294-9.
13. Haith-Cooper M. Problem-based learning within health professional education: what is the role of the lecturer? A review of the literature. *Nurse Educ Today* 2000;20(4):267-72.
14. Trappier B. Integrated problem-based learning in the neuroscience curriculum: the SUNY downstate experience. *BMC Med Educ* 2006;6:47.

APPENDIX A

Description of the Course Requirements

Team Projects

The class of approximately 100 students was divided into ten teams of ten students each. Ten major topics on various kinds of oral and maxillofacial lesions discussed previously were randomly assigned to these groups as team projects. Each team appointed one member to serve as the team leader for the semester. The major topic was divided into ten subtopics, and those were assigned to the team members through a lottery-type approach. The work on the project was distributed equally among team members, so that students could not allege any bias in the assignments. Each member of the team was then asked to prepare three or four slides about that subtopic that should include clinical and radiographic features of the lesion, radiographic pictures, and its management. They were asked to submit their assignment to their team leader two days before its due date, and the team leader assembled the work of the entire team and posted it on Blackboard two days before the discussion of this topic/seminar in class. This provided an opportunity for the entire class to review their classmates' PowerPoint presentations on that topic, while working on their reading assignment on the same topic from the required textbook.

The team members were advised to complete the team assignments as a team, with the team taking responsibility for the whole project. They were encouraged to discuss, consult, and even debate with each other about the project throughout the term.

General guidelines for preparing the presentation were as follows:

- A. Introduce the topic, and state the general clinical and radiographic features.
- B. Classify the disease entity (if applicable).
- C. Introduce each lesion, enumerate the salient clinical and radiographic features of the lesion, and state the differential diagnosis.
- D. Include radiographic and clinical pictures where appropriate. Students were asked to procure these from the Web, journals, or radiology textbooks and to develop a bibliography. If teams were having problems with their assignment, the instructor was available to meet with them at the class break or immediately after class to discuss the project and help them as necessary.

The team was evaluated and graded based on the presentation. The team project was evaluated as a whole and counted for 40% of students' final grade. (See Table 4 for grading rubric.)

Team Participation

The participation of each team member was essential; therefore, each member also evaluated the contributions of all his or her team members, using an evaluation rubric. The evaluations were handwritten or e-mailed to the instructor as attachments. The team grade was given only after the instructor received the team evaluations. Team participation counted for 20% of students' final grade.

Class Participation

Two days before the seminar, eight to ten radiographic images of lesions from the topic area were posted by the instructor on Blackboard. Minimal clinical history was made available at that point. This in-class lecture series was organized as a Clinic Radiology Conference (CRC). New cases are developed each year for all the major topics. Each CRC consisted of cases with questions. Prior to each CRC, the students were required to read the assigned pages noted in the beginning of each seminar outline. All the readings were from the radiology textbook. Students were asked to complete the CRC cases posted on Blackboard. The students were instructed to prepare their written assignment answering the questions posted on Blackboard with each case and to turn in their written assignment after class for a grade. At every CRC seminar, students were randomly called on by the moderator to share their observations and impressions with the rest of the class. The CRC was conducted in a "rounds" style with discussion of each case. Students were asked to describe the type of radiograph, lesion details, and any other significant findings that were visible on the radiograph and not related to the lesion but needed immediate attention, for example, carious mutilated teeth, severe periodontal condition, or periapical lesions. Based on these descriptions, the students were asked to come up with a provisional diagnosis.

If a student was struggling with the case and not ready with written answers, his or her grade for the in-class participation would be reduced. Students were also called on to comment on the previously presented case or to express or defend their observations and impressions on the cases. Discussion followed, with other students concurring or disagreeing with the initial diagnosis. The faculty member in turn presented varying circumstances that could have an impact on the diagnosis. It was not possible to call on all the students during the seminars, but attention to the details of the cases and participation by asking appropriate questions and making relevant comments earned them points for in-class participation. The students were encouraged to read the required textbook and explore other sources such as reference books and journal articles for other examples of lesions to enhance their knowledge. The aim of the in-class CRC was to prepare students to be competent in interpreting and discussing radiographic findings with their colleagues and patients in a professional manner. The class participation counted for 20% of their final grade.

Attendance

Students were required to attend all the seminars. When turning in the written assignment, students were asked to sign an attendance sheet. Only one excused absence was allowed during the semester. Only medically documented emergencies were granted more than one absence and earned the student a right to a make-up assignment on the missed topic to earn points towards class and team participation. Attendance and turning in the written assignment counted for the remaining 20% of the final grade.

APPENDIX B

Example Case

The case concerns a forty-seven-year-old female patient with no significant medical history. The patient presented with heavily restored dentition and multiple endodontically treated teeth. The patient complained of persistent pain throughout the jaw and was being considered for removal of third molars. Radiographic images associated with the case appear in Figures 1, 2, 3, and 4.



Figure 1. Conventional panoramic radiograph

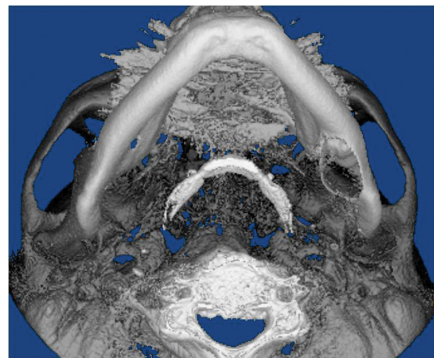


Figure 3. Three-dimensional virtual model-axial view

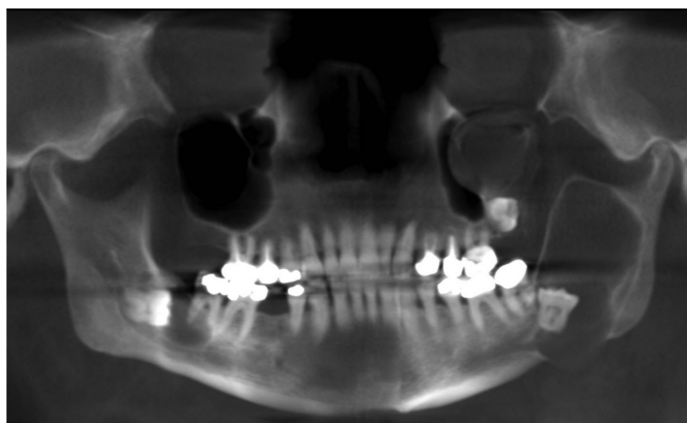


Figure 2. Reformatted panoramic view from cone beam computed tomography data

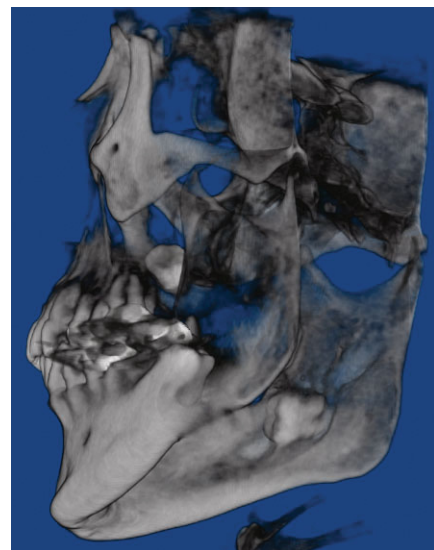


Figure 4. Three-dimensional virtual model-sagittal view
