Development of a graphic application and evaluation of teaching and learning of the bisecting-angle technique for periapical radiographs

HERALDO SILVEIRA, GABRIELA LIEDKE, RENI DALLA-BONA, HELOISA SILVEIRA
Universidade Federal do Rio Grande do Sul
heraldods@ig.com.br; gabiliedke@yahoo.com.br; renidallabona@ig.com.br; heloisa.silveira@uffrgs.br

Summary: The use of the bisecting-angle technique for periapical radiographs, one of the techniques most frequently used by dentists, yields a high rate of errors, and dental students should understand and master its performance. Difficulties in teaching this complex technique led teachers to reassess traditional teaching and learning processes. This study investigated a graphic application to prepare students to use the bisecting-angle technique, and evaluated its application in an undergraduate course. An interactive graphic application was developed with theoretical and practical lessons that cover the correct performance of the bisecting-angle technique. Twenty undergraduate students were selected: 10 for the test group (conventional teaching and computer-aided learning) and 10 for the control group (conventional teaching only). A practical simulation with patient and a practical test using phantoms were conducted for evaluation. In the simulation test, the mean score of the test group was 71.66%, and the control group, 58.33%. Mean grade in the practical test was also higher in the test group: 8.25 versus 6.95. All users felt that the application facilitated learning. The use of virtual resources improved the understanding and mastering of a radiographic technique by dental students.

Key words: learning; computer-aided learning; periapical radiograph.

1. INTRODUCTION

Dental radiography is of fundamental importance for diagnoses, and periapical, interproximal and occlusal radiographs are widely used forms of intraoral radiography. Periapical radiographs provide information about all tooth structures and the bone region adjacent to the root apex, which has made them the most frequent type of radiograph in dental practice. Two techniques are used for periapical radiographs: the paralleling and the bisecting-angle techniques. The paralleling technique makes use of positioning devices that facilitate its performance. However, students should also know and master the bisecting-angle technique because it enables them to obtain radiographs at any time and without the use of auxiliary devices (Pasler, 1999).

Ilgüy *et al.* (2005) reported that 62% of the dentists in their study preferred the bisecting-angle technique for periapical radiographs. However, problems with its performance have been reported (Patel & Greer, 1986; Consolo *et al.*, 1990; Eliasson *et al.*, 1990; Rushton & Horner, 1995; Helminen *et al.*, 2000; Matheus *et al.*, 2000). A number of studies demonstrated that 90.1% of all radiographic studies have errors, and that technical errors are more frequent than procedural ones (Consolo *et al.*,

1990; Matheus *et al.*, 2000). Patel & Greer (1986) classified the most common technical errors, and found that 64.9% were due to positioning of radiographic film, 11.75%, to vertical angulation, and 4.6%, to horizontal angulation. Several studies reported that incorrect vertical angulation is the most frequent cause of error (Patel & Greer, 1986; Consolo *et al.*, 1990; Eliasson *et al.*, 1990; Matheus *et al.*, 2000). Helminen et al. (2000), however, found that the incorrect positioning of film was the most frequent problem in intraoral radiographs.

Learning radiographic techniques is one of the objectives of dental radiology teaching all over the world. A radiographic technique should be simple enough to be taught and understood in the shortest possible time. However, periapical radiography using the bisecting-angle technique is highly complex, particularly due to the difficulty in calculating the bisecting line between the tooth axis and the film plane or in directing the central beam perpendicularly to this imaginary line (Pasler, 1999).

Traditional teaching methods are based on teacher lectures and the use of books and articles with static illustrations. The aim of current education is to build educational programs that combine conventional teaching and interactive learning materials, so that students may access learning materials regardless of the teacher's presence (Schleyer, 2002). Computers, whose use is an example of such methods, may contribute to study and professional practice exactly because they are innovative, available to all, and easily updated (Hennessey, 1990). Dentistry is also dependent on computers for the use of digital radiography, intraoral cameras and patient-education software, for example (Kordass, 2002). However, the investigation of other important uses of the computer, such as those related to teaching, has not advanced substantially (Schleyer, 2002).

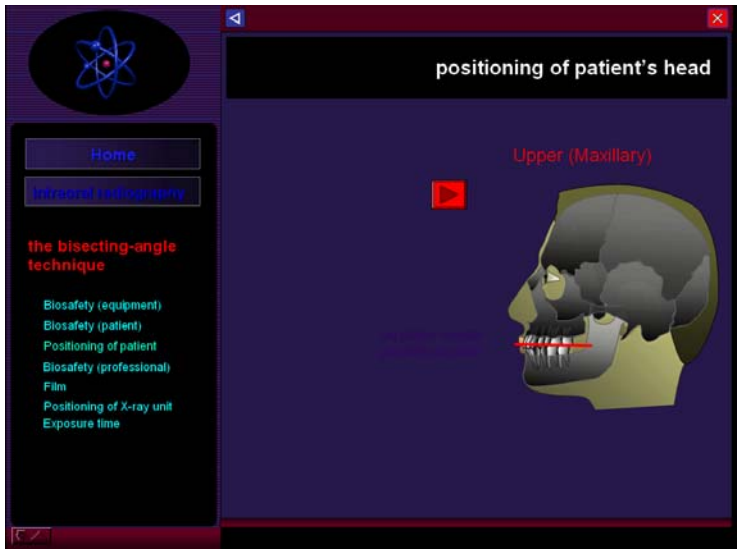
Computers may be useful aids in teaching theory and practice, and may enable students and dentists to obtain self-directed training and professional development in several areas. Students can get practical experience before the contact with real patients, which may help them feel more confident and improve their ability to visualize anatomic structures and understand the physiology of systems. This can all be achieved with the use of interactive software (Schleyer, 2002; Kordass, 2002).

The purpose of this study was to develop a graphic application (GA) to teach dental radiology and to evaluate its use in teaching and learning of undergraduate students. This paper reports to the evaluation of the use of the GA.

2. MATERIAL AND METHODS

A graphic application (GA) was developed for this project with PowerPoint (Office 2003, Microsoft, USA). The GA consists of an initial page with theoretical and practical points to be studied (Figure 1).

FIGURE 1: Presentation of one of the sections of the GA.

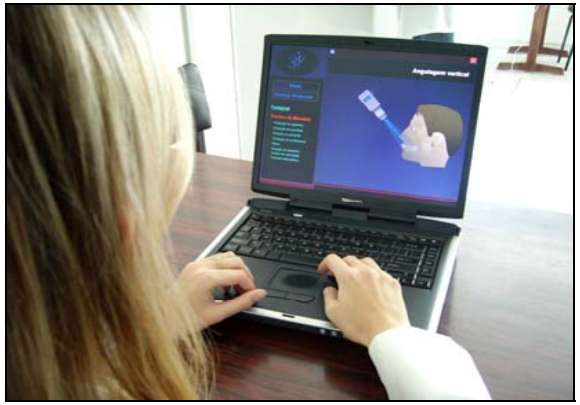


In the theoretical section, the bisecting-angle technique for periapical radiographs for the different regions (maxillary and mandibular incisors, canines, premolars and molars) is presented in the form of concise texts and graphic images to aid student understanding. The topics cover film selection, determination of exposure time according to region and film, positioning of

patient's head, film and X-ray unit according to vertical and horizontal angulation and exposure region, and biosafety (equipment and material used, patients and professionals). The practical section offers the student the opportunity to interact with the application and demonstrate understanding. For this purpose, the user should perform the radiographic technique virtually.

Twenty undergraduate students attending the radiology course in the School of Dentistry of Universidade Federal do Rio Grande do Sul were randomly selected and divided into a test (10 students) and a control group (10 students). All students agreed to participate in the study and signed an informed consent term. The control group was taught according to the conventional teaching method, which is based on theoretical classes and training of radiographic techniques using phantoms. The test group had classes that followed the conventional method and, during practical classes, each student was allowed 30 min to interact with the application installed in the radiology laboratory computers (Figure 2). At the end of the course, student learning was evaluated.

FIGURE 2: Interaction of student with application; student demonstrates understanding and performs virtual procedure.



Two instruments were used to evaluate the efficacy of the application: simulation of a periapical radiograph using the bisecting-angle technique; and a final practical test to obtain a radiograph with the same technique using phantoms. For the two evaluations, the region to be radiographed by all participants was randomly selected immediately before the examination. A student that was not participating in the study was selected to play the role of patient in the simulation test. A calibrated and trained teacher, previously selected and blinded to test and control groups, conducted the evaluation of students during the simulation. To determine each student's grade, a form was used to score correct or incorrect film selection, exposure time, positioning of the patient's head, film and X-ray unit, and biosafety. The evaluation forms were filled out by the examiner and later divided in two groups (test and control) for the analysis of results. The evaluation of the final practical test and the assignment of grades to each student were conducted by another professor, blinded to the study design and the existence of test and control groups.

Finally, the students answered and open question about their level of confidence during the performance of the radiographic examination.

Results were analyzed separately using a paired *t* test at a significance level of 95%. All students that participated in the study underwent the evaluation process[1].

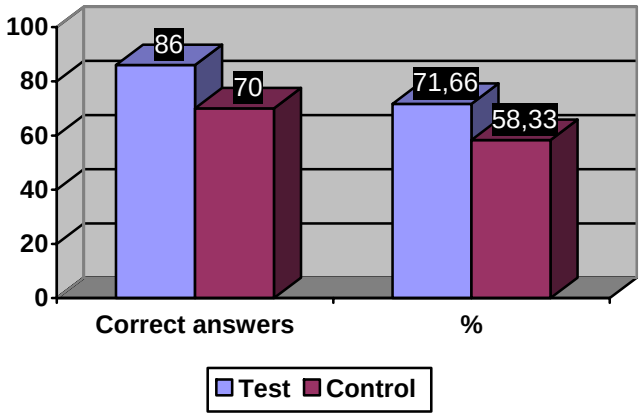
This study was approved by the Ethics and Research Committees of the School of Dentistry of Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil.

3. RESULTS

The simulation test had 12 items, and each group could obtain a maximum of 120 correct points. Figure 3 shows the results of this evaluation.

[1] The generalization of the results of the study has to be analysed with caution due to the small dimension of the control and test group.

FIGURE 3: Number and percentage of correct answers of test and control



Test group had a total of 86 points (71.66%), and the control group, 70 (58.33%). This difference was statistically significant ($p < 0.01$).

Figure 4 shows the results of the practical test. The mean grade in the group of students that used the GA was 8.25, and in the control group, 6.95. This difference between groups was statistically significant.

FIGURE 4: Mean grade of test and control groups in practical test using phantoms.

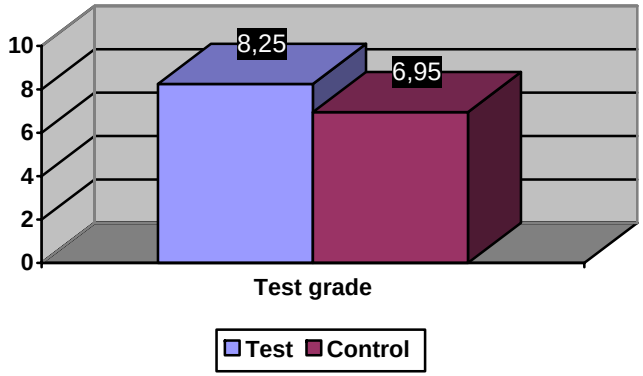
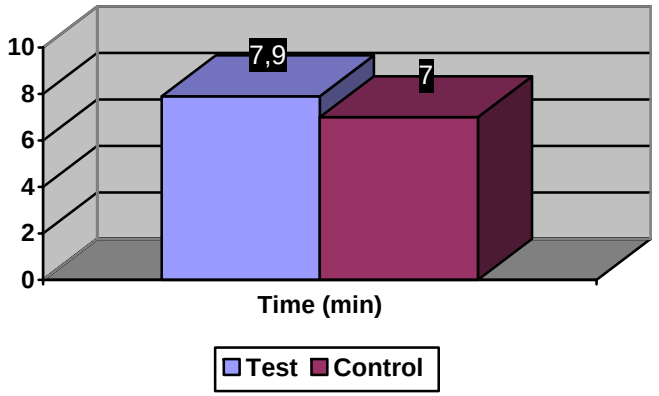


Figure 5 shows mean time used by students to perform the simulation test, and reveals that students in the test group took longer than the students in the control group.

FIGURE 5: Time spent in performance of radiographic simulation (min) by students in test and control groups.



In the open question, students that used the GA during practical classes reported that this method helped them master the technique, and that they felt more confident and better prepared to perform the radiographic procedure in real patients.

4. DISCUSSION OF RESULTS

According to Kordass (2002), virtual reality applied to dentistry may provide better preparation and training in several dental specializations, favor learning, improve and facilitate clinical care. The use of interactive software in other areas of dentistry, such as minor oral surgery (Matthew, 1998), temporomandibular joint dysfunction (Bagnall & Geissler, 1988), and computed tomography (Hennessey, 1990), has showed good results, such as an increase in theoretical and practical knowledge. Similarly, results of this

study showed that virtual teaching was efficient in promoting the comprehension and training of the bisecting-angle technique for periapical radiographs. Students that used the application accepted it well, and their number of correct answers was significantly higher than that of the control group.

A number of studies (Hennessey, 1990; Matthew, 1998; Bagnall & Geissler, 1988) showed that the use of hypermedia increased motivation to study and facilitated acquisition of knowledge. Complex structures, such as the temporomandibular joint and occlusion, may be more easily visualized by using graphic resources provided by computers. We observed that virtual resources were an acceptable, effective and pleasurable alternative to teaching the bisecting-angle technique for periapical radiographs, a traditionally difficult skill to learn.

Abbey (2002) used multimedia to simulate a virtual patient and obtained positive results with students. The experience of an interactive simulation with a patient introduces the student to the clinical environment early on, presents principles and processes for the solution of dental problems and facilitates the student's entry in clinical practice.

The GA was developed so that students may follow a logical path along the stages of radiographic examination. Therefore, students become familiar with a routine that should always be respected to obtain technically adequate radiographs and to meet biosafety norms.

Matheus et *al.*(2000) found that students' improvement in the use of radiographic techniques is progressive. The GA developed in this study enables students to obtain this necessary practical training out of the classroom. Therefore, the intensification of training by virtual resources may shorten the clinical time necessary for students to become proficient in radiographic techniques. A more proficient use of techniques has positive effects on clinical practice, decreases the number of retakes and, consequently, the radiation doses to which patients are exposed.

This study showed that the time spent by students to perform a radiographic simulation was longer in the test group. This may be assigned to the fact that students in the test group followed an established and well-known routine to perform the examination and spent time thinking about it before performing the different stages of the technique. The students in the control group conducted it in a less organized way, and sometimes left out important details. As they gain practical experience, time spent may show reverse results, that is, those students that learned the routine well may perform the exam faster, almost automatically.

Several studies (Pasler, 1999; Patel & Greer, 1986; Consolo *et al*., 1990; Eliasson *et al.*, 1990; Rushton & Horner, 1995; Helminen *et al*., 2000; Matheus *et al*., 2000) showed that the bisecting-angle technique for periapical radiographs yields a high number of errors, which points to a deficiency in the use of this technique that may be traced back to dental school. Rushton & Horner (1995), underscored the importance of a continued education project for dental professionals, and Long *et al.* (1994) argued that it is possible to use computed-aided learning (CAL) in distance learning. Dental practitioners confirm the need for constant learning and development in clinical practice, and believe that the process of learning cannot be discontinued after graduation. The successful use of the GA by students suggests that it may also be an easily available resource for recently graduated dentists or more advanced students that still feel insecure about the use of this technique. It provides the necessary contact with theory and the virtual training that will improve their performance.

5. FINAL CONSIDERATIONS

Dentists must master radiographic techniques, not only to ensure image quality, but also to protect patients from unnecessary exposure to radiation. Therefore, educators working in this area should investigate methods that help minimize the difficulties inherent to learning and that improve solutions for problems observed in clinical practice, as described in several studies. A computer program, no matter how complete and versatile, cannot replace a teacher, but can and should be explored as an additional teaching aid because it allows students to learn theory, put it in practice, make mistakes, learn with their own mistakes, and develop problem-solving skills before they have any real contact with patients. This study demonstrated that the technical preparation of students, routinely conducted with the help of

phantoms to practice radiographic techniques, may be optimized by virtual reality resources available any time, anywhere and without the teacher's assistance. Computer applications may identify errors, and the students are stimulated to look for solutions on their own.

A high number of errors and the difficulty in mastering the bisecting-angle technique for periapical radiographs led educators to investigate methodological and educational alternatives. Although traditional teaching methods will persist, students and teachers have gradually realized that they need to adapt to and assimilate new teaching and learning models. This study integrated conventional and interactive educational models, and found that the computer is an excellent tool in radiology teaching and an alternative to learning and training of the bisecting-angle technique for periapical radiographs.

This study demonstrated that the difficulties inherent to the learning and performance of the bisecting-angle technique for periapical radiographs might be overcome by using interactive computer-aided teaching, which promotes better understanding and virtual training of the procedure under study.

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Resumo: A radiografia periapical da bissetriz é a técnica radiográfica mais utilizada entre os cirurgiões-dentistas e também a que apresenta o maior índice de erros. Estes dados e também a dificuldade encontrada para o ensino desta complexa técnica levou os educadores a repensarem o processo de ensino-aprendizagem tradicional. O aprendizado auxiliado por computador (CAL) vem sendo utilizado na Odontologia e estudos comprovam que o uso da hipermídia não apenas aumenta a motivação para o estudo, como também facilita a absorção do conhecimento. O objetivo deste trabalho foi desenvolver um arquivo de tecnologia gráfica (ATG) para o treinamento e aperfeiçoamento da técnica radiográfica periapical da bissetriz e testá-lo junto aos alunos da graduação, como forma de facilitar o processo ensino-aprendizagem deste complexo procedimento. O ATG foi desenvolvido a partir do programa *Microssoft Power Point* e consta de sessões teóricas e práticas (para facilitar o aprendizado e treinamento dos usuários), abrangendo todos os passos inerentes a realização de adequada técnica radiográfica periapical da bissetriz. Vinte alunos foram selecionados para participar do estudo, sendo 10 do grupo teste (método convencional de ensino e CAL) e 10 do grupo controle (método convencional de ensino exclusivamente). A eficácia do CAL foi avaliada a partir de uma atividade prática simulada em paciente (através de critérios qualitativos desenvolvidos em uma ficha de avaliação) e de uma prova prática da técnica radiográfica em fanton. Os resultados mostraram que os alunos do grupo teste (CAL) obtiveram em média 71,66% de acertos e os do grupo controle, 58,33% durante a simulação. A média da nota na prova prática também foi superior no grupo teste: 8,25 contra 6,95. Todos os usuários do programa sentiram que este facilitou o aprendizado da técnica. A partir destes resultados conclui-se que o uso da tecnologia virtual facilita a compreensão e o domínio da técnica radiográfica por alunos de Odontologia.

Palavras chave: Aprendizagem; aprendizagem apoiada por computador; radiografia periapical.

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