The use of digital resources in the teaching of Dental Radiology: an integrative literature review

Elza Bernardes Monier*; Denizar Vianna Araujo; Ana Emilia Figueiredo de Oliveira***; Ana Carolina Uruçu Rego Fernandes****; Luana Martins Cantanhede*****; Manuela Almeida Montenegro Furtado******

* PhD student in Medical Sciences, UERJ
** PhD in Public Health, UERJ
*** PhD in Dental Radiology, UNICAMP
**** MSc in Adult and Child Health, UFMA
***** PhD student in Dentistry, UFMA
****** Master in Biotechnology, UFC

Received August 8, 2017. Approved January 9, 2018.

ABSTRACT

In dentistry, several resources have been adopted as strategies to aid the teaching-learning process in order to integrate theory and practice. This study aims to raise the main digital educational resources in the area of Dental Radiology and discuss the learning characteristics of these resources, according to the Kirkpatrick model. An integrative review of papers published between 2007 and 2017 was carried out in the databases PubMed, Virtual Health Library and Brazilian Digital Library of Theses and Dissertations, considering the descriptors: *"computer-assisted instruction"; dental education"; "educational technology"; "radiology"*. The final sample consisted of 13 articles that met the inclusion and exclusion criteria, in which the following digital educational resources were identified: 03 interactive module based on the Web; 03 digital learning objects; 02 virtual platform courses; 02 interactive digital tools; 01 3D visualization software; 01 simulator in oral radiology and 01 technological system of response to the student. From the adopted learning model, the following levels were identified in the study: participants' satisfaction and / or gain of knowledge of the participants before or after an intervention or both. The present literature review identified 7 types of digital educational resources used in oral radiology, which presented positive attitudes of students in relation to e-learning in all studies, in addition to a significant gain in knowledge in most of the studies.

Descriptors: Computer-assisted Instruction. Educational technology. Dentistry. Radiology.

1 INTRODUCTION

Computers have become an integral part of our personal and professional lives, and an obvious result of this is the introduction of personal computers and electronic devices in the fields of teaching and learning[1]. From a

pedagogical point of view, what is described as computer-aided instruction, computer-aided learning or e-learning consists of a wide range of instructional methodologies and tools to facilitate learning. Among the main technological resources applied to dentistry education are the applications of teleconferencing, computer assisted learning, simulations, e-learning platforms, and computer-based assessment[2].

In the field of dentistry, the use of these technologies in the teaching of Dental Radiology has been reported in the literature in recent years. This specialty is integrated with other areas of Dentistry as an important aid in diagnosis, planning and prognosis of oral diseases, and has presented constant development in recent years. Currently, digital images can be viewed, managed, stored and transmitted through computer networks[3,4]. However, a recent study affirms that electronic learning in Dental Radiology is still quite uncommon[5].

There are reports that computers can be used interactively to improve motivation and facilitate knowledge consolidation. It is also understood that digital environments enable teachers to visually display content effectively, encouraging student participation[6,7].

It is important, however, to understand the learning effectiveness achieved by e-learning in order to clarify when and how to use this method3. Kirkpatrick[8] created a four-level training assessment model: 1) reaction, in which participants' satisfaction and perceived value of training is measured; (2) learning, which raises how participants can change their attitude, broaden their knowledge and / or skills; (3) behavior, identifies how participants changed their behavior as a result of what was learned; and (4) results, which identifies the gains obtained with the training.

Therefore, this integrative review aimed to raise the main digital educational resources in the area of Dental Radiology and to discuss the learning characteristics of these resources, according to the Kirkpatrick model.

2 METHODOS

This is an integrative review of the literature, which presents as an advantage the inclusion of multiple studies with different research designs[9]. In order to do so, the following guiding questions were used: (1) "What are the main digital educational resources in the area of Dental Radiology?" And (2) "What are the learning characteristics (student satisfaction, learning outcome, practice change and result in health) have been evaluated in the studies that use these resources? "

The literature review was carried out considering the following databases: PubMed, Virtual Health Library (VHL) and Brazilian Digital Library of Theses and Dissertations (BDTD). Uncontrolled descriptors were adopted: "computer-assisted instruction"; "Dental education"; "Educational technology"; "Radiology". The database search was performed in April 2017, using the Boolean operators AND and OR. Such terms allow to make combinations of the descriptors used in the location of the articles, with AND being a restrictive combination and OR being an additive combination.

The analysis of the studies occurred in two stages: in the first one, after the cross-checking of the descriptors, the titles and summaries of the total sample were read, and those that were related to the inclusion criteria were separated. In the second, the pre-selected studies were analyzed in full, when the inclusion and exclusion criteria were used. These criteria were: studies published in full in English or Portuguese languages; who used a digital educational resource in the teaching of Dental Radiology; published between 2007 and 2017. Studies that did not clearly present in their results some level of learning evaluation of the Kirkpatrick model and repeated works were excluded.

3 RESULTS

In the first stage, 181 publications on the subject were identified. Figure 1 shows the diagram of the process of identification, selection, eligibility and inclusion of studies.

On stage 2, after applying the inclusion/exclusion criteria, 13 studies were selected, constituting the study sample, whose the general features are described in table 1.

Of the thirteen papers identified, eleven were in scientific paper format and two in the doctoral thesis format, two in Portuguese, and the other in English. All of them were research work carried out in study centers or universities, having as samples students of different levels and professionals. Seven types of digital educational resources were identified: 03 interactive module based on the Web; 03 digital learning objects; 02 virtual platform courses; 02 interactive digital tools; 01 3D visualization software; 01 simulator in oral radiology and 01 technological system of response to the student.

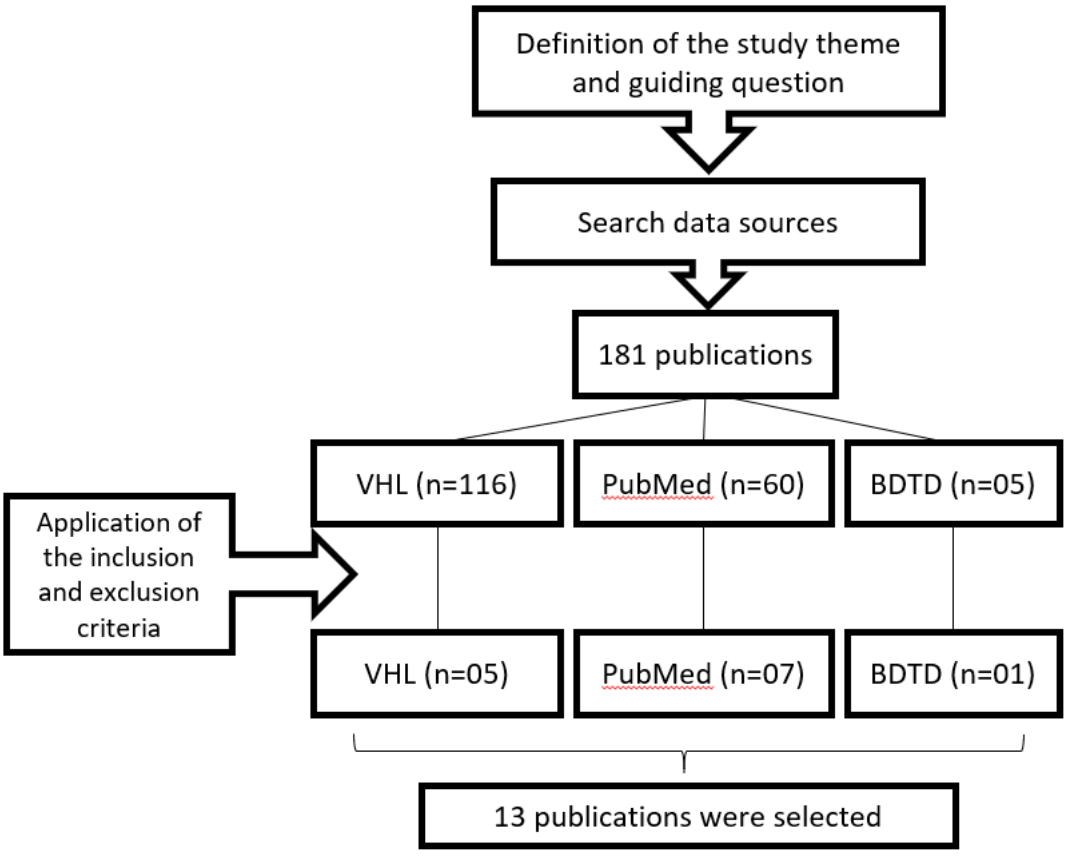

Figure 1. Flowchart of the selection process of articles that focus on the digital educational resources used in dental radiology education between the years 2007 to 2017.

Table 1. Characteristics of selected studies

	Title	Autors	Year	Educational resource	Objective(s)	Sample	Type
1.	Interactive learning in oral and maxillofacial radiology.	Ramesh A, Ganguly R.	2016	Technological student response system	To evaluate correlation between performance in course exams and self-assessment questionnaires	354 Dentistry students from the 2nd year.	Article
2.	Evaluation of a digital learning object (DLO) to support the learning process in radiographic dental diagnosis.	Busanello FH, *et al*.	2015	Digital learning object named Visual Basic Application (VBA)	To evaluate a digital learning object developed to improve skills in the diagnosis of radiographic dental alterations.	62 students, divided into 2 groups	Article
3.	Distance learning in dental radiology: immediate impact of the implementation	Cruz AD, Costa JJ, Almeida SM.	2014	Moodle platform	To evaluate the immediate impact of learning periapical radiographic anatomy after replacing the teaching method in the classroom with distance education	122 students divided into 2 groups	Article
4.	Evaluation of a blended learning course for teaching oral radiology to undergraduate dental students.	Kavadella A, *et al.*	2012	Combined course (on-site and online instruction)	To develop, implement and evaluate educational effectiveness (derived from student performance and responses to questionnaires) of a combined course.	47 students divided into 2 groups	Article
5.	Digital interactive learning of oral radiographic anatomy.	Vuchkova J, Maybury T, Farah CS.	2012	Interactive digital tool	To evaluate an interactive digital tool compared to a conventional radiology book in radiographic anatomy.	88 students (64 from the 2nd year and 24 from the 5th year), divided into 2 groups	Article
6.	Método de ensino-aprendizagem no diagnóstico radiográfico das anormalidades ósseas dos maxilares	Costa E.	2012	Virtual collaborative tool (DRAMA)	To evaluate the Virtual Collaborative Tool (DRAMA) in addition to the methodological approach in classroom teaching.	88 students, divided into 2 groups (test and control)	Thesis
7.	Desenvolvimento e teste de um objeto digital de aprendizagem para interpretação das imagens por ressonância magnética da articulação temporomandibular	Arús NA.	2012	Digital Learning Object (DLO) for Magnetic Resonance Interpretation of Temporomandibular Joint	To conduct assessment between interactive learning (through an DLO) and conventional learning	29 students divided into 2 groups	Thesis
8.	Testing the educational potential of 3D visualization software in oral radiographic interpretation.	Vuchkova J, Maybury TS, Farah CS.	2011	3D visualization software versus textbook	To carry out an evaluation between 3D visualization software from 2D radiographic images and textbook	59 students from the 4th year, divided into 2 groups	Article
9.	Dental student skill retention eight months after simulator-supported training in oral radiology.	Nilsson TA, Hedman LR, Ahlqvist JB.	2011	Simulator	To investigate the long-term effects on the ability to interpret spatial information on radiographs after conventional training and simulator.	45 students from the 7th and 9th semesters, divided into 2 groups	Article
10.	Introduction of e-learning in dental radiology reveals significantly improved results in final examination.	Meckfessel S et al.	2011	Web-based course	To evaluate the perceptions of students who used web-based teaching materials, as well as the effect on their final exam results	228 students divided into 4 groups	Article
11.	Web-based training method for interpretation of dental images.	Wu M et al.	2010	Computer-based tool for an educational program	Provide unique computer-based tools for an educational program to improve the interpretation of radiographs skills	15 participants of a conference, the majority being teachers	Article
12.	Implementing e-learning in a radiological science course in dental education: a short-term longitudinal study.	Tan PL, Hay DB, Whaites E.	2009	E-learning modules	To evaluate comparatively the different modes of learning (face-to-face and e-learning, only face-to-face and only e-learning)	140 students	Article
13.	Evaluation of the radiographic cephalometry learning process by a learning virtual object.	Silveira HLD, et al.	2007	Learning Virtual Object (LVO) Ceph Learning	Test the LVO Ceph Learning, verifying student performance improvement	40 students, divided into 2 groups.	Article

Regarding learning evaluation, the following results were found (table 2). **Level 1: Student satisfaction**, assessed through qualitative analysis in 12 of the 13 selected studies, using questionnaires. In all the works, positive attitudes were identified in relation to the resources tested. **Level 2: results of knowledge gain**, analyzed in 12 papers, whose assessment was made using several evaluation resources, such as multiple choice questionnaires, radiographic images to interpret, practice tests, among others. The results varied: 8 studies reported a significant gain in knowledge[1,4,6,10-14]; one found no significant difference[15]; in one study the group that did not use the educational resource presented better performance[16]; and one study observed lower knowledge outcomes after intervention compared to baseline scores[17]. Still, one study presented a high score in the visual ability test, but the scores in the evaluation of radiographic interpretation did not change after the intervention[7].

No studies were identified addressing the levels of learning 3 (Behavior) and 4 (Outcome), due to the difficulty of its measurement in health education.

4 DISCUSSION

The integration of technological tools in daily life has also increased the availability and use of these resources in education1. In the fields of medical and dental education, training with computer-aided techniques has been increasingly used in the last years[3,7].

It is understood as multimedia learning all forms of learning that use digital means to present and distribute learning materials[6]. The following digital educational resources were identified: interactive web-based systems/modules[6,13,18], digital learning objects[10,14,16], virtual platform courses[11,15], interactive digital tools[4,7], software for 3D visualization[17]; simulator[12] and student response technology called Learning Catalytics ™ (Pearson, New York, NY, USA).

The success of any form of teaching and determination of specific learning outcomes were usually measured during the assessment process. Many studies do not evaluate the results of the adoption of e-learning, which does not allow us to identify whether or not the methodology adopted can reduce the quality of learning outcomes[13]. For this reason, the assessment of learning of digital educational resources was carried out.

There is evidence of increased use of online tools for dental education[19,20]. The studies investigated reinforce this report, pointing also to the gain of knowledge through the use of e-learning[5,10]. This finding is in agreement with authors[21,22] who affirm that computer assisted learning is as effective as traditional methods.

Several positive points about the use of digital educational resources in dental education have been reported in the literature[23]. This statement dialogues with the results found in the works studied, highlighting the fact that resources can be used repeatedly, without time or local constraints5,13, teaching flexibility[13], as well as the facilitation of skills development in problem solving before effective contact with patients provided by the use of such tools[3].

However, there are also reports of criticism and restrictions on e-learning, such as the need to simplify navigation of programs, the presence of more self-assessment exercises[6], teacher training to use e-learning[3], and the understanding that these resources alone can not bring a change in teaching. Instead, the existing teaching-learning method needs to be strengthened[5].

Table 2. Learning evaluation results in studies selected according to the Kirkpatrick model

Study	Results of learning evaluation, according to the Kirkpatrick model		Evaluative resources used	
	Level 1	Level 2	Level 1	Level 2
1	Positive feedback on the use of LC in the radiology course	Positive but weak correlation found between students' performance in exams and in class tests	Evaluation statements	Online questionnaire
2	Positive assessment score (81.6 to 90.5)	Better test group performance	System Usability Scale (SUS)	Theoretical and practical tests
3	Positive satisfaction level	No significant difference between group notes	Questionnaire	Exam
4	Attitudes towards the elements of combined learning were very positive	The combined group showed significantly better performance than the conventional one in the post-course test.	Dichotomous questionnaires, open scale and five-point questions (Likert)	Right/wrong and multiple choice questions, questions and interpretation of radiographic images
5	The majority preferred the digital tool, everyone considered it easy to use, most people felt more confident learning with it	Visual-spatial skill test: all participants scored high; evaluation of radiographic interpretation: scores did not change after the intervention	Questionnaire using Likert scale	Multiple choice tests/mental rotation tests (MRT)
6	94.1% of the students consider the methodology's contribution to be valid or very valid	Better performance of the group that used the tool in counterpoint to the group that did not use it.	Multiple choice questionnaire	Multiple choice questionnaires; interpretation of radiographic images, written tests
7	Positive usability assessment (SUS) (effectiveness, efficiency and satisfaction), score 89	The 2 groups improved performance; control group presented better performance.	System Usability Scale (SUS)	Objective exam
8	Most students preferred to use 3D viewing than the book. All people indicated the need for combined use of 3D visualization with the book	After the intervention, the obtained score was lower than in the pre-intervention, suggesting that the use of the 3D visualization software did not improve the students' performance	Qualitative methods, using a structured Likert scale survey	Mental Rotation Test (MRT)
9	-	The ability to interpret spatial relationships after simulator use was best 8 months after training	-	Mental Rotation Test (MRT)
10	Most students showed a positive attitude towards e-learning	Reduction of failure in final exams	Questionnaire using Likert scale	Multiple choice exam
11	Very favorable evaluation, higher score for "learning" and less for "design"	-	Questionnaire	-
12	E-learning was well evaluated. However, face-to-face teaching had a better evaluation	Better results were achieved by the group of students with mixed learning (face-to-face and e-learning)	Feedback survey (on-line questionnaire)	Multiple choice exam
13	Approval of usability aspects	In the first post-test, group B, in which students used the object, presented higher average scores and more correctly identified milestones compared to group A, but this difference was not statistically significant. However, in the second post-test 15 days later, there were statistically significant differences between groups, with group B showing better results than group A.	System Usability Scale (SUS)	Multiple choice questionnaire

Such considerations reinforce the teacher's primary condition as moderator of knowledge3 and, thus, the resources for e-learning are used as a complement in education in Dental Radiology[4,11,12,14,16].

It is important to emphasize that in dentistry, specifically for the field of Radiology, the role of the computer is clearly more decisive than for other disciplines, since the area of diagnostic imaging makes more routine use of digital images. In radiological education, the student must be exposed to a large amount of visual information and the assimilation of these images is essential in the formation of their diagnostic capacity, thus constituting an important aid in the teaching of radiology[3,6].

It is important to reflect that learning can not be based only by the introduction of a technological tool by itself, but the impact that the technological tools can have on the habilitation of an interactive learning environment is impressive[1,3] and receptive attitudes of students can promote e-learning for courses in higher education, such as Dentistry, especially in the field of Dental Radiology[13].

5 CONCLUSION

Seven types of digital educational resources were described in the teaching of Dental Radiology. It was verified that the majority of the studies on e-learning in this area published in the last 10 years base the evaluation on the degree of satisfaction of the participants and/or gain of knowledge after the intervention. In all the studies, students' positive attitudes towards e-learning were identified, in addition to a significant knowledge gain in most of the time. No studies were found demonstrating changes in performance in the clinical practice or in the result obtained with the patient.

RESUMO

O uso de recursos digitais no ensino de Radiologia Odontológica: uma revisão integrativa de literatura

Na Odontologia, diversos recursos vêm sendo adotados como estratégias de auxílio ao processo de ensino-aprendizagem na perspectiva de integrar a teoria com a prática. Este estudo objetivou levantar os principais recursos educacionais digitais na área de Radiologia Odontológica e discorrer sobre as características de aprendizagem destes recursos, de acordo com o modelo de Kirkpatrick. Realizou-se revisão integrativa de trabalhos publicados no período de 2007 a 2017, nas bases de dados PubMed, Biblioteca Virtual em Saúde e Biblioteca Digital Brasileira de Teses e Dissertações, considerando os descritores: "*computer-assisted instruction*"; "*dental education*"; "*educational technology"*; "*radiology*". A amostra final foi composta por 13 artigos que atenderam aos critérios de inclusão e exclusão, em que foram identificados os seguintes recursos educacionais digitais: 3 módulos interativos baseado na Web; 3 objetos de aprendizagem digital; 2 cursos em plataforma virtual; 2 ferramentas digitais interativas; 1 software de visualização 3D; 1 simulador em radiologia oral e 1 sistema tecnológico de resposta ao aluno. A partir modelo de aprendizagem adotado, foram identificados os seguintes níveis nos trabalhos: satisfação dos participantes e/ou ganho de conhecimento dos participantes antes ou depois de uma intervenção ou ambos. A presente revisão de literatura identificou 7 tipos de recursos educacionais digitais utilizados em radiologia oral, que apresentaram atitudes positivas dos alunos em relação ao *e-learning* em todos os estudos, além de ganho significativo do conhecimento na maioria dos estudos.

Descritores: Instrução por Computador. Tecnologia Educacional. Odontologia. Radiologia.

REFERÊNCIAS

1. Ramesh A, Ganguly R. Interactive learning in oral and maxillofacial radiology. Imaging

Sci Dent. 2016;46:211-6.
2. Mattheos N, Stefanovic N, Apse P, Attstrom R, Buchanan J, Brown P, et al. Potential of information technology in dental education. Eur J Dent Educ. 2008;12:85-91.
3. Santos GNM, Leite AF, Figueiredo PT de S, Pimentel NM, Flores-Mir C, de Melo NS, et al. Effectiveness of e-learning in oral radiology education: a systematic review. J Dent Educ. 2016;80:1126-39.
4. Costa E. Método de ensino-aprendizagem no diagnóstico radiográfico das anormalidades ósseas dos maxilares [tese] Florianópolis: Faculdade de Engenharia e Gestão do Conhecimento. Universidade Federal de Santa Catarina; 2012.
5. Chang H-J, Symkhampha K, Huh K-H, Yi W-J, Heo M-S, Lee S-S, et al. The development of a learning management system for dental radiology education: A technical report. Imaging Sci Dent. 2017;47:51-55.
6. Meckfessel S, Stühmer C, Bormann KH, Kupka T, Behrends M, Matthies H, et al. Introduction of e-learning in dental radiology reveals significantly improved results in final examination. J Cranio-Maxillofacial Surg. 2011;39:40-8.
7. Vuchkova J, Maybury T, Farah CS. Digital interactive learning of oral radiographic anatomy. Eur J Dent Educ. 2012;16:79-87.
8. Maloney S, Haas R, Keating JL, Molloy E, Jolly B, Sims J, et al. Effectiveness of Web-based versus face-to-face delivery of education in prescription of falls-prevention exercise to health professionals: randomized trial. J Med Internet Res. 2011;13(4):e116. DOI: 10.2196/jmir.1680.
9. Mendes KDS, Silveira RC de CP, Galvão CM. Revisão integrativa: método de pesquisa para a incorporação de evidências na saúde e na enfermagem. Texto & Contexto Enferm.2008;17:758-64.
10. Busanello FH, da Silveira PF, Liedke GS Arús NA, Vizzotto MB, Silveira HE, et al. Evaluation of a digital learning object (DLO) to support the learning process in radiographic dental diagnosis. Eur J Dent Educ. 2015;19:222-8.
11. Kavadella A, Tsiklakis K, Vougiouklakis G, Lionarakis A. Evaluation of a blended learning course for teaching oral radiology to undergraduate dental students. Eur J Dent Educ. 2012;16:88-95.
12. Nilsson TA, Hedman LR, Ahlqvist JB. Dental student skill retention eight months after simulator-supported training in oral radiology. J Dent Educ. 2011;75:679-84.
13. Tan P, Hay DB, Whaites E. Science Course in Dental Education: A Short-Term Longitudinal Study. J Dent Educ. 2009;73:1202-12.
14. Silveira HLD, Gomes MJ, Silveira HED, Dalla-Bona RR. Evaluation of the radiographic cephalometry learning process by a learning virtual object. Am J Orthod Dentofac Orthop. 2009;136:134-8.
15. Cruz AD, Costa JJ, Almeida SM. Distance learning in dental radiology: immediate impact of the implementation. Brazilian Dent Sci. 2014;17:90-97.
16. Arús NA. Desenvolvimento e teste de um objeto digital de aprendizagem para interpretação das imagens por ressonância magnética da articulação tem-poromandibular [tese]. Porto Alegre: Faculdade de Odontologia, Universidade Federal do Rio Grande do Sul; 2012.
17. Vuchkova J, Maybury TS, Farah CS. Testing the educational potential of 3D visualization software in oral radiographic interpretation. J Dent Educ. 2011;75:1417-25. R
18. Wu M, Zhang X, Koenig L, Lynch J, Wirtz T, Mao E, et al. Web-based training method

for interpretation of dental images. J Digit Imaging. 2010;23:493-500.
19. Pahinis K, Stokes CW, Walsh TF, Cannavina G. Evaluating a blended-learning course taught to different groups of learners in a dental school. J Dent Educ. 2007;71:269-78.
20. Salajan, F., Mount G. University of Toronto's dental school shows "new teeth": moving towards online instruction. J Dent Educ. 2008;72:532-42.
21. Al-jewair TS, Azarpazhooh A, Suri S, Shah PS. Computer-Assisted Learning in Orthodontic Education: A Systematic Review and Meta-Analysis. J Dent Educ. 2009;73:730-9.
22. Al-Jewair TS, Qutub AF, Malkhassian G, Dempster LJ. A systematic review of computer-assisted learning in endodontics education. J Dent Educ. 2010;74:601-11.
23. Schleyer TK, Johnson LA. Evaluation of educational software. J Dent Educ. 2003;67:1221-8.

Correspondence to:
Elza Bernardes Monier
e-mail: bernardes.elza@gmail.com
Av. da Paz, bloco A, ap 204, Cond Rei Salomão V, 65072-570 Parque Shalon - São Luís/MA Brazil