



Application of E-learning in Dental Radiology Education at undergraduate level –a Systematic Review

Aplicação do E-learning no Ensino de Radiologia Dentária em nível de graduação - uma Revisão Sistemática

Shishir SHETTY¹, Raghavendra SHETTY¹, Rahul HALKAI¹, Prathiba PRASAD¹, Pooja ADTANI¹, Sunaina SHETTY²

1 – College of Dentistry – Gulf Medical University – Ajman – United Arab Emirates.

2 – Maitri Dental College – Durg– India.

ABSTRACT

With the increase in internet technology as well as the electronic content the web-based learning has become the desirable medium in the field of education. In medical, dental and allied health science education, the conventional method involves the use of textbooks, lectures, and images. But trends suggest that a change is poised in this field. **Objective:** the systematic review aims to evaluate the literature of studies about the application of the e-Learning methods in radiology education at the undergraduate level in comparison to conventional teaching-learning methods. **Material and Methods:** prominent scientific databases were searched for literature related to the application of e-Learning in undergraduate radiology education. The search keywords used for the search were- E-learning, dental radiology, oral radiology, undergraduate. English language full text of eligible article was systematically reviewed. **Results:** seven full text articles were obtained after scrutiny of the available literature. Most of the research work was carried out in the past decade and dental schools in different parts of the world. Almost all the studies showed that e-learning was as either equally effective or more effective when compared to conventional teaching in dental radiology. **Conclusion:** e-learning could be a suitable alternative to conventional teaching-learning method with significant improvement in student attitude and knowledge however, the influence of e-learning in improving the practical or clinical skills of dental radiography is still debatable.

KEYWORDS

Online learning; Dental digital radiography; Dental digital radiography; Dental education.

RESUMO

Com o aumento da tecnologia da Internet, como também o conteúdo eletrônico da aprendizagem baseada na web, estes tornaram-se um meio desejável no campo da Educação. Em ciências médicas, odontológicas e afins, o método convencional envolve o uso de livros didáticos, palestras e imagens. Mas tendências sugerem que há uma mudança nesse campo. **Objetivos:** esta revisão sistemática visa avaliar literatura de estudos sobre a aplicação de métodos de e-Learning no ensino de radiologia no nível de graduação em comparação com os métodos convencional de ensino-aprendizagem. **Material e Métodos:** bases de dados científicas importantes foram pesquisadas sobre literatura relacionada à aplicação do e-Learning na graduação em radiologia. As palavras-chave usadas para a pesquisa foram: E-learning, radiologia dentária, radiologia oral, graduação. O texto completo do artigo elegível em inglês foi sistematicamente revisado. **Resultados:** sete textos completos foram obtidos após análise minuciosa da literatura. A maior parte dos trabalhos de pesquisa foi realizada na década passada em escolas de odontologia em diferentes partes do mundo. Quase todos os estudos mostraram que o e-learning era igualmente eficaz ou mais eficaz quando comparado ao ensino convencional em radiologia dentária. **Conclusão:** o e-learning pode ser uma alternativa adequada ao ensino-aprendizagem convencional, com melhoria significativa nas atitudes e conhecimentos aluno. No entanto, a influência de e-learning para melhorar as habilidades práticas ou clínicas da radiologia dentária ainda é discutível.

PALAVRAS-CHAVE

Aprendizagem online; Radiografia digital odontológica; Educação odontológica.

INTRODUCTION

With the upsurge in internet technology and growth in the electronic information the web-based learning has become the preferred medium in the field of education [1]. In medical education, the conventional method involves the use of textbooks, lectures, and images. Over the past few years, the internet revolution has influenced the medical education system [2]. In recent years there has been rapid progress in the quality imaging modalities and its influence on practice in medicine as well as dentistry [3]. Due to limited availability of experienced faculties in specialties such as dental radiology, oral medicine, and oral pathology countries like the United Kingdom, conventional teaching methods are being increasingly substituted using e-learning [4].

Over the past few years, there has been an increase in the number of research and publications e-learning in dentistry. The importance of incorporation of web-based learning into the dental curriculum was also highlighted in one report published on dental education published by the American Dental Education Association [5]. Digitization has contributed to in oral radiology to a massive extent. The major advantage of the digital imaging systems over the conventional ones is that they can be, stored, and transmitted through the internet [6]. Taking into consideration these advantages we conducted a systematic review was to analyze the effectiveness of e-learning and compared it with in-class traditional learning methods in oral radiology education dental students.

MATERIAL AND METHODS

A systematic review was performed to evaluate the e-learning methods in oral radiology compared to in-class traditional lecture learning method to improve learning using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [7]. The protocol was registered in Figshare database [8]. An Internet-based search was done using PUBMED, SCOPUS, Since-direct and Google scholar databases. The keywords used for the search are listed in (Table 1). The end search date was April 24, 2019, across the databases. Manuscripts fulfilling the following eligibility criteria were included in the final review. Studies that compared the conventional method of learning in dental radiology with e-learning methods were included to assess the effectiveness of e-learning over conventional methods. Only full text English language articles were included for the final review. Abstracts, thesis work and non-English language full-text articles were not eligible for the final review. (Figure 1) The risk of bias in the selected studies was carried out using the Cochrane Collaboration's tool [9]. (Table 2)

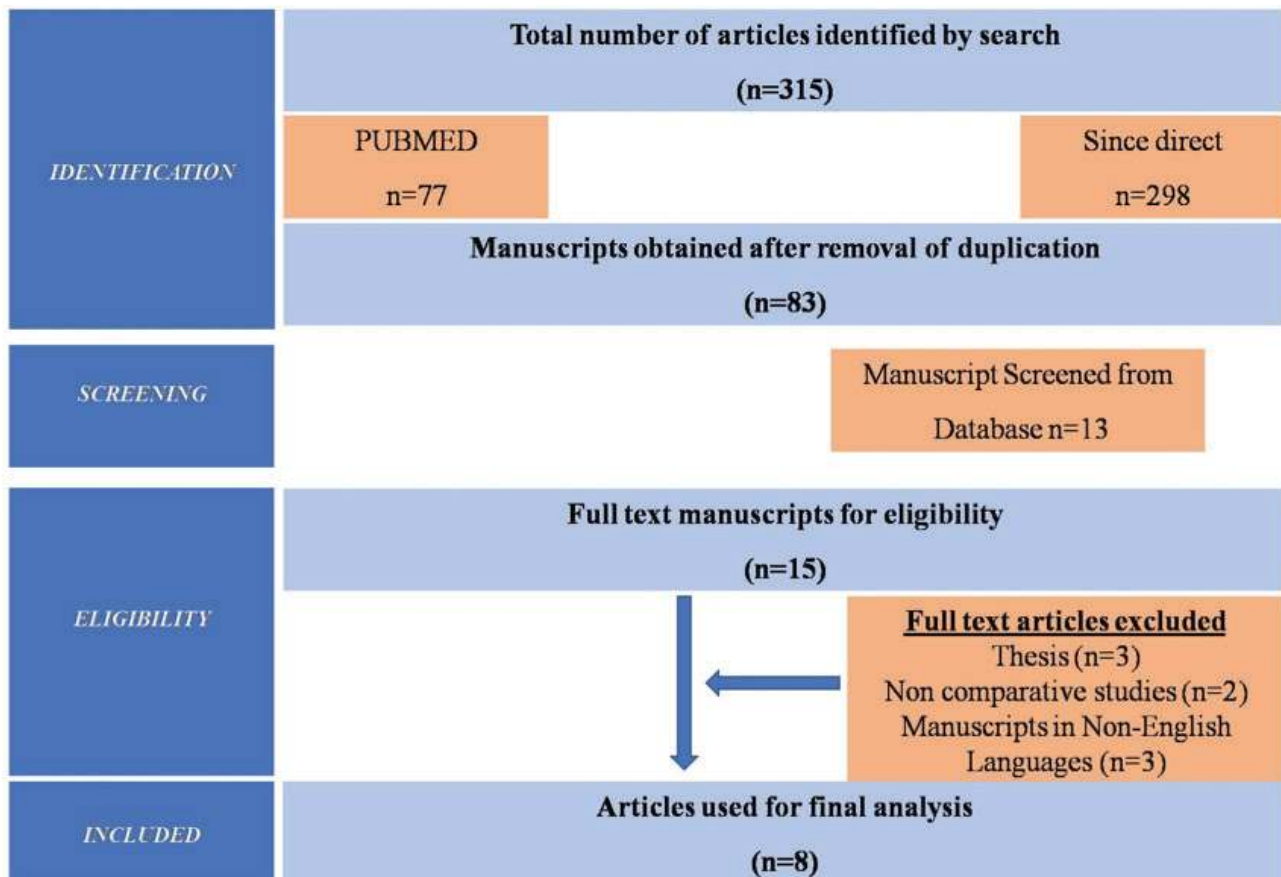


Figure 1 - Flowchart of systematic review process carried out using PRISMA guidelines.

The selection process was conducted in two phases. In the first phase, titles, and abstracts from the selected electronic databases were reviewed by 2 authors. Articles not full-filling the inclusion criteria were excluded from the review. In phase 2, the full-text articles obtained after filtering in phase 1, were evaluated by the same reviewers. In the case of a disagreement in the selection process between the two reviewers the two authors, a third author was called in to reach a consensus. Details about authors, year of publication, country, an e-learning portal, conventional learning method, educational status of the student, outcomes evaluation, results, and conclusion were evaluated. In case of any relevant missing

information the authors of the paper were contacted using email and the information was obtained. The effectiveness of e-learning in dental radiology education was evaluated based on Kirkpatrick's model of evaluation as demonstrated by Santos GN et al in their systematic review under 3 specific areas [6,13]. The primary factor to be evaluated was evaluated the attitude of the undergraduate student towards e-learning techniques employed in the studies. The second factor to be evaluated was, whether e-learning contributed a significant knowledge gain among the student population involved in the study and the third factor was whether it improved their performance in clinical situations[6].

RESULTS

Seventy-seven articles were obtained from the PUBMED search. In SCOPUS search fifty-five articles were obtained primarily with the above-mentioned keywords. Search in the ScienceDirect revealed 183 articles. A total of 315 articles were identified in the initial search. The number of eligible articles got reduced to 83 after deleting duplicated articles during the second stage of screening 13 full text articles were obtained. Two more articles were obtained from google search. During the third stage of determination of eligibility of the 8 articles were excluded which comprised articles in non-English languages, non-comparative studies and thesis works (Table 3, Figure 1). The earliest article was in the year 2002 and the most recent one in the year 2017. Over the past few years, there is an increase in the number of publications in this specific area of research. Two among the seven dental radiology e-learning studies were conducted in Europe, two each in North America and Asia South America and one study was conducted in South America. Of the seven full-text articles, three of them were published in dental education journals, three of them were published in dental imaging journal and one of them was published in dental applied research journal. In four of the studies, dental students were from the first and second semesters [4,12,13]. In two other studies third and final year dental students were involved. The level/year of study of the students was not mentioned in one of the studies. Blended learning option [face-to-face and e-learning] was used in two of the studies. Web-based learning tool was used in six of the studies, an interactive CD was used in one study. Detection of pathologic changes was the parameter used for the assessment of student performance in three studies. Basic of radiation physics and biology was assessed in two studies. The identification of

normal anatomical landmarks on radiographs was carried out in one study. Performing a radiographic procedure (full mouth radiographs) was carries in one study. When the quantity of knowledge gain (learning) was investigated in the seven studies six of them stated significant differences between e-learning whereas one study stated that there was not much difference between the conventional method and e-learning methods. The influence of web-based learning on the practical or clinical component of dental radiography was evaluated only in one of the studies considered for the systematic review.

Table 1 - list of keywords used for literature search in the scientific databases

Databases	Keywords used
PUBMED	dental radiology, oral radiology, maxillofacial radiology, craniofacial radiology, head and neck radiology, E-learning, Computed-aided learning, web-based interactive instruction, technology-enhanced learning, self instruction learning, blended learning, computer assisted learning, web based education, computational intelligence, machine learning, computer based learning, online learning, web based learning, Web-based Training
SCOPUS	dental radiology, oral radiology, maxillofacial radiology, craniofacial radiology, head and neck radiology, E-learning, Computed-aided learning, web-based interactive instruction, technology-enhanced learning, self instruction learning, blended learning, computer assisted learning, web based education, computational intelligence, machine learning, computer based learning, online learning, web based learning, Web-based Training
Google scholar and since direct	dental radiology, oral radiology, maxillofacial radiology, craniofacial radiology, head and neck radiology, E-learning, Computed-aided learning, web-based interactive instruction, technology-enhanced learning, self instruction learning, blended learning, computer assisted learning, web based education, computational intelligence, machine learning, computer based learning, online learning, web based learning, Web-based Training

Table 2 - The risk of bias in the selected studies were carried out using the Cochrane Collaboration's tool

Criteria	Chang HJ et al. 2017	Kavadella A et al. 2012	Tan PL et al.	Cruz AD et al. 2014	Ramesh A et al. 2016	Howerton et al. 2002	Wu M et al. 2010
Random sequence generation (selection bias)	Low	Low	Low	Low	Low	Low	Low
Allocation concealment (selection bias)	Low	Low	Low	Low	Low	Low	Low
Blinding of participants and researchers (performance bias)	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
Blinding of outcome assessment (detection bias)	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear
Incomplete outcome data (attrition bias)	Low	Low	Low	Low	Unclear	Low	Unclear
Selective reporting (reporting bias)	Low	Low	Low	Low	Unclear	Low	Unclear
Other bias	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear

Note: Articles were ranked on these three options: Low risk of bias (bias, if present, is unlikely to alter results seriously); Unclear risk of bias (a risk of bias that raises some doubt about the results); and High risk of bias (bias may alter the results seriously).

Table 3 - Summary of descriptive aspects of the studies included in the literature review

Authors	Journal	e-learning tool	Academic level of dental undergraduate student	Methods used Parameter used to assess the performance	Result	Outcome standard according to Kirkpatrick's criteria [17]		
						Reaction (Attitudes)	Learning (knowledge)	Behavior (clinical performance)
Chang HJ et al. 2017[9]	Imaging science in dentistry	Open-source software-learning management system (OSS-LMS).	Third year	Web based learning Detection of caries on panoramic radiograph on e-learning portal Moodle	The customized version of Moodle was effective in saving time and resources. It enabled training of dental students in a thorough and sequential pattern to interpret dental radiographs	✓	✓	X
A. Kavadella et al. 2012[10]	European journal of Dental education	Blended learning using the educational platform (learning management system, LMS)	Final year students	Blended learning on the course titled Differential diagnosis of mixed radiolucent-radiopaque bone lesions	The performance of the students in Students in the blended group was significantly better than the students comprising the conventional group	✓	✓	X

Authors	Journal	e-learning tool	Academic level of dental undergraduate student	Methods used Parameter used to assess the performance	Result	Outcome standard according to Kirkpatrick's criteria [17]		
						Yes (Y) No (X)		
						Reaction (Attitudes)	Learning (knowledge)	Behavior (clinical performance)
Tan PL et al. 2009[4]	Journal of Dental Education	Information Support Systems (ISS), King's College London Dental Institute	First year	Three options provided- 1) face to face lectures 2) blended learning [part face-to face lectures and part e-learning] 3) Complete e-learning	There was a positive response from the students. The results also emphasized that inspite of certain shortcomings e-learning could be fully implemented, without compromising the quality of learning.	✓	✓	X
Cruz AD et al. 2014[12]	Brazilian dental science	Moodle e-course (open-source software available in: http://moodle.com),	First and second semester students	Topic of radiation physics. Two groups of students subjected to conventional and e-learning mode method of teaching. Detection of anatomical landmarks on radiographs	The results obtained from the study revealed that the distance learning method using Moodle platform yielded the same results as obtained from a traditional educational methods	✓	✓	✓
Ramesh A et al. 2016[13]	Imaging science in dentistry	Learning Catalytics™ (LC) (Pearson, New York, NY, USA)	Second-year dental students.	The performance of the students in online quizzes and final exams Topics pertaining to dental radiology at three different levels ranging from radiation physics to diagnosis of anomalies and pathologies	The results obtained from the study revealed that LC system provided excellent enhancement of learning by improving communication between teacher and student	✓	✓	X

Authors	Journal	e-learning tool	Academic level of dental undergraduate student	Methods used Parameter used to assess the performance	Result	Outcome standard according to Kirkpatrick's criteria [17]		
						Yes (Y) No (X)		
						Reaction (Attitudes)	Learning (knowledge)	Behavior (clinical performance)
Hower-ton et al. 2002[21]	Journal of Dental Education	Interactive computer-assisted instructional module on CD	First-year dental students	Dental X-ray Training and Teaching Replica (DXTTR) Performance of full mouth radiograph	The results of the study showed that there was no significant difference in radiographic error points between the two groups. Dental students who reviewed the computer assisted instruction preferred using it and would recommend it to others before exposing their FMS.	✓	X	✓
Wu M et al. 2010[22]	Journal of digital imaging	Web-based tele-educational system for dental radiology developed by The Healthcare Informatics Program at the University of Wisconsin–Milwaukee (UWM) and the Dental Informatics Program at Marquette University School of Dentistry (MUSoD)	Dental undergraduate students (level not specified)	Interpret radiographic images. Students have place a mark as a region of interest on the digital dental image to identify the abnormality	The results of the study showed that The web-based training technique provided an alternative to conventional lecture sessions. The web based learning also mimics a one-on-one learning environment for the student.	✓	✓	X
Ramesh A et al. 2016[13]	Imaging science in dentistry	Learning Catalytics™ (LC) (Pearson, New York, NY, USA)	Second-year dental students.	The performance of the students in online quizzes and final exams Topics pertaining to dental radiology at three different levels ranging from radiation physics to diagnosis of anomalies and pathologies	The results obtained from the study revealed that LC system provided excellent enhancement of learning by improving communication between teacher and student	✓	✓	X

DISCUSSION

E-learning may be defined as any use of computers and networks in education in which the instructional content is delivered electronically as required by the learner [6]. The other synonyms used for e-learning are web-based learning, online learning, computer-assisted instruction, computer-assisted learning, and Internet-based learning [14-16]. During the initial search process of the review many of the above-mentioned synonyms were used to get the maximum number of the articles about this specific topic.

The application of e-learning techniques in dental radiology teaching is being carried out in dental schools in different parts of the world [4,10-13].

When the study outcomes were evaluated according to a well-known criterion it was found that in most studies the student had positive feedback on e-learning methods. This is a result of the ability of e-learning tools to visually display content efficiently and simultaneously boost the participation of students in learning activities [17,18]. A recently published systematic review revealed most of the papers were positive about the outcomes of the e-learning methods in dental radiology [19]. The Medline search engine was employed in their review. We conducted our study using PUBMED, SCOPUS and ScienceDirect search engine. The results of our review revealed that two of the studies revealed that the e-learning method was as effective as the conventional face to face interaction [4,11]. However, another review conducted in 2016 using multiple search engines- PubMed and SCOPUS databases revealed mixed results regarding the effectiveness of e-learning in dental radiology [6]. The number of full-text articles evaluated by them in the systematic review was 11 in contrast to 7 full text in our study. Santos GN et al used additional search engine LILACS and added (Spanish, Portuguese) language articles in their systematic review. Our systematic

review included only English language full texts. However, we were able to add two more studies published after September 2016 to our systematic review [7,13]. Like Santos GN et al. we adapted the Kirkpatrick's criteria for evaluation of the outcomes of the application of e-learning in our systematic review. The results of the study by Santos GN et al. revealed that e-learning was as either effective as conventional teaching methods or even better than the conventional teaching was evaluated in terms of student attitudes and knowledge gain [6]. A Similar pattern was observed in the analysis of the present review. The effectiveness of e-learning in practical or clinical part has been studied only in one research article included in our systematic review and in the review conducted by Santos GN et al. Howerton et al. conducted a study using Computer Assisted Instruction (CAI) module for dental students before they perform full-mouth intra-oral radiography. In their study, the number of errors in the radiograph of the students using the CAI module was like the one who received instructions by the conventional method. However, the students had a positive feedback regarding the CAI instruction module used in the study.

CONCLUSION

From the analysis of results obtained in the present review it can be concluded that e-learning can be as effective or even better than the conventional methods for teaching dental radiology. The method would be extremely beneficial in situations where the expertise in the subject is not available. However, number of comparative studies are required to arrive at a definite conclusion. E-learning seems to improve the knowledge component and interpretation skills of students in dental radiology. However further work needs to be carried-out to determine whether web-based teaching models can improve the radiography skills among students.

REFERENCES

- Zafar S, Safdar S, Zafar AN. Evaluation of use of e-Learning in undergraduate radiology education: A review. *Eur J Radiol*. 2014 Dec;83(12):2277-2287. doi: 10.1016/j.ejrad.2014.08.017. Epub 2014 Sep 6.
- Guliatto D, Boaventura RS, Maia MA, Rangayyan RM, Simedo MS, Macedo TA. Indian e-learning system for the interpretation of mammograms. *J Digit Imaging*. 2009 Aug;22(4):405-20. doi: 10.1007/s10278-008-9111-6. Epub 2008 Apr 19.
- Nyhsen CM, Lawson C, Higginson J. Radiology teaching for junior doctors: their expectations, preferences and suggestions for improvement. *Insights Imaging*. 2011 Jun;2(3):261-266. Epub 2011 Jan 29.
- Tan PL, Hay DB, Whaites E. Implementing E-Learning in a Radiological Science Course in Dental Education: A Short-Term Longitudinal Study. *J Dent Educ*. 2009 Oct;73(10):1202-12.
- McCann AL, Emet D, Hinton RJ, Schneiderman and Robert J. Hinton web-based learning E-Teaching and Learning Preferences of Dental and Dental Hygiene Students. *J Dent Educ*. 2010 Jan;74(1):65-78.
- Santos GN, Leite AF, Figueiredo PT, 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 Sep;80(9):1126-39.
- Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Open Med*. 2009;3(3):e123-30. Epub 2009 Jul 21.
- Figshare January 2012. At: <https://figshare.com/s/8eaab0b93c3943a2b370> Accessed 21 July 2019.
- Higgins JP, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomized trials. *BMJ*. 2011;343:d5928. doi: 10.1136/bmj.d5928.
- Chang HJ, Symkhampha K, Huh KH, YiWJ, Heo MS, Lee SS, et al. The development of a learning management system for dental radiology education: A technical report. *Imaging Sci Dent*. 2017 Mar;47(1):51-55. doi: 10.5624/isd.2017.47.1.51. Epub 2017 Mar 21.
- 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 Feb;16(1):e88-95. doi: 10.1111/j.1600-0579.2011.00680.x. Epub 2011 Feb 17.
- Cruz AD, Costa JJ, Almeida SM. Distance learning in dental radiology: immediate impact of the implementation. *Braz Dent Sci*. 2014;17(4):90-7. doi: 10.14295/bds.2014.v17i4.930.
- Ramesh A, Ganguly R. Interactive learning in oral and maxillofacial radiology. *Imaging Sci Dent*. 2016 Sep;46(3):211-6. doi: 10.5624/isd.2016.46.3.211. Epub 2016 Sep 20.
- Al-Rawi WT, Easterling L, Edwards PC. Development of a mobile device optimized cross platform-compatible oral pathology and radiology spaced repetition system for dental education. *J Dent Educ*. 2015 Apr;79(4):439-47.
- Al-Rawi WT, Jacobs R, Hassan BA, Sanderink G, Scarfe WC. Evaluation of web-based instruction for anatomical interpretation in maxillofacial cone beam computed tomography. *Dentomaxillofac Radiol*. 2007 Dec;36(8):459-64.
- Mattheos N, Stefanovic N, Apse P, Atstrom R, Buchanan J, Brown P, et al. Potential of information technology in dental education. *Eur J Dent Educ*. 2008 Feb;12 Suppl 1:85-92. doi: 10.1111/j.1600-0579.2007.00483.x.
- 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 Craniomaxillofac Surg*. 2011 Jan;39(1):40-8. doi: 10.1016/j.jcms.2010.03.008. Epub 2010 May 7.
- Vuchkova J, Maybury T, Farah CS. Digital interactive learning of oral radiographic anatomy. *Eur J Dent Educ*. 2012 Feb;16(1):e79-87. doi: 10.1111/j.1600-0579.2011.00679.x. Epub 2011 Feb 17.
- Bothelo MG, Aggarwal KR, Bornstein M. An systematic review of e-learning outcomes in undergraduate dental radiology curricula—levels of learning and implications for researchers and curriculum planners. *Dentomaxillofac Radiol*. 2018 Aug 1;20180027. doi: 10.1259/dmfr.20180027. [Epub ahead of print]
- Kirkpatrick DL, Kirkpatrick J. Evaluating training programs: the four levels. San Francisco: Berrett-Koehler; 1994.
- Howerton WB Jr, Platin E, Ludlow J, Tyndall DA. The influence of computer-assisted instruction on acquiring early skills in intraoral radiography. *J Dent Educ*. 2002 Oct;66(10):1154-8.
- 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 Aug;23(4):493-500. doi: 10.1007/s10278-009-9223-7. Epub 2009 Jul 8.

Dr Shishir Ram Shetty
(Corresponding address)

College of Dentistry
Gulf Medical University
Ajman, United Arab Emirates
E-mail: shishirshettyomr@gmail.com

Date submitted: 2019 Apr 24

Accept submission: 2019 Jul 29