European Annals of Dental Sciences
Official Publication of Ankara University, Faculty of Dentistry

EADS, 2024, 51 (Suppl), S4–6

e-ISSN : 2757-6744
doi : 10.52037/eads.2024.0029

Article Received/Accepted : September, 15 2024 / December, 25 2024

CONGRESS PROCEEDING

New Radiological Approaches in Dental Education

İrem Öztürk [1,*] and Kaan Orhan [1,2,3]

[1]1Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Ankara University, Ankara, Turkey and
[2]2Department of Dental and Maxillofacial Radiodiagnostics, Medical University of Lublin, Lublin, Poland and
[3]3Ankara University Medical Design Application and Research Center (MEDITAM), Ankara, Turkey

*Corresponding Author; iremozturk96@hotmail.com

Abstract

Purpose: Today, dentistry education is undergoing constant renewal, driven by the rapid advancements in technology. Among the most significant of these innovations are the remarkable strides in radiological imaging techniques, which have fundamentally transformed the way dental professionals are trained and practice their skills. The integration of cutting-edge technologies such as digital radiography, 3D imaging, and artificial intelligence (AI)-assisted diagnostic tools has opened new frontiers in dental education, offering enhanced visualization, precision, and diagnostic capabilities. These advancements not only provide students with a deeper understanding of oral structures and pathology but also equip them with practical experience that mirrors real-world clinical scenarios. This review aims to comprehensively evaluate the incorporation of these novel radiological approaches into dentistry education and analyze their effects on student learning outcomes, diagnostic accuracy, and clinical efficiency. Additionally, it seeks to explore the broader implications of these technologies in shaping the future of dental practice and improving patient care.
These technologies aim to address critical gaps in traditional dental education, such as limited diagnostic precision, insufficient exposure to complex clinical cases, and the lack of hands-on experience with advanced imaging tools, thereby enhancing both the quality and relevance of student training.
Objective and Method: : The purpose of this review is to discuss current studies on how new radiologic approaches in dentistry, especially artificial intelligence and its products, can provide differences and advantages in the field of education and it is a general literature review.. It is also aimed to give ideas about future studies and developments. It is to present a brief summary of recent studies on this subject. For this purpose, keywords such as dentistry education, ai, training, undergraduate students, new approaches , radiology, technology ,cbct, vr,ar were written to Pubmed. Original research and systematic reviews were included. We used various combinations of keywords. We obtained titles from the studies that emerged as a result of these combinations. In total, we obtained 380 articles with different combinations of 2 and 3 words. We removed the ones that were not directly related to radiology, those that were not in English, and those that were published before the last 6 years. In total, we were left with 34 different publications.
Results: We can address new radiological approaches under 5 basic headings. Digital Imaging, Three-Dimensional Imaging (CBCT - Cone Beam Computed Tomography), Artificial Intelligence-Assisted Image Processing, Digital Implant Planning and Augmented Reality (AR) and Virtual Reality (VR).

Key words: ai, ar, cbct, dentistry education, radiology, technology, vr

Introduction

Digital imaging is the process of recording and processing objects or scenes in digital format. This technology is often used in medical, industrial and scientific fields. For example, in dentistry, digital imaging allows high-resolution images of teeth and oral structures to be obtained with tools such as intraoral scanners and digital X-rays. This allows more accurate diagnoses to be made and treatment planning to be carried out more effectively. [1]

Digital imaging offers significant advantages in modern dentistry. For instance, digital radiography can reduce radiation doses by 50-80% compared to traditional film methods, minimizing patients' exposure to radiation . Additionally, digital images can be viewed instantly, significantly reducing patients' waiting times . By eliminating the need for chemical processing and darkroom requirements, it makes the imaging process more reliable. [2] Digital images also allow for easy adjustments to features like contrast and sharpness, enabling clearer images without additional radiation ex-

posure.[2] Finally, the ability to store and share digital images easily in a computer environment greatly facilitates access and management.[3] For these reasons, digital imaging has become a preferred method in dentistry.

The advantages of Cone Beam Computed Tomography (CBCT) include: Enhanced Visualization: CBCT provides high-resolution 3D images that allow for detailed anatomical analysis, which is particularly beneficial in dental and maxillofacial applications.[4]Reduced Radiation Exposure: Compared to traditional CT scans, CBCT typically exposes patients to lower doses of radiation, making it a safer option for imaging.[5] Multiplanar Reconstruction: CBCT allows for the reconstruction of images in multiple planes (axial, coronal, and sagittal), facilitating comprehensive evaluation of complex anatomical structures . Improved Diagnosis: The detailed imaging capabilities of CBCT enhance the accuracy of diagnoses, particularly in identifying conditions such as impacted teeth, root canal issues, and airway analysis.[6] Integration in Education: CBCT technology is increasingly being integrated into dental education, providing students with advanced tools for learning and understanding anatomical details .Legal and Forensic Applications: CBCT is also utilized in legal and forensic medicine for its effective analysis of anatomical details, which can be crucial in various investigations .These advantages highlight the growing importance of CBCT in both clinical practice and educational settings.[7]

Despite the significant potential, AI solutions have not yet become widely integrated into routine medical practice. In dentistry, for instance, convolutional neural networks have primarily been employed in research environments since 2015, mostly focusing on dental radiographs. Only recently have these technologies begun to be applied in clinical settings.[8] This is especially surprising given that dentistry is particularly well-suited for AI applications: 1) Imagery is fundamental to dentistry, playing a crucial role throughout the patient's dental journey, from initial screening to treatment planning and execution. 2) Dentistry frequently involves using different imaging modalities from the same anatomical region of the same patient, often supplemented by non-imaging data like clinical records, medical and dental histories, systemic health conditions, and medications. Additionally, data are often collected over multiple time points. AI has the capacity to integrate and analyze these diverse data sets, enhancing diagnosis, prediction, and clinical decision-making. 3) Many dental conditions, such as caries, apical lesions, and periodontal bone loss, are relatively common. Therefore, building large datasets with numerous "affected" cases can be accomplished without excessive difficulty. We identify three main factors that explain why dentistry has not fully embraced AI technologies. Addressing these issues will help to improve dental AI technologies and promote their adoption in clinical practice.

AI offers several benefits for dental education, significantly enhancing both the learning experience and student outcomes. One of the key advantages is personalized learning, where AI can tailor educational materials to meet the specific needs of individual students, thereby improving their understanding and retention of complex concepts.[9] Additionally, interactive simulations powered by AI, such as virtual reality (VR) simulations, allow students to practice procedures in a risk-free environment. This not only boosts their practical skills but also enhances their confidence in performing real-world tasks.[9] Another important application is automated feedback, as AI systems can provide immediate and constructive feedback on student performance, helping students pinpoint areas for improvement and fostering self-directed learning. Furthermore, AI tools can enhance communication between educators and students, ensuring that information is conveyed clearly and effectively, thus reducing misunderstandings and facilitating better learning outcomes. Lastly, AI can assist in data analysis for curriculum improvement, by examining student performance data to identify trends and gaps in knowledge. This valuable insight allows educators to refine curricula and teaching methods, ensuring that the learning experience is continually evolving to meet the needs of students.[9] Overall, these applications aim to create a more effective and engaging learning environment, ultimately leading to better-prepared dental professionals.

Digital Implant Planning The widespread integration of digital technology into oral implantology has significantly facilitated implant surgery and prosthetic treatments.[10] Digital technology plays a crucial role throughout the implant process, including data collection, virtual patient creation through information integration, the execution of surgical procedures, and subsequent implant restorations. A comprehensive review of developments in digital technology within implantology has found that it is continually updated and renewed based on previous methods or the creation of new digital techniques.[11]

Digital implant planning holds an important place in dental education, offering several advantages for teaching students modern dental practices. One of the key benefits is the use of advanced learning tools, as digital technologies provide tools such as 3D modeling and simulations. These tools help students better understand the implant placement process, allowing theoretical knowledge to be reinforced with practical applications.[12]

Moreover, digital implant planning teaches students how to plan the implant placement process with greater precision, which contributes to the development of their clinical skills. Additionally, digital workflows help students manage treatment processes more quickly and efficiently, enhancing their clinical experience and increasing patient acceptance rates.[12]

Another significant advantage is that digital implant planning provides students with knowledge about cost-effectiveness and resource management, helping them make more informed decisions in their future practices.[12] For these reasons, digital implant planning is considered an essential component of dental education.

Augmented Reality (AR) can be defined as a technological tool and offers the user an experience in a physical environment. This experience usually occurs through electronic devices such as mobile phones or tablets. AR offers different solutions by being used in various fields such as gaming, education, architecture, design, and health. Especially in education, it is possible to develop traditional narrative models with AR and to offer students visually and auditorily rich applications. Virtual Reality (VR) technology offers the user a virtual universe experience and is usually experienced using VR glasses. This new form of reality is associated with a concept called "Metaverse" and its use is foreseen to increase in the future. The user is in a three-dimensional world thanks to VR glasses. This new perception of reality has inspired various research areas and VR has begun to be used effectively in many sectors. In 2004, Le Blanc et al. conducted a study with second-year dentistry students at Columbia University, and provided one group with 110 hours of traditional preclinical laboratory training, while another group received 6-10 hours of simulation clinic training in addition to this training. In the evaluations made at the end of the year, it was observed that the students who received simulation training achieved higher grades.[13]

Conclusion

Many new approaches are being utilized today. In a changing world, it is necessary and inevitable to be open to new developments in education and to benefit from advancements in technology and software alongside traditional materials in radiology education. In light of the studies conducted, there is a growing need for more research and progress in this field in the near future, requiring a greater number and variety of studies. For instance, controlled studies could be conducted to better evaluate the educational effectiveness of these technologies, or studies directly comparing existing approaches could be included. Additionally, this study is merely a general literature review. An increasing number of studies are being published on the subheadings discussed here, and based

on these current studies, it is recommended to identify specific topics and conduct more detailed reviews at the systematic review level.

Author Contributions

Detailed literature review and compilation : I.O.
Manuscript preparation and editing : All authors

Conflict of Interest

There is no conflict of interest.

Acknowledgements

This material was previously presented as an oral presentation at the UDEG 2nd International Dentistry Education Congress on 22-24 February 2024.

Authors' ORCID(s)

I.O. 0000-0002-6496-6977
K.O. 0000-0001-6768-0176

References

1. Garrett PH, Faraone KL, Patzelt SB, Keaser ML. Comparison of dental students' self-directed, faculty, and software-based assessments of dental anatomy wax-ups: a retrospective study. J Dent Educ. 2015;79(12):1437–1444. doi:10.1002/j.0022-0337.2015.79.12.tb06043.x.
2. Shah N, Bansal N, Logani A. Recent advances in imaging technologies in dentistry. World J Radiol. 2014;6(10):794. doi:10.4329/wjr.v6.i10.794.
3. Nair M, Nair U, Gröndahl H, Webber R. Accuracy of tuned aperture computed tomography in the diagnosis of radicular fractures in non-restored maxillary anterior teeth—an in vitro study. Dentomaxillofac Radiol. 2002;31(5):299–304. doi:10.1038/sj.dmfr.4600712.
4. Angel JS, Mincer HH, Chaudhry J, Scarbecz M. Cone-beam Computed Tomography for analyzing variations in inferior alveolar canal location in adults in relation to age and sex. J Forensic Sci. 2011;56(1):216–219. doi:10.1111/j.1556-4029.2010.01508.x.
5. Corte-Real A, Pedrosa D, Saraiva J, Caetano C, Vieira DN. Tridimensional pattern analysis of foodstuff bitemarks—a pilot study of tomographic database. Forensic Sci Int. 2018;288:304–309. doi:10.1016/j.forsciint.2018.04.022.
6. Figueiredo C, Coelho J, Pedrosa D, Caetano C, Corte-Real F, Vieira DN, et al. Dental evaluation specificity in orofacial damage assessment: A serial case study. J Forensic Leg Med. 2019;68:101861. doi:10.1016/j.jflm.2019.101861.
7. Parashar V, Whaites E, Monsour P, Chaudhry J, Geist JR. Cone beam computed tomography in dental education: a survey of US, UK, and Australian dental schools. J Dent Educ. 2012;76(11):1443–1447. doi:10.1002/j.0022-0337.2012.76.11.tb05405.x.
8. Schwendicke F, Golla T, Dreher M, Krois J. Convolutional neural networks for dental image diagnostics: A scoping review. J Dent. 2019;91:103226. doi:10.1016/j.jdent.2019.103226.
9. Thorat V, Rao P, Joshi N, Talreja P, Shetty AR. Role of Artificial Intelligence (AI) in Patient Education and Communication in Dentistry. Cureus. 2024;16(5). doi:10.7759/cureus.59799.
10. D'haese J, Ackhurst J, Wismeijer D, De Bruyn H, Tahmaseb A. Current state of the art of computer-guided implant surgery. Periodontol 2000. 2017;73(1):121–133. doi:10.1111/prd.12175.
11. Chackartchi T, Romanos GE, Parkanyi L, Schwarz F, Sculean A. Reducing errors in guided implant surgery to optimize treatment outcomes. Periodontol 2000. 2022;88(1):64–72. doi:10.1111/prd.12411.
12. Joda T, Brägger U. Digital vs. conventional implant prosthetic workflows: a cost/time analysis. Clin Oral Implants Res. 2015;26(12):1430–1435. doi:10.1111/clr.12476.
13. LeBlanc VR, Urbankova A, Hadavi F, Lichtenthal RM. A preliminary study in using virtual reality to train dental students. J Dent Educ. 2004;68(3):378–383. doi:10.1002/j.0022-0337.2004.68.3.tb03754.x.