Journal of Advanced Medical and Dental Sciences Research
@Society of Scientific Research and Studies NLM ID: 101716117

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Indian Citation Index (ICI) Index Copernicus value = 100

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Original Research

Artificial Intelligence: The paradigm shift for future

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ABSTRACT:
Advancements in the field of science & technology has led to the implementation of newer application-based artificial intelligence (AI) in dental and medical sciences. Artificial Intelligence (AI) possess the potential to process huge datasets, disclose human essence computationally and perform like humans as technology advances. AI-technology has been employed in a wide range of applications related to the diagnosis of oral diseases and other aspects of dentistry that have demonstrated phenomenal precision and accuracy in their performance. . In the domains of dentistry, artificial intelligence has yet to come a long way. As a result, dentists must be aware of the potential implications for a profitable clinical practice in the future.
Keywords: Artificial Intelligence (AI), Dentistry, machine learning, neural network, evidence based dentistry

Received: 12 October, 2023 Accepted: 18 November, 2023

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This article may be cited as: Kamboj S, Sandal B, Arora A, Kaur R, Sachdeva G, Thakur A. Artificial Intelligence: The paradigm shift for future. J Adv Med Dent Scie Res 2023;11(12):61-65.

INTRODUCTION

Technological advancements in recent years have revolutionized the field of medicine and dentistry. Newer technologies are being consistently developed based on the principles that try to mimic the human brain functioning to develop solutions that do not just follow pre programmed instructions, but also have some traits of the human's such as the reasoning ability and experienced learning. One such thing which has come up in the recent decades is the use of artificial intelligence in dentistry. Artificial intelligence (AI) has emerged throughout the world to mimic human intelligence and tackle certain challenges [1]. Artificial intelligence in the field of medicine and dentistry benefitted healthcare professionals, to improve patient healthcare services and may serve as a great tool. One of its definitions [2] is "the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision making, and translation between languages". Many studies on AI applications in dentistry are undergoing or even have been put into practice in the aspects such as diagnosis, decision-making, treatment planning, prediction of treatment outcome, and disease prognosis

HISTORY OF AI

Artificial intelligence is not a new term. Alan Turing wrote in his paper "Computing Machinery and Intelligence" [3] in the 1950 issue of Mind: "I believe that at the end of the century (20th), the use of words and general educated opinion will have altered so much that one will be able to speak of machines thinking without expecting to be contradicted."Back then, there was no term to interpret AI; Turing described AI as "machines thinking". He mathematically investigated the feasibility of AI and explored how to construct intelligent machines and assess machine intelligence.Later, in 1955, the term AI was first proposed in a 2-month workshop: Dartmouth Summer Research Project on Artificial Intelligence [4] led by John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon. From 1957 to 1974, the AI field was fast-growing because of the growth of computer power, its accessibility, and AI algorithms. Examples include ELIZA, a computer program that could interpret spoken language and solve problems via text [5]. However, AI had its breakthrough between the two periods with very few developments. In the 1980s, it developed through two paths: machine learning (ML) and expert systems. They are two opposite approaches to AI considering their theory. ML allows computers to learn by experience [6]; expert systems, on the contrary, simulate the decision-making process of human experts [7]. In other words, ML finds the solution by learning and summarizing the experience by itself, while expert systems need human experts to input all possible situations and solutions in advance. Expert systems have largely been used in industry since then. The example includes R1 (Xcon) program, an expert system with around 2,500 rules for assisting components selection for computer assembly was developed [8] and used by DEC, a computer manufacturer. Later famous AI examples include Deep Blue—a chess-playing expert system, which defeated chess champion of the time Gary Kasparov in 1997 [9]; 20 years later in 2017, Google's AlphaGo, a DL program, defeated the world No. 1 ranked player Jie Ke in a Go match [10]; recently in late 2022, Open AI launched Chat GPT (Chat Generative Pre-trained Transformer), it is a text-generation model that can generate human-like responses based on text input, the model received extensive discussion since its launch [11]. These examples used different AI approaches to operate.

CLASSIFICATION OF AI

AIs are commonly categorized into three types: artificial narrow intelligence (ANI), artificial general intelligence (AGI), and artificial super intelligence (ASI). ANI, known as weak AI, possesses narrow abilities suitable for very specific tasks. These systems do not perform outside the single task for which they are designed [12]. For clinical purposes in dentistry (e.g., cone beam computed tomography (CBCT), 3D convolutional neural networks (3D CNN)) is more suitable for more complex AI implementations. These are frequently applied even in interdisciplinary fields, such as forensic dentistry. AGI known as "strong" or "deep AI" is about as capable of solving problems as a human [13]ASI will exceed human capabilities and will be able to learn and improve itself beyond our comprehension [12]

AI IN OPERATIVE DENTISTRY

Detecting early-stage lesions is challenging when deep fissures, tight interproximal contacts, and secondary lesions are present. Eventually, many lesions are detected only in the advanced stages of dental caries, leading to a more complicated treatment, i.e., dental crown, root canal therapy, or even implant. Although dental radiography (whether panoramic, periapical, or bitewing views) and explorer (or dental probe) have been widely used and regarded as highly reliable diagnostic tools detecting dental caries, much of the screening and final diagnosis tends to rely on dentists' experience. In a two-dimensional (2D) radiograph, each pixel of the grayscale image has intensity, i.e., brightness, which represents the density of the object. By learning from the abovementioned characteristics, an AI algorithm can learn the pattern and give predictions to segment the tooth, detect caries, etc. For example, Lee et al. [14] developed a CNN algorithm to detect dental caries on periapical radiographs. Kühnisch et al. [15] proposed a CNN algorithm to detect caries on intraoral images. Schwendicke et al.[16] compared the cost-effectiveness of AI for proximal caries detection with dentists' diagnosis; the results showed that AI was more effective and less costly.

AI IN CONSERVATIVE DENTISTRY AND ENDODONTICS

For screening and diagnosis of dental caries, dental probes are most used. This is aided by observation of the texture and discoloration of tooth structure based on which one can determine whether the tooth is sound or not. Nevertheless, this method is very subjective and is based on the dentist's experience. In particular, the proximal surfaces may be problematic in dental examination [17]. Neural network use in conservative dentistry has developed quickly. Algorithms can be used to locate the edges of anatomical and pathological structures, which might be very similar to each other due to the image noise and low contrast [18].AI can be useful in detecting periapical lesions and root fractures, root canal system anatomy evaluation, predicting the viability of dental pulp stem cells, determining working length measurements, and predicting the success of retreatment procedures [19]. To reveal periapical translucencies, most are taken as periapical or panoramic radiographs and cone-beam computed tomographic images. Setzer et al. in their research used deep learning to detect periapical lesions on cone-beam computed tomographic (CBCT) images. The accuracy of finding the lesions was 93% [20]. AI technology has also proven to be very efficient in comparison to periapical radiographs in diagnosing vertical root fractures on CBCT images [21].

AI IN ORTHODONTICS

Li P et al. used an ANN in their study to predict whether patients need extractions or not in their treatment plan. Moreover, they took the anchorage patterns into consideration. The accuracy of the artificial neural network in the success of the treatment plan was 94.0% for extractions and 92.8% in the prediction of the use of maximum anchorage. These results indicate that ANN can be used by orthodontists to make more precise treatment plans [22]. In addition, ANN may help in the determination of the growth and development periods. The growth-development periods and gender were determined from the cervical vertebrae by using ANN and the accuracy value of the results was found to be 94.27%[23]

AI IN PERIODONTICS

Krois et al. evaluated panoramic radiographs with the help of convolutional neural networks to detect periodontal bone loss in percentage of the tooth root length. The results were compared with the measures made by six experienced dentists. The CNN had higher accuracy (83%) and reliability than the dentists (80%) in detecting periodontal bone loss [24]. Peri-implant bone loss can be detected on dental periapical radiographs, but the difficulty is that the margins of bone around the implants are usually unclear, or the margins can overlap. For this reason, convolutional neural networks can assess the marginal bone level, top, and apex of implants on dental periapical radiographs. In the study by Jun-Young Cha et al., the bone loss percentage was calculated and classified by the automated system. This method can be used to assess the severity of peri-implantitis [25].

AI IN ORAL SURGERY

Extraction of the lower third molar is one of the most popular dental surgery procedures. The paresthesia of the nerve after mandible wisdom tooth extraction is quite a common complication [26]. In Byung Su Kim et al.'s work, convolutional neural networks were used to predict whether third molar extraction may lead to paresthesia of the inferior alveolar nerve. The panoramic images were used before the extraction and the anatomical relationship between the nerve canal and dental roots was used by the CNN to predict the occurrence of nerve paresthesia. However, the authors concluded that two dimensioned images as panoramic radiographs may lead to falser positive and false negative results [27]. Other applications for AI in maxillofacial surgery include predicting results and planning orthognathic and craniofacial surgical procedures (i.e., after skeletal trauma) with the use of digital imaging, photographs, 3D photography and intraoral scans [28].

AI IN PROSTHODONTICS

AI is used during the scanning process to automatically remove excess soft tissues and material [12]. Artificial intelligence can also be used to predict debonding of CAD/CAM restorations based on die images [29]. In removable prosthodontics, dental arches can be classified with the use of CNN [30]. AI can help with precise shade matching [31]. Various manufacturers provide software that uses AI to facilitate the smile-designing process [32].

AI IN ORAL AND MAXILLOFACIAL PATHOLOGY

AI has been researched mostly for tumour and cancer detection based on radiographic, microscopic and ultrasonographic images. Besides, abnormal locations can also be detected from radiographs by AI [33], such as nerves in the oral cavity, interdigitated tongue muscles, and parotid and salivary glands. CNN algorithms were demonstrated to be a suitable tool for the automatically detecting cancers [34, 35]. It is worth mentioning that AI also plays a role in managing cleft lip and palate in risk prediction, diagnosis, pre-surgical orthopaedics, speech assessment, and surgery [36]. Early detection and diagnosis of various mucosal lesions are essential to classify benign or malignant. Surgery resection is required for malignant lesions. However, some of the lesions behave similarly in appearance, thus requiring the diagnosis by biopsy slides and radiographs. Pathologists diagnose disease by observing the morphology of stained specimens on glass slides using microscopic [37]. It is tedious work that requires much of effort for pathologists. Of all the biopsies that need to be examined, only around 20% of them are found to be malignancies. Thus, AI can be a suitable tool for aiding pathologists in this task. Warin et al. [38] used a CNN approach to detect oral potentially malignant disorders (OPMDs) and oral squamous cell carcinoma (OSCC) in intraoral optical images. In addition to intraoral optical images, OCT has been used in identify benign and malignant lesions in the oral mucosa. James et al. [39] used ANN and SVM models to distinguish malignant and dysplastic oral lesions. Heidari et al. [40] used a CNN network, Alex Net (17), to distinguish normal and abnormal head and neck mucosa. Abureville et al.[34] used a CNN algorithm to automatically diagnose oral squamous cell carcinoma (SCC) from confocal laser endomicroscopy images; the study showed that the CNN algorithm used in the study was especially suitable for early diagnosis of SCC. Poedjiastoeti et al. [41] also used a CNN algorithm to identify and distinguish ameloblastoma and keratocystic odontogenic tumour (KCOT). The two oral tumours with similar features in radiographic images. By comparing the computer-generated results with the biopsy results, the accuracy of the CNN algorithm was found to be 83% and the diagnostic time 38 s. These values were similar to those of oral and maxillofacial specialists

CONCLUSION

With the advancements in science and technology, newer technologies are developed and adopted rapidly in the dental field. AI is among the most promising ones. Although multiple studies have shown potential applications of AI in dentistry, these systems are far from being able to replace dental professionals. Rather, the use of AI should be viewed as a complementary asset, to assist dentists and specialists. The road to successful integration of AI into dentistry will necessitate training in dental and continuing education, a challenge that most institutions are not currently prepared for. The only limitations currently AI have the insufficient data and expensive installation. Therefore dentist, clinicians and Computer science engineers must perform tasks together for providing quality treatment to society

REFERENCES

1. W. J. Park and J.-B. Park, "History and application of artificial neural networks in dentistry," European Journal of Dentistry, vol. 12, no. 4, pp. 594–601, 2018.

2. Stevenson A. Oxford Dictionary of English. USA: Oxford University Press (2010).
3. Turing AM, Haugeland J. Computing machinery and intelligence. MA: MIT Press Cambridge (1950)
4. McCarthy J, Minsky M, Rochester N, Shannon CE. A proposal for the dartmouth summer research project on artificial intelligence. AI magazine. (2006) 27(4):12–14.
5. Weizenbaum J. ELIZA—a computer program for the study of natural language communication between man and machine. Commun ACM. (1966) 9(1):36–45.
6. Schmidhuber J. Deep learning. Scholarpedia. (2015) 10(11):32832.
7. Liebowitz J. Expert systems: a short introduction. Eng Fract Mech. (1995) 50(5– 6):601–7.
8. McDermott JP. RI: an expert in the computer systems domain. AAAI Conference on artificial intelligence (1980).
9. Campbell M, Hoane Jr AJ, Hsu F-h. Deep blue. Artif Intell. (2002) 134(1– 2):57–83.
10. Chao X, Kou G, Li T, Peng Y. Jie ke versus AlphaGo: a ranking approach using decision making method for large-scale data with incomplete information. Eur J Oper Res. (2018) 265(1):239–47.
11. Chao X, Kou G, Li T, Peng Y. Jie ke versus AlphaGo: a ranking approach using decision making method for large-scale data with incomplete information. Eur J Oper Res. (2018) 265(1):239–47.
12. Open AI. Chat GPT. Optimizing language, odels for dialogue. Available at: https://openai.com/blog/chatgpt/ (accessed on 7 February 2023).
13. Thurzo A, Urbanová W, Novák B, Czako L, Siebert T, et al. (2022) Where Is the Artificial Intelligence Applied in Dentistry? Systematic Review and Literature Analysis. Healthcare Basel 10(7): 1269
14. Thurzo A, Jančovičová V, Hain M, Thurzo M, Novák B, et al. (2022) Human Remains Identification Using Micro-CT, Chemometric and AI Methods in Forensic Experimental Reconstruction of Dental Patterns after Concentrated Sulphuric Acid Significant Impact. Molecules 27(13): 4035
15. Lee J-H, Kim D-H, Jeong S-N, Choi S-H. Detection and diagnosis of dental caries using a deep learning-based convolutional neural network algorithm. J Dent. (2018) 77:106–11. Kühnisch J, Meyer O, Hesenius M, Hickel R, Gruhn V. Caries detection on intraoral images using artificial intelligence. J Dent Res. (2021) 101(2).
16. Schwendicke F, Rossi J, Göstemeyer G, Elhennawy K, Cantu A, Gaudin R, et al. Cost-effectiveness of artificial intelligence for proximal caries detection. J Dent Res. (2021) 100(4):369–76.
17. Beltrán Aguilar ED, Barker LK, Canto MT, Dye BA, Gooch BF, et al. (2005) Centers for Disease Control and Prevention (CDC). Surveillance for dental caries, dental sealants, tooth retention, edentulism, and enamel fluorosis--United States, 1988-1994 and 1999-2002. MMWR Surveill Summ 54(3): 1-43.
18. Gravel P, Beaudoin G, De Guise JA (2004) A method for modeling noise in medical images. IEEE Trans Med Imaging 23(10): 1221-1232.
19. Aminoshariae A, Kulild J, Nagendrababu V (2021) Artificial Intelligence in Endodontics: Current Applications and Future Directions. J Endod 47(9): 1352-1357.
20. Setzer FC, Shi KJ, Zhang Z, Yan H, Yoon H, et al. (2020) Artificial Intelligence for the Computer-aided Detection of Periapical Lesions in Cone-beam Computed Tomographic Images. J Endod 46(7): 987-993.
21. Fukuda M, Inamoto K, Shibata N, Ariji Y, Yanashita Y, et al. (2020) Evaluation of an artificial intelligence system for detecting vertical root fracture on panoramic radiography. Oral Radiol 36(4): 337-343.
22. Li P, Kong D, Tang T, Su D, Yang P, et al. (2019) Orthodontic Treatment Planning based on Artificial Neural Networks. Sci Rep 9(1):2037
23. Kök H, Izgi MS, Acilar AM (2021) Determination of growth and development periods in orthodontics with artificial neural network. Orthod Craniofac Res 24 Suppl 2: 76-83.
24. Krois J, Ekert T, Meinhold L, Golla T, Kharbot B, et al. (2019) Deep Learning for the Radiographic Detection of Periodontal Bone Loss. Sci Rep 9(1): 8495
25. 25.Cha JY, Yoon HI, Yeo IS, Huh KH, Han JS (2021) Peri-Implant Bone Loss Measurement Using a Region-Based Convolutional Neural Network on Dental Periapical Radiographs. J Clin Med 10(5): 1009.
26. Ossowska A, Kusiak A, Świetlik D (2022) Artificial Intelligence in Dentistry-Narrative Review. Int J Environ Res Public Health 19(6): 3449.
27. Kim BS, Yeom HG, Lee JH, Shin WS, Yun JP, et al. (2021) Deep Learning-Based Prediction of Paresthesia after Third Molar Extraction: A Preliminary Study. Diagnostics (Basel) 11(9): 1572.
28. Patcas R, Bernini DAJ, Volokitin A, Agustsson E, Rothe R, et al. (2019) Applying artificial intelligence to assess the impact of orthognathic treatment on facial attractiveness and estimated age. Int J Oral Maxillofac Surg 48(1): 77-83.
29. Yamaguchi S, Lee C, Karaer O, Ban S, Mine A, et al. (2019) Predicting the Debonding of CAD/CAM Composite Resin Crowns with AI. J Dent Res 98(11): 1234-1238.
30. Takaichi A, Fueki K, Murakami N, Ueno T, Inamochi Y, et al. (2022) Systematic review of digital removable partial dentures. Part II: CAD/CAM framework, artificial teeth, and denture base. J Prosthodont Res 66(1): 53-67.
31. Hein S, Modri´c D, Westland S, Tomeˇcek M (2020) Objective Shade Matching, Communication, and Reproduction by Combining Dental Photography and Numeric Shade Quantification. J Esthet Restor Dent 33: 107-117.
32. Jreige CS, Kimura RN, Segundo ÂRTC, Coachman C, Sesma N (2022) Esthetic treatment planning with digital animation of the smile dynamics: A technique to create a 4-dimensional virtual patient. J Prosthet Dent 128(2): 130-138
33. Choi E, Lee S, Jeong E, Shin S, Park H, Youm S, et al. Artificial intelligence in positioning between mandibular third molar and inferior alveolar nerve on panoramic radiography. Sci Rep. (2022) 12(1):1–7.
34. Aubreville M, Knipfer C, Oetter N, Jaremenko C, Rodner E, Denzler J, et al. Automatic classification of cancerous tissue in laserendomicroscopy images of the oral cavity using deep learning. Sci Rep. (2017) 7(1):1–10.
35. Xu B, Wang N, Chen T, Li M. Empirical evaluation of rectified activations in convolutional network. arXiv preprint arXiv:150500853 (2015).

36. Dhillon H, Chaudhari PK, Dhingra K, Kuo R-F, Sokhi RK, Alam MK, et al. Current applications of artificial intelligence in cleft care: a scoping review. Front Med. (2021) 8:1–14.
37. Chang HY, Jung CK, Woo JI, Lee S, Cho J, Kim SW, et al. Artificial intelligence in pathology. J Pathol Transl Med. (2019) 53(1):1–12.
38. Warin K, Limprasert W, Suebnukarn S, Jinaporntham S, Jantana P, Vicharueang S. AI-based analysis of oral lesions using novel deep convolutional neural networks for early detection of oral cancer. PLoS One. (2022) 17(8):e0273508.
39. James BL, Sunny SP, Heidari AE, Ramanjinappa RD, Lam T, Tran AV, et al. Validation of a point-of-care optical coherence tomography device with machine learning algorithm for detection of oral potentially malignant and malignant lesions. Cancers. (2021) 13(14):3583.
40. Heidari AE, Pham TT, Ifegwu I, Burwell R, Armstrong WB, Tjoson T, et al. The use of optical coherence tomography and convolutional neural networks to distinguish normal and abnormal oral mucosa. J Biophotonics. (2020) 13(3):e201900221.
41. Poedjiastoeti W, Suebnukarn S. Application of convolutional neural network in the diagnosis of jaw tumors. Healthc Inform Res. (2018) 24(3):236–41.