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ORIGINAL ARTICLE

A Systematic Review on Artificial Intelligence Applications in Restorative Dentistry

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ABSTRACT

Statement of problem: Artificial intelligence (AI) applications are increasingly used in restorative process. But existing dentistry restoration effectiveness as well as growth and IA applications have not yet been systematically analyzed or documented.

Purpose: The goal of such comprehensive evaluation is to discover & assess the abilities associated with artificial intelligence models in restorative dentistry for the analysis of caries as well as vertical tooth fracture, evaluate margins in preparing tooth, and analyze reconstructive failures.

Methods: A systematic electronic review of 5 databases was carried out: PubMed/ MEDLINE, World of Science, EMBASE, Scopus and Cochrane. The investigation was carried out manually as well. Research using AI models was chosen on the basis of 4 criterion: dental caries diagnostics, diagnostics, vertical tooth fracture, tooth preparation recognition, & cause of failure of restoration. Both researchers rated the quality of the study for Critical Appraisal Checklist for Quasi-Experimental Studies (nonrandomized experimental studies). The 3rd author was asked for resolving the dispute.

Results: 34 researches were made the part of this analysis: from which 29 contains artificial intelligence techniques including the diagnostics or treatment related to caries and its causes according to sensitivity models, 2 to diagnose vertical tooth fractures, 1 to prepare the teeth. Among the studied analysis, the accuracy of caries diagnosis in the AI models was tested from 76-88.3%, sensitivity from 73-90%, as well as specificity from 61.5-93%. In the study, the accuracy of predicted caries ranges from 83.6-97.1%. The performed research showed the accuracy of the analysis of a vertical tooth fracture from 88.3-95.7%. The study, which uses AI models to find a destination, had details with the range of 90.6-97.4%.

Conclusions: AI models are a powerful tool for diagnosing caries as well as vertical tooth fractures, recognizing preparation margins and predicting restoration failures. But, the dental use of AI models continues to evolve. More research is needed to evaluate the clinical effectiveness of artificial intelligence models in restorative dentistry.

Keyword: Artificial intelligence, restorative dentistry, vertical tooth fractures.

INTRODUCTION

The term artificial intelligence (AI) is the ability of an engineering system for acquiring, discarding, and applying skills normally associated with the human mind. AI is a vast academic discipline which investigates agents capable of achieving "intelligent agents" or flexible autonomous operations[1-2]. AI systems vary from expert systems to systems that teach complex computational models to predict new information. The 2nd classification of systems makes machine learning rich in tools, techniques, and algorithms[3-4]. Machine learning is about new models that are "trained" in a specific set of data (called training data) about AI algorithms and model sets to find fresh information with equivalent fashions (test data). This knowledge of the model facilitates a range of activities, including categorization (predicting a specific category of data points from a predefined set of categories), regression (predicting the value of a function for a specific input), as well as grouping (grouping elements) similarities and various measures[5-6]. There are two approaches to train machine learning algorithms: supervised or un supervised. The former is the Learning to learn with in training data, every data point contains several inputs and outputs, knowing that the model output has more inputs[7-8]. The aim of the training is to establish the relation among the data that is input as well as output in order for the model to forecast the result of the input test data. The categorization of Object as well as regression are most often accomplished by uncontrolled learning. For unsupervised learning, this dataset does not provide clear instructions on what to do[9-10]. The main purpose of unsupervised learning identifies the model and isolate it through complementary data set functions. Hence, unsupervised learning is utilized in tasks like grouping data and shrinking dimensions. Deep neural networks, a subset of machine learning approaches, have gained popularity in recent years within a variety of industries[11]. Deep neural networks seem to be artificial neural network extensions formed by the brain[12]. The input set is used for performing various machine learning work like regression as well as grouping. Various forms of AI began to affect dentists, including better radiographic imaging, diagnostic procedures for cysts as well as tumors, diagnosis of periapical lesions, identification of root anatomy and endodontics, diagnosis of periodontitis in place, cephalometric points in orthodontics[13]. Various uses of AI in blood restoration were assessed. Hence, for understanding the capability associated with artificial intelligence's methodology in restorative dentistry, a systematic classification as well as a description regarding development, functionality, as well as constraints of artificial intelligence is required[14]. This review should recognize as well as analyze the effectiveness of artificial intelligence restoration in the dentist. The paper analyzes dental caries diagnostics as well as vertical fractures, recognition of margin for dental preparation as well as the prognosis of restorative defects.

MATERIALS AND METHODS

The Population or Problem, Comparison, Outcome (PICO) is the clinical application in conservative dentistry to diagnose vertical tooth fractures and dental caries, to prepare the teeth for discovery and prognosis. Recover bugs; the intervention was to teach artificial intelligence; the comparison was found not to apply; and the result was the functionality of diagnosis regarding AI model for tooth decay as well as caries diagnostics, the validity of the location of the destination of the dental preparation and the prognosis of clean restoration. Without shortening the deadline, five different databases were selected: PubMed/ MEDLINE, World of Science, EMBASE, Scopus or Cochrane. The investigation was carried out manually as well (Table:1).

Table 1:

Database	MeSH Terms and Search Terms
MEDLINE/ PubMed	(“Dental prosthesis”[MeSH] OR “Tooth preparation”[MeSH] OR “crowns”[MeSH] OR “Tooth crown”[MeSH] OR “fixed dental prosthesis” or “bridge” OR “intraoral scan” OR “intraoral scanner” OR “digital impression” “intraoral digital scan” OR “Decay” OR

	OR “Dental caries”[MeSH] OR (“Artificial intelligence”[MeSH] AND “Tooth”[MeSH]) OR“ Carious dentin” OR “Machine Intelligence” OR “Computational Intelligence” OR “AI-based” OR“Computer Reasoning” OR “Knowledge Acquisition” OR“Computer Vision Systems” OR “Machine learning”[MeSH] OR “Knowledge Representation” OR “Supervised machine learning”[MeSH] OR“ Deep learning”[MeSH] OR “Expert systems”[MeSH] OR “Unsupervised Machine Learning”[MeSH] OR “Natural Language Processing”[MeSH] OR“Fuzzy Logic”[MeSH] OR Computer” or “Neural Networks [MeSH])

The assessment was conducted on All titles as well as abstracts according to the initial inclusion criterion, including in vitro or clinical studies, to evaluate the effectiveness of AI models in the diagnosis of caries as well as vertical tooth fractures, the discovery associated with margin preparing and the prognosis of restorations. After evaluating this systematic review, reviewing the complete wording of such articles in accordance with pre-determined inclusion criteria related to systematic reviews as well as meta-analysis (PRISMA), testing AI analysis from other dental disciplines but not related to conservative dentists; such as periodontics, endodontics, pediatric dentistry, orthodontics, maxillofacial surgery or tooth segmentation studies, review of articles on the AI model, unwritten AI model, letter to the editor, dental robotics, computed tomography (CT). Two qualified reviewers collected the chosen research’s information and structured tables. Disagreements were settled via agreement by use of 3rd reviewer. The evaluator ratings assessed the study quality, with a critical list of similar studies performed by the Institute (Experimental Rental Research) (Table 2). A third reviewer (UK) was consulted to resolve the problem of disagreement.

Table 2:

	Question	Answer
1	Is it clear in the study what is the cause and what is the effect ie, there is no confusion about which variable comes rst)?	Yes, no, unclear, or not applicable
2	Were the participants included in any similar comparisons?	
3	Were the participants included in any comparisons receiving similar treatment/care other than the exposure or intervention of interest?	
4	Was there a control group?	
5	Were there multiple measurements of the outcome both before and after intervention/exposure?	
6	Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analyzed?	
7	Were the outcomes of participants included in any comparisons measured in the same way?	
8	Were outcomes measured in a reliable way?	
9	Was appropriate statistical analysis used?	

RESULTS

Cohen's kappa values among assessor were about 0.974 (P <0.001), which means a clear consensus among examiners. The AI models are listed in Table:3.

Table 3:

Expert Systems	Classical Machine Learning Models	Artificial Neural Networks
Computer programs that make decisions based on a set of expert theories	Regression analysis: Estimations of the association among variables.	Neural networks (NNs) and Artificial neural networks (ANNs): grounded on assembly of connected units or nodes called artificial neurons. An artificial neuron that obtains a signal is then processed and can signal neurons associated with it. The connections are called edges. Normally, neurons and layers are aggregated.
	k-nearest neighbors (k-NN)	Perceptron NN
	Support vector machine (SVM)	Classifier NN
	Decision tree learning: Prediction model using classification tree.	Multi Layered Perceptron (MLP)
	Random forecast	Convolutional Neural Networks (CNN) NN
	Random tree	Back-Propagation
	Case-based reasoning: Accomplishes cases (past knowledges) to resolve new difficulties.	Deep neural network (DNN)
	Fuzzy logic learning: Makes levels of likelihoods of input to attain a certain output	Probabilistic neural network (PNN)

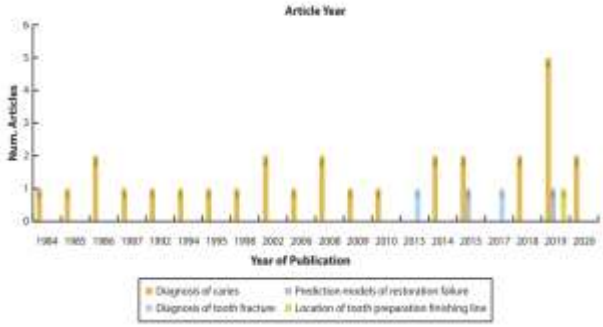

Figure 1: shows the number of releases divided into four categories per year on the basis of AI model application. 1,596 studies were conducted among the search strategies.

After reviewing the titles and abstracts, 38 research were recognized, 4 were rejected after reviewing the complete words of the research (Figure 2).

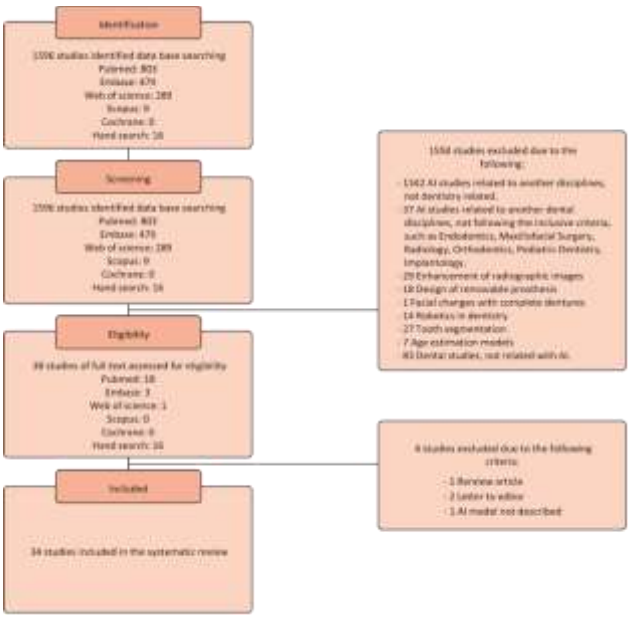

Figure 2: Preferred Reporting Items for Meta-Analyses and Systematic Reviews flow diagram with information through phases of study selection.

Depending upon this usage of AI, relevant literature was categorized into four groups: dental caries diagnostics and interesting development in models of sensitivity errors, diagnosis of vertical tooth fractures, detecting finishing of tooth preparation, forecasting reconstructive defects. About 29 research were the part of this analysis on caries. 18 research utilized periapical and / or occlusal radiographical imaging, 5 studies used intra-oral images, one study looked at infrared techniques, and one research revealed a fiber displacement sensor as an input source. The other application associated with AI was performed after direct reconstruction following the development of postoperative prediction and sensitivity models (Supplementary Tables 1 to 3, available online). 2 research were the part of the analysis, i.e., AI models with periapical radiographs or CBCT images in diagnosing vertical tooth fracture (Supplementary Table:4, available online). 1 of them utilized the procedures specified in AI to detect the finishing of dental preparations (Supplementary Table:5, available online), and the latter used AI for predicting reconstruction failure (Supplementary Table:6, online). The Critical Assessment List with Quasi experimental studies show all articles have a zero percent chance of being biased written in questions 1, 8 as well as 9. In question 4, 60 percent risk of biasness, whereas 40% risk and the assumption were calculated by Aliag et al. aluminum. Casalegno et al., Gakenheimer, Moutselos et al., Mustselos et al., Lee et al., Renson and Pitts, Vladimirov et al, Rahman et al and Yamaguchi et al. As there were no specific tools to improve the quality of the in vitro study, Questions 2 as well as 6 seemed inapplicable in accordance with this analysis. None of the answers to questions 3, 5, & 7 applicable to either of the submissions. (Figure 3).

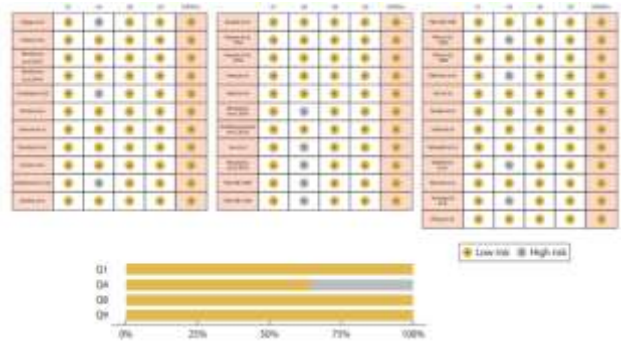

Figure 3: The Critical Appraisal Checklist for Quasi-Experimental

DISCUSSION

The number of articles published using AI techniques in conservative dentistry is found to be risen significantly in previous two yrs., yet, it has been small in recent years[15-16]. Sophisticated AI models have evolved slowly since 1984, but the use of various machine learning methods has increased significantly since 2015. AI learning techniques are slowly being adopted by dentists as access to them is limited as well as possible. 18 out of 29 research in this systematic study assessed various AI models using periapical or X-ray images to diagnose caries. The AI models involved expert systems, regression analysis, blurry learning logic, neural perceptual networks, multi-layer perceptron, neural retransmission networks, as well as convolutional networks[17-18]. Twelve of this research represented human radiography and six on clinical radiographs. 1 research failed to identify that where did the radiography come from? Although every research tried normalizing the collected data of radiographs, distinguishment between the research was recognized which includes projection geometry, light factors, film contrast, and film speed. 5 research do the comparative analysis on radiographic presentation of the AI model in order to diagnose caries as well as analysis regarding sample's histology was conducted. Eight studies did comparative analysis on radiographs related to AI model or another AI models[19-20]. Most studies show improvements in caries diagnosis using software, one study found no significant difference, and two studies found clinicians offer much reliable diagnostics of carries in contrast to AI programs[21-22]. The difference among enamel as well as dentin caries is crucial in the diagnosis of dental caries; But every research does not focus on the spread caries on dentin, classifying it only as the presence of lesions[23]. Valizadeh et al reviewed the AI model for diagnosing proximal caries on periapical radiographs as well as to compare the results of the AI model along with the study on sample's histology. The software diagnoses 97% of dentin caries but only 60% of email caries[24]. Like Devito et al. An artificial intelligence model was assessed for the diagnosis of proximal seizures using false X-rays and the histological evaluation included the use of human teeth, human teeth used in the project. The outcomes indicate a finer diagnosis of the proximal crisis related to AI program in contrast to a detailed study[25-26]. The assessment of radiographic images was performed differently between studies to assess whether caries was present throughout the AI models' training period. The training dataset is the basic information developed by the AI model; so earthly truth does not necessarily represent true truth. Among the studies studied, there were differences in the training, verification, & test data sets in terms of total quantity of pictures gathered[27-28]. The studies assessed the accuracy of caries diagnosis in the AI models ranging from 76-88.3%, sensitivity from 73%-90% as well as specificity from 61.5-93%. The comparative analysis between research was hard due to the differences in the methods used. Various models of artificial intelligence with oral imaging, such as regression analysis and bubble-based decision making, and artificial neural networks. Five studies developed artificial intelligence models that use clinically occlusive images to diagnose dental caries, four out of five used extracted human teeth while two research assessed clinical images of oral caries[29]. Several studies have found different photo-analysis standardization settings, like resolution, magnification, exposure, or white balance, that may be affected by outcomes. When occlusal images were utilized like a source of information, all studies used the International Caries Detection and Assessment System (ICAD) for assessment as well as classifying the occurrence of caries[30]. In most studies studied, ICAD professionals or competent doctors conducted the imaging exams, and only one study compared visual and histological findings. These judgments were used as true based on the AI training phase, which could indicate a false creation of training data. Using oral photos, the AI model showed accuracy in caries diagnostics from 80-86.3%, accuracy from 95.6-98.3%, and sensitivity from 80-100%. Hence the comparative analysis between research was hard to be conducted due to the differences in the methods used[31].

Both in vitro studies developed artificial intelligence models to diagnose vertical tooth fractures. Kositbobornchai et al. 200 processed premolars radiographs with an accuracy of 88.3% to 95.7%, a sensitivity of 97.2% to 98% and an accuracy of 60% to 90.5%. Only one Research represented the CNN AI model to find the target of tooth preparation in crowns[32]. 380 premolars and a virtual tooth crown were obtained from an unidentified source. Between the two studies, an artificial intelligence model was developed to present cork defects to identify images and restorations from virtual dental protests and predict material duration. Yamaguchi et al, they tried to prepare for crown imbalances by developing resin bonding using the CNN AI model[33]. Aliaga et al. Use the case-based learning model to instantly reproduce better material (composite resin or amalgam) as well as forecast restorations duration. Information collection about the patient was done which includes characterization of the tooth that received the correct reconstruction of the teeth and the features associated with the patient. The researchers came to the conclusion that the model can predict the sort of repair required and by anticipating the duration per each technique that is most appropriate in terms of patient[34]. The criterion in selecting restorative materials for the data were developed on the basis of experiences of teachers from a dental school and private clinics that responded to the survey[34]. Oral scans and imaging data might

be combined in future restorative dentistry concepts to thoroughly evaluate the data and increase diagnostic reliability. Implementing a specific class of specific brushing methods, such as less than 1 in 1 machine learning, which requires less data points in contrast to neural network models, AI models will be easier to implement and enhance for dental restoration applications[35]. In dentistry diagnostics, accurate data analysis is crucial, standardizing and referencing datasets can rise reliability associated with AI models when predicting tooth caries and vertical root fracture or tooth restoration errors. Keeping datasets open makes it easier to build AI models[36].

CONCLUSION

The results obtained were formed depending upon the findings of this comprehensive study: 1. Utilization of AI models for diagnosing caries as well as vertical line fractures, detect tooth finishing, and predict restorative errors has increased significantly since 2019. Detection and forecasting restoration failure were also documented. The use of AI models in dentistry seems to be in the early stages of research. More research is needed to evaluate the clinical effectiveness of artificial intelligence models in restorative dentistry.

REFERENCES

1. Boreak N. Effectiveness of Artificial Intelligence Applications Designed for Endodontic Diagnosis, Decision-making, and Prediction of Prognosis: A Systematic Review. The Journal of Contemporary Dental Practice. 2020 Aug;21(8):927.
2. Hung K, Montalvao C, Tanaka R, Kawai T, Bornstein MM. The use and performance of artificial intelligence applications in dental and maxillofacial radiology: A systematic review. Dentomaxillofacial Radiology. 2020 Jan;49(1):20190107.
3. Tamimi F, Hirayama H. Digital Restorative Dentistry. Springer International Publishing; 2019.
4. Shan T, Tay FR, Gu L. Application of artificial intelligence in dentistry. Journal of dental research. 2021 Mar;100(3):232-44.
5. Yasa Y, Çelik Ö, Bayrakdar IS, Pekince A, Orhan K, Akarsu S, Atasoy S, Bilgir E, Odabaş A, Aslan AF. An artificial intelligence proposal to automatic teeth detection and numbering in dental bite-wing radiographs. Acta Odontologica Scandinavica. 2020 Nov 17:1-7.
6. Rodrigues M, Andrade I, Cruz R. Current Point-of-Care testing in cancer and future perspectives: a systematic review. European Journal of Public Health. 2020 Jun 1;30(Supplement_2):ckaa040-033.
7. Maffulli N, Rodriguez HC, Stone IW, Nam A, Song A, Gupta M, Alvarado R, Ramon D, Gupta A. Artificial intelligence and machine learning in orthopedic surgery: a systematic review protocol. Journal of Orthopaedic Surgery and Research. 2020 Dec;15(1):1-5.
8. Schwendicke F, Rossi JG, Göstemeyer G, Elhennawy K, Cantu AG, Gaudin R, Chaurasia A, Gehrung S, Krois J. Cost-effectiveness of Artificial Intelligence for Proximal Caries Detection. Journal of Dental Research. 2020 Nov 16:0022034520972335.
9. Corbella S, Srinivas S, Cabitza F. Applications of deep learning in dentistry. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology. 2020 Nov 18.
10. Zheng Q, Yang L, Zeng B, Li J, Guo K, Liang Y, Liao G. Artificial intelligence performance in detecting tumor metastasis from medical radiology imaging: A systematic review and meta-analysis. EClinicalMedicine. 2021 Jan 1;31:100669.
11. Blatz MB, Chiche G, Bahat O, Roblee R, Coachman C, Heymann HO. Evolution of aesthetic dentistry. Journal of dental research. 2019 Nov;98(12):1294-304.
12. Retrouvey JM, Panayi N, Tsolakis A. Evolution of the Orthodontic Diagnosis in the Age of Artificial Intelligence. 3D Diagnosis and Treatment Planning in Orthodontics: An Atlas for the Clinician. 2021 Apr 14:3-20.
13. Gokul GL, Ganesh S B, Don KR. Artificial Intelligence in Dentistry-A Review. Indian Journal of Forensic Medicine & Toxicology. 2020 Oct 1;14(4).
14. Joda T, Bornstein MM, Jung RE, Ferrari M, Waltimo T, Zitzmann NU. Recent trends and future direction of dental research in the digital era. International journal of environmental research and public health. 2020 Jan;17(6):1987.
15. GAYATHRI R, PRIYA VV, KAVITHA S. Awareness On Application Of Artificial Intelligence In Medicine Among Dental Students-A Survey. Journal of Contemporary Issues in Business and Government. 2021 Mar 16;27(2):3130-42.
16. Pethani F. Promises and Perils of Artificial Intelligence in Dentistry. Australian Dental Journal. 2020 Dec 19.
17. Graham HD, Ashley M. The ADEPT Study, A Comparative Study of Dentists' Ability to Detect Enamel-only Proximal Caries in Bitewing Radiographs With and Without the use of AssistDent® Artificial Intelligence Software.
18. Graham HD, Ashley M. The ADEPT Study, A Comparative Study of Dentists' Ability to Detect Enamel-only Proximal Caries in Bitewing Radiographs With and Without the use of AssistDent® Artificial Intelligence Software.
19. Schwendicke FA, Samek W, Krois J. Artificial intelligence in dentistry: chances and challenges. Journal of dental research. 2020 Jul;99(7):769-74.
20. Pyo SW, Kim DJ, Han JS, Yeo IS. Ceramic Materials and Technologies Applied to Digital Works in Implant-Supported Restorative Dentistry. Materials. 2020 Jan;13(8):1964.
21. Tandon D, Rajawat J. Present and future of artificial intelligence in dentistry. Journal of Oral Biology and Craniofacial Research. 2020 Jul 24.
22. Rutkūnas V, Borusevičius R, Gečiauskaitė A, Pletkus J. Digital Technologies in Clinical Restorative Dentistry. Practical Advanced Periodontal Surgery. 2020 May 6:213-32.
23. Katne T, Kanaparthi A, Gotoor S, Muppirala S, Devaraju R, Gantala R. Artificial intelligence: demystifying dentistry–the future and beyond. Int J Contemp Med Surg Radiol. 2019;4:D6-9.
24. Malek M, Farzaneh F, Samani Y, Pachenari F, Pachenari H. The applications of nanotechnology in restorative dentistry: a review study. Nanomedicine Journal. 2019 Oct 1;6(4):241-9.
25. Reda R, Zanza A, Mazzoni A, Cicconetti A, Testarelli L, Di Nardo D. An Update of the Possible Applications of Magnetic Resonance Imaging (MRI) in Dentistry: A Literature Review. Journal of Imaging. 2021 May;7(5):75.
26. Pauwels R. A brief introduction to concepts and applications of artificial intelligence in dental imaging. Oral radiology. 2021 Jan;37(1):153-60.
27. Al-Imam A, Al-Khazraji A. Alveolar Osteitis Following Tooth Extraction: Systematic Review and Google Trends Analysis Instigated by the First Upper Premolar Case Reported from Iraq. Modern Applied Science. 2019;13(3):1-2.
28. Kılıc MC, Bayrakdar IS, Çelik Ö, Bilgir E, Orhan K, Aydın OB, Kaplan FA, Sağlam H, Odabaş A, Aslan AF, Yılmaz AB. Artificial intelligence system for automatic deciduous tooth detection and numbering in panoramic radiographs. Dentomaxillofacial Radiology. 2021 Mar;50:20200172.
29. Bordea IR, Candrea S, Alexescu GT, Bran S, Băciuț M, Băciuț G, Lucaciu O, Dinu CM, Todea DA. Nano-hydroxyapatite use in dentistry: A systematic review. Drug metabolism reviews. 2020 Apr 2;52(2):319-32.
30. Mishra S, Satpathy A, Mohanty R, Nayak R, Nayak M, Das AC. Artificial Intelligence: A Cognitive Advancement towards Future Dentistry. Indian Journal of Public Health Research & Development. 2019 Nov 1;10(11).
31. Kokol P, Vošner HB, Završnik J, Turčin M. How 'smart'is smart dentistry?. F1000Research. 2019;8.
32. Heo MS, Kim JE, Hwang JJ, Han SS, Kim JS, Yi WJ, Park IW. Artificial intelligence in oral and maxillofacial radiology: what is currently possible?. Dentomaxillofacial Radiology. 2021 Mar 1;50(3):20200375.
33. Elfanagely O, Toyoda Y, Othman S, Mellia JA, Basta M, Liu T, Kording K, Ungar L, Fischer JP. Machine Learning and Surgical Outcomes Prediction: A Systematic Review. Journal of Surgical Research. 2021 Aug 1;264:346-61.
34. Sarkis-Onofre R, Pereira-Cenci T, Tricco AC, Demarco FF, Moher D, Cenci MS. Systematic reviews in restorative dentistry: discussing relevant aspects. Journal of Esthetic and Restorative Dentistry. 2019 May;31(3):222-32.
35. Setzer FC, Shi KJ, Zhang Z, Yan H, Yoon H, Mupparapu M, Li J. Artificial intelligence for the computer-aided detection of periapical lesions in cone-beam computed tomographic images. Journal of endodontics. 2020 Jul 1;46(7):987-93.
36. Hung K, Yeung AW, Tanaka R, Bornstein MM. Current Applications, Opportunities, and Limitations of AI for 3D Imaging in Dental Research and Practice. International Journal of Environmental Research and Public Health. 2020 Jan;17(12):4424.