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Review

Artificial Intelligence in Restorative Dentistry and Endodontics- A Review

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Abstract

Artificial intelligence is a branch of computer science that was described by John McCarthy in the year 1956. It has the potential to replicate human intelligence and has been described as the fourth industrial revolution. In health care two types of artificial intelligence methods are used, namely virtual and physical. Different methods have been employed to train the artificial intelligence system. In restorative dentistry they have been used for the detection of dental caries, vertical root fracture, predict restoration failures, locate preparation margins etc. In endodontics they have proved to be helpful in detection of periapical lesion, crown and root fracture, working length determination and also throw light on retreatment predictions and the viability of stem cells etc.So this article provides an overview of the role of artificial intelligence in restorative dentistry and endodontics and its scope for the future.

Keywords: *Artificial Intelligence, Restorative Dentistry, Endodontics, Dental caries, Root fracture, Periapical lesions.*

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Introduction

Artificial Intelligence (AI) is a branch of applied computer science that was described by John McCarthy in 1956.[1] It is defined as the capability of an engineered system to record, process, apply knowledge and skills acquired through experience or education that are generally associated with human intelligence.[2] It has the potential to replicate human intelligence and has been described as the fourth industrial revolution. In health care two types of artificial intelligence methods are used, namely virtual and physical.[3] Virtual method makes use of mathematical algorithms and is used for diagnosis and prognosis in clinical practise.[4] Physical method makes use of robotics and their prevalence in the field of restorative dentistry and endodontics are still under study.[5]

Training of AI systems

Based on AI algorithms, AI systems can be trained in two different ways namely supervised and unsupervised.[2] The former is based on an input- output pairs, where the model is exposed to a number of inputs whose output is already known.[2] The goal of this system is to develop a relationship between input and output so as to predict the output for a test data input. The latter, mainly serves

the purpose of object classification and regression.[6] Instructions on the entire process are given. The goal of this system is to identify patterns by extracting the most relevant features from a data set. It serves the purpose of clustering and dimensionality reduction.[7]

AI Methods

Various AI methods are employed that provides the desirable outputs for a given input. Few of them are as follows. Firstly the machine learning method, where the system learns rules from the data that is available and output is based on this data that has been collected or stored.[8] Another method is the case based reasoning, where the output for a particular input is based on previous encounter with the similar case scenarios.[9] This system actually mimics the human intelligence, similar to how the clinicians arrive at the diagnosis based on their previous case encounters and ruling out various differential diagnosis. Another AI method known as the neuro-fuzzy interface system mainly adheres to few fuzzy rules and parameters. i.e., for a given input, output is derived after fulfilling the preset rules and parameters.[10] It revolves around the possibilities of an input to get a desirable or definite output.[11] Other methods such as artificial neural network (ANN) and convolutional neural network (CNN) are nothing but a collection of data neural node i.e. artificial neuron.[12-16] It is used for object classification, detection and segmentation. Another method known as the deep learning is a subset of machine learning and neural networks and provides more precise values.[17] Probabilistic neural network, one of the AI methods derives the most probable output from a set of all possible outputs for a given input.[18,19]

Application in restorative dentistry

In restorative dentistry the applications of various AI methods have been substantially increasing over the years. It is used for caries diagnosis and is able to detect both enamel and dentinal caries, with a precision of 60 percent for enamel caries and 97 percent for dentinal caries. It has shown around 100 percent success in detecting caries in cavities of upto 0.6mm depth.[2] AI models most commonly take reference from periapical radiographs for detection of caries.[1,20] AI models can also be used to detect vertical root fractures. AI models when used with CBCT have shown to give output with greater accuracy and specificity.[21] Periapical radiographs can also be used as the reference though their results and are far more inferior to that of the former.

Tooth preparation margins and the finish lines can also be located using various AI models. They accurately predict the depth and type of finish line to be used for a particular tooth preparation. And it is reported to have 90.6-97.4 percent accuracy.[2] AI models are also used to predict restorative failures, including failure of crowns by making use of the images captured from virtual dies. It can be used to increase the longevity of the composite restorations as it predicts the debonding of the composite resins by analyzing the images of the tooth preparation. It also throws light on the preferred restorative material for a particular tooth preparation.[22] Table –1

Restorative dentistry	AI methods
Caries diagnosis	CNN, ANN
Vertical root fracture	CNN
Locate preparation margins	CNN
Predict restoration failure	CNN
Preferred restorative material and longevity	CBR

Table 1- Different AI methods used in restorative dentistry
CNN- Convolutional Neural Network, ANN –Artificial Neural Network, CBL – Case Based Reasoning

Application in endodontics

In endodontics AI has been used to detect periapical lesions. It takes reference from radiographs and CBCT and has the capability to differentiate cyst and granuloma. It has proven to be 92.8 percent reliable.[1] AI models can also be used to determine the working length and can exactly locate apical foramen, major and minor diameter.[23] Root and canal morphology can better be visualized using AI systems. It gives clear clinical picture of the curvatures of the root and canals and also provides a 3-dimensional modification for such canal preparation that can be used by the clinicians as a guide while preparing such curved and torturous canals.[24]

AI has also been used to detect crown and root

fractures and the fracture lines can be traced accurately. Studies have found promising results when CBCT was taken as the reference by the AI systems and there are various ongoing researches on the same. AI systems have also been used to predict the viability of the stem cells after treating them with bacterial lipopolysaccharide.[25] So it can be used to predict the success rate of various regenerative procedures. It also helps in retreatment predictions and predicts the statistical probability for extraction of the tooth in interest. Table –2

Procedure	AI method
Detect periapical lesions	CNN, ML, DL
Working length determination	ANN, ML
Crown and root fracture	ML, CNN, PNN
Predict the viability of stem cells	ML, ANN, NFIS
Retreatment predictions	CBR, ML

Table 2- Different AI methods used in endodontics CNN- Convolutional Neural Network, ML-Machine Learning, DL- Deep Learning, ANN –Artificial Neural Network, PNN-Probabilistic Neural Network, CBL – Case Based Reasoning

Future of AI

AI systems can be trained for appointment scheduling, patient management and recall based on the diagnosis or the treatment provided. It can be used to predict the drug interactions by looking on to patients past medical history and the present treatment protocol. It can also be relied on to provide accurate diagnosis. Another topic of interest is the navigation in endodontic surgery and robotic microsurgery that can bridge the gap between dentistry and modern technology and can create a milestone in both the fields.

Conclusion

Artificial intelligence in restorative dentistry and endodontics is an advancing and promising branch. Tough it cannot replace the clinician, but can aid in accurate diagnosis, treatment planning and make the clinical procedures less cumbersome and timesaving. It can always be looked upon for a second opinion and guidance.

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Conflict of interest

The authors declare that they have nothing to disclose and there is no conflict of interest.

Author contributions

Conceptualization: SCK, BMJ;Formal Analysis: BMJ; Investigation: SCK, ABH; Methodology: SCK, ABH; Project Administration: SR, ABH; Writing – Original Draft: ABH, BMJ; Review & Editing: SR, ABH

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