IJBPAS, October, 2023, 12(10): 4392-4409

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

ENDODONTICS USING ARTIFICIAL INTELLIGENCE- AN ENTHRALLING UNCOVERING

CHRISTABEL SL[1], CLARIBEL SM[2], SUSHMITHA M[3] AND KANNAN KS[4]

1: Assistant Professor, Department of Conservative Dentistry and Endodontics, Madha Dental College and Hospitals, Chennai, Tamil Nadu, India

2: Second year, M.Sc., Clinical Research, Sri Ramachandra Institute of Research and Higher Education, Chennai, Tamil Nadu, India

3: Second year, M.Sc., Clinical Research, Sri Ramachandra Institute of Research and Higher Education, Chennai, Tamil Nadu, India

4: Second year, M.Sc., Clinical Research, Sri Ramachandra Institute of Research and Higher Education, Chennai, Tamil Nadu, India

***Corresponding Author: Dr. S. Linda Christabel: E Mail:** linnchriss791@gmail.com

Received 16th July 2022; Revised 20th Sept. 2022; Accepted 17th Jan. 2023; Available online 1st Oct. 2023

https://doi.org/10.31032/IJBPAS/2023/12.10.7437

ABSTRACT

In this current digital world, newer technologies are evolving to a great extent. Among them, artificial intelligence plays a significant role in many fields. In dentistry, AI technologies are incorporated for better diagnosis and ease of treatment procedures. This reduces the treatment time and the accuracy of the diagnosis proved to be better than the traditional methods. The efficacy of AI is far superior than humans. So using artificial intelligence wisely will yield tremendous benefits for the dental field. In this article, the role of artificial intelligence in Endodontics is reviewed.

Keywords: artificial intelligence, endodontics, deep learning, machine learning

INTRODUCTION:

The term "artificial intelligence" (AI) was coined by John McCarthy in 1956to describe the concept of creating machines that can accomplish jobs that people routinely do **[1]**. Artificial intelligence (AI) is a technique for creating software or a machine that can readily replicate human intelligence and execute specified tasks **[2]**. "The study of intelligent agents, any device that senses its environment and takes action that maximizes its possibility of successfully accomplishing its goals (Russell and Norvig 2003)" is how artificial intelligence is defined **[3, 4]**. Machine learning and deep learning are two different types of artificial intelligence. Arthur Samuel **[5]** coined the term "machine learning," which is based on a system of principles for learning the mathematical frameworks and edifices in data, allowing for the prediction of hidden data. ML models are neural networks (NNs) that outperform traditional ML systems on dynamic figures **[3]**. Algorithms are used in Machine Learning (ML), a subfield of AI, to accomplish tasks by learning patterns from data. Machine learning requires adjusting parameters related to the underlying technique, such as the number of neurons and layers in a neural network; population size, mutation rate, and crossing over rate in genetic algorithms, and so on. 2 Machine learning models such as Genetic algorithms, Artificial Neural Networks (ANN), and Fuzzy logic can learn and inspect data in order to perform diverse functions. ANN is the most popular model among these. The artificial neuron, which is a mathematical model system affected by the human neuron, is one of the most important components of any ANN.A network capable of accomplishing specific tasks like image categorization (e.g., radiographic image displaying a decaying tooth, identifying canals during RCT) is constructed by creating artificial neurons and linking the layers of these artificial neurons using multiple mathematical operations **[6]**. Because of its ability to represent images and arrange topographies, deep learning is particularly beneficial for complex data. It's a machine learning technique in which artificial neural networks are used to train models (ANN). An artificial neural network (ANN) is a collection of many ordered processing components that evaluate data based on their programmed potent responses to external inputs. Using computer imaging and natural language processing, it has achieved significant achievements in a variety of non-health and wellness programs.

Hornik (1991) defined deep neural networks as universal approximation machines **[1, 3]**. Moving on to Deep Learning (DL), a subset of ML that refers to ANN with a complicated multilayer structure. This system has a more complicated layering system and a larger number of associated neurons, allowing it to visualise simple elements such as lines, edges, corners, and macroscopic patterns in a hierarchical framework **[6, 7]**. Deep learning networks are increasingly widely employed, because to advances in graphics cards and algorithmic improvements **[8]**. Complementing human intellect with AI could improve the quality of diagnostic outputs significantly **[9]**. Artificial intelligence is an area of biomedical engineering that uses neural networks (AI). In clinical medicine, neural network applications have attracted a lot of attention **[10-14]**. There are two types of AI in health care: virtual and physical (robotics) **[15]**. The virtual kind is concerned with mathematical algorithms for diagnosis and prognosis **[16]**, imaging and osteoporosis **[17]**, appointment scheduling **[18]**, drug dosage algorithms **[19]**, drug interactions **[20]**, and electronic health records **[21]**. Robotic surgery **[22]** telepresence **[23]**, rehabilitation **[24]**, and socially assistive robots in senior care **[25]** are all examples of the physical element **[8]**. Warren McCulloch and Walter Pitts released a paper in 1943 proposing the use of neural networks to mimic human brains **[26]**. With the start of the Stanford University Medical Experimental Computer System for AI in Medicine project in the early 1970s, a link between AI and medicine was formed **[27, 28]**. In recent times, AI has been used in the field of dentistry. Dentistry has numerous prospects for robotic automation and assistive technologies to improve dental treatment quality **[29]**. Artificial intelligence offers a wide range of uses in dentistry. In this article, contributions of AI in the field of Endodontics are discussed in detail.

ASSESSMENT OF ROOT MORPHOLOGY OF THE MANDIBULAR FIRST MOLARS:

A clinically significant element in successful endodontic treatment is understanding the variations in root canal shape **[30]**. Additional disto-lingual roots in the mandibular first molars are regarded to constitute a prominent anatomical variation **[30, 31]**. Vertucci used a dissecting microscope to examine specimen teeth and developed a classification system based on root canal structure **[32]**. The most prevalent root canal designs in the mesial and distal roots, according to Vertucci, were types IV and I, respectively **[32]**. Many research have been conducted on the three-dimensional classification of root canal designs using CBCT, and they have all found comparable frequency trends **[30-34]**. Future study should focus on using a deep learning system to assess the anatomy of this root canal. The deep learning system could be useful in diagnostics. 12 A deep learning system that classifies photos could aid in the interpretation of images by unskilled clinicians. Because the root canal morphology of essential teeth cannot be assessed microscopically, it is most likely to be determined via CBCT, which can be done with great precision **[31, 33-35]**. Cone-beam computed tomography (CBCT) has established the gold standard for minimizing treatment failures due to morphological variations and optimizing endodontic therapy clinical outcomes. However, owing of the greater radiation exposure compared to traditional radiographs **[36]**, CBCT is not routinely employed. To address these issues, artificial intelligence (AI) has been used to classify the data using a CNN **[37]** to determine whether the distal root of the first mandibular molar has one or more additional canals. 760 mandibular first molar radiographs were evaluated using dental CBCT. After determining the presence or absence of atypia, picture patches of the roots produced from corresponding panoramic radiographs were classified using a deep-learning system. Despite the CNN's relatively high accuracy of 86.9% **[35]**, it has a number of drawbacks when it comes to clinical integration. The photos must be segmented manually, which takes a long time. Furthermore, the obtained images must be of sufficient size and focus on a small area to allow the system to focus on the object being investigated while still covering enough space to incorporate relevant information **[38, 39]**. Furthermore, the study confirmed that the deep learning system was equal to or slightly better than trained radiologists in detecting the presence or absence of an additional root in the distal root of mandibular first molars **[35]**. Deep learning models were created by extracting image patches from panoramic radiographs and inputting them into deep learning systems. System developed by Hiraiwa *et al* demonstrated high accuracy in the differential diagnosis of a single or multiple root(s) in the distal roots of mandibular first molars. An algorithm developed by AI and information analysis has demonstrated the ability to measure the root canal curvature and its 3-dimensional modification after the instrumentation. Results obtained from CBCT images showed 21.4% of diagnostic accuracy of whether distal roots were single or had extra roots.In diagnosing the distal roots of mandibular first molars, the deep learning system was more accurate in knowing whether it has a single or additional root **[35]**.

DETECTION OF PERIAPICAL LESIONS USING CNNS ON PERIAPICAL RADIOGRAPH:

Apical lesion is a very common dental disease and are caused by various factors. Nowadays, for the endodontic treatment, X-rays of patients are taken and the lesions are marked manually, which is a time consuming process. In order to diagnose periapical lesions, a radiographic examination is required. Intraoral radiography (IOR) is often employed for this purpose, however because of anatomic overlap, it has shown limited diagnostic value for tiny, periapical bone lesions **[40-44]**. hence 3D visualisation of lesions by CBCT was introduced to overcome the disadvantages of 2 dimensional periapical radiographs. CBCT imaging, on the other hand, was found to be less accurate in identifying apical periodontitis in root-filled teeth **[45]**. In general, radiograph identification of a periapical lesion varies greatly amongst examiners, and discriminatory skill is heavily dependent on an examiner's experience **[46]**. The use of AI technologies can lessen the differences between examiners and bias **[46-48]**. The potential use of artificial intelligence (AI) as a diagnostic tool has recently gotten a lot of interest in the field of radiology **[48]**. It is now possible to train and assess AI systems for the diagnosis of periapical lesions thanks to advances in deep learning, notably convolutional neural networks (CNNs) **[49]**. A prior work combining transfer learning and CNN-based periapical lesion detection on IOR found great performance on test pictures **[44, 50]**. The accuracy of a CNN system in properly recognizing a periapical lesion from CBCT images was around 92.8 percent. Volume measurements performed by a deep CNN system and humans were similar, according to some authors **[8, 51]**. In a study, it was proposed that the automatic diagnosis by a lesion area analysis model based on convolutional neural networks (CNN) was performed. The collection of individual tooth images comprised the image database and they were used as input into the CNN migration learning model. The diagnostic accuracy was of 92.5% by using CNN model. The proposed model successfully aided the automatic diagnosis of the apical lesion **[52]**. The use of AI systems to diagnose a periapical lesion using radiographs and CBCT scans should help physicians achieve detection accuracies comparable to or better than experienced specialists **[8, 46, 47, 51]**.

WORKING LENGTH DETERMINATION:

Working length can be accurately assessed, which is critical to the success of root canal therapy. To determine working length, radiographic, digital tactile sense, the patient's reaction to a file or paper point put into a root canal system, electronic apex locators, and CBCT imaging **[53-56]** have all been used. Radiography and electronic apex locators are the most prevalent procedures used by doctors in dental practice. However, a variety of other factors might cause radiographic readings to change, potentially leading to a misdiagnosis **[57]**. As a result, computer-assisted methods for routinely identifying precise working lengths are necessary **[8]**. According to Saghiri *et al* **[56]**, ANNs can be employed as a second opinion on radiographs to locate the apical foramen, which can improve the accuracy of working length determination. According to a study, the working length of single-rooted teeth on the dry cranium was calculated using an AI-based model. With a 93 percent accuracy rate, ANNs provided excellent results **[58]**. Another study used a human cadaver model to test the accuracy of ANNs in calculating working length, and came up with similar results. The AI-based model had a 96 percent accuracy rate, which was higher than experienced endodontists' 76 percent accuracy rate **[8, 59]**. These findings suggest that AI-based algorithms may accurately predict the apical foramen and working length. These models can be very useful for less experienced dentists and non-specialists, as they can be utilized in clinical applications when specialists are not available **[60]**.

PREDICTING POSTOPERATIVE PAIN FOLLOWING ROOT CANAL TREATMENT:

Discomforts occur in 1–58 percent of RCT patients, with postoperative pain being the most common **[61]**. After RCT, about 15–25 percent of patients experience moderate to severe discomfort **[62, 63]**. Over the last few years, methods for controlling or reducing pain have been successfully developed **[64, 65]**. Practitioners, on the other hand, frequently measure pain after RCT based on personal clinical experience rather than objective methodologies. Inaccurate pain prediction may have detrimental consequences for the planning of subsequent therapeutic schedules, resulting in a bad medical experience for patients **[66]**. Dentists may strive to alleviate pain by controllable factors like modifying operating details and adjusting medication if they have reasonable methods to predict postoperative pain.

Dentists can only predict discomfort after RCT based on personal clinical experience for a specific situation. Postoperative pain is influenced by a number of factors. As a result, knowing how many and to what extent the elements have a role in the pain's incidence is difficult. Clinical experience alone is insufficient to predict the risk of postoperative discomfort. As a result, we'll need a mathematical tool that can analyze the non-linear relationship scientifically. According to reports, ANN may be able to identify key characteristics and accurately predict post-treatment pain. The fundamental benefit of ANN is that it can analyze a large number of predictors (or variables) without statistical modelling and can effectively handle non-linear issues. The accuracy of a back propagation (BP) artificial neural network model for predicting postoperative discomfort after root canal therapy was investigated (RCT). The BP neural network model correctly predicted postoperative pain after RCT 95.60 % of the time. The BP network model could be used to predict postoperative discomfort in RCT patients **[67]**.

ASSESSMENT OF THE PULP SPACE OF TEETH FOLLOWING REGENERATIVE DENTAL PROCEDURES

The goal of regenerative endodontic operations (REPs) is to restore the dental pulp and its surrounding components in an orderly manner **[68]**. In addition, a growing amount of evidence suggests that REPs can help young teeth with pulpal necrosis mature their roots **[69-72]**. However, because traditional image interpretation techniques are based on two-dimensional (2D) radiography, it's difficult to notice minor volumetric changes after a REP **[73-75]**. The intra-canal deposition of cementum or bone-like structures caused the reduction in pulp space volume after REP. This hypothesis is supported by a number of histological observations in juvenile teeth with apical periodontitis treated with REP **[76-78]**. The secondary results of regenerative endodontic therapies are also influenced by the volumetric change in the pulp space over time (REPs). Any compromise in the geometric design of these radiographs results in inaccuracies and, as a result, erroneous readings, which have a negative impact on the interpretation of the imaging outcomes. Researchers examined the accuracy of two artificial intelligence-based medical imaging technologies, OsiriX MD (v 9.0, Pixmeo SARL, Bernex Switzerland and 3D Slicer, to estimate the volume of the pulp space following a REP. The open-source programme (3D Slicer) was shown to be as accurate as commercially available technologies in terms of volumetric measurement of the post-REP pulp space. This was the first study to demonstrate how to use 3D Slicer, an open-source multiplatform software application for segmenting and volume estimation of the pulp areas of teeth treated with REPs that is user-friendly and easy to use **[9]**.

DETECTION OF VERTICAL ROOT FRACTURES IN INTACT AND ENDODONTICALLY TREATED PREMOLAR TEETH BY DESIGNING A PROBABILISTIC NEURAL NETWORK

Detection of vertical root fractures (VRFs) at their early stage is a critical issue, which prevents the propagation of injury to the adjacent supporting structures. It is critical to diagnose these root fractures early on in order to avoid harm to the root's supporting structures **[79]**. The majority of the time, VRFs go unnoticed since they present only minor symptoms, and in some cases, no signs at all **[60, 80]**. Radiographs and CBCT imaging aid in the diagnosis of a VRF, which can be difficult to identify. Due to a lack of a definitive diagnosis, an unneeded surgical operation or tooth extraction may be required **[8]**. CNNs, according to Fukuda *et al*40, may be a promising method for detecting VRFs on panoramic radiographs (recall 5 0.75 [sensitivity], precision 5 0.93 [positive predictive value], and F measure 5 0.83 [index used to evaluate machine learning performance]. A probabilistic neural network was created using periapical radiographs and CBCT images to diagnose VRFs in intact and root-filled teeth **[81]** in another investigation **[8]**. A study reported on the usage of an AI-based model using a PNN architecture for diagnosing VRFs on both intact and endodontically treated teeth when applied to periapical radiographs and CBCT images. The model proved to be particularly good at diagnosing VRFs on CBCT images when compared to periapical radiography. In a similar study, **[81]** CNNs were utilised to detect VRFs on OPGs. The results were very positive, meaning that the accuracy and performance of these models in detecting VRFs is extremely promising, and that they can be widely used in clinical practise **[60]**. Using periapical and CBCT radiographs, a study was conducted to develop a probabilistic neural network (PNN) to diagnose VRFs intact and endodontically treated teeth. In order to detect VRFs, researchers compared the performance of two imaging approaches. The proposed neural network can be utilised as a model for detecting VRFs on CBCT pictures of endodontically treated and undamaged teeth; CBCT images are more effective than periapical radiography in this context. The use of sound one-rooted premolar teeth free of caries and dental fillings, as well as the lack of simulation of neighbouring anatomic tissues, are limitations of that study. More in vitro research with a full-skull CBCT and skin/bone modelling is required **[81]**.

PREDICTION OF VIABILITY OF STEM CELLS:

Human stem cells are unspecialized cells that can be found throughout the body. They have the power to differentiate into any cell in an organism and to self-renew. MSC populations with high proliferative capability and multilineage differentiation have been produced from various human tissues, peripheral blood, and bodily fluids in recent years. Dental pulp stem cells (DPSCs) **[82]**, stem cells from human exfoliated deciduous teeth (SHEDs) **[83]**, periodontal ligament stem cells (PDLSCs) **[84]**, dental follicle progenitor stem cells (DFPCs) **[85]**, and stem cells from apical papilla (SCAPs) **[86]** have all been isolated as MSCs. DPSCs, which are derived from the cranial neural crest, display early markers for both MSCs and neuroectodermal stem cells and are considered a good source of MSCs phenotypic, and DPSCs have a lot of potential in regenerative medicine for treating dental disorders **[87]**. This study's unique and original ANFIS-based model gives an 189 simple and reliable method for predicting cell viability under various situations. The neuro-fuzzy inference method was used to estimate cell survival after microbial infection throughout various regenerative regimens **[88]**. The neuro-fuzzy inference method was used to estimate cell viability after microbial infection throughout various regenerative protocols **[88]**. The authors tested the viability of dental pulp stem cells after inducing an inflammatory response using lipopolysaccharide. The scientists next used adaptive neuro-fuzzy interferences to assess the accuracy of the outcome in predicting cell survival of these stem cells after microbial invasion **[8]**.

CONCLUSION:

As any other human invention, the artificial intelligence also has it's pros and cons. Highly skilled individuals are needed to perform such complex techniques. if artificial intelligence is used appropriately, it can greatly serve dentistry. More developments of artificial intelligence in the dentistry especially in fields like endodontics are expected. It will greatly reduce the complex nature of dental procedures in all phases.

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