Review Article

Artificial intelligence in dentistry: A boon or bane?

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ABSTRACT

This article provides an overview of the application of the intelligent technology in healthcare especially in the various specialities of dentistry and how much it has enhanced the quality of care being provided. Artificial intelligence is widely gaining popularity in various other sectors and is thought to be useful in the healthcare industry for diagnostic purposes and eventually with time programming, the technology to help healthcare personnels to carry out less invasive procedures.

1. Introduction

Artificial Intelligence is now being introduced in the markets worldwide including the health sector changing the face of medical and dental care and treatment.

Artificial intelligence came into existence when a program "Logic Theorist" which was developed to cater to analytical skills of humans was put forward at Dartmouth Summer Research Project on AI (DSRPAI) hosted by John McCarthy and Marvin Minsky in 1956.[1] The event paved way for artificial intelligence research in future. Artificial intelligence (AI), the term first introduced by John McCarthy; refers to machines that can initiate human knowledge and behaviour.[2] The potentiality can be executed through a course of data.

2. Implications of Artificial Intelligence

2.1. Uses of artificial intelligence in healthcare[3]

At Stanford MYCIN was developed for diagnosing blood borne bacterial infection proving the fact that disease interpretation and treatment planning has been the foremost aim of AI.

AI could aid to improve the care being provided to the patients with latest equipped technologies leading to accurate and least erroneous diagnosis. The improved imaging can result in better understanding of the patient's condition and surgeries can be planned accordingly.

The use of AI in pharmaceutical industry can fasten the process of drug identification.

AI can also help to identify high risk pregnancies. Hospital settings equipped with the latest technology in supporting AI interface can be used to manage any high-risk pregnancies in order to aid in decreased mortality rates and postpartum problems.

AI is also being used to develop powered exoskeleton that can assist those suffering from paralysis or limb/ hand

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amputations to regain control and resume function.

2.2. Uses of AI in dentistry

AI is being used in dentistry to improve image quality for accurate diagnosis and treatment planning. Advent of CBCT has been advantageous to both the clinicians as well as the patients.[4] The accurate location of canals, distance of tooth from mandibular canal, amount of bone available for implant placement are some of the things that can be accurately measured. These have resulted in less time consumption and reduced invasive treatment options.

AI has great application in orthodontics wherein a comprehensive history and extra as well as intraoral examination is of utmost importance for accurate treatment plan.[5] A unique strategy was executed using Artificial Neural Network (ANN) model for decision making regarding extraction in orthodontic patients. The model had a favourable outcome around 90-93% in differentiating between extraction and non-extraction cases.[6]

The different types of periodontitis can be studied by applying the potentialities of AI.[7]

The age estimation in forensic dentistry could be enhanced by AI assistance as efficiency of the images being produced will be of greater quality.[8]

2.3. Methods in artificial intelligence

Machine Learning. This subset of AI is designed such that it allows the machine to learn and make predictions based on experience.[9]

Representation learning. It is a type of artificial intelligence wherein the main objective is learning multiple ways of representing and abstraction of data. This type of AI has the ability to interpret data in its raw form. It can also identify the representations necessary to classify or detect in a pre-programmed manner.[10]

Deep Learning. It is a subset of machine learning that imitates the way humans gain certain type of information. In this type there is no need for programming the various functions that need to be carried out.[10]

2.4. Artificial intelligence applications in dentistry

The renewing technology and its ever increasing demand is also evident in the healthcare sector including dentistry. The merits of this intelligent technology can be put to use to reduce the human workload and improve the efficiency and quality of work. AI has certain applications in all fields of dentistry.

2.5. AI uses in oral medicine and radiology[11]

Intelligent technology can be used to improve the image quality. The software is pre-programmed with algorithms for the detection of anatomical landmarks, lesions, caries, etc. are of utmost importance for image acquisition and analysis. CAD systems were developed with the aim to detect lesion.

2.6. AI uses in Orthodontics[12]

Orthodontics deals with the correction of malocclusion which requires comprehensive history and series of radiographs for proper treatment planning. The various aspects in Orthodontics in which AI can be employed include:

1. Patient database collection
2. Cephalometric analysis
3. Growth estimation and facial analysis
4. Treatment simulation and appliance designing

History taking and formulation of diagnosis is a tedious process which can be simplified by employing AI. Use of AI can be of great advantage for accurate treatment planning as all the pros and cons as well as difficulties that can arise can be considered beforehand.

Cephalometric analysis can be done either manually or on computer. The use of computers for the same

reduces chances of errors and save time and moreover can show greater accuracy. The main roadblock to the use of computer for the same is the inconsistency in identifying anatomical landmarks which may lead to random errors.

Lee et al in 2020 used deep convolutional neural network-based analysis for cephalometric analysis.[13] Other authors confirmed that the software showed high success rate in differential diagnosis of cephalometric landmarks.

Growth and development are two parameters that need to be considered while planning the treatment for a patient. Radiographs of hand, wrist, cervical vertebrae have been used for age estimation.

Kok et al compared seven different AI algorithms to estimate cervical vertebrae maturation levels.[14] Moreover, facial proportions can be calculated with ease.

Akcam and Tanaka in 2002 developed a system based on fuzzy logic which could be useful to select the optimum type of headgear for the patient. This model made use of parameters such as overjet, overbite and mandibular plane angle.[15]

2.7. AI uses in prosthodontics

Prosthodontics is the art and science of dentistry that deals with the diagnosis, treatment planning, rehabilitation and preservation of oral structures function, comfort, aesthetics and health of the patients with clinical problems associated with missing or deficient teeth and oral and maxillofacial tissues.

AI can be applied in following areas of Prosthodontics:[16]

1. CAD/CAM

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┌──────────────────────────────────────────────────────────────┐
│        Prepared tooth is scanned using an intra-oral scanner    │
└──────────────────────────────────────────────────────────────┘
                              │
                              ▼
┌──────────────────────────────────────────────────────────────┐
│          3 D scans obtained are displayed on the computer screen │
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                              │
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│          Restoration fabricated with milling using ceramic block │
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│  In case of FPD, the prepared tooth structure is scanned, and the │
│   software is utilized to evaluate and plan the treatment.[17]    │
└──────────────────────────────────────────────────────────────┘
                              │
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┌──────────────────────────────────────────────────────────────┐
│  In case of partial edentulous the software will be used to       │
│        recommend optimal RPD design.[17]                          │
└──────────────────────────────────────────────────────────────┘
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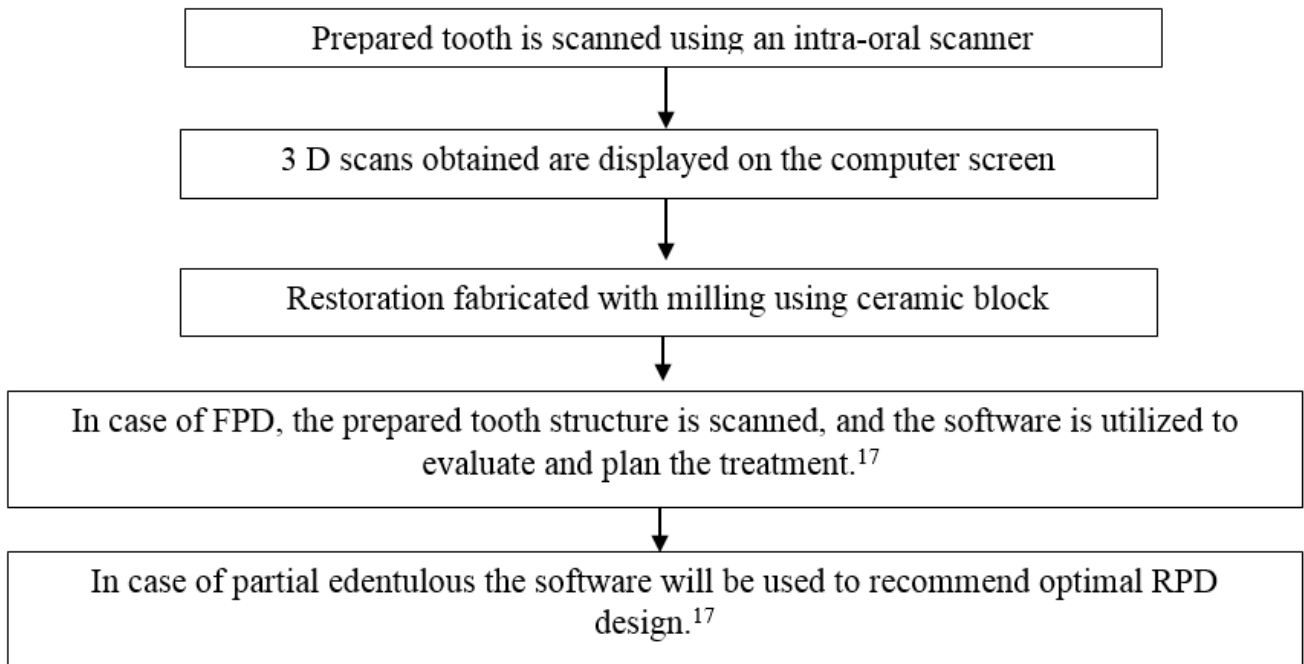
Fig. 1:

2. Fixed and removable partial dental prosthesis
3. Dental implantology
4. Maxillofacial prosthesis

CAD/CAM has gained popularity in Prosthodontics for the following reasons:

1. Reduced patient visits
2. Chairside procedure
3. Accurate aesthetics and designing

Inlays, onlays, crowns and bridges can be fabricated using AI. AI algorithms have been programmed to design various parts of fixed as well as removable partial dental prosthesis.

The treatment planning of dental implant requires the information such as precise location of mandibular canal, available amount of bone height. This has been made possible when CBCT and intraoral scans are used in combination.[17]

Maxillofacial prosthesis rehabilitation restores the function and aesthetics due to facial abnormalities or injuries replacing the missing tissue. AI allows the digital planning, designing and fabrication of maxillofacial prosthesis with precision and accuracy.

2.8. AI uses in periodontics[18]

Periodontal disease has a multifactorial etiology, one of them being the cesspool of bacteria.

Lee et al used CAD system based on deep convolutional neural network algorithm for diagnosing and predicting teeth that are compromised with periodontal health.[19,20]

Yauney et al used AI system based on CNN wherein they correlated periodontal health with systemic health outcomes and reported that AI can be used for automated diagnosis and can also be useful for screening of other diseases.[21]

2.9. AI uses in oral and maxillofacial surgery

The successful use of AI has been noted in the field of oral surgery specifically in case of orthognathic surgery for evaluating the facial proportions post operatively.

The use of AI has been postulated as follows:[22]

1. Accurate diagnosis using enhanced maxillofacial imaging such as CBCT
2. Treatment planning using 3D models
3. For the construction of custom orthodontic or surgical appliances using CAD/CAM

In case of maxillofacial fractures these can be visualised and STL model can be created which is a 3D model on which mock surgery can be conducted to predict the challenges during the surgery.[22] CBCT can be used to accurately visualise the proximity of the third molar to the inferior alveolar nerve predicting the difficulty in its surgical removal.[23]

2.10. AI uses in endodontics

Apart from the application of CBCT and digital imaging techniques which have been useful in the successful root canal treatments there is another entity that is gaining popularity – Guided endodontics.

Guided endodontics is a technique used for the treatment of calcified canals. Calcified canals commonly occur as a result of subluxation or concussion injuries to the tooth during young adult age. Most common clinical sign frequently seen is tooth discoloration. These calcified canals pose challenges to the root canal treatment which include root canal preparation. In such situations, potential procedural errors that can occur include: iatrogenic perforation, file separation, missed root canal etc.

This technique makes use of CBCT scans to visualise the canals in sagittal as well as axial sections. Intra-oral scans are obtained to form a 3D guide template that is fabricated to accurately plan access and obtain the correct glide path. The 3D guide is placed inside the mouth and access opening is done with the help of long shank surgical burs after which the working length is determined followed by obturation and post-op restoration.

Chong et al in 2019 suggested a new computer aided dynamic navigation which in combination with CBCT displays the suggested pathway and motion of drill within the canals. [24]

3. Conclusion

With the latest innovations in AI new improvements are being made which aim to provide accurate and better results. This intelligent technology that has been introduced in dentistry can be used efficiently to reduce workload and strengthen the quality of care that is being provided.

Although it may still have some limitations that might result in erroneous outcomes but with advancements these drawbacks can be controlled.

One also needs to learn to use the technology to its advantage in doing the smart work and remain up to date with the current scenario.

4. Source of Funding

None.

5. Conflict of Interest

None.

References

1. Rockwell A. Science in the News. Retrieved from Harvard University school of arts and sciences. Available from: https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/.
2. Chen YW, Stanley K, Att W. Artificial intelligence in dentistry: current applications and future perspectives. *Quintessence Int*. 2020;51(3):248–57.
3. Shaheen MY. Applications of Artificial Intelligence (AI) in healthcare: A review. *ScienceOpen Preprints*. 2021;doi:10.14293/S2199-1006.1.SOR-.PPVRY8K.v1.
4. Hosny A, Parmar C, Quackenbush J, Schwartz LH, Aerts HJ. Artificial intelligence in radiology. *Nat Rev Cancer*. 2018;18(8):500–10.
5. Asiri SN, Tadlock LP, Schneiderman E, Buschang PH. Applications of artificial intelligence and machine learning in orthodontics. *APOS Trends Orthod*. 2020;10(1):17–24.
6. Xie X, Wang L, Wang A. Artificial neural network modeling for deciding if extractions are necessary prior to orthodontic treatment. *Angle Orthod*. 2010;80(2):262–6. doi:10.2319/111608-588.1.
7. Sachdeva S, Mani A, Vora H, Saluja H, Mani S, Manka N, et al. Artificial intelligence in periodontics: A dip in the future. *J Cell Biotechnol*. 2021;7(2):119–24.
8. Banjšak L, Milošević D, Subašić M. Implementation of artificial intelligence in chronological age estimation from orthopantomographic X-ray images of archaeological skull remains. *Bull Int Assoc Paleodontology*. 2020;14(2):122–9.
9. Jiang F, Jiang Y, Zhi H, Dong Y, Li H, Ma S, et al. Artificial intelligence in healthcare: past, present and future. *Stroke Vasc Neurol*. 2017;2(4):230–43. doi:10.1136/svn-2017-000101.
10. Hamet P, Tremblay J. Artificial intelligence in medicine. *Metabolism*. 2017;69S:36–40. doi:10.1016/j.metabol.2017.01.011.
11. Nagi R, Aravinda K, Rakesh N, Gupta R, Pal A, Mann AK, et al. Clinical applications and performance of intelligent systems in dental and maxillofacial radiology: A review. *Imaging Sci Dent*. 2020;50(2):81–92.
12. S TA, Me. A review of the use of artificial intelligence in orthodontics. *Journal of Experimental and Clinical Medicine*. 2021;38(3s):157–62.
13. Lee KS, Ryu JJ, Jang HS, Lee DY, Jung SK. Deep Convolutional Neural Networks Based Analysis of Cephalometric Radiographs for Differential Diagnosis of Orthognathic Surgery Indications. *Appl Sci*. 2020;10(6):2124. doi:10.3390/app10062124.
14. Kök H, Izgi MS, Acilar AM. Determination of growth and development periods in orthodontics with artificial neural network. *Orthodontics & craniofacial research*. 2021;24:76–83.
15. Akçam MO, Takada K. Fuzzy modelling for selecting headgear types. *Eur J Orthod*. 2002;24(1):99–106.
16. Singi SR, Sathe S, Reche AR, Sibal A, Mantri N. Extended Arm of Precision in Prosthodontics: Artificial Intelligence. *Cureus*. 2022;14(11):30962. doi:10.7759/cureus.30962.
17. Komuro A, Yamada Y, Uesugi S, Terashima H, Kimura M, Kishimoto H, et al. Accuracy and dimensional reproducibility by model scanning, intraoral scanning, and CBCT imaging for digital implant dentistry. *Int J Implant Dent*. 2021;7(1):1–7. doi:10.1186/s40729-021-00343-w.
18. Sachdeva S, Mani A, Vora H, Saluja H, Mani S, Manka N, et al. Artificial intelligence in periodontics: A dip in the future. *J Cell Biotechnol*. 2021;7:119–24. doi:10.3233/JCB-210041.
19. Lee JH, Kim DH, Jeong SN, Choi SH. Diagnosis and prediction of periodontally compromised teeth using a deep learning-based convolutional neural network algorithm. *J Periodontal Implant Sci*. 2018;48(2):114–23. doi:10.5051/jpis.2018.48.2.114.
20. Pareek M, Kaushik B. Artificial intelligence in prosthodontics: A scoping review on current applications and future possibilities. *Int J Adv Med*. 2022;9(3):367–70. doi:10.18203/2349-3933.ijam20220444.
21. Yauney G, Angelino K, Edlund D, Shah P. Convolutional neural network for combined classification of fluorescent biomarkers and expert annotations using white light images. In: 2017 IEEE 17th International Conference on Bioinformatics and Bioengineering (BIBE). IEEE; 2017. p. 303–9.
22. Bouletreau P, Makaremi M, Ibrahim B, Louvrier A, Sigaux N. Artificial Intelligence: Applications in orthognathic surgery. *J Stomatol Oral Maxillofac Surg*. 2019;120(4):347–54.
23. George AL, Panicker P, Johny J, Bhaskar M, Jacob BM, Zulthana H, et al. Reliability of Cone Beam Computed Tomography in Comparison with Panoramic Radiography to Predict the Anatomical Relationship of Inferior Alveolar Nerve with Mandibular Third Molar: A Radiological and Clinical Study. *J Pharm Bioallied Sci*. 2020;12(1):S367–72. doi:10.4103/jpbs.JPBS_107_20.
24. Chong BS, Dhesi M, Makdissi J. Computer-aided dynamic navigation: a novel method for guided endodontics. *Quintessence Int*. 2019;50(3):196–202. doi:10.3290/j.qi.a41921.

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