

A REVIEW ON FOOTSTEPS AND CLINICAL APPLICATIONS OF ROBOTICS AND ARTIFICIAL INTELLIGENCE IN DENTISTRY

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ABSTRACT

The expression of artificial intelligence alludes to a machine that is being quipped for performing human undertakings. Computer-based intelligence applications will smooth out care, diminishing dental labor force, expanding wellbeing at a much lower costs to more extensive population, and work with customized, prescient, participatory, preventive and dentistry. Artificial Intelligence (AI) still have not entered schedule dental practice, basically because of restricted information accessibility, availability, design, and completeness. Any AI application in dentistry ought to exhibit substantial-worth by, for instance, further development and improved quality of care, increased efficiency and security of administrations, engaging patients, clinical examination, or expanding maintainability. It is important to keep a proactive mentality toward AI to guarantee its positive turn of events and elevate human-innovation compatibility to alter dentistry. The current review diagrams the advancement of AI in clinical diagnosis, plan treatment and to make a setting for future exploration in this quickly growing field.

Keywords: Robotics, Artificial intelligence, Dentistry, Future, Human

INTRODUCTION

Human beings' brain is the complex supreme design that is being available till today. The usefulness was first given by Plato in the researchers and scientists both have year 400 BC. From that point forward consistently stayed curious with regards to it and still have not had the option to recreate the specific neural organization and work that runs this entire framework. Comprehensively it comprises various interlinked neurons which communicate signals all through the human body where it controls it's working. A crude model of person cerebrum's design that is being available till today. The usefulness was first given by Plato in the researchers and scientists both have year 400 BC. From that point forward various creations have been finished with the assistance of consistently working on innovation to recreate the nearest conceivable model of human mind work. The summit of all these developments is ascent of Artificial Intelligence (AI).^[1]

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Man-made brainpower (AI) is characterized as 'an area of science and designing worried about computational comprehension of what it is regularly called intelligence, and the production of artifacts which shows such conduct. It is fundamentally the space for software engineering which underscores intelligent machines production which responds and work like humans.^[2] Its advancements have expanded in regions like master frameworks, game turn of events, hypothesis demonstrating, normal language translation, acknowledgment of pictures, and mechanical technology in different fields like media transmission and aviation.^[3] As of now, robots are likewise arising in the field of stomatology, where starting advancement been made that has established the framework for the future improvement of robotics in dentistry.^[4] It is a machine equipped for doing a perplexing series of activities naturally. Robotics isn't yet utilized in dentistry even though every one of the essential innovations as of now has been created and could be adjusted easily.^[5] This present review focus on the progress and potential applications of the artificial intelligence and robotics in different fields of dental practice.

FOOTSTEPS OF ROBOTICS IN DENTISTRY

Service:

Robots can play out some pre-learned errands in moving appendages. They used to serve medications and foods to patients or older individuals and as automated toys for engaging the pampered child.^[6]

Assistant:

Can be utilized in computer-assisted dental implantology. In this current, it's achievable to move a pre-usable arrangement to the careful field by a layout. Such a template can be performed and manufactured easily by active and passive robots.^[6]

Education:

As an outgrowth, a global yield of innovators is making a frantic race to foster helping approaches to uniquely reduce showing time and practice on human patients. The teaching test systems comprising of a palm estimated automated handpiece and a computer screen have been created. The individual can feel and control the 3D augmented simulation in maxillary and mandibular dental curves seen on a computer screen. Humanoid robots have been fostered that emulate a patient. They make unexpected neck turn, snuffle, and hack as though the automated patient feels genuine agony. It even shows weariness by opening the mouth during the

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dental treatment and retches if the student unintentionally contacts the uvula with a sensor.^[6]

Prosthodontics:

Precise tooth preparation is of utmost importance for long-term success. Due to restricted oral space, the shaking of human hands, and the constraint of clinicians' specialized abilities, the state of prepared teeth may not be great. To tackle this issue, a small laser control robotic device for crown preparation, called LaserBot was created. These robots can automatically control the laser to cut the teeth in three dimensions. Research on human teeth in vitro shows the robot can supplant manual crown preparation, and the accuracy can arrive at clinical requirements. The course of tooth arrangement in complete dentures requires numerous fine adjustments to accomplish an ideal occlusal relationship. To save human undertaking, a solitary controller automated framework dependent on the CRS-450 robot, which was utilized for tooth arrangement in the total dental manufacturing.^[4]

Orthodontics:

Precise archwire bending is the critical innovation in the treatment of fixed orthodontics.^[7] When compared with a customary manual of bending the framework, efficiency, exactness of bending the archwire could be enhanced

by utilizing robots for its exact posture controlling capacity.^[8] In 2004, Sure Smile arch wire-bending robot was designed by Butscher et al^[9], 2009 it's Zhang et al^[10] and Du et al^[11] designed an orthodontic arch wire-bending robot with Motoman UP6 robot and by using these four types of orthodontic archwires can be bent, in 2011 Gilbert et al^[12] developed LAMDA system for precise and rapid work, 2013 Jiang^[13] constructed the third-order S addition and subtraction cure control method, 2014 Xia et al^[14] designed end effector that can change the pincer automatically and it was verified by ROS and Gazebo a robot simulation platform and in 2016, it's Jiang et al designed a robot based on LabVIEW and ATmega2560.^[15]

Endodontics:

To work and improve root canal treatment, in 2007 Dong et al designed a multipurpose endodontic microrobot. Probing, drilling, cleaning, and filling can be understood by realizing the automatic treatment procedure through computer control by fixing it on the patient's tooth.^[16] Robots can also assist the clinician to prepare cavities by operating the drill to get accuracy and smoothness, therefore decreasing iatrogenic injuries. Robots can execute pre-programmed instructions to select and utilize the desired instruments which were developed by

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Nelson et al and experiments showed treatment time reduced by 4.4%.^[17]

Oral Surgery:

The anatomical structures of oral and surrounding structures are complex and interest in this dental field is high due to its esthetic demand. Consequently, the orthognathic procedure should be highly precise and performed with negligible injury.^[4] Experiments on living pigs mandible showed that the robot can be utilized under an assortment of conditions in the maxillofacial procedure for the convenience of the specialist. The posture memory capacity of the robot permits it to participate more efficiently with the expert in the restricted operation space around the surgical table.^[18] For benign and recurrent malignant neoplasms robotic surgery in laryngopharynx, oral cavity seem to have high recovery, low-risk hemorrhage, high rates of negative margin, and by reducing the intraoperative and postoperative complications when compared to conventional open surgery.^[19] To obtain an excellent cosmetic result, functional recovery, low positive margin rate, and no apparent neurovascular damage, the use of Transoral surgery by robots for minor and major oropharyngeal tumors of the salivary gland, sublingual ranula showed

excellent and favorable surgical and functional outcomes.^[20]

For maxillofacial fracture treatment, a robotic surgical system consists of reduction and fixation procedures. Developments of robots are more difficult because fracture segments position changes after the reduction, therefore, its difficult to layout correct navigation, and due to lack of tactile sensation robots are unable to come up with resistance during the fixation. As now, robots are integrated with force sensors for arthroplasty, like ROBODOC, Bone Resection Instrument Guidance by Intelligent Telem manipulator (BRIGIT), and (ACROBOT) Active Constraint Robot. Reduction and fixation by robots are just utilized for fracture of pelvic and long bones. The robotic system in clinical use of fractured maxillofacial region is still not has been reported yet.^[20]

ARTIFICIAL INTELLIGENCE IN DENTISTRY

Patients' clinical management:

The center of practice is the "Dental Chair" that has advanced from manual siphons frameworks, hydraulic factors to an electric chair with a sensors system. With the assistance of AI, the dental seats have consolidated a more up-to-date "voice order" innovation, which will work on vocal guidelines killing the need for actual touch. As of late at the Consumer

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hardware Summit, 2020, two driving brands have delivered AI-powered toothbrushes, toothbrush sets with telephone through Bluetooth and connect it to an application in the telephone which translates that information. The organization asserts that this will give exact data continuously that is specific to each oral cavity.^[21]

The forward leap of AI in dentistry is by making a virtual dental assistant. The virtual helper, "D Assistant" is planned by Dentem, will hear orders, analyze data's including dental pictures and records, and give data-driven ideas during dental treatments. It's intended to be the ideal assistance for both dental professionals and assistants, diminishing mistakes and smoothing out choice making.^[21] Along these lines, the thorough virtual information of patients will be produced which can help in giving ideal treatment to patients in the long-term run.^[22]

Oral disease treatment and diagnosis:

Artificial intelligence upheld analysis has high specificity and sensitivity, subsequently demanding the significance of AI in accomplishing the right interpretations and diminishing human errors.^[21] In this process, effectively prepared neural organizations could be a valuable tool to diagnosticians, especially in conditions and infections with

multifactorial reason or in etiology. Artificial intelligence is considered as the value and optimal tool modalities for diagnosing, planning treatment, and treating oral lesions.^[22] Indeed, even insignificant in minute changes at a degree of single-pixel that may go imperceptible to the natural eyes can be recognized. Artificial intelligence will be able to definitively guess the inclination of qualities in the oral disease for an enormous population.^[21]

Oral radiology:

The machine-learning algorithm could identify lymph nodes in head and neck pictures as an ordinary and unusual provided as it is prepared by a radiologist by investigating many such pictures that are marked as both normal or it is abnormal.^[23] Artificial intelligence-based Convolutional neural networks (CNN's) and assessed powerful teeth acknowledgment by depending on the marked tree alongside course network structure. CNN's to recognize the tooth numbering in intraoral periapical radiographs and afterward to distinguish the teeth. These models exhibited extremely superior accuracy. The outcomes showed that AI advances will make it advantageous for dentists to tackle all clinical work and need not enter all the details physically. Utilizing these

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mechanized frameworks dental specialists will be able to enter dental graphs digitally, coming about in high efficiency.^[24] Radiological data can come from various scans, for example, 3D outputs, Intraoral periapical X Rays or RVGS, Cone Beam Computed Tomography (CBCT), and so on.^[1] Applications of AI in oral radiology are divided into three types, i.e., Types of application, Clinical workflow, Classes of use cases.^[22]

Dental caries:

Exploration in the new past has set up that a greater part of dental caries can't be recognized in routine assessments including x-rays. While occlusal caries is not difficult to recognize through an ordinary clinical assessment or x-ray survey, yet these identification techniques are not reliable for a higher percentage of caries, like those below the surface of the tooth, interproximal, and root caries. An AI organization, ParallelDots, Inc., began a cloud-based AI application for caries detection on dental x-rays. They named this new clinical gadget device Dentistry.AI.

To perceive designs from these huge data sets, an AI algorithm is prepared and trained. The benefit is exposure to the large number of data that works on its effectiveness to play out a particular task.

Effectively interpret X-rays and 3D pictures requires a ton of involvement and experience, and AI assistant makes the work a lot simpler as it has as of now saw 1,000,000 images. It holds applications in periodontics, orthodontics, implants, and caries detection. Thus, AI trained attains a great degree of accuracy for anticipating the location of caries.

Oral Surgery:

By using CNN to score the cytology malignancy images from the telemedicine site, showed the greatest sensitivity in identifying oral cavity malignancies (93%) and (73%) high-grade malignant lesions. Regardless of these astounding outcomes, contemporary models of AI for maxillofacial surgery focused on just one kind of data, like the radiographic result or cytopathologic images. For exceptionally exact determination, models that incorporate more clinical data about the patient are required.^[26] for detecting cancer 63 AI has been used. It is very useful in predicting any facial or oral swelling postoperatively after extraction of the tooth.^[27]

Prosthodontics:

Artificial intelligence supports prosthodontics by the utilization of computer-planned design and computer-supported manufacturing technology for an accurate fit of prosthesis, research facilities

are utilizing AI to automatically created dental restoration for a precise fit and ideal function and esthetic appearance. This not exclusively will assist and support dentistry but also has immense potential on it and have an effect on Oro-facial or craniofacial prosthesis.^[21] To simulate facial profiles in post-treatment can use technology like Virtual reality simulation (VRS).^[28] Computers can guide with the help of AI during the procedure of digital impressions and aids in helping the dentist to make an ideal impression.^[29]

Implantology: AI can make precise identification in cortical bone thickness and types of bone which might be important for identifying a suitable location for the placement of implants.^[1]

Orthodontics:

Diagnosis shapes the center of the treatment in orthodontics. Artificial intelligence helps in analysis, planning treatment, and progression of treatment by analyzing photographs and radiographs.^[30] Artificial neural networks (ANN's) can support the clinical decision-making process. In orthodontics, it is fundamental to plan a treatment cautiously to achieve good results. In predicting movements of the tooth, plan orthodontic treatment, the outcome of treatment including extraction/no extraction, and anchorage pattern determination can be done with the

help of AI software. There are AI-aided orthodontic aligners that help in performing a treatment, to monitor treatment progress, and to reduce the time of treatment and appointment schedules.^[31]

A pre-trained Convolutional neural network (CNN) model investigated pre and post orthodontic treatment facial photographs. AI which detected the outcomes will reveal the result like increasing facial attractiveness and decrease in age appearance. Machine Learning helps to prospectively pre-visualize the patient's outcome of treatment.^[32]

Periodontics:

Periodontal disease is quite possibly the most well-known oral disease influencing humanity. This indeed is the primary reason behind early loss of a tooth.^[33] Using radiographs deep learning analysis assist in periodontal disease diagnosis and planning treatment for any early changes of the periodontium, horizontal or vertical bone loss, and surrounding bone density.^[34] AI can alleviate pain during scaling and root planing periodontal procedures by using virtual reality (VR) distraction which aid as an effective method to control pain.^[34] Periodontal conditions in the oral cavity could be predicted by CNN models with radiographs. To differentiate between

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aggressive and chronic periodontitis by examining the sublingual plaque to identify microbial profiles was done by the support vector machine (SVM) model.^[35] AI model is used to not only detect primary teeth dental plaque but also dental plaque on a permanent tooth, tooth restorations like implants, and ceramic crown.^[36]

Oral Pathology:

A neural network is useful for the identification of high-risk individuals with oral cancer and pre-cancer conditions and it's used for health education.^[37] AI is helpful in the reproducibility of histopathological and clinical diagnosis for a lesion concerning other mucosal diseases in the oral cavity.^[38] Fuzzy logic is used to predict lymph nodes in the cervical region or any metastasis in carcinoma of the tongue, nasopharyngeal, esophageal cancer, and in outcome prediction of oral cancer.^[39]

Endodontics:

AI in endodontics could accurately locate teeth which are prone to caries, find complex peri-apical pathogenesis, define boundaries of the lesion and enable their differentiation.^[40] Detection and characterization of proximal caries AI-based program have been designed to assist dentists by Logicon Caries DetectorTM program (Logicon Inc.,

USA).^[41] It also helps in finding the life span of restorative materials and for suitable cases to choose them wisely and aids in locating the minor apical foramen, hence strengthening the working length accuracy.^[42]

Forensic Odontology:

An important aspect in forensic is age estimation that's been estimated over years for several grounds. By using facial images estimation of human age is tremendous in the recent past.^[43] AI technology uses an automated technique which is based upon CNNs in mandibular 3rd molar development staging to estimate the age of an individual using a panoramic radiograph. When comparing to trained examiners it showed excellent results.^[44] using artificial neural network (ANN) to predict mandibular pattern either class I, II, or III lateral cephalography was used.^[45] For forensic odontology this technology saves time, so they do not require to look for all data and compare one by one. The computing period could be optimized with the new algorithm and it's very useful.

PUBLIC HEALTH SIGNIFICANCE

AI has several benefits over conventional and clinical analytic decision-making techniques. Modern health care faces a lot of challenges in the current world for collecting, analyzing, and diagnosing, and treat diseases. AI-based systems usage in

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healthcare is more curated, structured, as well as helpful in systematic patient data collections and chiefly suitable for overcoming variations for examination and in facilitating effective care by lowering the treatment plan cost. Safeguarding compliance in the use of AI medical information is under HIPAA (Health Insurance Portability and Accountability ACT of 1996) is another concern. As technology improves it helps the dentist to perform at a higher level by making their jobs easier without human error. It will be greatly expanded in the field of dentistry by few years and transform dental and medical in several ways.

CONCLUSION

Artificial intelligence is not an allegory but also our future in the field of dentistry and its applications in each and every area is growing slowly day by day. It has become tremendous in the last decade in the medical field. Applications in daily life are growing in leaps and bounds. It progresses rapidly in treatment, diagnosis, and prognosis prediction. These systems look forward to having a promising and splendid future outlook both in maxillofacial radiology and dentistry. The biggest limitation, however, the large and sound database requires to get error-free results. There is a long way still to go but hopefully expecting the transformation in

the future decade. A robotic system is novel, having a good impact on the minimally invasive procedure and development in dentistry is still in the early stages. Several hurdles and challenges have to be made to broaden the application and adopt this technique. Thus, the field of dentistry and dental research has several roles to ensure that AI and robotics will make dental treatment and planning easier, at a lesser cost, thereby benefiting providers, patients, and a wider section of society.

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