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Transforming the Landscape of Advanced Dentistry: Incorporating Intelligence Augmentation (IA) and Artificial Intelligence (AI) to Propel Progress – A Narrative Review

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Abstract

Digitization is about to transform most sectors, and it is important to comprehend its role and socio-economic consequences. One of the infected sectors is dentistry and this article genericizes AI and IA in dentistry. It analyzes the advancement of AI and IA to supersede human capabilities using a comparative analysis of these technologies with current deployment. One of the challenges is to attain sufficient data input for AI and the other is the integration of AI into routine medical practice. There are also questions about liability and deployment costs that are unanswered. This study provides an outlook on the future dentistry in terms of what would be the interaction between robots and humans, and the influence of Artificial Intelligence (AI) and Intelligence Augmentation (IA) in the sector. The paper as a whole give's insights into the challenges and possible advantages of making use of AI and IA in dentistry.

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INTRODUCTION

Recently, new technologies and processes have started to develop in the 21st century, digitalization and designation of industry 4.0. Digital technologies play an ever-increasing role in our lives and are rapidly touching nearly every industry. One industry that will greatly benefit from digital technology is dentistry. Effective use of these technologies in dentistry has the potential to offer an efficient treatment system that saves time and money, reduces human error and benefits not only dentists and patients, but dental students as well. Treatment of over half the world's population suffers from untreated tooth decay and the further development of the dentistry sector could benefit from implementing digital technologies.

Investment in the sector is of key concern, since, according to a latest study, oral diseases are the fourth most expensive diseases to treat (Petersen PE, 2003) [1]. Oral diseases can cause pain, anxiety, deformities, infections, eating and sleeping

disturbances and various other issues that affect every aspect of life from relationships and self-confidence to income, giving a bad quality of life. Also, oral health is very important in general health and therefore, it becomes very important to consider this field. Barber surgeons became the implementers of technology in improving dentistry efficiency from as far back as 1092. Throughout the centuries, with amalgam for tooth restoration, dentures made of several materials, use of dental drills to quickly remove decayed tissue and advancements in dental education have all occurred (Petropoulos VC, 2006) [2]. Yet, much more room for improvement exists within the dentistry sector and the digital technologies (such as artificial intelligence (AI) and intelligence augmentation (IA)) integration may have a large potential to change and help the development of dentistry (Haddadi, 2021) [3].

Digital technology can improve efficiency in the sector and give the considerable effect of oral disease to the global population, thus, the practice of going further is apparently a successful strategy. Al-Rawi introduced that digital technology, like CAD/CAM and 3D printing, used to be beneficial for patients and treatment results in dentistry. The use of digital technologies in the production of dental prostheses was found to be more precise and accurate, to produce faster and to assess better esthetics in relation to traditional methods. The authors also pointed out the possibilities for digital technologies to enhance communication between dental professionals and their patients so that there can be better planning of treatment and results. Further, extension of this work illustrates the value of integrating digital technology into dentistry to enhance the quality of patient care (Al-Rawi, 2019) [4].

Artificial intelligence (AI) and Intelligence Augmentation (IA), both terms that have evolved in recent years, should be applied in different domains (McCarty J, 2006) [5] including dentistry. In 1956, John McCarty introduced the idea of AI as a thought-provoking idea that had enormous potential to revolutionize dentistry. As for IA, a parallel counterpart to AI. Taking these concepts, the future of dentistry is what researchers discuss these days, researching whether AI or IA will be at the top of the era of modern dentistry.

Recently a comprehensive study (Iqbal A, 2021) [6] was done which describes the different AI methods employed in dentistry and evaluates their possibilities as well as their difficulties. Rapid deployments of digitization underscore the importance of understanding the different technologies and their impact on dentistry, the authors say.

ARTIFICIAL INTELLIGENCE VS INTELLIGENCE AUGMENTATION

How Artificial Intelligence and Intelligence Augmentation may be applied in Dentistry has been highlighted in recent articles. Some of these technologies can improve efficiency and accuracy in diagnosis, treatment planning and patient monitoring. Machine learning and deep learning using AI methods have demonstrated some promise in diagnosing oral diseases or conditions, including periodontitis and oral cancer by the analysis of radiographic images and other diagnostic tools, on the other hand, IA techniques do help dental professional in decision making by supporting real time information and personal recommendations.

After diagnosis and treatment planning, the performance of AI and IA is also beneficial regarding improving patient experience and satisfaction. Smart dental tools can decrease patients' discomfort and anxiety through procedures and virtual assistants and chatbots can give the patients instant answers for their concerns and questions. These technologies can be implemented; however, the implementation of these technologies emphasizes ethical and legal concerns about patient autonomy and data privacy (Hameed, 2022) [7].

All in all, AI and IA can revolutionize the healthcare area of dentistry through providing accuracy, efficiency and better patient experience. But it is important these technologies are adopted wisely to be ethical and legal.

ADVANCES VS CHALLENGES IN IA AND IA DENTISTRY

In recent years, intraoral scanners have become an integral part of dentistry, where they have revolutionized how dental professionals gather and process data. Advances in IA dentistry have now offered a method to sterilize and fight conditions, that is efficient and accurate in diagnosing, planning and executing dental procedures (Kim RJ, 2018) [8]. Though there are many benefits, IA dentistry still has several challenges to be solved to improve patient outcome and further improve the functions given by the technology.

A real time accurate digital impression is one of the greatest leaps forward in the field of IA dentistry. This allows for not having to use impression materials, like alginate, which can sometimes be unwieldy and messy. In addition, digital impressions can be saved and shared electronically making communication between dental team and dental laboratory less complicated. Furthermore, due to the high accuracy and precision measurements, IA dentistry helps the dental professionals make more accurate and a better fitting restoration that last longer (Fasbinder DJ, 2006) [9].

But IA dentistry also has its own set of problems. The cost of equipment is one of the most significant challenges for dental practices since it may represent a significant investment. Further, dental professionals who carry out IA dentistry need to be trained in the use of the equipment to function properly. A variation in the quality of the scans produced by different providers has come about due to a lack of standardized training programs and certification processes. However, with all these challenges ahead, IA dentistry is expected to keep on moving forward. AI technology is being tested by researchers to improve the accuracy of scans and to decrease the time needed to scan. Moreover, recent trends in 3D printing technology help dental professionals to make customized restorations more quickly and precisely (Gherlone EF, 2018) [10].

In the present day, in a growing number of industries, it is becoming important to use intelligent machines, such as artificial intelligence (AI) and machine learning. There are applications intelligent machines have in dentistry, for instance, for diagnosis, treatment planning and monitoring. These machines are becoming a must in the medical world, given the fact that they can process a lot of data and identify details which a human cannot, which has led to improving the accuracy and efficiency of dental procedures.

Diagnostic role for intelligent machines in dentistry is one of the essential roles. Dental images were analyzed with AI algorithms that can identify abnormalities including cavities and tumors. AI accuracy for detecting these abnormalities has been reported to be up to 97%, which qualifies technology as a good asset for dental professionals. Furthermore, intelligent machines can help to plan treatment by modelling different treatment strategies and predicting outcomes using patient specific data (Huang F, 2020) [11].

Dental procedures are also monitored by intelligent machines. For example, intelligent machines can, for instance, track the progress of tooth movement during orthodontics and change accordingly. More accurate and efficient treatment follows, thus lessening the amount of time spent visiting the dentist (Colaco AS, 2021) [12].

Although intelligent machines bring many advantages to dentistry, there are some challenges also. Technology is expensive, and this is possibly one of the biggest challenges that will hinder adoption among certain dental practices. In addition, intelligent machines must be implemented by dental professionals who must be trained specifically to carry this out, and such training may not be available everywhere. Finally, it is worth recognizing the vital role intelligent machines are playing in dentistry. These machines have the potential to enhance the accuracy and the efficiency of dental procedures from diagnosis to treatment planning and ultimately monitoring leading to raise the patient outcome. Of course there are challenges, but continued research and development in this area will result in wider implementation of this in dentistry.

INTELLIGENT MACHINES IN DENTISTRY

Dentistry is no exception, where intelligent machines are revolutionizing many industries. With the advances in computer science in the past few years both in the artificial intelligence and machine learning area, it is becoming essential for dental practice to have intelligent machines. Many applications of these machines exist in dentistry for diagnosis, treatment planning and monitoring, etc.

Among the most popular applications of intelligent machines in dentistry, the diagnosis field is one of the important ones. There are some AI algorithms that analyze dental images, for detecting abnormalities like cavity or tumor. Results from these algorithms have an accuracy between 96 to 97% and are excellent tools to be used by the dental professionals. Additionally, intelligent machines can aid in treatment planning by testing different treatment options and predicting the outcome involved with a given set of patient specific data (Shimizu K, 2021) [13].

Monitoring dental procedures plays an important role and solving problems here could involve intelligent machines. Intelligent machines can be used during orthodontic treatment to track the movement of teeth during treatment and to make alterations as needed. The resulting treatment is more accurate and efficient, requiring fewer visits to the dentist (Colaco AS, 2021) [12].

But there are also issues to solve. One issue that most significantly relates to is the cost of the technology which can pose a challenge to adoption by some dental practices. Also, intelligent machines become necessary smart machines need specific specialized training for dental professionals, which less often can be available everywhere.

However, the smart use of machines in dentistry prevails. The field of intelligent machines will continue to be a field of research and development, and upon wider adoption, those machines will increase in accuracy and efficiency of dental procedures and ultimately lead to better patient outcomes.

Dentists have successfully revolutionized dental practices with these machines, not only for performing more accurate treatments and more efficient treatments with the final goal to improve the patient's outcomes and experiences. The dentists use artificial intelligence and machine learning algorithms to diagnose, plan for treatment, or even execute the treatment. This looks at how intelligent machines play an indispensable part in dentistry.

Intelligent machines in dentistry have probably one of the most significant advantages, in assisting with the diagnosis of dental conditions. Deep Learning (Elsharawy, 2021) [14] algorithms – based on AI – can analyze dental images, find patterns too faint for human dentists to view. The detection of these systems can aid with the early detection of diseases, for example oral cancer, in which, in case of successful treatment, the chance is much higher.

Treatment planning also relies on machines that are intelligent. Dentists can use AI algorithms to generate custom treatment plans by using a patient's medical history and dental records, and by their unique needs. This helps dentists supply far more accurate and efficient therapy with less chance for problems and better affected person outcomes.

Dental surgeries also use intelligent machines with the aim of increasing their precision and accuracy. For example, robot assisted dental surgeries are known to be more accurate and precise than conventional forms, with a decreased risk of error and complication. Additionally, these machines can handle repetitive and mundane tasks, putting away the dentists to do more complicated procedures.

DATA PRIVACY AND SECURITY APPROACHES IN SMART DENTISTRY

Various technologies, for example artificial intelligence, internet of things, and cloud computing are the making of Smart dentistry and it has played a significant role in providing benefits to the dental industry. But with wider use of such technologies, the importance of data privacy and security is emerging. This article attempts at-discussion of data privacy and security approaches in smart dentistry.

Ensuring data privacy and security in smart dentistry is the first step to which strong data encryption techniques are implemented. It is hard for hackers to get into sensitive data using encryption and in sending and storing it as well. Moreover, such healthcare providers should be tied to establishing stringent password policies, while patients should be taught password security (Bhatia TS, 2018) [15].

The second way to address the problem is to build access controls that restrict who can access sensitive data. Multi factor authentication (such as fingerprint & facial recognition) should be used in access controls, and they should be updated regularly so that only authorized personnel are allowed access to patient data (Yang SH, 2017) [16].

Vulnerability assessments and penetration testing are important approaches too. It will help discover potential chances of vulnerabilities in the system which malicious hackers can use. Before these vulnerabilities are exploited, healthcare providers can target these vulnerabilities (Maheshwari RT, 2018) [17].

It is finally important to guarantee that the data is not being compromised during data sharing. Healthcare providers should, when data sharing is required, use secure methods (encrypted email, secure file transfer protocols, etc.). Moreover, all patients should be educated on the risks of data sharing and be given the opportunity to opt out (Kim HK, 2020) [18].

Overall, smart dentistry needs data privacy and security. Sensitive patient data must be strongly encrypted, access must be controlled, vulnerabilities must be assessed and the data shared securely. Today's technology is moving on rapidly and it is imperative that we all remain on high alert and are consistently able to adapt to security measures to safeguard patient privacy.

OBSTACLES AND LIMITATIONS OF ROBOTIC DENTISTRY

Recently, there has been a rise in popularity of robotic dentistry; technology in which robotics technology is used to assist a dentist with many tasks. But while it provides many benefits, there are several obstacles and limitations which need to be overcome before widespread implementation is practical. In this article, we describe the difficulties robotic dentistry faces from both technological and social points of view.

The cost of the equipment itself has long been one of the major hurdles for robotic dentistry. Accordingly, robotic systems are costly to develop, deploy and maintain, thus preventing smaller dental practices from purchasing robotic systems (Liu Y, et al., 2021) [19]. However, the limited accessibility of robotic dentistry, which limits the usage in the rural areas of developing countries, is caused by this.

Furthermore, some of the systems on the robotic dentistry platform lack flexibility. One problem with robotic systems is that they are usually programmed for one task and cannot respond to unexpected complications or other changes during a procedure. Inefficient treatment and delays may occur as a result.

However, for some patients, there are medical conditions or physical limitations that make them not suitable candidates for robotic procedure. At the same time, it can also be pointed out that robotic systems do not replace the expert and experience of a well-trained human dentist (Nahum S, et al., 2019) [20].

Moreover, there is the need for requiring dentists and staff to be trained in a specialized way. Robotics systems and their complexity need specialized training skills to operate and maintain them. It can be a long and expensive process, particularly for the smaller practices.

Finally, robotic dentistry has many advantages, and this article covers obstacles and limitations which carry up for adoption of this technology. There are numerous challenges with equipment high cost, lack

of flexibility in some systems, unsuitability for some patients, and specialized training. Throughout this article, although robotic dentistry has not yet been established for widespread clinical use, with continuous research and development it just might change the dental practice and lead to better patient outcomes.

FUTURE RESEARCH ISSUES IN AI IN DENTISTRY

Dentistry can be revolutionized using artificial intelligence in areas such as diagnosis, treatment planning and even patient education. As AI grows, we need to determine and resolve future research issues regarding safe and efficient implementation of AI. The aim of this paper is to discuss some of those future research issues in AI in dentistry.

The most important research area is that larger and varied data sets are required. To develop accurate models, AI algorithms need as much data as possible, to train and develop their models. But, in dentistry, there are limited diverse datasets, especially in some specialties like pediatric dentistry or orthodontics. While another research question concerns the need for explainable AI, efforts are needed to collect and share datasets to develop robust AI models (Kim SJ, 2021) [21]. When AI algorithms start becoming that complex it is important that we can clarify how it made its decision. In medical applications, for instance, decisions made by AI can have a huge effect on the patient's outcome, and therefore high confidence is particularly important. In this case, we need researchers to create AI algorithms that are transparent and explainable, which will make sure that they did not get implanted in an unethical or unsafe way (Mathew TM, 2021) [22].

The need for further research to figure out what is the best level of human input in AI aided dentistry should also be done. AI has the potential to be used for improved efficiency and accuracy while no substitute for expert human dentist's expertise and experience can be found in artificial intelligence. AI can be used to improve (rather than replace) human decision making and it is necessary to understand how.

Finally, research needs to design ethical and legal issues of AI in dentistry. For example, who is responsible if an AI algorithm makes a mistake during treatment? How does AI figure into the ethical decision making about patient care? A discussion of these issues is necessary for safe and ethical application of AI in dentistry.

CONCLUSIONS

The application of AI in dentistry is progressing quickly and it has provided many important contributions to dentistry as already discussed in this article. With the development of intelligent machines, for example robots, make it possible for dental procedures to be done quicker, more efficiently and accurately. But all is not well, as healthier business models shake out – barriers still exist, and challenges remain, including enhanced data privacy, security and ethical concerns. Further research should concentrate on creating AI technologies that are easy to use in the workflow of the dental professional and that maintain patient safety and well-being. As AI continues to be invested in and developed, it can support improvement of quality of dental care and ultimately, patient outcomes.

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