



## APPLICATION OF ARTIFICIAL INTELLIGENCE IN PROSTHODONTICS

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### ABSTRACT:

Artificial intelligence (AI) is a fast-moving technology that enables machines to perform tasks previously exclusive to humans. Advances in Artificial Intelligence offer a glimpse of such health care benefits as decreasing postoperative complications, increasing quality of life, improving decision-making and decreasing the time management. Artificial intelligence is utilized in every field, from automation to dentistry. It is helpful specially in the field of Prosthodontics as it helps in the designing of prostheses and in the making of functional maxillofacial appliances. It is also helpful in the process of patient documentation, diagnosis, treatment planning and patient management; hence it helps the dental health care professional to work smarter not harder.

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### INTRODUCTION:

Artificial intelligence (AI) is a fast-moving technology that enables machines to perform tasks previously exclusive to humans. Advances in AI offer a glimpse of such health care benefits as decreasing postoperative complications, increasing quality of life, improving decision-making and decreasing the number of unnecessary procedures. Nowadays, medicine most commonly uses a branch of AI called machine learning and, more recently, deep learning.<sup>1</sup> Machine learning (ML) is a branch of AI in which systems learn to perform intelligent tasks without a prior knowledge or hand-crafted rules.<sup>1</sup> Artificial intelligence is gaining attention all over the globe as it has marked a high

impact, breakthrough in the field of intelligence innovation. It is utilized in every field, from automation to dentistry.<sup>2</sup> The term artificial intelligence was first used by John McCarthy in the year 1955. John McCarthy was an arithmetician and is known as the father of artificial intelligence. Artificial intelligence means the aptitude of a machine to imitate human knowledge and behaviour. Machine learning is a field of artificial intelligence that was first mentioned in 1959 by Arthur Samuel and he defined it as the process that enables computer to learn without definite programming.<sup>2</sup>



### **MACHINE LEARNING:**

Machine learning, computers are able to infer their own rules by using advanced algorithms. Machine learning is used in e commerce, automobile, internet search, sensor, robotics, speech recognition, image recognition etc. Machine learning is subdivided into four categories of learning

**Supervised learning:** The computer has a tracing data set which is correctly labelled by a human expert.

**Unsupervised learning:** The computer does not use a tracing data set, but it tries to take up the data without the human guidance separating the data into clusters or groups.

**Semi supervised learning:** It is not easy to supervise every dataset so when a large amount of unlabelled data is combined with a small amount of labelled data the accuracy of machine learning can be improved.

**Reinforced learning:** According to Hal Varian, it is a form of sequential experimentation of a computer in an attempt to achieve a goal while interacting with a dynamic external environment.<sup>3</sup>

**Neural network:** As the name suggests, it uses artificial neurons to set the algorithm .it works almost similar to the human brain. **Deep learning:** It is a type of machine learning that utilizes the network with different computational layers to analyse the input data. Deep learning is also known as conventional neural network. Application of AI in dentistry can range from use of collection of patient data, radiological image analysis and predicting disease patterns such as dental caries.AI can also integrate the CBCT and MRI imaging, and can help detect minor abnormalities of the human body, which the human eye can never detect.

### **ARTIFICIAL INTELLIGENCE IN PROSTHODONTIC REHABILITATION:**

Digital techniques such as CAD CAM (Computer Aided Design and Computer Aided Manufacturing) have been advocated in the fabrication of fixed dental prosthesis and

complete denture prosthesis. Digitization of data of prepared teeth through intraoral or extra oral scanners, with virtual designing of dental crown and automated milling has currently been successful in the dental market. CAD CAM dentures have been proposed through pre polymerized PMMA blocks and 5 axis milling with computer software. The advantages of CAD CAM dentures are lesser clinical visits, milling pre-polymerized dentures eliminating occurrence of porosities with better denture fit. The clinical steps however, in the current CAD CAM system follow the conventional procedures. Thermoplastic or custom impression trays are used to record the denture bearing areas, peripheral limiting structures, neutral zone and phonetic positions for teeth arrangement. The impressions are then scanned and virtual teeth arrangement is performed on virtual casts. Dentures on virtual casts are milled with recesses to accommodate denture teeth for further bonding. in laboratory steps have made an impact in the form of milling or 3 D printing. Denture base adaptations, retention of CAD CAM dentures have been found to be comparable to the conventional dentures. Digital technology has been applied in the specialty of prosthodontics, particularly in smile designing. Comprehensive assessment of facial and dental structures, are essentially done through facial, dental and dentogingival analysis through software applications. The advantages of virtual smile designing are patient involvement, treatment plan visualization and its prediction.<sup>4</sup>

### **IMPLANT THERAPY AND AI**

In the field of implant prosthodontics, the new digital workflows involve the use of intraoral scanners to capture the position of the implants through the scan body, the digital version of the old implant transfer . The accuracy of intraoral scanners is high today.<sup>5</sup> The number of publications that use AI models for implant dentistry applications has



risen notably since 2018.<sup>6</sup> Treatment planning of dental implant can be most successful if we combine the CBCT image and intraoral scan. The introduction of AI in the field of implantology has the potential to merge both together and design the future prostheses. A new model was proposed by researchers at the Finnish Center for Artificial Intelligence (FCAI), the University Hospital of Tampere, Planmeca and the Alan Turing Institute to accurately and automatically identify the exact position of the mandibular canal for dental implant operations. Using deep learning based object detection, implant systems can be detected from panoramic radiographic images. In implant-supported digital fixed prosthesis, one ideal option today is the use of customised abutments. These custom abutments, designed with computer-aided design (CAD) software and subsequently milled and sintered in zirconia, are cemented extraorally on titanium bonding bases. Once applied, they allow obtaining an ideal emergence profile, high compatibility with soft tissues and high aesthetics<sup>7</sup>. Above these customised abutments, it is possible to cement monolithic restorations<sup>7,8</sup>. However, while several clinical studies show that the use of these abutments can represent an ideal solution for the fixed rehabilitation of the implant patient, not only in the anterior but also in the posterior areas.

#### **MAXILLOFACIAL PROSTHESES AND AI**

The bionic eye, developed in the United States, has already been tested in a dozen patients with vision damages. Without the need for surgery, these devices can benefit the people in attaining vision with the help of artificial intelligence. In this way, a smart camera mounted on special glasses allows the user to read text or recognize faces. With the help of a small headset, the expertise processes the information seized by the camera and converts it into audio, which is conducted to the ears of the visually impaired person. Due to amputation of limbs, patients

can lose the sensory capacity in those areas. Artificial skin developed by researchers from the California institute of technology (USA) and the federal polytechnic school of Zurich (Switzerland) is changing this scenario. The tissue composed with a thin, clear film of pectin and water, senses temperature variations in the range between 5 and 50 degrees Celsius. Artificial olfaction plays a crucial role in robotics by mimicking the human olfactory structure that can identify different smells that compare to a range of fields, together with environmental monitoring, disease diagnosis, public security affairs, agricultural production and food industry

#### **RESTORATION AND AI**

The AI modalities: machine learning, deep learning, cognitive computing, computer vision (recognizes the content in photos and videos), and natural language processing (to both analyze and generate human speech with the help of machines), are promising and practiced in dentistry. Along the advent of AI better restoration, options are available with longer shelf life and superior esthetics and function.<sup>9</sup>

#### **RPD FABRICATION AND AI**

Chen et al developed an ontology and case-based reasoning software program for the automatization of RPD design. The designing rules were based on the philosophy of the Peking University Hospital and School of Stomatology.<sup>10</sup> One study developed a deep convolutional neural network for classifying photographs of maxillary or mandibular completely or partially edentulous diagnostic casts by using the Kennedy classification for partial edentulism. The program was trained with 1016 images and tested with 168 images. The authors reported a percentage of correct predictions for complete and partially edentulous diagnostic cast images of more than 95% for all types of dental arches, the diagnostic accuracy being significantly higher in the mandibular than in the maxillary



images. This application would represent the first step for designing an RPD. Future research directions might consider the implementation of intraoral scans or digitized diagnostic casts to increase diagnostic accuracy.<sup>10</sup>

#### **AI AND GENERAL DENTISTRY**

Beyond prosthodontics, AI was previously linked to other dental disciplines<sup>11</sup>. In tooth preservation, radiologically driven AI analyses can help detect root fractures and identify periapical pathologies<sup>12</sup> or classify root morphologies. AI is increasingly being applied to dentistry including in diverse areas of prosthetic research for efficient data processing. The first application of AI within dentistry was in the classification of diagnostic images and processing of data from surface scanning techniques, because the digitally coded images could easily be transferred into AI systems. The application of AI in diagnostics continues to be developed. AI technologies in dentistry have the power to become central in the triad of patient data management, health care application, and services, and can facilitate future developments in patient-centered individualized treatment. Beyond prosthodontics, AI was previously linked to other dental disciplines. In tooth preservation, radiologically driven AI analyses can help detect root fractures and identify periapical pathologies or classify root morphologies. In periodontology, disease progression can be evaluated while clinical and radiological periodontal parameters are automatically determined following AI technology. In oral surgery, AI can be used to screen radiological images for pathological changes, such as cysts and bony tumors. Furthermore, there are possible applications in implantology. AI-based treatment planning in CAD/CAM implant dentistry could be of great interest in order to simplify virtual 3D treatment planning, and, consecutively, robotic insertion of dental implants using AI

applications. AI has a disruptive potential to renew processes in all fields of dentistry; but, due to the complexity of prosthetic treatment concepts, the adoption of AI technology in prosthodontics is still rather hesitant. AI systems are particularly beneficial for processing and analyzing large amounts of data to classify outcomes, and for processing repetitive workflows. AI algorithms will likely provide support in evidence-based dental decision making, particularly for less experienced practitioners, and facilitate the analysis of individual patient cases.<sup>13</sup> The combination of AI technologies in the field of prosthodontics could lead to a wide variety of novel options, such as AI systems for generating occlusal surface design for crowns accounting for existing intraoral wear facets, as automatic set-up designers for complete dentures, for determining the emergence profile in implantology, or in automatic framework designs for removable partial dentures.<sup>14</sup> Finally, as an educational tool, AI already provides the opportunity to support less experienced undergraduate students in their professional development.<sup>15</sup>

#### **CONCLUSION:**

The willingness to learn new treatment protocols and to trust computerized applications has been proven as a strong negative driver for dentists.<sup>16</sup> In addition, new technologies require continuous investment of the dental community. As long as the research results are not demonstrating superiority, the routine implementation of AI applications in prosthodontics will be delayed. Here, the university and dental schools need to foster AI technology in research and education. A critical topic and crucial factor for the successful rehabilitation of complex prosthetic cases is the correct clinical definition of vertical and horizontal maxillo-mandibular relationships. AI technology could be used for automatic registering of jaw relationships based on radiological landmarks in cone-beam computed tomography. In this



context, the configuration of virtual dental articulators could be synchronized with the radiological situation to simulate individual patient movements for treatment simulation and final fabrication of prosthetic reconstructions.

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