Medical Life Sciences (2022) 2(2): 46–53
ISSN (E): 2976-7245

The Predictive, Preventive and Personalized Medicine in Dentistry

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How to cite this article:

Chan, W. S. H. (2022). The predictive, preventive and personalized medicine in dentistry. *Medical Life Sciences*, *2*(2), 46–53.

Received: 8 July 2022 / Accepted: 27 October 2022 / Published online: 5 December 2022

Abstract

Nowadays we are moving from reactive or curative medicine to preventive medicine. The medicine is undergoing a paradigm shift to strive from the diagnosis and treatment for prediction and prevention. Dental Artificial Intelligence (AI) is revolutionizing how dentists diagnose and present treatment. Overjet's AI algorithms can detect calculus, cavities, bone loss and other oral health problems. Moreover, major biotechnological and genetic advances such as DNA sequencing, have provided us with new tools that facilitate the application of more patient-oriented medicine, which considers the specific characteristics of each patient and aims to prevent the diseases to which they are most at risk. Furthermore, in PPPM (predictive, preventive, and personalized medicine), the first objective is the drug-based correction of the abnormalities detected under the heading of preventive measures. The second objective is the detection of subclinical abnormalities with a selection of suitable targets for the next step of PPPM protocol, i.e., drug-based prevention. Thus, PPPM is a medical model being tailored to the individual and dictates a construction of PPPM algorithms to diagnose, to predict, and to prevent in time. This is an exciting and rapidly evolving field, and I am thrilled to share with you some of the latest developments and insights.

Keywords: Gum Disease; Outcomes; Periodontitis; Malocclusion; Oral Cancer; Algorithms; Plaque; Targets; Sequencing; Proactive

1 Introduction

People in developing countries are burdened excessively by oral diseases, particularly periodontal disease. These are aggravated by poverty, poor living conditions, ignorance concerning health education, and lack of Government funding and policy to provide sufficient oral healthcare workers. In the coming years, we can expect to see a continued growth in the use of Artificial Intelligence (AI) and Machine Learning (ML) in various industries, including healthcare, finance, and transportation. We can also expect to see advancements in robotics and automation, which change the way we work and live. The term AI was first coined by John Mc Carthy in the year 1956 who is called as "Father of Artificial Intelligence." He defined AI as “the science and engineering of making intelligent machines.” The use of AI in dentistry has several advantages,

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including lower costs, predictive analytics, personalized treatment plans, improved accuracy and efficiency.

1.1 The Future of the Internet of Things

Over the past few years, Internet of Things (IoT) has become one of the most important technologies of the 21st century. The adoption of IoT (Swaminathan et al., 2022) is increasing across all sectors, and companies are investing heavily in IoT solutions to increase efficiency, reduce costs, and improve customer experiences. We are now able to connect everyday objects to the Internet through embedded devices, enabling seamless communication between; people, processes and things. With the help of low-cost computing power, cloud, big data, analytics and mobile technologies, physical things can share and collect data with minimal human intervention. In this hyperconnected world, digital systems can record, monitor and adjust the interactions between connected products. The physical world meets the digital world, and they work together.

With the use of IoT, dentists may take care of their patient's oral health outside of the clinic, and this method leads to better preventive dental treatment and better health outcomes. In addition, with the advancements of AI (Carrillo-Perez et al., 2021; Khanagar et al., 2020), IoT and the promotion of precision medicine, the future of dentistry will be heavily based on these innovative digital technologies. Its future is endless. It is expected to become a US $ 1.6 trillion market by 2025, with more than 75 billion connected devices worldwide.

Predictive Dentistry

It is a modern approach that uses advanced technology and data analysis to predict dental problems before they occur. It involves using various tools such as digital imaging, computer-aided design, and 3D printing. It can help dentists to identify potential problems and provide proactive treatment to prevent them from becoming more severe. For example, we can use genetic testing to identify individuals who may be at higher risk of developing periodontal disease or tooth decay. By identifying these patients early on, we can take proactive steps to prevent these conditions from developing or worsening. Hence, this approach can result in better outcomes for patients and can save time and money in the long run.

The following ways we supposed that AI will help dentists determine which patients may be at risk for oral health problems and create appropriate treatment plans to reduce the risk and promote optimal health.

(i) Predicting the Risk of Oral Cancer

Dental AI software could analyze patient data such as age, gender, medical history, and lifestyle factors to predict the risk of developing oral cancer. For example, AI could identify patients who are over a certain age, have a history of smoking, or have a family history of oral cancer and provide personalised (Mozaffari et al., 2019) recommendations for reducing the risk of developing oral cancer, such as quitting smoking, reducing alcohol consumption, and increasing oral cancer screening.

(ii) Predicting the Risk of Gum Disease

To analyze patient data such as smoking history, medical history, and genetics to predict the risk of developing gum disease. For example, AI could identify patients who smoke, have a history of periodontitis, or have a genetic predisposition to gum disease and generate recommendations to reduce the risk of developing gum disease, such as quitting smoking, improving oral hygiene habits, and using mouthwash to kill bacteria.

(iii) Predicting the Risk of Dental Implant Failure

AI algorithms could analyze patient data. For example, AI could identify patients who have low

bone density, have a history of diabetes, or smoke and generate customized recommendations for reducing the risk of dental implant failure, such as improving bone density, managing diabetes, and quitting smoking.

(iv) Predicting the Need for Orthodontic Extractions

Extraction of teeth is one of the most critical and controversial decisions in orthodontic treatment, largely because extractions are irreversible. There is an immense variety of orthodontic (Takada et al., 2019) techniques. Each of them has specific uses and indications from which to select the most appropriate options for each clinical situation. These decisions are based on clinical evaluations, patient photographs, dental study models, radiographs, and substantially rely on the experience and knowledge of the clinician. Nowadays, decisions must be made based on scientific evidence-the therapeutic modality must be chosen according to irrefutable evidence that the method selected is the best option for a given patient. Research in 2022 found that machine learning models accurately predicted the orthodontic need for tooth extractions up to 93.9% of the time.

Preventive Dentistry

In the early 20th century, a few progressive dentists promoted the idea of preventive (Proffit et al., 2013) care and transformed the health of the nation over the next 100 years. It is all maintaining good oral healthcare habits now, to ward off more serious problems in the future. Prevention includes a wide range of activities --- known as interventions --- aimed at reducing risks or threats to health. It will greatly reduce the risk of problems such as cavities, gum disease, loss of tooth enamel, and periodontitis. It refers to the practice of maintaining good oral hygiene and taking measures to prevent dental problems (Waring et al., 2020) before they occur. This includes regular dental check-ups, cleanings, fluoride treatments and oral health education. It also helps to reduce the need for more extensive and costly dental treatments in the future. However, PPPM takes preventive (Asiri et al., 2020) medicine a step further by providing personalized preventive care based on a patient's unique risk factors. Overall, preventive dentistry is an essential aspect of maintaining good oral health and overall well-being. Hence, by focusing on prevention, dentists can help patients maintain healthy teeth and gums and avoid the need for more invasive and costly treatments.

For example, dentists have a critical role in preventing and reducing the prevalence and severity of dental caries. Dental caries (Haugeland, 1989) is a multifactorial disease. Plaque bacteria, fermentable carbohydrates, and a susceptible tooth surface are basic requirements to its occurrence. These factors are influenced by other variables include genetics, lifestyle, education, and socio-economic, cultural and environmental conditions. Hence, employing the concepts of caries risk assessment and early establishment of a dental home are essential to develop an individualized treatment plan for each child. This plan may include some specific preventive measures, such as dietary cancelling, oral hygiene instructions, topical antimicrobials, pit and fissure sealant, F therapy (fluoride therapy) and using CPP-ACP (Casein PhosphoPeptide-Amorphous Calcium Phosphate).

Personalized Dentistry

While personalized dental medicine is still far from being a reality, advanced AI (Negnevitsky & Intelligence, 2005) technologies with improved data analytic approaches are expected to integrate diverse data from the individual, setting, and system levels, which may facilitate a deeper understanding of the interaction of these multi-level data and therefore bring us closer to more personalised, predictive, preventive dentistry. Use of personalised medicine in dentistry, especially in periodontology (Mitcell, 2007) is progressing rapidly, and dentist should consider this approach while treating patients. Hence, personalised medicine is not only associated with improvement in

treatment but also very useful in preventive care. Personalised medicine has great utilization in periodontitis, rampant caries, cancers, which have uncertain treatment outcomes. Direct application of personalised medicine (Foster, 1990) to routine dentistry is closer than one might think.

Personalised medicine now in the age of genomics means we are living in dynamic times. It is a progressing area in which physicians use diagnostic tests to identify particular biological markers, often genetic, that aid in describing which medical treatments, as well as technique, will work best for each patient. It covers key areas such as advances in molecular diagnosis, cost-benefit issues for precision medicine, impact of precision medicine on healthcare and pharmaceutical industry. Although personalised medicine in the medical field is escalating and becoming more common, in dentistry (Ciuffolo et al., 2005) it is still in infancy and there are not yet enough products in the market that have penetrated the average consciences of the patient care. Dentists can help patients achieve better outcomes and improve their overall quality of life.

Personalised Medicine for Oral Cancer

Oral cancer is one of the most common malignant lesions of the head and neck. It is believed to develop due to a number of molecular inequities that affect strategic genes and signaling pathways. The mechanisms involved in the pathogenesis and development of oral cancer still require extensive research and understanding. Once the nature of cancer is established in early stage, effective management strategy can be made with options of chemotherapy, radiotherapy, and surgery. The option or combination of options can be tailor-made for each patient based on the sensitivity of cancer cells rather than one common protocol for all patients with head and neck cancer. In the field of orthodontics, genetics has its own prominence as its concepts are evolving day by day over the past century period. The knowledge of genetics related to orthodontics is helpful in understanding the etiology of the malocclusion, normal variation between induviduals, and prevention of malocclusion to some degree. So, we can apply our collective knowledge with regard to precise risk factors comprising the novel concepts of genetics to enable deterrent medical facilities to individuals who certainly require it and improve patient's oral health.

In current times, the advanced genetic research studies are focusing toward genomic basis of craniofacial growth and genetic variants of dentofacial abnormalities. Such genome-associated research has laid path toward an innovative mode of orthodontics (Rajaraman, 2014), which is called as personalized orthodontics.

Personalized Orthodontics

It is customized to an individual in whom the genomic evidence and clinical data can be utilized, the susceptibility to developing malocclusion (s) can be anticipated, and consequently, the treatment plan is implemented precisely. Dental malocclusion is a common condition globally. It is a dentofacial anomaly that affects occlusal function, esthetics, and quality of life, and orthodontics is the discipline that encompasses the evaluation, prevention, and treatment of malocclusions.

In orthodontics (Reddy et al., 2019), for instance, by mandibular prognathism (Class III) and left lip and palate are primarily genetic in origin and a certain number of them are environmental in origin. In such conditions, personalized orthodontics may play a vital role by the deployment of individual's genomic evidence, thereby the risk factors can be anticipated, and precise orthodontic care is concentrated.

2 Class III Malocclusion

This mandibular protrusion obvious in Spain Charles royal families, also called as Hapsburg jaw is considered as a monogenic dominant phenotype, and is also an expression of certain genes that

encode specific growth factors accountable for Class III malocclusion. Certain genes such as transmembrane protein 1 and GAD1, are responsible for occurrence of cleft lip and cleft palate and also certain genetic variants REFIRF6, PVRL1, and MS1 are involved in the formation of syndrome-associated cleft lip and palate. Successful treatment of malocclusions requires astute orthodontic treatment planning, which often necessitates a decision on whether or not to extract teeth.

The Future Vision of Dentistry

In today's science, researchers are rapidly emerging and using diagnostic tests in medical diagnosis based on genomic (Ławrynowicz & Tresp, 2014), proteomics, and metabolomics to enhance and prophesy patient's reactions to targeted therapy. So, what does all this mean for the future of dentistry? We are already seeing a shift towards a more personalised, preventive, and predictive approach to dental care. It is likely that the future of dentistry will involve more personalised (LeCun et al., 2015; Murata et al., 2017) and preventive care, with a focus on early detection and treatment of dental issues. With advances in technology and data analytics, we are able to identify and treat dental conditions (Cheraskin & Ringsdorf, 1982; Palanivel et al., 2021) earlier and more effectively than ev 22er before. Additionally, there may be a greater integration of digital technologies, such as 3D printing and virtual reality, in the field of dentistry. The future of technology (Baumrind et al., 1996; Dunbar et al., 2014) is exciting and full of potential, but it will require careful consideration and planning to ensure that it benefits everyone in society. Of course, there are still challenges to overcome in this field. One of the biggest barriers is the cost of some of these advanced was tailoring our treatments to each patient's unique needs, we can improve outcomes and help our patients achieve healthier, happier smiles (Dietterich, 2000).

3 Conclusions

The healthcare sector is a complex and global industry sector. Though there are transformative changes occurring in healthcare (Krooks et al., 2016), one thing remains the same --- the need for consistent, high quality patient care. In the future, AI (Abid et al., 2023) will play an increasingly important role in helping dentists with predictive (Fontana & Zero, 2006) analytics. AI algorithms will be able to analyze patient data, including medical history, lifestyle, and genetics to predict the risk of developing dental problems such as tooth decay (Chung, 2020; Murray, 1989), gum disease, and oral cancer. Dentists will be able to use this information to create personalised prevention (Featherstone, 2006; Mitchell & Mitchell, 2014), plans for factors that can help reduce the risk of developing dental problems (Berezow & Darveau, 2010; Grigoriadou et al., 2010).

Predictive, preventive, and personalised medicine (Carlson, 2015; Eng et al., 2011) has the potential to revolutionize dentistry by allowing dentists to identify and treat dental problems before they become serious and by providing personalised treatment (Cox, 2004) plans that take into account each patient's unique needs and preferences. There are many benefits of PPPM (Ray, 2012), such as --- we can improve the selection of new molecular targets for drug discovery ; we can reduce the adverse drug effects by more effective early assessment of individual drug responses; we can stratify patients into groups that enable the selection of optimal preventive treatment (Duncan et al., 2019; Sadkovsky et al., 2014); we can shift the emphasis from illness to wellness; we can detect disease at a subclinical stage, when it is easier and less expensive to treat effectively. So, by embracing PPPM, dentists can help patients achieve better outcomes and improve their quality of life.

4 Acknowledgments

First and foremost, I am deeply grateful to my family: my parents Mr. Chan Sum and Mrs. Lon Siu Ying, for giving birth to me at the first place and supporting me spiritually with wise counsel and sympathetic ear throughout my life. You are always there for me. Also, I am extremely

thankful to my friend, Mr. Tung Sze Hong, former Senior Engineer, Foxconn Technology Group, Taiwan, China, for his scholarly advice and technical consultations. To all my top best medical team members, I say thank you for your friendship and courtesies. I think the most important thing is to work from our heart and to honor all those I encounter in my work with love and support. As always, I thank my family for loving me and always being there for me.

5 References

Abid, M., Jamal, H., Alsahafi, E., Dziedzic, A., & Kubina, R. (2023). Tissue engineering supporting regenerative strategies to enhance clinical orthodontics and dentofacial orthopaedics: A scoping, perspective review. *Biomedicines*, *11*(3), 795. https://doi.org/10.3390/biomedicines11030795

Asiri, S. N., Tadlock, L. P., Schneiderman, E., & Buschang, P. H. (2020). Applications of artificial intelligence and machine learning in orthodontics. *APOS Trends in Orthodontics*, *10*, 17–24. https://doi.org/10.25259/apos_117_2019

Baumrind, S., Korn, E. L., Boyd, R. L., & Maxwell, R. (1996). The decision to extract: Part 1—inter-clinician agreement. *American Journal of Orthodontics and Dentofacial Orthopedics*, *109*(3), 297–309. https://doi.org/10.1016/S0889-5406(96)70153-1

Berezow, A. B., & Darveau, R. P. (2010). Microbial shift and periodontitis. *Periodontology 2000*, *55*(1), 36–47. https://doi.org/10.1111/j.1600-0757.2010.00350.x

Carlson, D. S. (2015). Evolving concepts of heredity and genetics in orthodontics. *American Journal of Orthodontics and Dentofacial Orthopedics*, *148*(6), 922–938. https://doi.org/10.1016/j.ajodo.2015.09.012

Carrillo-Perez, F., Pecho, O. E., Morales, J. C., Paravina, R. D., Della Bona, A., Ghinea, R., Pulgar, R., Del Mar Pérez, M., & Herrera, L. J. (2021). Applications of artificial intelligence in dentistry: A comprehensive review. *Journal of Esthetic and Restorative Dentistry*, *34*(1), 259–280. https://doi.org/10.1111/jerd.12844

Cheraskin, E., & Ringsdorf, W. (1982). Predictive dentistry: A study in carbohydrate metabolism. *Medical Hypotheses*, *9*(1), 71–85. https://doi.org/10.1016/0306-9877(82)90067-6

Chung, S. (2020). Suggestions for Preventive Dental Care Guidelines according to Age and Oral Health Status. *International Journal of Clinical Preventive Dentistry*, *16*(2), 45–50. https://doi.org/10.15236/ijcpd.2020.16.2.45

Ciuffolo, F., Epifania, E., Duranti, G., De Luca, V., Raviglia, D., Rezza, S., & Festa, F. (2006). Rapid prototyping: A new method of preparing trays for indirect bonding. *American Journal of Orthodontics and Dentofacial Orthopedics*, *129*(1), 75–77. https://doi.org/10.1016/j.ajodo.2005.10.005

Cox, T. C. (2004). Taking it to the max: The genetic and developmental mechanisms coordinating midfacial morphogenesis and dysmorphology. *Clinical Genetics*, *65*(3), 163–176.

Dietterich, T. G. (2000, June 21–23). *Ensemble methods in machine learning* [Paper presentation]. Proceedings of International workshop on multiple classifier systems. Cagliari, Italy

Dunbar, A., Bearn, D., & McIntyre, G. (2014). The influence of using digital diagnostic information on orthodontic treatment planning - a pilot study. *Journal of Healthcare Engineering*, *5*(4), 411–428. https://doi.org/10.1260/2040-2295.5.4.411

Duncan, H. F., Galler, K. M., Tomson, P. L., Simon, S., El-Karim, I., & Bjørndal, L. (2019). European Society of Endodontology position statement: Management of deep caries and the exposed pulp. *International Endodontic Journal*, *52*(7), 923–934. https://doi.org/10.1111/iej.13080

Eng, G., Chen, A., Vess, T., & Ginsburg, G. (2011). Genome technologies and personalized dental medicine. *Oral Diseases*, *18*(3), 223–235. https://doi.org/10.1111/j.1601-0825.2011.01876.x

Featherstone, J. D. (2006). Caries prevention and reversal based on the caries balance. *Pediatric*

Dentistry, *28*(2), 128–132.
Fontana, M., & Zero, D. T. (2006). Assessing patients' caries risk. *The Journal of the American Dental Association*, *137*(9), 1231–1239. https://doi.org/10.14219/jada.archive.2006.0380
Foster, T. D. (1990). *A textbook of orthodontics* (third edition). Blackwell Scientific Publications
Grigoriadou, M. E., Koutayas, S. O., Madianos, P. N., & Strub, J. R. (2010). Interleukin-1 as a genetic marker for periodontitis: Review of the literature. *Quintessence International*, *41*, 517–25.
Haugeland, J. (1989). *Artificial intelligence: The very idea*. MIT Press.
Khanagar, S. B., Al-Ehaideb, A., Maganur, P. C., Vishwanathaiah, S., Patil, S., Baeshen, H. A., Sarode, S. C., & Bhandi, S. (2020). Developments, application, and performance of artificial intelligence in dentistry – A systematic review. *Journal of Dental Sciences*, *16*(1), 508–522. https://doi.org/10.1016/j.jds.2020.06.019
Krooks, L., Pirttiniemi, P., Kanavakis, G., & Lähdesmäki, R. (2016). Prevalence of malocclusion traits and orthodontic treatment in a finish adult population. *Acta Odontologica Scandinavica*, *74*(5), 362–367. https://doi.org/10.3109/00016357.2016.1151547
Ławrynowicz, A., & Tresp, V. (2014). Introducing machine learning. *Perspectives on Ontology Learning*, *18*, 35–50.
LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. *Nature*, *521*(7553), 436–444. https://doi.org/10.1038/nature14539
Mitcell, L. (2007). *An introduction to orthodontic* (third edition). Oxford University Press.
Mitchell, D. A., & Mitchell, L. (2014). *Oxford handbook of clinical dentistry*. Oxford University Press.
Mozaffari, M. S., Emami, G., Khodadadi, H., & Baban, B. (2019). Stem cells and tooth regeneration: prospects for personalized dentistry. *The EPMA Journal*, *10*(1), 31–42. https://doi.org/10.1007/s13167-018-0156-4
Murata, S., Lee, C., Tanikawa, C., & Date, S. (2017, October 24–27). *Towards a fully automated diagnostic system for orthodontic treatment in dentistry* [Paper presentation]. Proceedings of 13th international conference on e-science (e-science). Auckland, New Zealand.
Murray, J. J. (1989). *The prevention of dental disease*. Oxford University Press.1989.
Negnevitsky, M., & Intelligence, A. (2005). *A guide to intelligent systems: Artificial intelligence*. Pearson Education Publisher.
Palanivel, J., D, D., Srinivasan, D., NC, S. C., Kalidass, P., Kishore, S., & S, S. (2021). Artificial intelligence – creating the future in orthodontics–a review. *Journal of Evolution of Medical and Dental Sciences*, *10*(28), 2108–2113. https://doi.org/10.14260/jemds/2021/431
Proffit, W., Fields, H. W., & Sarver, D. M. (2013). *Contemporary Orthodontics* (5th edition). Mosby.
Rajaraman, V. (2014). JohnMcCarthy—father of artificial intelligence. *Resonance*, *19*, 198–207. https://doi.org/10.1007/s12045-014-0027-9
Ray, R. (2012). The future of medicine. *The American Journal of Medicine*, *125*(3), 236–239. http://doi.org/10.1016/j.amjmed.2011.06.035
Reddy, S., Fox, J., & Purohit, M. P. (2019). Artificial intelligence-enabled healthcare delivery. *Journal of the Royal Society of Medicine*, *112*(1), 22–28. https://doi.org/10.1177/0141076818815510
Sadkovsky, I. A., Golubnitschaja, O., Mandrik, M. A., Studneva, M. A., Abe, H., Schroeder, H., & Suchkov, S. V. (2014). PPPM (Predictive, Preventive and Personalized Medicine) as a new model of the national and international healthcare services and thus a promising strategy to prevent a disease: From basics to practice. *International Journal of Clinical Medicine*, *5*(14), 855–870. https://doi.org/10.4236/ijcm.2014.514115
Swaminathan, B., Choubey, S., Anushkannan, N. K., Arumugam, J., Suriyakrishnaan, K., Almoallim, H. S., Alharbi, S. A., Soma, S. R., & Mosissa, R. (2022). IOTEML: An Internet of Things (IoT)-Based Enhanced Machine Learning model for tumour

investigation. *Computational Intelligence and Neuroscience*, *2022*, Article e1391340. https://doi.org/10.1155/2022/1391340

Takada, K., Yagi, M., & Horiguchi, E. (2009). Computational formulation of orthodontic Tooth-Extraction decisions. *The Angle Orthodontist*, *79*(5), 885–891. https://doi.org/10.2319/081908-436.1

Waring, J., Lindvall, C., & Umeton, R. (2020). Automated machine learning: Review of the state-of-the-art and opportunities for healthcare. *Artificial Intelligence in Medicine*, *104*, 101822. https://doi.org/10.1016/j.artmed.2020.101822