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Artificial intelligence in orthodontics: A review

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Abstract---This article aims to discuss how Artificial Intelligence (AI) with its powerful pattern finding and prediction algorithms are helping orthodontics. Much remains to be done to help patients and clinicians make better treatment decisions. AI is an excellent tool to help orthodontists to choose the best way to move teeth with aligners to

pre-set positions. On the other hand, AI today completely ignores the existence of oral diseases, does not fully integrate facial analysis in its algorithms, and is unable to consider the impact of functional problems in treatments. AI do increase sensitivity and specificity in imaging diagnosis in several conditions, from syndrome diagnosis to caries detection. AI with its set of tools for problem-solving is starting to assist orthodontists with extra powerful applied resources to provide better standards of care.

Keywords---artificial intelligence, orthodontics, aligners, diagnosis, dentistry.

Introduction

The last decades have witnessed enormous changes in our profession. The arrival of new and more aesthetic options in orthodontic treatment, the transition to the fully digital workflow, the emergence of temporary anchorage devices and new imaging methods all work to provide both patients and professionals with a new focus in orthodontic care.¹

To make the diagnostic process more accurate and efficient, the use of Artificial Intelligence (AI) in orthodontics has grown significantly in recent years. This knowledge is fundamental for predicting treatment prognosis. However, the addition of this AI-based knowledge does not change the fact that the health professionals, with their own knowledge gained through specialized education and years of experience, are the ones that ultimately have to diagnose and determine the best treatment plan. Nevertheless, AI can be useful when making specific clinical decisions in a limited time. AI applications can guide clinicians to make better decisions and perform better, because the results obtained from AI are highly accurate and therefore, in some cases, can prevent human errors.² Orthodontic treatments are usually long procedures with an average treatment duration of nearly 29 months,³ which is why orthodontists must become more efficient to adapt to the needs of society. The application of Machine Learning (ML) techniques can help to solve this issue. Recent technological innovations in orthodontics, including cone beam computed tomography (CBCT) and 3D visualizations, intraoral scanners, facial scanners, instant teeth modelling software capabilities and new appliance developments using robotics and 3D printing, are changing the face of medical care and are quickly becoming integrated into dentistry.⁴ These tools enable a better understanding of the patient's anatomy and are able to create dynamic anatomical reconstructions for the specific patient, and therefore accommodate the possibility of 3D treatment planning. Convolutional neural networks (CNNs) are increasingly applied for medical image diagnostics, most frequently for the detection, segmentation or classification of anatomical structures. Deep learning has also recently been used for geometric feature learning and classification.⁵ Machine-learning approaches, which are algorithms trained to identify patterns in large data sets, are ideally suited to facilitate data-driven decision-making.⁶ Dentists need to use all their acquired knowledge to diagnose and decide the best treatment option. They are also required to predict the prognosis where they need accurate clinical decision-

making skills. However, in some cases, dentists do not have enough knowledge to make the right clinical decision in a limited period. AI applications can serve as their guide so that they can make better decisions and perform better. Shortliffe, Chae et al., Schleyer et al., reported that dentists have become dependent on computer applications to get insights for clinical decision making. The aim of this review was to identify the development of AI applications that are widely employed in dentistry and to evaluate their performance in terms of diagnosis, clinical decision-making, and predicting the prognosis of the treatment.⁷⁻⁹

What is AI?

Broadly speaking, AI is the behavior of non-biological entities that perceive, learn, or react to complex environments.¹⁰ AI is not a computational tool that necessarily mimics the workings of the human brain; rather, it is a set of tools for problem-solving, each with its own specific rules. Research is being performed in the field of AI to achieve human-like generality.^{11,12} However, most of the progress on AI has been on models that focus on a single problem, having a constrained set of rules-problems such as playing chess or identifying caries from X-ray scans.¹³ For many of these problems, computers far surpass human results. While an AI model can be classified as narrow or general on the basis of its problem-solving capabilities, from an algorithmic perspective, there are two main categories of AI: Symbolic AI and machine learning. Symbolic AI is a collection of techniques that are based on structuring the algorithm in a human-readable symbolic manner. This category was the paradigm of AI research until the late 1980s and is widely known as GOFAI – good old-fashioned AI.¹⁴ The techniques in symbolic AI use rules, such as if-then statements, where if a certain criterion is met, then the corresponding action must be taken. These systems are limited to the current human understanding of the problem and the ability to organize this understanding in an algorithmic form. Symbolic AI is still used for solving problems, in which the possible outcomes are limited, computational power is scarce, or human explainability is essential. However, in health care, where problems tend to be complex, not always fully understood, and have with many explanatory variables, building a model based on a set of rules is extremely difficult, if not impossible.¹² The other structural approach to AI is machine learning, which is the current paradigm. The fundamental difference between machine learning and symbolic AI is that, in machine learning, the models learn from examples rather than a set of rules established by a human. In this way, algorithms shift from rules on how to tackle a problem, to rules on how to learn from the data available. Different types of machine learning algorithms process data in different ways. Some algorithms, known as unsupervised learning algorithms, require only a set of input data to group and identify patterns in the data. Principal component analysis, a common type of unsupervised learning algorithm, can be used, for example, to indicate the determining attributes to arch size, shape, and occlusal relations from a wide set of variables.¹³

Machine Learning for Tooth Movement Planning

The use of AI for assisting in orthodontic treatment planning has apparently been a reality for some time. More than one aligner company claims to use AI algorithms to optimize orthodontic planning, thereby saving the time of

orthodontists in this process. Because these algorithms are industry secrets, the truth is that the point where AI algorithms end and marketing strategies begin is unknown. AI is an excellent tool to help orthodontists to choose the best way to move, for instance, a tooth or group of teeth from point A to point B, once the orthodontist instructs the machine where the final position should be. This is useful because orthodontics performed in a totally traditional way – with brackets only – require high manual skill, and many professionals do not have or have not received proper training to develop it. AI assists these dentists, but there are several limitations of machine learning in contemporary aligner treatment. AI used in contemporary planning does not consider the impact of functional problems and the stability of the tooth position – or lack thereof – when tooth movements are performed. For example, problems associated with important functional etiology, such as the open bite malocclusion, can be treated using aligners.¹⁴ However, AI today cannot determine the etiology of the problem or predict specific retention strategies.

AI in Diagnosis

Imaging diagnoses have gradually incorporated AI to increase sensitivity (ability to adequately predict the existence of a disease or problem in a patient) and specificity (ability to exclude the disease or problem when an individual does not have it). AI has excellent application in imaging diagnostics due to the ease with which the machine deals with patterns. There are more than 8000 identified genetic syndromes. However, despite all the advances in genetics, including next-generation sequencing-based tests, establishing the correct diagnosis is still a difficult task. Timely diagnosis of genetic syndromes tends to improve the outcomes. By the same token, craniofacial phenotypes are extremely informative for establishing the correct diagnosis of genetic congenital diseases because many syndromes have recognizable facial features. These changes in facial morphology are often of significant orthodontic interest. Several syndromes lead to dentofacial deformities and malocclusions that require orthodontic treatment.^{15,16} In this field, AI has helped in a relevant way. One such advancement is a mobile phone application called Face2Gene (FDNA, Boston, USA). The application uses the contrast of a patient's image against thousands of images in its databases to determine the subtle patterns that different syndromes tend to have. The diagnostic hypothesis established by the App has already proved to be useful for Caucasian and Asian populations¹⁷ and outperformed clinicians in diagnosing a number of syndromes.¹⁸ Another interesting recent application of AI is the prediction of extractions in orthodontic planning.¹⁹ The teeth to be extracted (first and second premolars) and the variability of dentofacial alterations included in this study were limited, and this arbitrary constraint probably reflects the relatively small original database. However, this is a promising and exciting first step toward determining whether extractions are required in the treatment plan. AI has already been used to diagnose and classify osteoarthritis in the temporomandibular joint,²⁰ and it may provide future data for establishing treatments for problems that are specific to the different severities of the condition.

Conclusion

AI is a set of tools for problem-solving that can assist orthodontists with extra powerful and applied tools to provide better standards of care. AI can assist orthodontists to choose the best way to move a tooth or group of teeth, but AI today completely ignores the existence of oral diseases, does not fully integrate facial analysis in its algorithms, and is unable to consider the impact of functional problems in treatments. At the same time, imaging diagnosis has been incorporating AI do increase sensitivity and specificity in numerous conditions, from syndrome diagnosis to caries detection.

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References

1. Allareddy V, Rengasamy Venugopalan S, Nalliah RP, Caplin JL, Lee MK, Allareddy V. Orthodontics in the era of big data analytics. *Orthod Craniofac Res.* 2019;22(Suppl 1):8-13.
2. Khanagar SB, Al-chaideb A, Maganur PC, et al. Developments, application, and performance of artificial intelligence in dentistry –A systematic review. *J Dent Sci.* 2021;16(1):508-522.
3. Jung MH. Factors influencing treatment efficiency: a prospective cohort study. *Angle Orthod.* 2021;91(1):1-8.
4. Nayyar N, Ojcius DM, Dugoni AA. The role of medicine and technology in shaping the future of oral health. *J Calif Dent Assoc.* 2020;48(3):127-130.
5. Schwendicke F, Golla T, Dreher M, Krois J. Convolutional neural networks for dental image diagnostics: a scoping review. *J Dent.* 2019;91:103226.
6. Jung SK, Kim Ansan TW. New approach for the diagnosis of extractions with neural network machine learning. *Am J Orthod Dentofac Orthop.* 2016;149(1):127-133.
7. Shortliffe EH. Testing reality: the introduction of decision support technologies for physicians. *Methods Inf Med* 1989;28:1e5.
8. Chae YM, Yoo KB, Kim ES, Chae H. The adoption of electronic medical records and decision support systems in Korea. *Healthc Inform Res* 2011;17:172e7.
9. Schleyer TK, Thyvalikakath TP, Spallek H, Torres-Urquidy MH, Hernandez P, Yuhaniak J. Clinical computing in general dentistry. *J Am Med Inf Assoc* 2006;13:344e52.
10. Nilsson NJ. *Artificial Intelligence: A New Synthesis.* San Francisco: Morgan Kaufmann; 1998. p. 493.
11. Goertzel B, Pennachin C. *Artificial General Intelligence.* Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg; 2007.
12. Schwartz WB, Patil RS, Szolovits P. Artificial intelligence in medicine. Where do we stand? *N Engl J Med* 1987;316:685-8.
13. Hung M, Voss MW, Rosales MN, Li W, Su W, Xu J, et al. Application of machine learning for diagnostic prediction of root caries. *Gerodontology* 2019;36:395-404.

14. Michael W, Haugeland J. "Artificial Intelligence: The Very Idea." *Technology and Culture*. 1987; 28(4): 905-22. www.jstor.org/stable/3105179.
15. Harris EF, Smith RJ. Occlusion and arch size in families. A principal components analysis. *Angle Orthod* 1982;52:135-43.
16. Moshiri S, Araújo EA, McCray JF, Thiesen G, Kim KB. Cephalometric evaluation of adult anterior open bite non-extraction treatment with invisalign. *Dent Press J Orthod* 2017;22:30-8.
17. Mishima H, Suzuki H, Doi M, Miyazaki M, Watanabe S, Matsumoto T, *et al*. Evaluation of Face2Gene using facial images of patients with congenital dysmorphic syndromes recruited in Japan. *J Hum Genet* 2019;64:789-94.
18. Gurovich Y, Hanani Y, Bar O, Nadav G, Fleischer N, Gelbman D, *et al*. Identifying facial phenotypes of genetic disorders using deep learning. *Nat Med* 2019;25:60-4.
19. Jung SK, Kim TW. New approach for the diagnosis of extractions with neural network machine learning. *Am J Orthod Dentofacial Orthop* 2016;149:127-33.
20. Ribera NT, de Dumast P, Yatabe M, Ruellas A, Ioshida M, Paniagua B, *et al*. Shape variation analyzer: A classifier for temporomandibular joint damaged by osteoarthritis. *Proc SPIE Int Soc Opt Eng* 2019;10950:1095021.