Austin Journal of Dentistry

Open Access

Austin Publishing Group

Review Article

Artificial intelligence in Orthodontics- Review of Literature

Don G Geojan and Jibin Joy Daniel*
Assistant Professor, Pushpagiri College of Dental Sciences, Thiruvalla, India

***Corresponding author:** Jibin Joy Daniel, Assistant Professor, Pushpagiri College of Dental Sciences, Thiruvalla, India
Email: jibinjoythayyil@gmail.com

Received: March 28, 2025
Accepted: April 14, 2025
Published: April 17, 2025

Abstract

As people look for more efficient, modern, and intelligent ways to complete tasks, artificial intelligence (AI) is evolving more quickly. In many scientific and technological domains, the fusion of human intelligence and machine learning has advanced to the point where the technology is already a part of everyday life. By using self-adapting algorithms, the computer mimics human intellect and enhances its capabilities.

Artificial intelligence has brought many benefits in various industries, particularly in medicine, where it plays a vital role in the evolution of the medical industry, ranging from virtual assistants to producing a better diagnosis and treatment using accumulated patient data. The main goals of orthodontic treatment are to modify the occlusion, regulate the growth of dentoalveolar components, and address growth anomalies. An effective assessment of these difficulties assists in evaluating the need for therapy and to prioritize it. A successful orthodontic practice depends on accurate diagnosis and providing comprehensive, pertinent information. Artificial intelligence has recently been used in orthodontics to help in decision-making and treatment planning.

In order to save burden and time while simultaneously improving accuracy and monitoring, artificial intelligence can be used to simulate a variety of clinical scenarios in the three crucial steps of diagnosis, treatment planning, and treatment. Since clinical practice involves more than just diagnosis and treatment planning, artificial intelligence cannot in any way take the role of a dentist. Therefore, humans should be familiar with the fundamentals of artificial intelligence models to help with clinical judgment, not to take the place of human knowledge and skill.

Keywords: Artificial intelligence; Machine learning; Orthodontics; Review

Introduction

The term artificial intelligence (AI), coined by John McCarthy in 1955, refers to the capacity of machines to carry out tasks that are deemed intelligent. Over the past 70 years, there have been times of great optimism surrounding the advancement of AI, interspersed by failures, cuts to research funding, and pessimism. A breakthrough occurred in 2015 when AlphaGo, an AI program created by Google, defeated the "GO" world champion. The success of AI over a human player spurred additional research and interest, which was heightened in 2022 with the launch of the Chat-GPT. These incidents acted as forerunners to the astounding expansion of AI applications across a range of domains, including daily life and healthcare [1].

These AI algorithms can now be used to more complicated jobs thanks to the growing availability of processing power in recent years. In actuality, this technique has changed several fields of medicine. Some AI applications exhibit impressive potential to assist in making medical decisions and, in certain situations, even surpass skilled physicians in terms of diagnostic ability [2]. As a result, scholarly publications attempting to incorporate AI into ordinary orthodontic procedures have increased exponentially in recent years. The research outlines various interesting methods for therapy planning, orthodontic diagnostics, and the outlook for the results of treatment [3]. These include, but are not restricted to, identifying reference points, segmenting anatomical or diseased structures in imaging, and assistance in making decisions. While seasoned professionals may realize the advantages of regularly utilizing AI, particularly in terms of time savings for specific diagnostic processes, novice practitioners would want to take into account the main benefits of such algorithms, particularly with regard to improved quality management through assisted decision-making [4]. However, in order to recognize and understand the potential limitations and implications of such AI solutions, a thorough examination of their scientific foundation is required before any type of clinical application can take place.

Thus, this article's goal is to give the reader a summary of the state-of-the-art in terms of AI applications in orthodontics and to offer a viewpoint on how these AI solutions might be used in normal clinical settings. In light of this, this manuscript highlights a few AI-assisted orthodontic applications for which extensive scientific study is already accessible and talks about the pertinent scientific foundation in terms of their advantages and disadvantages [5].

Citation: Don G Geojan, Jibin Joy Daniel. Artificial intelligence in Orthodontics- Review of Literature. Austin J Dent. 2025; 12(1): 1188.

AI and Orthodontic Treatment Need

Thanthornwong assessed the necessity for orthodontic treatment using facial photos and orthodontic impressions.Missing teeth, overjet, overbite, anterior and posterior openbite, anterior and posterior crossbite, anterior and posterior displacement, supernumerary teeth, ectopic eruption, anteroposterior molar relationship, and upper and lower lip to Eline were the variables they used to build the prediction model.With 1,000 individuals in their sample, they used 80% of the data as training data to develop a prediction model, which was then tested using 20% of the data, or the test data [6]. The data sets were validated using a sample of 20 patients. The model with the highest specificity (100%), sensitivity (95%), and accuracy (96%) was selected from among the five models they built. The necessity for therapy was predicted by two orthodontists with over five years of expertise. The model was used to calculate the therapy needs once 200 patients' data was entered. While lower ratings suggested no need for treatment, higher levels suggested that it was necessary. When this network was validated, a significant degree of agreement was discovered (kappa values of -0.894 with orthodontist B and -1.00 with orthodontist A). They came to the conclusion that the prediction model was a useful tool for assessing treatment requirements.

Cephalometric X-Ray Analysis [7]

Introduced by Broadbent in 1931, cephalometric Xray analysis is a fundamental component of orthodontic treatment planning. Finding landmarks is the initial stage in the analysis of cephalometric images.A sagittal and vertical examination of the facial skull is made possible by the geometric assessments that may be carried out using these landmarks in the form of angles, distances, and ratios.Before artificial intelligence (AI), software programs only helped with geometric structures and measurements; the practitioner still had to identify the landmarks by hand. In recent years, various researchers have been able to automatize this time-consuming and error-prone process by using AI-algorithms. The majority of studies investigating the use of AI for automated cephalometric X-ray analysis evaluate the accuracy of their AI based on the metric deviation between the landmarks set by the AI and the human gold standard. In this context, Schwendicke et al., performed a meta-analysis in which the accuracy of the automated landmark detection of different researchers was analyzed. The authors demonstrated that the majority of the included studies were able to identify landmarks within a metrical tolerance limit of 2 mm. This 2 mm tolerance is generally accepted as sufficiently accurate for clinical purposes in this regard. However, not only the metric deviation but also the direction of this deviation is of decisive importance to determine the actual clinically relevant accuracy of the orthodontic parameters that are measured on the basis of these landmarks.

In order to get over this limitation, evaluating automatic cephalometric assessments according to the orthodontic parameters themselves is an additional method of determining their accuracy. Nevertheless, very few studies in the literature use this criterion to measure the caliber of AI evaluations. Based on widely used orthodontic criteria, Kunz et al. (2020) examined the accuracy of their AI for automated cephalometric analysis. The authors demonstrated that, of the twelve orthodontic factors (including the oral, skeletal sagittal, and skeletal vertical parameters), only one was discovered to be substantially distinct from the human gold standard. For every parameter, the average differences between the AI evaluations and the human gold standard were much less than one degree. Therefore, it can be presumed that the discrepancies between the AI's predictions and the human gold standard are, at most, clinically inconsequential or of little significance.

Despite all of these encouraging strategies, Schwendicke et al. noted that most studies looking at the use of AI for the automated analysis of cephalometric pictures had a higher risk of bias. It is important to consider this fact attentively as Such software solutions are already available from certain commercial vendors, but the underlying scientific data for the AI is either missing, ambiguous, or poorly explained. The quality of automated cephalometric evaluations from these commercial suppliers has only been the subject of a small number of studies to far. The majority of authors came to the conclusion that fully automated cephalometric analyses should only be used under the human supervision of skilled clinicians after the results of these studies showed significant differences in the assessment qualities of those various providers.

AI in Orthodontic Treatment Planning [8,9]

Over time, there has been a steady increase in interest in using AI to improve orthodontic treatment outcomes and plans. Previous research involved developing mathematical algorithms that could accurately identify patients who required extractions. The Takada, et al and Yagi, et al. carried out a two-phase study in which they set up a mathematical model that could determine the necessity and the intended extraction pattern for a case. It was created to accurately identify the characteristics that influenced the model's selection of extractions and to project an unexpected treatment outcome with extractions.

Orthodontic casts, radiographs, and standardized patient photos made up the input data.The model would locate the closest template next to the characteristics of the presenting malocclusion within the system already. Several choices were made based on the particulars of the case. Before the final result was presented, an overall computation of the results was performed. When the model's accuracy was compared to the physicians' choices, a 90.4% accuracy rate was achieved. The characteristics that contribute to Over jet and the difference in upper and lower arch lengths were the reasons for the extraction decisions. To ascertain extraction patterns in comparison to clinicians, the developed model was adjusted and put to the test. Correcting incisor inclination, overjet, and overbite as extraction causes resulted in an accuracy of 86%. Through the use of ANN, Xie et al. further developed the model. The model's capacity to distinguish between extraction and non-extraction scenarios as well as potential extraction causes was evaluated. The model identified extraction patients between the ages of 11 and 15 with 80% accuracy. Proclined lower incisors and inadequate lips were the causes of extraction.

The accuracy of various programs for extraction/non-extraction decision making has been evaluated. Jung and Kim created a machine model using the R programming language.

software that may accurately identify patients undergoing extractions. The model's capacity to identify both identical and varied extraction patterns was further examined using five treatment plan groups that were integrated into the system. An expert orthodontist's clinical strategies were matched to the model. With an overall extraction plan accuracy of 84%, the model identified patients in need of extractions with a 93% accuracy rate.

Since dynamic patient records are favored over static ones, orthodontic record-keeping has evolved over time to become more technologically sophisticated. Tanikawa and Yamashiro investigated the potential for an artificial intelligence system to distinguish between cases involving extraction and orthognathic surgery using stereophotogrammetry.

Decision Support for Orthodontic Extractions [10]

In addition to the applications of AI in orthodontic diagnostics presented so far, modern AI algorithms can also be used to support therapeutic decision-making. One example is the decision for or against indicated tooth extractions in orthodontic therapy. With the multitude of clinical, radiographic, and even sociocultural factors that must be considered when deciding on the indication for orthodontic extraction therapy, such decisions remain challenging even for highly experienced orthodontists. It is difficult to make "an ideal decision" in the patient's interest as it also depends on the personal training, experience, and philosophy of the practitioner. Therefore,it is not uncommon for experts to arrive at different conclusions, therefore making different decisions, especially in borderline cases.

In recent years, there have been several approaches to automatize and objectify this complex decision-making process through the use of AI. For this purpose, different algorithms have been trained on a large number of patient examples consisting of a selection of clinical factors, radiological findings, model parameters, and the corresponding expert assessment for or against orthodontic extraction therapy. The first studies show promising results with a "correct" prediction between 80 and 94% for whether an extraction is necessary. Important orthodontic parameters, such as the extent of crowding, the position of the anterior teeth, overjet, and overbite, as well as lip closure, were identified by the AI algorithms, which significantly influenced the extraction decision. This point, it is important to consider that—especially in borderline cases—there is often no definite decision for or against orthodontic extraction therapy. The necessity of carefully weighing the advantages and disadvantages of both treatment options against each other continues to persist for every clinician.

Management of Impacted Canine [11,12]

For the best orthodontic and periodontal results, a multidisciplinary approach is necessary for the complex therapeutic management of impacted teeth. Depending on how far the canine is from the neighboring incisors, the length of the treatment period increases. Between artificial intelligence and statistics, the Bayesian Network (BN) adopts a middle ground. Using angular and linear measures, panoramic and lateral cephalometric radiographs can be used to predict impacted maxillary canines. The random forest algorithm demonstrated the highest performance, accurately predicting the canine eruption state with 83% accuracy. Wang et al. introduced a machine learning method called Learning-based multi-source IntegratioN frameworK for Segmentation (LINKS), which was used with CBCT to quantify the variation in maxilla in cases of unilateral canine impaction.

In Treatment outcomes [13]

Headgear

In order to anchor, distalize, or prevent forward maxillary growth, headgear, an orthopedic device, applies extraoral stresses to the upper arch. High, medium, and low pull headgear are the three varieties. To help less experienced orthodontists make decisions, Akgam et al. created a computer-assisted inference model for choosing the appropriate kind of headgear device. The purpose of the model was to determine the level of assurance in selecting headgear with low, medium, or high pull. The decisions that the system inferred were assessed by eight orthodontic specialists. Most of the time, the system identified the exact headgear properly [14].

Soft Tissue Out Come [15]

The assessment of facial profiles is a crucial component of orthodontic diagnosis and treatment planning. Features of the soft tissues of the face include harmony and balance. The bare skeleton gains depth from the soft tissue aesthetics. In order to achieve an aesthetic dimension in orthodontic treatment, the interaction between the nose, lips, and chin is crucial. The ability of ANN to forecast changes in lip curvature after orthodontic treatment, with or without extractions, was demonstrated by Nanda SB et al. For the upper and lower lips, the actual change was 7% and the expected change was 29.6%, respectively. substantial with an increase in face beauty.

Conclusion

In the medical field, artificial intelligence (AI) has advanced significantly. Medical and dental fields have been revitalized by AI advancements such as neural networking, natural language processing, image identification, and speech recognition. Efficiency, accuracy, precision, reduced effort, time savings, and improved monitoring are some of AI's benefits. AI-integrated systems are helpful in simulating clinical scenarios related to diagnosis, treatment planning, and treatment in orthodontics. In the digital age of dentistry, where all patient records are being converted to digital format, it is very crucial. AI should only be utilized after thorough consideration because improper application can result in inaccurate information.

References

1. Kunz F, Stellzig-Eisenhauer A, Zeman F, et al. Artificial intelligence in orthodontics: evaluation of a fully automated cephalometric analysis using a customized convolutional neural network. J Orofac Orthop. 2020; 81: 52-68.
2. Bahaa K, Noor G, Yousif Y. The artificial intelligence approach for diagnosis, treatment and modelling in orthodontic. Principles in Contemporary Orthodontics. 2011: 451.
3. Martina R, Teti R, D'Addona GI, et al. Neural network-based system for decision making support in orthodontic extractions. Intelligent Production Machines and systems. 2006: 235-240.
4. Xie X, Wang L, Wang A. Artificial neural network modeling for deciding if extractions are necessary prior to orthodontic treatment. Angle Orthod. 2010; 80: 262-266.
5. Asiri SN, Tadlock LP, Schneiderman E, et al. Applications of artificial intelligence and machine learning in orthodontics. APOS Trends in Orthodontics. 2020; 10: 17-24.
6. Poedjiastoeti W, Suebnukarn S. Application of convolutional neural network in the diagnosis of jaw tumors. Healthc inform Res. 2018; 24: 236-241.

7. Yong TH, Lee SJ, Yi WJ. Odontogenic cysts and tumors detection in panoramic radiographs using Deep Convolutional Neural Network (DCNN). International Conference on Medical Imaging with Deep Learning. 2019.

8. Yilmaz E, Kayikcioglu T, Kayipmaz S. Computer-aided diagnosis of periapical cyst and keratocystic odontogenic tumor on cone beam computed tomography. Comput Methods Programs Biomed. 2017; 146: 91-100.

9. Park JH, Hwang HW, Moon JH, et al. Automated identification of cephalometric landmarks: part 1-comparisons between the latest deep-learning methods YOLOV3 and SSD. Angle Orthod. 2019; 89: 903-909.

10. Leonardi R, Giordano D, Maiorana F, et al. Automatic cephalometric analysis. Angle Orthod. 2008; 78: 145-151.

11. Arik SÖ, Ibragimov B, Xing L. Fully automated quantitative cephalometry using convolutional neural networks. J Med Imaging (Bellingham). 2017; 4: 014501.

12. Kök H, Acilar AM, İzgi MS. Usage and comparison of artificial intelligence algorithms for determination of growth and development by cervical vertebrae stages in orthodontics. Prog Orthod. 2019; 20: 41.

13. Chen S, Wang L, Li G, et al. Machine learning in orthodontics: Introducing a 3D auto-segmentation and auto-landmark finder of CBCT images to assess maxillary constriction in unilateral impacted canine patients. Angle Orthod. 2020; 90: 77-84.

14. Jung SK, Kim TW. New approach for the diagnosis of extractions with neural network machine learning. Am J Orthod Dentofacial Orthop. 2016; 149: 127-133.

15. Li P, Kong D, Tang T, et al. Orthodontic treatment planning based on artificial neural networks. Scientific Reports. 2019; 9: 1-9.