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The Role of Artificial Intelligence in Orthodontics

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Abstract
Artificial Intelligence (AI) has rapidly emerged as a transformative tool in orthodontics, enhancing diagnostic accuracy, treatment planning, and clinical workflows. From its early conceptualisation to its present integration into healthcare, AI now plays a pivotal role in optimising orthodontic outcomes through data-driven decision-making and automation. This review synthesises current literature on the applications, benefits, and limitations of AI in orthodontics. It explores AI paradigms, including symbolic AI, machine learning, and deep learning, while categorising their functionalities into classification, regression, detection, and segmentation. Key databases and recent studies were evaluated to gather relevant data and outcomes across multiple subdomains of orthodontic practice. AI has been effectively implemented in diverse orthodontic tasks such as cephalometric analysis, bone age prediction, airway assessment, facial proportion analysis, and appliance fabrication. AI-assisted systems have demonstrated high accuracy (often >90%) in diagnosis, treatment planning, and prediction models. Notably, applications like extraction decision support, impacted canine management, and orthognathic surgery planning have shown significant promise. The integration of AI with teleorthodontics and 3D printing also opens new avenues for remote and customised care. AI is reshaping orthodontic practice by improving precision, efficiency, and patient outcomes. While challenges such as data bias, privacy concerns, and regulatory gaps remain, ongoing innovations suggest a future where AI could democratise access to advanced orthodontic care, especially in underserved regions. Strategic implementation and ethical governance will be key to its successful integration into routine practice.

ORIGINAL ARTICLE

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Introduction

Artificial Intelligence (AI), a term first introduced in 1955 by John McCarthy, describes the ability of machines to perform tasks that are classified as intelligent.[1,2] It is the simulation of human intelligence in machines, enabling them to learn, reason, and make decisions with minimal human input.[2,8] AI systems can analyse vast amounts of data, recognise patterns, and make decisions with minimal human intervention, improving efficiency and automation in various fields.[3]. In orthodontics, AI enhances diagnostic accuracy, treatment planning, and overall patient care by analysing large datasets, recognising patterns, and predicting outcomes with minimal human intervention.[8]

Paradigms of AI in Orthodontics

1. Symbolic AI (GOFAI): Symbolic AI, also referred to as "good old-fashioned AI" (GOFAI) which was popular until the late 1980s, uses rules, such that when a certain criterion is met, a corresponding action must be taken.[6] Rule-based systems using "if-then" logic.[6]

2. Machine Learning (ML)[4]: Machine learning is a term first phrased by Arthur Samuel in 1952.[5] In machine learning (ML), algorithms are classified according to the kind of learning and the desired

result. There are three main categories: [4] Supervised learning: Supervised learning is a procedure used in orthodontic decision-making, such as extraction planning, where predictions or classifications are guided by known outcomes.[4] In supervised learning the output data is known in advance and this helps AI to be able to make precise predictions about a newly input data.[8] Unsupervised learning: In orthodontics, unsupervised learning arranges data without labels, exposing patterns or connections. It helps with tasks that do not have defined results, making analyses and classifications easier. [4,8,13]

Reinforced learning: Reinforced learning helps systems improve by learning through trial and error using feedback, without prior knowledge. In orthodontics, this approach enhances efficiency by enabling systems to learn from mistakes and refine their methods over time.[4]

3. Deep Learning (DL): Deep learning (DL) is a branch of machine learning that automatically extracts features from raw data. It uses artificial neural networks (ANNs), developed in the 1990s.[5] With better computing power, deeper and more complex networks have been created. These "deep" networks can solve more advanced problems. DL reduces the need for manual input. It learns patterns from data on its own. This makes it useful in areas like image analysis and healthcare.[5] As a subset of machine learning, deep learning uses neural networks and has excelled in processing complex data structures, particularly high-dimensional data such as images.[7,10]

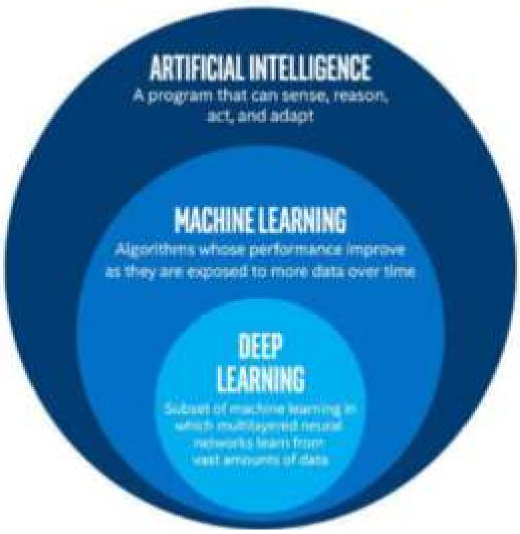

Figure 1: Shows a simplified AI diagram, which shows machine learning as a paradigm of artificial intelligence and deep learning, a subset of machine learning.

Four AI driven tasks

The 4 major AI-driven tasks in dentistry are :

1. Classification 2. Regression
3. Detection, and 4. Segmentation

(1) Classification is the most known AI-driven task and it assigns objects to categories that have been pre-specified or pre-labeled.[9] Examples include; support vector machine (SVM), decision trees and many more.[9] (2) Regression analysis is a statistical and machine learning method used to identify relationships between variables and predict continuous outcomes. For example, it can estimate a patient's age based on tooth wear or bone density by finding patterns in the data.[9] (3) Object detection focuses on determining the location of objects within

an image or video. Unlike basic image classification, which merely identifies the presence of objects, detection goes a step further by pinpointing their exact positions. A widely used method for object detection is the Region-based Convolutional Neural Network (R-CNN), which involves generating region proposals, extracting features using a CNN, and classifying each proposed region.[9] (4) In dentistry, object segmentation involves pixel-level classification to distinguish different structures within a region of interest.[9] This technique helps divide dental images into components like teeth, gums, bones, and lesions, aiding diagnosis and treatment planning. In orthodontics, for instance, it allows individual teeth to be isolated for alignment assessment and appliance design.

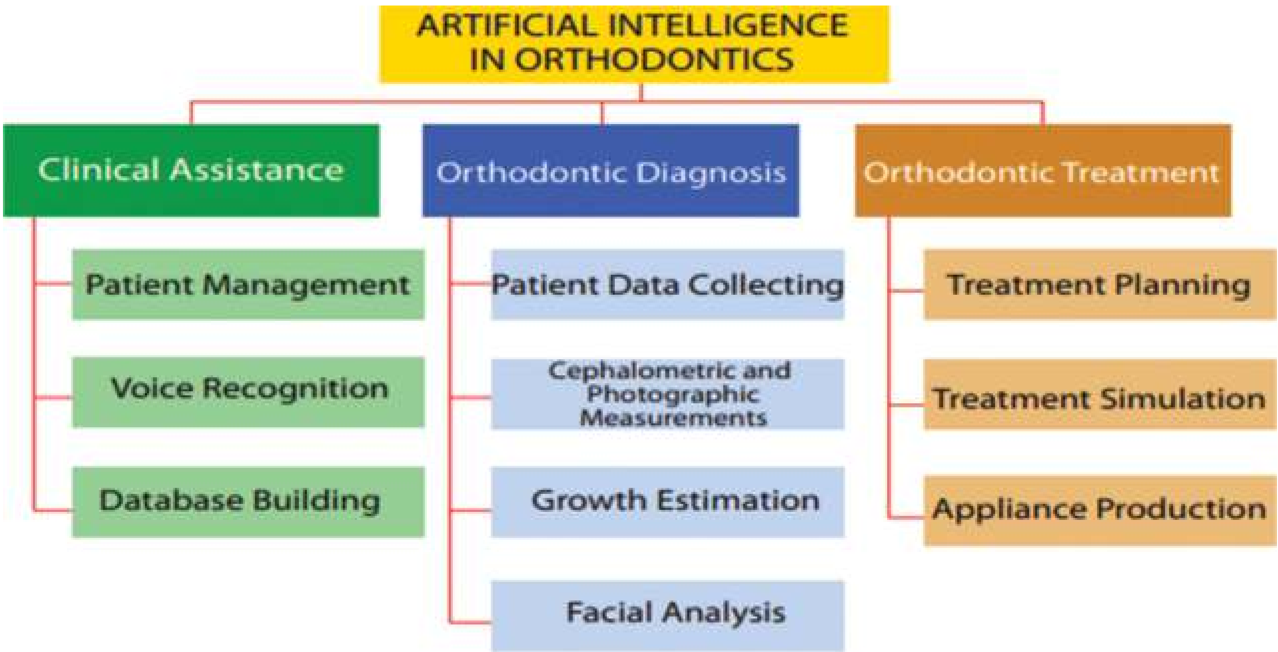

Figure 2: Key Applications of AI in Orthodontics

Diagnosis and Treatment Planning

The area of orthodontic diagnosis and treatment planning is changing as a result of the integration of artificial intelligence which gives better accuracy and efficiency.[4] Machine learning and computer vision have made it easy for AI to automate complex patient evaluations and this gives orthodontists access to a wide range of cephalometric analytic tools.[4] A study by Ezhov (2021) compared AI-assisted and unaided dentists in oral CBCT evaluations. The AI system improved diagnostic performance, with higher sensitivity (0.8537 vs. 0.7672) and specificity (0.9672 vs. 0.9616) in the AI-aided group.[6] Systematic reviews and meta-analyses on AI for detecting caries and periapical lesions have shown varying accuracy (68%–99.2%) depending on imaging methods.[6] A 2019 meta-analysis reported 88.75% accuracy for AI in detecting radiolucent lesions, while a 2023 study aby Sadr found AI had high sensitivity (0.925) and specificity (0.852).[6] These findings suggest AI can serve as an effective diagnostic aid in diagnosis and treatment planning.[6] Due to the ability of AI, machine language, computer vision and natural language processing combined simplify patient diagnosis and treatment planning.[4]

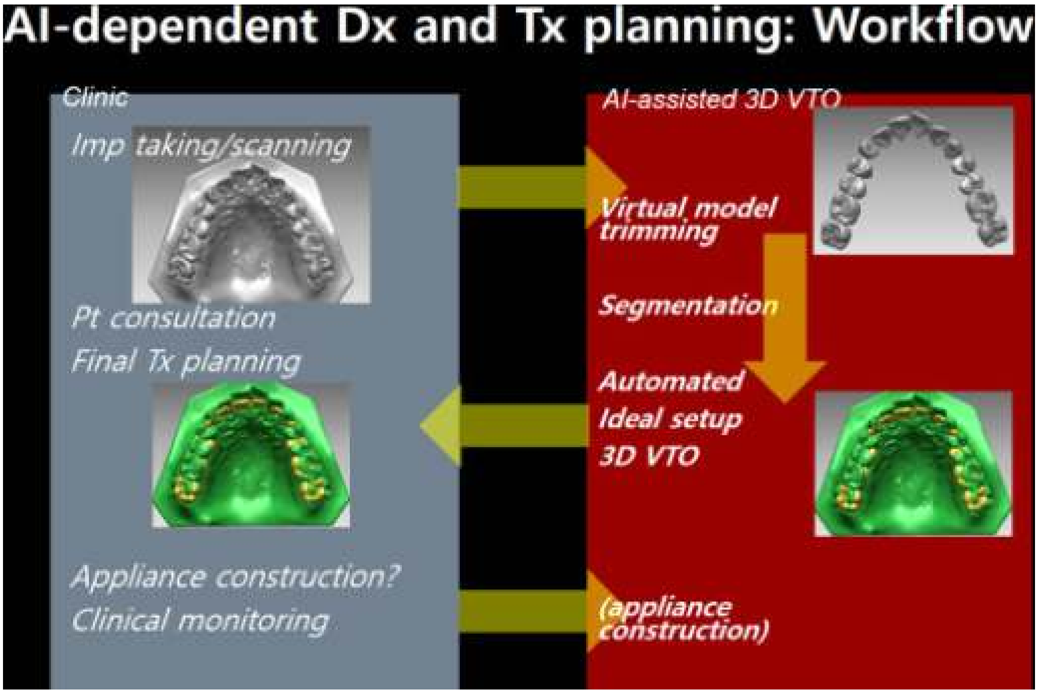

Figure 3: It shows AI depends diagnosis and treatment planning workflow

Bone Age Prediction

The choice of proper treatment timing depends on bone age prediction based on cervical vertebrae maturity, and this is very vital because it directly impacts the effectiveness of orthodontic treatments.[6] The Machine Learning-based methods, which include the convolutional neural networks, according to Seo et al. (2021), have shown >90% accuracy for vertical and sagittal skeletal maturation diagnosis.[6] In orthodontics, classification models have shown greater accuracy than clustering methods for predicting bone age. Among various classifiers, the artificial neural network (ANN) achieved the highest performance, with a weighted kappa of 0.926, indicating its effectiveness in determining cervical vertebral maturation.[10]

Airway Obstruction Assessment

There is a reciprocal relationship between skeletal deformities and airway obstruction. Impaired airflow, such as that caused by upper-airway obstruction, can influence breathing patterns and disrupt normal craniofacial growth, potentially resulting in malocclusion and other facial irregularities. Therefore, identifying conditions like adenoid hypertrophy is essential for accurate orthodontic assessment and effective treatment planning.[11] In light of this, Dong et al. introduced two deep learning models—hierarchical masks self-attention U-net (HMSAU-Net) for upper airway segmentation and 3D-ResNet for diagnosing adenoid hypertrophy from CBCT scans. The 3D-ResNet10 model demonstrated a high accuracy of 0.912 in diagnosing adenoid hypertrophy.[12]

Landmark Identification and Cephalometry Tracing

The use of artificial intelligence (AI) in identifying anatomical landmarks on radiographs has enhanced orthodontic diagnosis and treatment planning.[4] In order to advance cephalometric analysis, Montúfar et al. (2018) introduced a hybrid approach that automates the annotation of anatomical landmarks in cephalometric images.[18] This method integrates artificial intelligence (AI) algorithms with dynamic shape models, allowing for more accurate and efficient identification of key landmarks, thus streamlining the process of cephalometric analysis.[4] In addition, Montúfar et al. (2018) developed an AI-driven system for automatic 3D cephalometric landmark identification, aimed at simplifying the analysis of craniofacial changes in response to orthodontic therapy.[18]

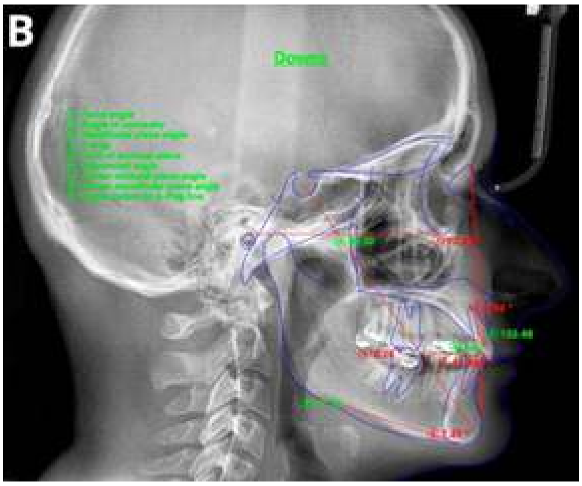

Figure 4: Shows a sample of automatic cephalometric landmark tracings performed using WebCeph. It shows that the results of Downs cephalometric analysis are superimposed on the tracing and measurements outside the standard range marked in red with asterisks.

Growth and Development Estimation

Evaluating growth and development indicators is vital for properly timing orthodontic treatment. Key markers like skeletal maturity, physical height, and chronological age play a significant role in orthodontic diagnosis and planning.[4] Kök et al. (2019) reported that among seven different AI approaches used to evaluate cervical vertebral maturation, Artificial Neural Networks (ANN) demonstrated the highest performance.[17] By mimicking the structure and function of the human nervous system, Artificial Intelligence (AI) significantly enhances both the precision and speed of analyzing growth and skeletal maturity indicators in orthodontics.[4]

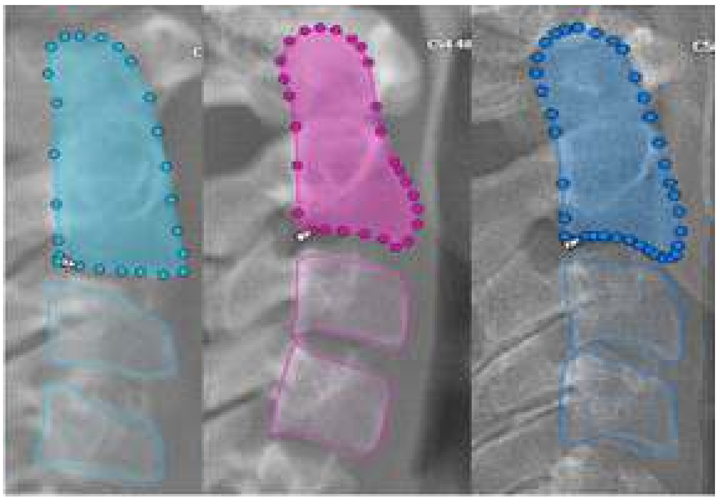

Figure 4: It shows an artificial intelligence-based algorithm for cervical vertebrae maturation stage assessment where AI algorithms are used to automatically identify and outline cervical vertebrae (C2–C4) on lateral cephalometric radiographs. By analyzing the shape and size of these bones, the AI accurately determines the patient's skeletal maturation stage, helping orthodontists plan growth-related treatments more objectively and efficiently.

Facial Proportion Analysis

Ai is revolutionising facial proportion assessment by using optical facial recognition, in contrast to traditional method relying on profile photographs and lateral cephalometric radiographs.[19] By surpassing the limitations of traditional dimensional analysis, artificial intelligence (AI) enables the assessment of angular measurements and facial ratios. AI offers objective evaluations of facial aesthetics by incorporating various beauty parameters, potentially enhancing orthodontic and surgical decision-making through a deeper understanding of facial attractiveness.[4]

Extraction Prediction:

Xie et al. created an expert system (ES) using artificial neural networks (ANN) that achieved 80% accuracy. This was done in order to determine whether extraction is needed for management of malocclusion in patients between the ages of 11 and 15.[21] Jung et al. used artificial neural networks (ANN) to forecast extraction patterns with 84% accuracy.[20] Artificial intelligence (AI) technologies simulate human decision-making, achieving 80-90% accuracy in orthodontic extraction decisions. These technologies particularly assist orthodontists with less experience, offering guidance that enhances decision-making. AI algorithms not only optimise treatment outcomes but also reduce human error, streamline processes, and help tailor orthodontic interventions to individual patient needs, improving overall efficiency in clinical practice.[4]

Management of Impacted Canines

AI-assisted Radiographic Analysis: Deep learning models analyse panoramic and CBCT (Cone Beam Computed Tomography) images to detect impacted canines early, even before they become clinically evident.[22] A study by Kumar et al. demonstrated that CNN successfully detects impacted and non impacted maxillary canines on cropped and uncropped Panoramic radiographs.[22]

AI helps in identifying dental and skeletal landmarks, improving accuracy in localizing impacted canines. AI models simulate the likely eruption path of impacted canines. It involves the utilisation of CBCT to enhance early diagnosis and interception of canine impactions and this addresses the limitations found in traditional 2D radiographs.[23] Virtual Surgical Planning (VSP): AI assists in planning surgical exposure of impacted canines, optimizing flap design and minimizing complications.[24] AI significantly improves precision, speed, and reliability in the management of impacted canines in orthodontics. It aids in early identification, treatment strategy, and follow-up care, leading to fewer mistakes and better patient results.[25]

Treatment Outcome Assessment

Traditional multi-regression models analyse dental treatment outcomes but are limited by their linear assumptions and inability to capture all possible results.[4] Artificial neural networks overcome these limitations by modeling complex, non-linear relationships, especially in orthodontic cases like Class II and III malocclusions, further enhanced by the digital clear aligner technology introduced in 1997.[4]

Appliance Fabrication

AI-driven 3D scanning and CAD/CAM technology create custom-fitted orthodontic appliances (e.g., clear aligners). The development of digital clear aligner devices has made it easier to simulate orthodontic treatment, since manual methods made this procedure more difficult.[27] AI-generated data is fed into CAD (Computer-Aided Design) software to create digital models of braces, aligners, or retainers. CAD designs are then sent to CAM (Computer-Aided Manufacturing) systems, which use 3D printing or milling machines to create the appliance.[27] In 1946, Dr. Kesling introduced a removable plastic orthodontic appliance designed to make minor tooth movements—an innovation that laid the foundation for modern clear aligner therapy. Decades later, this concept evolved into a transformative orthodontic solution with the introduction of the Invisalign system by Align Technology in 1998.[26]

Orthognathic Surgery Planning

AI models, especially those using facial images and key measurements, are increasingly used to support orthognathic surgery decisions by improving diagnostic accuracy and offering guidance, though challenges like feature selection and overfitting remain.[9] AI is transforming orthognathic surgery by automating diagnostics, improving the accuracy of treatment planning, and enhancing surgical outcomes through tools like 3D simulations and machine learning-based decision systems.[8]

Cleft Lip and Palate (CLP)

The clinical application of AI in diagnosis and treatment planning of cleft patients can be seen from different aspects. Diagnosis and Prediction: Some studies used AI in identifying clefts and morphologic features in individuals with CLP. In this diagnosis ultrasound images can be used prenatally.[14] Agarwal et al. used AI in the identification of digital camera images through Support Vector machine (SVM) with a previously trained convolutional neural network. This combination identified images of individuals with clefts from normal, and differentiated between unilateral and bilateral.[14]

Pre-surgical Orthopaedics: Sequential plates for infants with cleft lip and palate who required naso-alveolar moulding (NAM) was developed using AI. Moulding of foetal tissues was done, taking into account the growth of the maxillary arch using AI. A sequence of plates for NAM was generated, and this can be 3D-printed and delivered.[14] In a study conducted among healthy control and non-syndromic cleft lip and palate infants (NSCL/P), machine learning algorithms were used in detecting defective variants in two genes necessary in folic acid and Vitamin A biosynthesis (methylenetetrahydrofolate reductase (MTHFR) and retinol-binding protein 4 (RBP4) genes).[14] A study by Machado et al. on the Brazilian population for NSCL±P revealed interactions among 13 SNPs as well as defects in genes involved in folate metabolism.[14,29]

Tele-orthodontics

Artificial intelligence (AI) has significantly advanced orthodontic remote monitoring by enhancing diagnosis, treatment planning, and patient follow-up. Systems like Dental Monitoring and Grin use AI-driven platforms to track oral hygiene, aligner progress, and treatment outcomes through patient-generated images and videos, reducing the need for in-office visits and improving efficiency[30]. Complementing this, AI integration into telehealth systems, as demonstrated by Thurzo et al., has enabled real-time monitoring, early issue detection, and tailored interventions, improving patient compliance and allowing clinicians to manage more cases with personalised care[4].

Benefits of AI in Orthodontics

- Faster and more accurate diagnoses
- Improved treatment planning
-Enhanced workflow and clinical efficiency
- Teleorthodontic capabilities
- Better patient experience and engagement
- Higher treatment success rates
- Significant time savings

Challenges and Limitations ([4],[8],[28],[9])

- Data bias and quality issues
- High initial setup costs
- Lack of standardization and regulation
- Limited human oversight and ethical concerns
- Patient privacy and data security risks
- Resistance to change among practitioners
- Inaccuracy in complex or non-standard cases

Possibilities of Integration of AI in Underserved Countries

1. Fully Automated Diagnosis: Advanced AI models will be able to detect malocclusions, assess skeletal structures, and generate instant treatment plans with minimal human intervention. AI will integrate with CBCT, intraoral scanners, and panoramic X-rays to provide real-time orthodontic analysis. Automated detection of orthodontic treatment needs like the index of orthodontic treatment need (IOTN) and index of orthognathic functional treatment need (IOFTN) would also be investigated.

2. 3D Printing Integration: AI will design and 3D-print fully customised clear aligners, braces, and orthodontic devices in real time. Machine learning algorithms will optimise instant tooth movement predictions, making treatments faster and more efficient. Patients may soon receive on-demand, in-office aligners without needing external manufacturers.

3. Smart Braces: AI-integrated smart braces will monitor tooth movement and automatically adjust forces using built-in sensors. Self-adjusting brackets with micro-robotics could gradually apply precise forces to reduce treatment time. AI-driven sensors will predict potential treatment delays and recommend adjustments in real-time.

4. AI + 5G for Remote Care: 5G networks will enable real-time AI analysis of patient scans from anywhere in the world. AI-powered remote monitoring tools will reduce clinic visits and allow orthodontists to track patient progress from their smartphones. Teleorthodontics will become more advanced, allowing orthodontists to provide instant consultations and treatment adjustments.

5. Virtual Assistants: AI chatbots will act as virtual assistants, answering patient queries, scheduling appointments, and providing treatment reminders. AI will analyse patient habits (e.g., aligner wear time) and provide real-time compliance feedback. Patients will get personalised oral hygiene recommendations based on AI-driven risk assessments.

6. Predictive Analytics: AI will use big data analysis to predict treatment success rates and suggest the most efficient treatment plans. Machine learning models will forecast how teeth will move over time, allowing orthodontists to prevent complications before they arise. AI could also help in early orthodontic intervention for children, predicting future orthodontic issues before they fully develop.

7. Ethical Advancements: AI-driven orthodontics will require new regulations and ethical guidelines to ensure patient data privacy and accuracy. More orthodontists will undergo AI training, integrating AI seamlessly into daily practice.

Conclusion

Artificial Intelligence is reshaping orthodontics by enhancing diagnostics, personalising treatments, and streamlining workflows. With ongoing advancements, AI is set to make orthodontic care more precise, efficient, and accessible, ultimately leading to better outcomes and higher patient satisfaction

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References

1. Haenlein, M.; Kaplan, A. A Brief History of Artificial Intelligence: On the Past, Present, and Future of Artificial Intelligence. Calif.Manag. Rev. 2019, 61, 5–14.
2. Zhu X, Liu L, Sun Y, Li Y. Artificial Intelligence: A Powerful Paradigm for Scientific Research. Trends in Science & Technology. 2021;5(3):1-2. doi:10.1016/j.trst.2021.05.004.
3. Zaman BU. Big Data, Machine Learning, and AI in Decision Making. ResearchGate. Published October 2023. Available from: https://www.researchgate.net/publication/374616592_Big_Data_Machine_Learning_and_AI_in_Decision_Making
4. Amutha M, Kumaran NK. Artificial Intelligence in Orthodontics - A Narrative Review. IOSR J Dent Med Sci. 2024;23(8):38-43. doi:10.9790/0853-2308043843
5. Bichu YM, Hansa I, Bichu AY, Premjani P, Flores-Mir C, Vaid NR. Applications of artificial intelligence and machine learning in orthodontics: a scoping review. Prog Orthod. 2021;22(1):1-2.

6. Kazimierczak N, Kazimierczak W, Serafin Z, Nowicki P, Nożewski J, Janiszewska-Olszowska J. AI in Orthodontics: Revolutionizing Diagnostics and Treatment Planning—A Comprehensive Review. J Clin Med. 2024;13(2):1-19.
7. Carillo-Perez F, García-Godoy F, González-Cabezas C. Applications of artificial intelligence in dentistry: A comprehensive review. J Esthet Restor Dent. 2021; 33(4):
8. Thakur SM, Shenoy U, Hazare A. et al. Transforming Orthodontics with artificial intelligence: A comprehensive review. J Adv Dental Prac Res. 2024; 3(2):56-64.
9. Liu J, Chen Y, Li S, Zhao Z, Wu Z. Machine learning in orthodontics: Challenges and perspectives. Adv Clin Exp Med. 2021;30(10):1065–1074
10. Amasya H, Yildirim D, Aydogan T, Kemaloglu N, Orhan K. Cervical vertebral maturation assessment on lateral cephalometric radiographs using artificial intelligence: Comparison of machine learning classifier models. Dentomaxillofac Radiol. 2020;49(5):20190441.
11. Liu J, Zhang C, Shan Z. Application of artificial intelligence in orthodontics: current state and future perspectives. Healthcare (Basel). 2023;11(20):2760. doi:10.3390/h
12. Dong W, Chen Y, Li A, Mei X,Yang Y. Automatic detection of adenoid hypertrophy on cone-beam computed tomography based on deep learning. Am. J. Orthod. Dentofac. Orthop. 2023, 163, 553–560.e553.
13. Asiri Sn, Tadlock Lp, Schneiderman E, Buschang Ph. Applications Of Artificial Intelligence And Machine Learning In Orthodontics. Apos Trends In Orthodontics. 2020;10:17-24.
14. Dhillon H, Chaudhari PK, Dhingra K, Kuo R-F, Sokhi RK, Alam MK, Ahmad S. Current applications of artificial intelligence in cleft care: a scoping review. Front Med. 2021 Jul 28;8:676490. doi: 10.3389/fmed.2021.676490.
15. Hwang, H.W.; Park, J.H.; Moon, J.H.; Yu, Y.; Kim, H.; Her, S.B.; Srinivasan, G.; Aljanabi, M.N.A.; Donatelli, R.E.; Lee, S.J.Automated Identification of Cephalometric Landmarks: Part 2-Might It Be Better than Human? Angle Orthod. 2020, 90, 69–76.
16. Rudolph, D.J.; Sinclair, P.M.; Coggins, J.M. Automatic Computerized Radiographic Identification of Cephalometric Landmarks.Am. J. Orthod. Dentofac. Orthop. 1998, 113, 173–179.
17. 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 Nov 15;20(1):41
18. Montúfar J, Romero M, Scougall-Vilchis Rj. Automatic 3-Dimensional Cephalometric Landmarking Based On Active Shape Models In Related Projections. Am J Orthod Dentofacial Orthop. 2018 Mar;153(3):449-458
19. Tomasetti P, Enz A, Roth C, Giunta RE, Ehrl D. F4CE: a mobile application for automated measurement of facial proportions using artificial intelligence. Aesthetic Plast Surg. 2024 Apr 4.
20. Jung Sk, Kim Tw. New Approach For The Diagnosis Of Extractions With Neural Network Machine Learning. Am J Orthod Dentofacial Orthop. 2016 Jan;149(1):127-33
21. Xie X, Wang L, Wang A. Artificial Neural Network Modeling For Deciding If Extractions Are Necessary Prior To Orthodontic Treatment. Angle Orthod. 2010 Mar;80(2):262-6.
22. Kumar V, Abdulkreem A, Tanmoy M, et al. Artificial intelligence-based automated preprocessing and classification of impacted maxillary canines in panoramic radiographs. Dentomaxillofac Radiol. 2024;53(1):20230289. doi:10.1259/dmfr.20230289.
23. Cadenas de Llano Perula M. AI-based prediction of maxillary canine eruption pathway [Internet]. KU Leuven Research Portal; 2024 Sep 2 [cited 2025 Apr 19]. Available from: https://research.kuleuven.be/portal/en/project/3M240152

24. Kivovics, M., Szanyi, S. M., Takács, A., Répási, M., Németh, O., & Mijiritsky, E. (2024). Computer-assisted open exposure of palatally impacted canines for orthodontic eruption: A randomized clinical trial. Journal of Dentistry, 147, 105110.
25. López-Castaño F, Arnabat-Domínguez J, Vela-Netto A, Gay-Escoda C. Artificial intelligence for orthodontic diagnosis and treatment planning. Med Oral Patol Oral Cir Bucal. 2024 Mar 1;29(2):e121–8..
26. Ruiz DC, Luz JG, Oliveira DD, Silva FFD, Elias CN. Unveiling the role of artificial intelligence applied to clear aligner therapy: A scoping review. J Dent. 2025 Mar;154:105564.
27. Smiles LA. Dental 3D printing in pediatric dentistry [Internet]. Los Angeles: Smiles LA; [cited 2025 Apr 21]. Available from: https://smilesla.com/pediatric-dentistry-los-angeles/dental-3d-printing/
28. Nordblom NF, Büttner M, Schwendicke F. Artificial Intelligence in Orthodontics: Critical Review. J Dent Res. 2024;103(6):577–584. doi:10.1177/00220345241235606.
29. Machado RA, de Oliveira Silva C, Martelli-Junior H, das Neves LT, ColettaRD. Machine learning in prediction of genetic risk of nonsyndromic oral clefts in the Brazilian population. Clin Oral Invest. (2021) 25:1273–80. doi: 10.1007/s00784-020-03433-y
30. Miranda F, Barone S, Gillot M, Baquero B, Anchling L, Hutin N, et al. Artificial intelligence applications in orthodontics. J Calif Dent Assoc. 2023;51(1):2195585. doi:10.1080/19424396.2023.2195585.