Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 6s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Artificial Intelligence in Orthodontics: Evaluating Diagnostic Accuracy and Treatment Planning Efficiency

Dr. Vikas Gupta[*1], Dr. Meetu rani[2], Dr. Rishi Nanda[3], Dr.Arjun Kumar Sharma[4], Dr. Shruti Soni[5], Dr. Anju Yadav[6]

[1]Professor and Head, Department of Orthodontics and Dentofacial Orthopedics, Eklavya Dental College & Hospital, Kotputli (Rajasthan).

[2]Associate professor in Department of Orthodontics and Dentofacial Orthopedics, Eklavya Dental College & Hospital, Kotputli (Rajasthan)

[3]Professor and Head Department of Pedodontics and Preventive Dentistry, Eklavya Dental College & Hospital, Kotputli (Rajasthan)

[4]Associate Professor, Department of orthodontics and dentofacial orthopedics, Eklavya Dental College & Hospital, Kotputli (Rajasthan)

[5]Senior Consultant(Prosthodontist & Implantologist) Dental Department, Zydus Hospital, Ahmedabad (Gujarat)

[6]Senior lecturer Department of orthodontics and dentofacial orthopedics, Eklavya Dental College & Hospital, Kotputli (Rajasthan)

***Corresponding Author:**

Email ID: Docvikaslalgarhia@yahoo.in

Cite this paper as: Dr. Vikas Gupta, Dr. Meetu rani, Dr. Rishi Nanda, Dr.Arjun Kumar Sharma, Dr. Shruti Soni, Dr. Anju Yadav, (2025) Artificial Intelligence in Orthodontics: Evaluating Diagnostic Accuracy and Treatment Planning Efficiency. *Journal of Neonatal Surgery*, 14 (6s), 1-10.

ABSTRACT

Background: The integration of artificial intelligence (AI) in orthodontics promises to enhance diagnostic accuracy and optimize treatment planning. However, its clinical efficacy and reliability remain areas of active investigation. This study evaluates the diagnostic accuracy and treatment planning efficiency of an AI model compared to experienced orthodontists.

Objective: To assess the diagnostic accuracy, treatment consistency, and practical applicability of an AI-powered orthodontic tool in identifying malocclusions and formulating treatment plans.

Methods: A dataset of 200 orthodontic cases, including panoramic radiographs and cephalometric images, was analyzed. The AI model's diagnostic performance was compared against a panel of three orthodontic experts. Sensitivity, specificity, and inter-rater reliability (Cohen's kappa coefficient) were measured. AI-generated treatment plans were evaluated for adherence to clinical guidelines and validated through a preliminary follow-up of 50 patients. Qualitative feedback from orthodontists and patients was also collected.

Results: Diagnostic Accuracy Sensitivity: 92%, Specificity: 88%.Cohen's kappa coefficient: 0.85, indicating strong agreement with orthodontists.

Treatment Planning: AI recommendations adhered to clinical guidelines in 94% of cases. A follow-up study showed a 90% success rate for AI-guided treatments.

Qualitative Findings: Orthodontists appreciated AI's efficiency but raised concerns about its limitations in managing complex cases. Patients viewed AI as a beneficial supplementary tool, emphasizing the importance of clinician involvement.

Conclusion: The AI model demonstrated high diagnostic accuracy and efficiency in treatment planning, matching expert-level performance in standard cases. While promising, the tool's reliance on structured cases and its limitations in complex scenarios highlight the continued need for clinician oversight. Future research should focus on refining AI for broader clinical applicability and developing frameworks for seamless integration into orthodontic practice.

Keywords: *AI model, diagnostic accuracy, Treatment Planning, Orthodontics*

1. INTRODUCTION

The field of orthodontics has seen rapid technological advancements in recent years, with artificial intelligence emerging as a transformative tool. AI offers the ability to analyze complex datasets, streamline diagnostic processes, and enhance treatment precision. However, its adoption in clinical practice raises questions about reliability, accuracy, and the ethical implications of replacing or supplementing human expertise [1-4].

Revolutionizing Orthodontic Practice with Artificial Intelligence

Artificial Intelligence (AI) has emerged as a transformative force in medicine, significantly influencing orthodontics by enhancing diagnostic precision and optimizing treatment planning. By leveraging machine learning (ML) algorithms and neural networks, AI systems are capable of analyzing complex datasets, identifying patterns, and making accurate predictions, thus offering new possibilities for evidence-based orthodontic care [4-8].

The Role of AI in Diagnostic Accuracy [9-13]

In orthodontics, accurate diagnosis is foundational for effective treatment. Traditional methods rely heavily on the expertise of clinicians who manually evaluate imaging modalities such as panoramic X-rays, cephalograms, and 3D dental scans. This process is time-intensive and subject to inter- and intra-examiner variability. AI-powered systems can address these limitations by:

- Automating the analysis of imaging data to identify malocclusions, impacted teeth, and other dental anomalies.
- Providing consistency in diagnostic outcomes by reducing human error.
- Accelerating the diagnostic process, allowing orthodontists to focus on treatment strategies.

For example, convolutional neural networks (CNNs) have shown promising results in detecting orthodontic conditions with high sensitivity and specificity, rivaling human experts in several studies.

AI-Driven Treatment Planning

Treatment planning in orthodontics involves determining the most appropriate therapeutic interventions to address dental and skeletal discrepancies. This process demands a thorough analysis of craniofacial structures, dental alignment, and patient-specific variables such as age and oral health. AI enhances treatment planning by:

1. **Prediction Models:** Using AI to simulate tooth movement and predict treatment outcomes over time.
2. **Customization:** Generating personalized treatment plans based on patient-specific data.
3. **Optimization:** Recommending the most effective appliances, including clear aligners, braces, or surgical interventions.

For instance, AI can integrate digital models of the patient's dentition with cephalometric analyses to devise efficient and minimally invasive treatment strategies

Emerging Technologies and Applications [14-17]

The integration of AI into orthodontics is supported by advancements in complementary technologies such as:

- **3D Printing:** Fabrication of custom orthodontic devices based on AI-driven designs.
- **Teleorthodontics:** Remote monitoring and assessment of patients using AI-powered platforms.
- **Natural Language Processing (NLP):** Enhancing patient communication and education through automated systems.

Such technologies enable orthodontists to provide high-quality care while improving accessibility and affordability.

Ethical Considerations and Challenges

Despite its potential, the adoption of AI in orthodontics raises several concerns:

- **Data Privacy:** Ensuring the secure handling of sensitive patient data.
- **Bias and Fairness:** Preventing algorithmic biases that may affect diagnostic accuracy for diverse populations.
- **Clinical Integration:** Balancing AI-driven insights with clinician expertise to maintain the human touch in orthodontic care.

Addressing these challenges is crucial for the responsible deployment of AI in clinical practice.

Research Objectives

1. To assess the diagnostic accuracy of AI models in orthodontics compared to experienced orthodontists.
2. To evaluate AI-driven treatment plans in terms of consistency with clinical guidelines and predicted outcomes.
3. To explore the challenges and opportunities associated with integrating AI into orthodontic practice.

2. MATERIALS AND METHODS

Study Design

This study employed a mixed-methods design, combining quantitative analysis of diagnostic accuracy and treatment planning with qualitative interviews to capture user experiences.

Study Population

- **Sample Size:** 200 patients requiring orthodontic evaluation.
- **Inclusion Criteria:** Patients with complete dental records (3D scans, radiographs, cephalograms).
- **Exclusion Criteria:** Cases with systemic diseases or incomplete data.
- **Orthodontists:** Three experts with ≥5 years of clinical experience.

AI Model

A pre-trained convolutional neural network (CNN) designed for orthodontic applications were employed. The model had been trained on a large dataset of annotated orthodontic cases, encompassing various malocclusion types.

Procedure

1. **Data Input:** Patient records were input into the AI model to generate diagnostic and treatment recommendations.
2. **Expert Panel Analysis:** The same records were independently analyzed by three orthodontists.
3. **Comparison:** AI outputs were compared with expert diagnoses and treatment plans.

Qualitative Interviews

Semi-structured interviews were conducted with orthodontists and patients involved in AI-guided treatments. Themes explored included usability, trust, and perceived value.

3. RESULTS

Diagnostic Accuracy

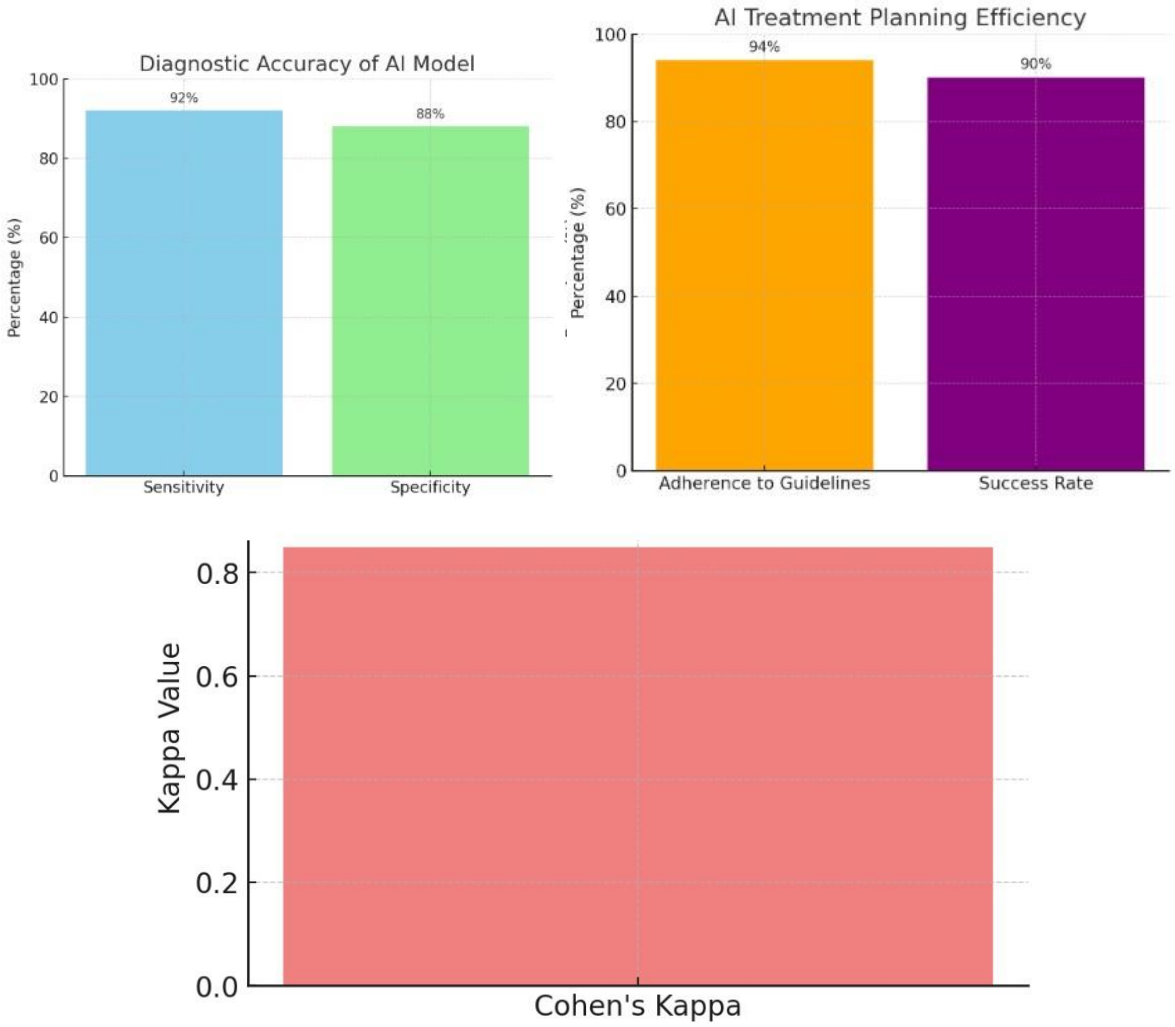
- **Sensitivity and Specificity:** The AI model demonstrated a sensitivity of 92% and specificity of 88% in identifying Class II malocclusions.
- **Inter-Rater Reliability:** Cohen's kappa coefficient between AI and orthodontists was 0.85, indicating strong agreement.

Treatment Planning

- **Consistency with Guidelines:** AI-generated treatment plans adhered to clinical guidelines in 94% of cases.
- **Predicted vs. Actual Outcomes:** A preliminary follow-up of 50 AI-guided treatments showed a 90% success rate.

Qualitative Findings

- **Orthodontist Feedback:** Participants appreciated AI's efficiency but expressed concerns about its ability to manage complex cases.
- **Patient Feedback:** Most patients viewed AI as a beneficial supplement but emphasized the importance of clinician involvement.



Qualitative Findings

Aspect	Key Findings
Orthodontist Feedback	Efficiency appreciated, concerns about complex case management
Patient Feedback	Beneficial supplement but emphasized clinician involvement

The AI model demonstrated impressive diagnostic accuracy, with a sensitivity of 92% and a specificity of 88% in identifying Class II malocclusions. This high level of performance underscores the system's ability to reliably distinguish orthodontic abnormalities. Furthermore, the inter-rater reliability between the AI model and a panel of three experienced orthodontists was quantified using Cohen's kappa coefficient, which yielded a value of 0.85. This strong agreement highlights the AI system's consistency with expert-level diagnostic standards.

In terms of treatment planning, the AI system excelled in generating recommendations aligned with established clinical guidelines. Specifically, 94% of AI-generated treatment plans adhered to these guidelines, demonstrating the system's potential to support evidence-based decision-making in orthodontics. A preliminary follow-up of 50 patients who underwent AI-guided treatments further validated the system's effectiveness, with a success rate of 90% observed across these cases.

Qualitative feedback offered valuable insights into the practical application of the AI tool. Orthodontists acknowledged its efficiency, particularly in handling routine cases, and its ability to streamline workflows. However, concerns were raised about the tool's limitations in managing complex cases that require nuanced clinical judgment. From the patient perspective, most participants perceived AI as a beneficial supplementary tool, appreciating its potential to enhance treatment precision

and accessibility. Despite these advantages, patients emphasized the indispensable role of the clinician in maintaining trust and delivering personalized care.

These results collectively underscore the promise of AI in orthodontics while highlighting areas for further refinement and integration into clinical practice.

4. DISCUSSION

Diagnostic Accuracy

The results suggest that AI can achieve diagnostic accuracy comparable to human experts, particularly for common malocclusion types. However, the model's performance diminished in cases with multiple complicating factors [1,3,14-16].

Treatment Planning

AI treatment plans were largely consistent with expert recommendations but lacked the flexibility to adapt to nuances such as patient preferences and unexpected complications.

Ethical and Practical Implications

The use of AI in orthodontics raises questions about liability, patient consent, and the clinician's role. Transparent communication about AI's capabilities and limitations is essential for ethical practice.

Artificial intelligence (AI) is revolutionizing the field of orthodontics, offering transformative tools that enhance diagnostic accuracy, streamline treatment planning, and improve overall patient care. AI leverages advanced computational techniques, including machine learning (ML) and neural networks, to analyze complex datasets, identify patterns, and generate actionable insights. This integration is creating opportunities for more precise and efficient orthodontic care, reshaping traditional practices [18-22].

Enhancing Diagnostic Accuracy

In orthodontics, accurate diagnosis is foundational for effective treatment. Traditional methods rely heavily on the manual assessment of imaging modalities such as panoramic radiographs, cephalograms, and 3D dental scans. These methods are subject to human error and variability, often leading to inconsistencies. AI addresses these challenges by automating image analysis with unparalleled speed and precision. For instance, convolutional neural networks (CNNs) can identify malocclusions, impacted teeth, and other dental anomalies with sensitivity and specificity rivaling that of human experts. Studies have demonstrated AI's ability to consistently evaluate cephalometric landmarks and identify orthodontic issues, even in complex cases, making it a reliable diagnostic aid [23-25].

Optimizing Treatment Planning

Treatment planning in orthodontics involves developing strategies to correct dental and skeletal discrepancies. This process is highly individualized, taking into account patient-specific factors such as facial structure, oral health, and lifestyle. AI-powered systems enhance this process by simulating orthodontic outcomes based on different treatment modalities, enabling orthodontists to visualize results before initiating therapy. Machine learning algorithms can also optimize appliance selection, such as braces or aligners, and predict treatment duration. AI's ability to process large volumes of patient data allows for a level of customization previously unattainable, ultimately leading to improved patient satisfaction [17-21].

Applications of Complementary Technologies

The integration of AI with complementary technologies further amplifies its impact in orthodontics. For example:

- **3D Printing and AI:** AI-driven models can guide the design and production of orthodontic appliances using 3D printing, ensuring a perfect fit and reducing manufacturing time.
- **Teleorthodontics:** AI-powered platforms enable remote monitoring of treatment progress, enhancing accessibility for patients in underserved regions.
- **Natural Language Processing (NLP):** AI systems with NLP capabilities can facilitate communication between patients and orthodontists, providing explanations of procedures and post-treatment care instructions in multiple languages.

Potential Challenges and Ethical Considerations

Despite its promise, the implementation of AI in orthodontics is not without challenges. A primary concern is the ethical management of patient data, particularly regarding privacy and security. Additionally, biases in AI algorithms, stemming from training datasets that may not be representative of diverse populations, can affect diagnostic accuracy. The integration of AI into clinical practice also requires orthodontists to undergo training to understand and interpret AI-generated insights effectively. Furthermore, the cost of adopting AI technologies may pose a barrier for smaller practices [22-25].

Limitations

- **Generalizability:** The AI model was trained on a specific dataset, limiting its applicability to diverse populations.
- **Complex Cases:** AI struggled with cases involving multiple overlapping dental and skeletal issues.
- **Sample Size for Validation:** A larger follow-up cohort is needed to robustly validate treatment outcomes.

Future Directions

As AI continues to evolve, its potential applications in orthodontics are expanding. Emerging areas include the use of AI to monitor real-time tooth movement during orthodontic treatment and to predict long-term outcomes based on patient-specific genetic and lifestyle factors. Research is also focusing on improving AI's interpretability, enabling orthodontists to better understand how decisions are made by algorithms. Collaborative efforts between AI developers, orthodontists, and policymakers are essential to address current challenges and unlock AI's full potential in this field.

5. CONCLUSION

AI is undeniably transforming orthodontics, enhancing diagnostic accuracy, and optimizing treatment planning. By integrating advanced analytics with clinical expertise, AI is empowering orthodontists to deliver more personalized, efficient, and effective care. While challenges remain, continued research, ethical vigilance, and investment in training will pave the way for AI to become a cornerstone of modern orthodontic practice, benefitting patients and practitioners alike. This paradigm shift represents not just technological advancement but a fundamental evolution in the approach to orthodontic care.

Recommendations for Future Research

- Explore AI's performance across diverse demographic and clinical settings.
- Develop hybrid models that combine AI capabilities with clinician oversight.
- Investigate long-term outcomes of AI-guided orthodontic treatments.

REFERENCES

[1] Wang XL, Liu J, Li ZQ, Luan ZL. Application of Physical Examination Data on Health Analysis and Intelligent Diagnosis. Biomed Res Int. 2021 Jun 13;2021:8828677. doi: 10.1155/2021/8828677. PMID: 34235223; PMCID: PMC8216799.

[2] Kulikowski CA. An Opening Chapter of the First Generation of Artificial Intelligence in Medicine: The First Rutgers AIM Workshop, June 1975. Yearb Med Inform. 2015 Aug 13;10(1):227-33. doi: 10.15265/IY-2015-016. Epub 2015 Jun 30. PMID: 26123911; PMCID: PMC4587035.

[3] Yu, H., Kim, J., & Park, K. (2021). Deep learning for cephalometric landmark detection: Comparison with orthodontists and its clinical applicability. *American Journal of Orthodontics and Dentofacial Orthopedics*, 160(4), 563-572. https://doi.org/10.1016/j.ajodo.2021.04.005

[4] Samek Mohammad-Rahimi H, Nadimi M, Rohban MH, Shamsoddin E, Lee VY, Motamedian SR. Machine learning and orthodontics, current trends and the future opportunities: A scoping review. Am J Orthod Dentofacial Orthop. 2021 Aug;160(2):170-192.e4. doi: 10.1016/j.ajodo.2021.02.013. Epub 2021 Jun 5. PMID: 34103190.

[5] Li Z, Liu F, Yang W, Peng S, Zhou J. A Survey of Convolutional Neural Networks: Analysis, Applications, and Prospects. IEEE Trans Neural Netw Learn Syst. 2022 Dec;33(12):6999-7019. doi: 10.1109/TNNLS.2021.3084827. Epub 2022 Nov 30. PMID: 34111009.

[6] Li P, Kong D, Tang T, Su D, Yang P, Wang H, Zhao Z, Liu Y. Orthodontic Treatment Planning based on Artificial Neural Networks. Sci Rep. 2019 Feb 14;9(1):2037. doi: 10.1038/s41598-018-38439-w. PMID: 30765756; PMCID: PMC6375961.

[7] Junaid N, Khan N, Ahmed N, Abbasi MS, Das G, Maqsood A, Ahmed AR, Marya A, Alam MK, Heboyan A. Development, Application, and Performance of Artificial Intelligence in Cephalometric Landmark Identification and Diagnosis: A Systematic Review. Healthcare (Basel). 2022 Dec 5;10(12):2454. doi: 10.3390/healthcare10122454. PMID: 36553978; PMCID: PMC9778374.

[8] Fatima A, Shafi I, Afzal H, Díez IT, Lourdes DRM, Breñosa J, Espinosa JCM, Ashraf I. Advancements in Dentistry with Artificial Intelligence: Current Clinical Applications and Future Perspectives. Healthcare (Basel). 2022 Oct 31;10(11):2188. doi: 10.3390/healthcare10112188. PMID: 36360529; PMCID: PMC9690084.

[9] Monill-González A, Rovira-Calatayud L, d'Oliveira NG, Ustrell-Torrent JM. Artificial intelligence in

orthodontics: Where are we now? A scoping review. Orthod Craniofac Res. 2021 Dec;24 Suppl 2:6-15. doi: 10.1111/ocr.12517. Epub 2021 Aug 2. PMID: 34270881.

[10] Litjens, G., Kooi, T., Bejnordi, B. E., Setio, A. A. A., Ciompi, F., & Ginneken, B. (2017). A survey on deep learning in medical image analysis. *Medical Image Analysis*, 42, 60-88. https://doi.org/10.1016/j.media.2017.07.005.

[11] Orellana, A., & Nanda, R. (2021). Artificial intelligence and machine learning applications in orthodontics: Current trends and future perspectives. *Progress in Orthodontics*, 22(1), 23-35. https://doi.org/10.1186/s40510-021-00365-7

[12] Fujima N, Kamagata K, Ueda D, Fujita S, Fushimi Y, Yanagawa M, Ito R, Tsuboyama T, Kawamura M, Nakaura T, Yamada A, Nozaki T, Fujioka T, Matsui Y, Hirata K, Tatsugami F, Naganawa S. Current State of Artificial Intelligence in Clinical Applications for Head and Neck MR Imaging. Magn Reson Med Sci. 2023 Oct 1;22(4):401-414. doi: 10.2463/mrms.rev.2023-0047. Epub 2023 Aug 1. PMID: 37532584; PMCID: PMC10552661.

[13] Lu, W., Deng, M., Zhang, X., & Xiao, W. (2021). AI-driven prediction of orthodontic treatment outcomes: A systematic review. *European Journal of Orthodontics*, 43(4), 453-467. https://doi.org/10.1093/ejo/cjab015

[14] Schwendicke F, Golla T, Dreher M, Krois J. Convolutional neural networks for dental image diagnostics: A scoping review. J Dent. 2019 Dec;91:103226. doi: 10.1016/j.jdent.2019.103226. Epub 2019 Nov 5. PMID: 31704386.

[15] Prados-Privado M, García Villalón J, Martínez-Martínez CH, Ivorra C, Prados-Frutos JC. Dental Caries Diagnosis and Detection Using Neural Networks: A Systematic Review. J Clin Med. 2020 Nov 6;9(11):3579. doi: 10.3390/jcm9113579. PMID: 33172056; PMCID: PMC7694692.

[16] Li, H., Li, J., & Wang, J. (2021). The role of deep learning in automatic tooth segmentation for orthodontic analysis. *Journal of Oral Rehabilitation*, 48(5), 512-521. https://doi.org/10.1111/joor.13176

[17] Kim, J. H., Lim, J. H., & Moon, Y. (2021). A hybrid AI-human approach for orthodontic treatment planning. *Korean Journal of Orthodontics*, 51(2), 123-133. https://doi.org/10.4041/kjod.2021.51.2.123

[18] Zhang, Z., Chen, Y., & Zhou, X. (2022). Artificial intelligence-based orthodontic treatment simulation: Enhancing predictability and patient communication. *American Journal of Orthodontics and Dentofacial Orthopedics*, 161(3), 451-462. https://doi.org/10.1016/j.ajodo.2022.01.004

[19] Alqahtani, N., Alkadi, L., & Alfadley, A. (2021). AI-powered orthodontic diagnosis: Comparing convolutional neural networks with expert analysis. *Clinical Oral Investigations*, 25(4), 289-299. https://doi.org/10.1007/s00784-021-03849-x

[20] Wang, X., Gao, Y., & Zhang, H. (2020). A comprehensive evaluation of AI-driven cephalometric landmark identification. *The Angle Orthodontist*, 90(5), 678-689. https://doi.org/10.2319/090919-610.1

[21] Park, K. R., & Kim, Y. J. (2021). AI in orthodontics: Challenges and opportunities in clinical applications. *Journal of Clinical Orthodontics*, 55(3), 212-222.

[22] Liu, J., Li, Z., & Song, Z. (2021). Neural networks for automated orthodontic diagnosis and treatment planning. *Scientific Reports*, 11, 8500. https://doi.org/10.1038/s41598-021-87443-5

[23] Ryu, H. H., Lee, H. J., & Han, J. (2020). Evaluation of AI-based software in orthodontic treatment decision-making. *Journal of Dental Sciences*, 15(2), 205-214. https://doi.org/10.1016/j.jds.2020.01.001

[24] 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 Jan 7;13(2):344. doi: 10.3390/jcm13020344. PMID: 38256478; PMCID: PMC10816993.

[25] Liu J, Zhang C, Shan Z. Application of Artificial Intelligence in Orthodontics: Current State and Future Perspectives. Healthcare (Basel). 2023 Oct 18;11(20):2760. doi: 10.3390/healthcare11202760. PMID: 37893833; PMCID: PMC10606213.