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Short Communication

Artificial Intelligence in orthodontics: Clinical revolution or technological illusion?

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1. Introduction

Orthodontics has undergone significant transformation over the past few decades, evolving from a discipline based mainly on mechanical tooth movement to one increasingly influenced by digital technology and data-driven decision making. Among recent advancements, artificial intelligence (AI) has emerged as one of the most rapidly developing tools in modern dentistry. AI refers to computer systems capable of performing tasks that normally require human intelligence, such as pattern recognition, prediction, and decision support. In orthodontics, the integration of AI into clinical workflows is changing the approach to diagnosis, treatment planning, and outcome assessment, generating both enthusiasm and skepticism among clinicians.[1]

Recent studies show that AI-based systems can analyze large volumes of clinical data with high speed and consistency, improving efficiency and reducing operator-dependent variability. Applications include automated cephalometric landmark identification, malocclusion classification, and prediction of treatment outcomes.[2] The increasing use of digital records such as cone-beam computed tomography, intraoral scans, and facial imaging has further accelerated the development of machine-learning algorithms that assist clinicians in making more precise decisions.[3] Despite these advantages, concerns remain regarding the true clinical value of artificial intelligence. While some consider AI a revolutionary advancement, others caution that excessive dependence on automated systems may reduce the importance of clinical judgment.[4] The accuracy of AI models also depends on the quality and diversity of training data, and variations in growth pattern, craniofacial morphology, and biological response may limit the ability of algorithms to replace human expertise.[5]

Therefore, artificial intelligence in orthodontics should be viewed not only as a technological innovation but also as a paradigm shift requiring critical evaluation. Determining whether AI represents a true clinical revolution or merely a technological illusion is essential to ensure that progress enhances patient care without compromising professional responsibility.[6]

2. Applications of Artificial Intelligence in Orthodontics

Artificial intelligence has been applied at multiple stages of orthodontic practice, including diagnosis, treatment planning, monitoring, and outcome prediction. One of the most common applications is automated cephalometric analysis, where machine learning algorithms identify landmarks with high precision and reproducibility, reducing manual tracing time and operator-dependent errors.[1,4] AI is also used in malocclusion classification and assessment of treatment need. By analyzing dental casts, intraoral scans, and radiographic images, AI-based systems can categorize occlusal relationships and skeletal discrepancies with accuracy comparable to experienced orthodontists, making them useful decision-support tools rather than replacements for clinical judgment.[6]

In treatment planning, predictive models can estimate the outcomes of different approaches such as extraction, growth modification, or orthognathic treatment. By processing large datasets from previously treated cases, AI can detect patterns that help improve individualized treatment planning and patient-specific outcomes.[3,5] Artificial intelligence is widely integrated into digital orthodontics, particularly in aligner therapy and three-dimensional simulations, where software can generate virtual setups, predict tooth movement, and monitor treatment progress using intraoral scans. These tools improve workflow efficiency and patient communication.[2] AI is also increasingly used in research and education for data analysis, image interpretation, and development of new clinical protocols, and its role in orthodontics is expected to expand further with the growth of digital records.[1]

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3. Advantages of Artificial Intelligence in Orthodontics

The rapid adoption of artificial intelligence in orthodontics is largely driven by the advantages it offers in terms of accuracy, efficiency, and standardization of clinical procedures. One of the major benefits of AI-based systems is their ability to process large amounts of data in a short period of time, allowing clinicians to obtain diagnostic information more quickly than with conventional methods. Automated cephalometric analysis and image recognition systems have shown high levels of precision, reduced the possibility of human error and improved the reproducibility of orthodontic records.[1,4]

Artificial intelligence also contributes to improved treatment planning by enabling predictive analysis based on previously treated cases. Machine learning algorithms can evaluate multiple variables simultaneously, including skeletal pattern, dental relationships, and growth potential, to estimate the likely outcome of different treatment approaches. Such predictive capability supports evidence-based decision making and helps clinicians select the most appropriate treatment plan for each patient.[3,5]

Another important advantage is the enhancement of workflow efficiency in modern digital orthodontics. AI-powered software used in aligner therapy, three-dimensional simulations, and remote monitoring systems allows faster treatment setup and more accurate tracking of tooth movement. These tools not only reduce chairside time but also improve communication with patients by providing visual representation of expected results.[2]

Artificial intelligence also promotes standardization in orthodontic practice. Because AI systems follow predefined algorithms, the variability associated with operator experience can be minimized. This may be particularly useful in large clinical settings, academic institutions, and tele-orthodontic services where consistency of diagnosis and treatment planning is essential.[6]

Furthermore, the use of AI in research has facilitated the analysis of complex datasets, leading to better understanding of treatment outcomes and contributing to the development of new clinical protocols. As more data become available, artificial intelligence is expected to play an increasingly important role in achieving personalized and precise orthodontic care.[1]

4. Limitations and Concerns of Artificial Intelligence in Orthodontics

Despite the numerous advantages associated with artificial intelligence, its application in orthodontics is not without limitations. One of the primary concerns is the potential over-reliance on automated systems, which may reduce the importance of clinical judgment and experience. Orthodontic treatment involves complex biological processes that cannot always be predicted accurately by algorithms, especially in growing patients where individual variation plays a significant role. Although AI can assist in diagnosis and planning, the final decision must remain the responsibility of the clinician.[2]

Another limitation is related to the quality and diversity of data used to train artificial intelligence models. AI systems depend heavily on large datasets, and if the training data are incomplete, biased, or not representative of different populations, the accuracy of the results may be compromised. This is particularly relevant in orthodontics, where variations in craniofacial morphology, growth pattern, and treatment response are common. Therefore, the reliability of AI-generated predictions should always be interpreted with caution.[1,6]

Technical limitations also exist in the current generation of AI software. While automated cephalometric tracing and digital treatment simulations have shown promising accuracy, they may still require manual correction in many cases. Errors in landmark identification, image quality issues, and software limitations can affect the final diagnosis and lead to inappropriate treatment planning if not carefully reviewed by the orthodontist.[4]

Cost and accessibility represent additional challenges. The implementation of artificial intelligence requires advanced software, digital equipment, and continuous updates, which may not be feasible in all clinical settings. Smaller practices and institutions with limited resources may find it difficult to adopt such technologies, creating a gap between technologically advanced centers and conventional orthodontic practices.[3]

Furthermore, the rapid commercialization of AI-based orthodontic systems has raised concerns about the promotion of technology without sufficient clinical validation. Some digital platforms claim high accuracy and efficiency, but long-term evidence supporting their effectiveness is still limited. As a result, clinicians must critically evaluate new technologies before incorporating them into routine practice.[5]

5. Conclusion

Artificial intelligence has brought significant technological advancement to orthodontic practice by improving diagnostic accuracy, treatment planning, and clinical efficiency. At the same time, orthodontic treatment remains a biologically driven process that cannot be fully controlled by algorithms alone. Over-reliance on automated systems may reduce the importance of clinical judgment, which continues to be essential for successful outcomes.

Artificial intelligence should therefore be considered a supportive tool rather than a replacement for the orthodontist. The future of orthodontics will depend on a balanced integration of technology and professional expertise, where innovation enhances patient care without compromising fundamental clinical principles. Whether artificial intelligence becomes a true clinical revolution or merely a technological illusion will depend on its responsible and evidence-based application in everyday practice.

6. Authors Contributions

1. **Anshuman Mishra:** Conceptualization, resources, visualization, writing – original draft.
2. **Subash Chandra Nayak:** Formal analysis.

7. Source of Funding

None.

8. Conflict of Interest

None.

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