IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 24, Issue 11 Ser. 7 (November. 2025), PP 08-14
www.iosrjournals.org

Comparative Study of Effectiveness of AI Technologies (Gemini, Meta AI, ChatGPT) in Orthodontic Patient Education – A Prospective Study

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Abstract:
Background: *AI has witnessed significant growth in recent years, with advancements including AI technologies like Gemini, Meta AI, and ChatGPT. While these AI chatbots offer interactive communication, their impact and effectiveness in orthodontic patient education remain largely unexplored.*
Aim and Objective: *The study aims to assess the effectiveness of three different AI Large Language Models (LLMs) in enhancing patient understanding during orthodontic consultations by comparing baseline knowledge scores and after interaction with each model. The objective is to evaluate patient comprehension of orthodontic concepts by assessing variations in patient satisfaction and ease of use across different AI tools.*
Methodology: *A total of 90 participants were randomly assigned to one of three AI tools. Initially, all participants completed a pre-bonding questionnaire via Google Forms to assess their baseline understanding. After receiving education through their designated AI tool, participants filled out the same questionnaire again. Comparing the pre- and post-education scores allows for the evaluation of AI's effectiveness in orthodontic patient education and provides insights into which AI tool may offer the greatest benefit in enhancing patient comprehension.*
Results: *Significant improvements in knowledge scores were observed after using AI chatbots, with Gemini and ChatGPT showing higher scores than Meta AI. Intergroup comparisons revealed significant differences between Gemini and Meta AI.*
Conclusion: *AI chatbots, particularly Gemini and ChatGPT, significantly enhance orthodontic patient education, outperforming Meta AI. These tools offer personalized, accessible information, with future research needed to explore long-term impacts and diverse populations.*
Keywords: *AI Chatbots, Orthodontic education, Gemini, Meta AI, ChatGPT*

Date of Submission: 14-11-2025 Date of Acceptance: 29-11-2025

I. INTRODUCTION

Orthodontic treatment is a widely utilized procedure aimed at correcting malocclusions, aligning teeth, and improving both functional and aesthetic outcomes for patients[1]. However, the success of orthodontic treatments is not solely dependent on clinical expertise and technological advancements; patient compliance and understanding of the treatment process play an equally important role[2]. Effective patient education can significantly enhance compliance, reduce treatment duration, and lead to better treatment outcomes[3]. Yet, traditional methods of educating orthodontic patients, which often rely on verbal communication, printed materials, and standard videos, can sometimes fall short of addressing individual learning needs or providing personalized support[4]. In recent years, advancements in technology have offered new opportunities to improve patient education[5]. One of the most promising innovations in this area is the use of Artificial Intelligence (AI) tools[6]. AI-based platforms, such as ChatGPT, Meta AI, and Gemini AI, present unique capabilities to provide

personalized, interactive, and real-time engagement with patients[7]. These AI LLM's can offer tailored explanations, answer patient queries, and adjust educational content to suit the individual's learning style[8]. With their capacity to adapt and provide detailed, accessible information, these tools hold the potential to revolutionize the way orthodontic patients learn about their treatment plans, objectives, and protocols[9]. Despite the potential of AI in enhancing patient education, there is a gap in empirical evidence assessing its effectiveness specifically in the context of orthodontics[10]. Most existing studies on AI in healthcare focus on general patient education or medical fields such as radiology and surgery[11]. However, the specific impact of AI tools on orthodontic patients' understanding of their treatment process, expectations, and compliance has not been thoroughly explored[12]. This study seeks to address this gap by comparing the effectiveness of three AI technologies—Gemini, Meta AI, and ChatGPT—in improving patient education for orthodontic care.

Each of these AI platforms has distinct features that could influence how they contribute to patient education[13]. ChatGPT, for instance, provides natural language processing capabilities, allowing for dynamic, conversational interactions that simulate a human-like dialogue[14].

Meta AI offers a range of tools that leverage data from Facebook and Instagram, providing personalized insights and content tailored to user interests. Gemini AI, a more recent addition, combines cutting-edge machine learning algorithms with real-time data processing to deliver highly customized and intuitive educational experiences.

The aim of this study is to assess and compare the impact of these three AI LLM's on patients' knowledge levels before and after their orthodontic bonding process. By measuring changes in patient knowledge, this study seeks to determine which of the three AI tools offers the most significant educational benefit. The findings from this study could provide valuable insights into how AI can be integrated into orthodontic practices to improve patient engagement, enhance education, and ultimately contribute to better outcomes[15].

II. MATERIALS AND METHODS

This study aims to evaluate and compare the effectiveness of three AI technologies—Gemini AI, Meta AI, and ChatGPT— in enhancing orthodontic patient education. To achieve this, the participants are randomly divided into three groups, each receiving education through one of the three AI LLM's. The methodology follows a structured approach, beginning with a baseline assessment of the participants' knowledge, followed by exposure to AI-based educational tools, and concluding with a post-education reassessment to measure any changes in knowledge and understanding.

Study Participants

A total of 90 participants is recruited for the study. These participants are randomly divided into three equal groups, each consisting of 30 individuals. The groups are as follows:

- **Group 1**: Participants assigned to the Gemini AI group (30 participants).
- **Group 2**: Participants assigned to the Meta AI group (30 participants).
- **Group 3**: Participants assigned to the ChatGPT group (30 participants).

The participants are selected based on specific inclusion criteria, ensuring that they are all in the early stages of orthodontic treatment and have not yet undergone the bonding procedure. This selection process ensures that all participants have a similar baseline understanding of orthodontic treatments.

Pre-Bonding Questionnaire

Before the educational intervention, all participants are required to fill out a pre-bonding questionnaire. The purpose of this questionnaire is to assess their baseline knowledge and understanding of orthodontic treatments. The questions are designed to evaluate participants' general knowledge in several key areas, such as:

- The purpose and goals of orthodontic treatment.
- The common types of orthodontic appliances and their functions.
- The expected timeline for treatment.
- The importance of patient compliance in achieving successful outcomes.
- Potential challenges or side effects associated with orthodontic treatments.

The pre-bonding questionnaire includes multiple-choice questions, providing a comprehensive overview of participants' initial knowledge. This baseline data will serve as a comparison point when measuring changes in knowledge after exposure to the AI-based education.

AI-Based Education

After the pre-bonding questionnaire is completed, each group receives patient education through their assigned AI tool. The three AI platforms used in this study are:

- **Gemini AI**: Participants in this group engage with an AI platform that uses advanced machine learning

algorithms to deliver personalized and interactive educational content. Gemini AI provides detailed explanations of orthodontic procedures, potential outcomes, and patient responsibilities. It allows participants to ask specific questions and receive immediate responses tailored to their individual needs.

- **Meta AI**: Participants in this group use Meta AI, an AI tool which offers insights based on the participant's preferences, such as treatment expectations, and delivers engaging visuals and interactive elements to enhance understanding. Participants are able to navigate through content at their own pace and revisit key concepts as needed.
- **ChatGPT**: Participants in this group interact with ChatGPT, a conversational AI tool that uses natural language processing to simulate a dialogue with users. ChatGPT provides text-based, real-time answers to patient questions, offering explanations and clarifications about the orthodontic process. Participants can ask follow-up questions and engage in a dynamic learning experience.

Each AI platform provides a comprehensive education session covering the essential components of orthodontic treatment, including the treatment objectives, expected timeline, and the importance of patient compliance.

Post-Education Assessment

Following the educational session, all participants complete the same questionnaire that they filled out prior to the educational intervention. The post-education assessment allows researchers to measure any changes in the participants' knowledge and understanding of orthodontic treatments. The questionnaire is identical to the pre-bonding version to ensure that any differences in responses can be attributed to the AI-based education intervention rather than other variables.

The responses from the pre- and post-education questionnaires are analyzed to determine the effectiveness of each AI tool. Researchers will compare the changes in knowledge within each group, as well as between the three groups. This will allow for a comparison of the three AI technologies in terms of their ability to enhance patient understanding and education.

Statistical analysis

The data collected were entered in Microsoft Excel and analysed using SPSS (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY, USA: IBM Corp.). The normality of the data was assessed prior to analysis using the Shapiro-Wilk's test/Kolmogorov-Smirnov test. Data were found to be normally distributed. Thus, parametric test was chosen. Descriptive statistics were used to calculate the mean values. One way ANOVA was carried out to determine the difference between the groups and Tukey post hoc test were carried out to determine the difference between the groups. All statistical tests were performed at a significance level of 5% ($p \leq 0.05$).

III. RESULTS

Table 1 summarizes the comparison of mean knowledge scores before and after using AI chatbots (Gemini, Meta AI, and ChatGPT) among participants. Before using AI Chat bots, Meta AI had the highest mean score (9.00 ± 2.27), while Gemini and ChatGPT had similar lower scores. After using AI Chat bots, both Gemini (13.03 ± 1.75) and ChatGPT (13.07± 1.64) showed higher mean scores compared to Meta AI (11.97 ± 1.90). One-way ANOVA indicated significant differences among the groups both before (p=0.008) and after (p=0.027) the intervention. Paired t-tests showed significant improvements in scores across all groups (p<0.001). The intergroup comparison using Tukey's post hoc test revealed significant differences between Gemini and Meta AI before and after using chatbots, but there was no significant difference between Gemini and ChatGPT (Table 1 and Figure 1).

***Table 1**. Comparison of the mean knowledge scores before and after using AI chatbots among participants*

Knowledge mean score		**Gemini (n=30)**	**Meta AI (n=30)**	**Chat GPT (n=30)**	**F**	***p* value †**
Before using AI	Mean±SD	7.23±1.59[a]	9.00±2.27[b]	7.70±2.64[a]	5.139	0.008*
	95% CI	6.64 – 7.83	8.15 – 9.85	6.71 – 8.69		
After using AI	Mean±SD	13.03±1.75[a]	11.97±1.90[b]	13.07±1.64[a]	4.210	0.027*
	95% CI	12.38 – 13.69	11.26 – 12.68	12.46 – 13.68		
t		- 16.25	-8.71	-10.51		
***p value* ‡**		<0.001*	<0.001*	<0.001*		

** p<.05 is considered statistically significant. CI-Confidence interval; SD – Standard deviation. The statistical test used: †One way ANOVA and ‡ Paired t test. Different lowercase (small letters a, b, c) indicates a significant difference between the groups within the same row.*

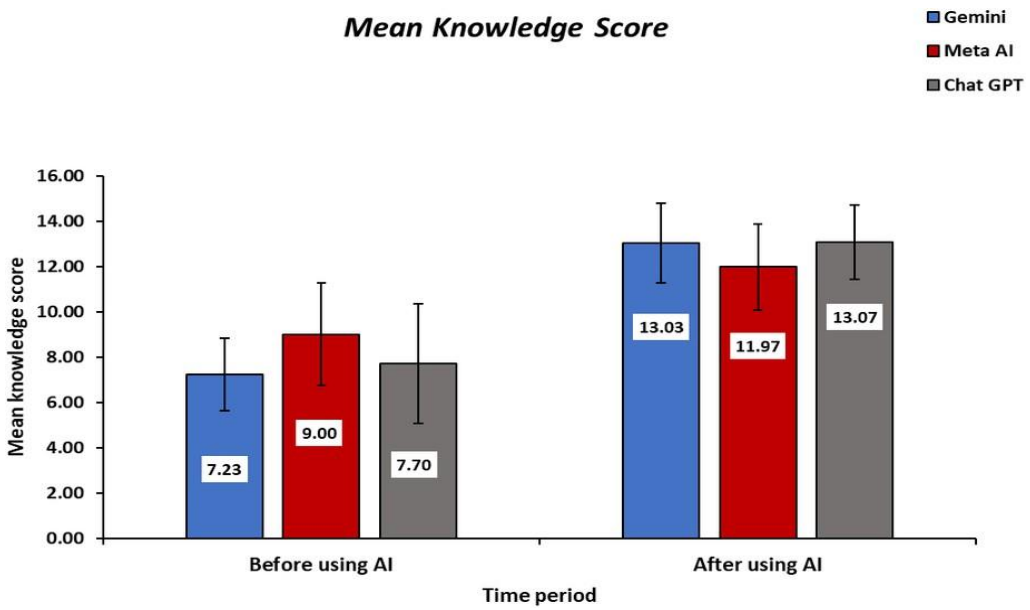

Figure 1. *Comparison of the mean knowledge scores before and after using AI chatbots among participants.*

Table 2 summarizes the mean difference in knowledge scores before and after using AI chatbots (Gemini, Meta AI, and ChatGPT) among participants. Gemini (5.80 ± 1.96) and ChatGPT (5.37 ± 2.80) showed significantly higher mean differences compared to Meta AI (2.97 ± 1.87). The 95% confidence intervals indicate consistent improvements for Gemini and ChatGPT. One-way ANOVA revealed a significant difference among the groups ($p<0.001$). The intergroup comparison using Tukey's post hoc test revealed significant differences between Gemini and Meta AI before and after using chatbots, but there was no significant difference between Gemini and ChatGPT (Table 2 and Figure 2).

Table 2. *Comparison of the mean difference in knowledge scores before and after using AI chatbots among participants*

	Gemini (n=30)	**Meta AI (n=30)**	**Chat GPT (n=30)**	***F***	***p*-value**
Mean ± SD	5.80 ± 1.96[a]	2.97 ± 1.87[b]	5.37 ± 2.80[a]	13.86	<0.001*
95% CI	5.07 – 6.53	2.27 – 3.66	4.32 – 6.41		

** p<.05 is considered statistically significant. CI-Confidence interval; SD – Standard deviation. Different lowercase (small letters a, b, c) indicates a significant difference between the groups within the same row.*

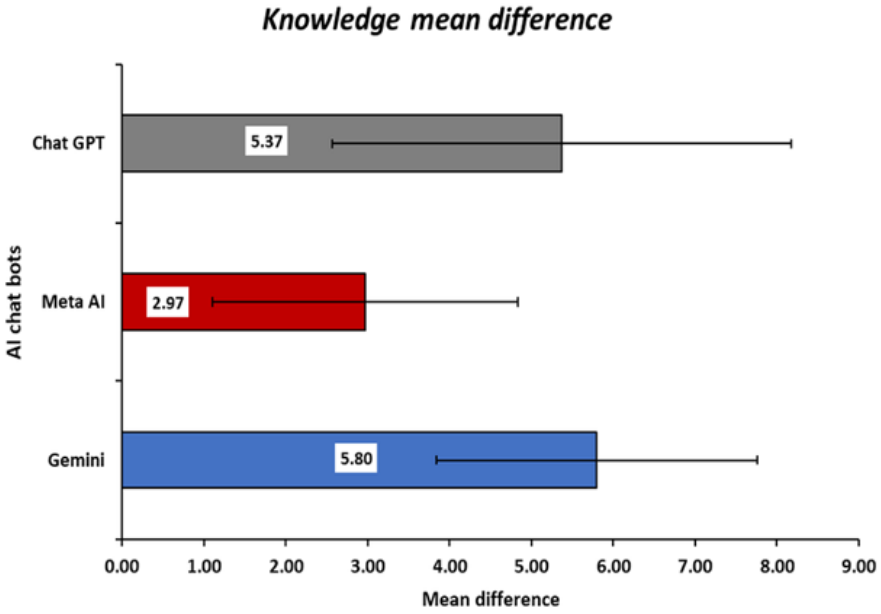

Figure 2. *Comparison of the mean difference in knowledge scores before and after using AI chatbots among participants*

IV. DISCUSSION

Artificial intelligence (AI) has become an integral part of modern life due to advancements in computing power, data digitization, and algorithm accuracy, yet many remain unaware of its role in everyday technologies like fitness trackers, chatbots, and email spam filters[16].

Since the inception of artificial intelligence in 1955 by John McCarthy, AI has experienced cycles of optimism and setbacks, with key milestones such as AlphaGo's 2015 victory and the introduction of ChatGPT in 2022 reigniting interest and development. AI has been made accessible on mobile devices and widely adopted in both clinical and research settings[17]. Artificial intelligence (AI) has made significant strides since its inception, with large language models (LLMs) like ChatGPT and Google Bard leading the charge. These models, pre-trained on vast text corpora and optimized for specific tasks, excel in generating human-like text. ChatGPT-4, for example, outperforms previous versions and specialized medical models in mock examinations, showcasing its potential in clinical support and medical education[18]. Artificial intelligence (AI) tools, such as ChatGPT and Google Gemini, are emerging as powerful tools in patient education, offering accessible information and enhancing personalized medicine. However, challenges include verifying their accuracy, potential overreliance on AI for diagnosis, and lack of personal connection with doctors[19]. AI tools like ChatGPT and Gemini are revolutionizing patient education by providing precise, context-aware responses. ChatGPT-4, launched by OpenAI, offers advanced capabilities such as interpreting images and generating context-specific descriptions. Similarly, Google's Gemini, an enhanced version of Bard, improves language comprehension and accuracy. These large language models (LLMs) are being explored for their utility in answering specialty-specific questions, supporting multilingual communication, and enhancing patient care[20].

Artificial intelligence (AI) has revolutionized multiple fields, including healthcare, with significant developments like ChatGPT, a large language model by OpenAI. ChatGPT uses deep learning and transfer learning to generate contextually accurate text, with applications in various medical disciplines, improving diagnostics and treatment decisions. Despite its promising potential, AI systems like ChatGPT require precise, unbiased prompts for effective results[21]. Large language models (LLMs), such as ChatGPT, Gemini, and Google Bard, are transforming medicine by improving diagnostic accuracy, clinical decision-making, and patient monitoring[22]. Effective communication in dentistry is crucial for establishing trust, enhancing cooperation, and promoting long-term patient care[23].

This study evaluates how these AI models can improve patient awareness and education for those seeking orthodontic treatment. It evaluates the accuracy and readability of ChatGPT and Gemini and Meta AI in answering common orthodontic treatment related questions posed by the general public.

The study assessed the impact of three AI chatbots—Gemini, Meta AI, and ChatGPT—on participants' knowledge by comparing pre- and post-intervention scores. Before the intervention, baseline knowledge levels varied significantly among the groups. The Meta AI group demonstrated the highest mean score (9.00 ± 2.27), indicating better initial knowledge compared to the Gemini group (7.23 ± 1.59) and the ChatGPT group (7.70 ± 2.64). These differences reflect participants' prior knowledge and could be attributed to variations in educational backgrounds or random group assignment, as no chatbot intervention had occurred at this stage. Post-intervention, all groups showed significant improvements in knowledge. The Gemini group (13.03 ± 1.75) and ChatGPT group (13.07 ± 1.64) achieved higher and comparable mean scores compared to the Meta AI group (11.97 ± 1.90), suggesting superior efficacy in enhancing understanding. The mean improvement in scores was significantly higher for the Gemini group (5.80 ± 1.96) and ChatGPT group (5.37 ± 2.80) than for the Meta AI group (2.97 ± 1.87). Tukey's post hoc analysis confirmed significant differences between Meta AI and the other two chatbots, while Gemini and ChatGPT showed comparable efficacy. These findings were statistically significant ($p < 0.05$), validating the results and highlighting Gemini and ChatGPT as effective educational tools.

The study demonstrates that AI chatbots like Gemini and ChatGPT significantly enhance patient education and knowledge in orthodontics. These chatbots outperformed Meta AI, showing higher improvements in pre- and post-intervention knowledge scores. Research by Maleki Varnosfaderani S et al. highlights the growing role of AI in healthcare, specifically in patient education, where AI models have been shown to provide tailored, accurate information that aids decision-making and treatment understanding[24]. Additionally, a study by Chustecki M et al. supports the finding that AI-driven systems can bridge knowledge gaps and improve health literacy in patients[25]. While this study confirms the effectiveness of Gemini and ChatGPT, the findings align with Ng FYC et al. in healthcare AI, which emphasize the benefits of personalized education through AI platforms[26]. However, as with all technology, challenges remain, such as ensuring long-term retention and preventing overreliance on AI for clinical decision-making[27]. Thus, future studies should expand to larger, more diverse samples and assess long-term educational outcomes, while also exploring qualitative feedback to refine these tools for optimal educational effectiveness.

The study's limitations include a small sample size, a focus on short-term knowledge gains, and the lack of long-term retention assessment. Additionally, the Meta AI group demonstrated higher scores in the pre-

bonding assessment compared to the other groups, potentially indicating a stronger baseline understanding among participants in this group. Future research should address these limitations by involving larger, more diverse populations, evaluating long-term outcomes, and incorporating qualitative feedback to refine chatbot functionalities and better understand baseline differences across groups.

V. CONCLUSION

In conclusion, AI chatbots, particularly Gemini and ChatGPT, show significant potential in improving patient education and knowledge in orthodontics. The study highlights their effectiveness in enhancing understanding of orthodontic treatments, with both chatbots outperforming Meta AI. These results suggest that AI tools can be valuable assets in patient education, offering personalized and accessible information, though future research should address long-term impacts and diverse populations.

Acknowledgments: Nil
Conflict of Interest: Nil
Funding: Nil
Ethical approval: Ethical approval was obtained from Institutional Ethical committee of CSI College of dental sciences and research CSICDSR/IEC/0313/2024

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