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ASSOCIATION BETWEEN AI-BASED TREATMENT PLANNING TOOLS AND PSYCHOSOCIAL SATISFACTION IN ORTHODONTIC PATIENTS: A CROSS-SECTIONAL STUDY

Original Article

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ABSTRACT

Background: The integration of artificial intelligence (AI) in orthodontic treatment planning, particularly through digital aligner systems, has introduced new possibilities for enhancing both clinical outcomes and patient-centered care. However, limited research exists on how AI-based planning impacts psychosocial satisfaction and self-perception during treatment.

Objective: To explore the association between AI-enhanced digital aligner treatment planning and psychosocial satisfaction in adolescent and adult orthodontic patients.

Methods: A cross-sectional study was conducted over eight months in orthodontic clinics across urban Pakistan. A total of 420 participants aged 13–40 years undergoing or recently completing AI-based aligner therapy were enrolled. The Psychosocial Impact of Dental Aesthetics Questionnaire (PIDAQ) was used to assess domains such as dental self-confidence and psychological impact. Patient satisfaction with AI-driven features—such as visual simulations, treatment predictability, and perceived control—was measured using a Likert-based scale. Statistical analyses included descriptive statistics, Pearson's correlation, and multiple regression, with data analyzed via SPSS v26. Normality of data was confirmed prior to analysis.

Results: Participants showed high satisfaction with AI features, particularly in visual clarity (mean score 4.15 ± 0.74) and treatment confidence (4.09 ± 0.77). The highest PIDAQ domain score was observed in dental self-confidence (3.89 ± 0.81). Positive correlations were noted between satisfaction with AI tools and self-confidence ($r = 0.48$, $p < 0.001$), while negative correlations were found with social impact, psychological impact, and aesthetic concern. These findings suggest a significant psychosocial benefit associated with AI-enhanced orthodontic planning.

Conclusion: AI-integrated aligner treatment planning contributes positively to patient satisfaction and psychosocial well-being, supporting its role in modern, patient-centered orthodontic care.

Keywords: Adolescent, Artificial Intelligence, Dental Aesthetics, Digital Orthodontics, Patient Satisfaction, Self-Concept, Treatment Outcome.

INTRODUCTION

The integration of artificial intelligence (AI) into healthcare continues to reshape patient experiences and treatment outcomes, with orthodontics emerging as one of the specialties most affected by this technological shift. Among the innovations gaining ground is AI-based treatment planning, particularly in the realm of digital aligners (1). These tools promise not only clinical efficiency and improved precision in planning orthodontic treatments but also the potential to impact psychosocial outcomes—factors such as self-image, satisfaction with care, and social confidence (2). While the clinical efficacy of AI-driven systems is steadily being documented, for example in rehabilitation where AI-assisted gait analysis has shown outcome benefits (3), there remains a critical gap in understanding how these tools influence the subjective experiences of patients undergoing treatment, especially in regard to their psychosocial well-being. Orthodontic treatment, especially among adolescents and adults, is often sought not purely for functional corrections but also for its perceived benefits to aesthetics and self-esteem. The psychological and emotional dimensions of orthodontic care are deeply intertwined with patient satisfaction (4). In this context, the rise of AI-based digital aligner systems—capable of offering simulations, predictive modeling, and treatment personalization—could play a pivotal role in shaping patient perception and expectations (5). However, despite their increasing adoption, relatively little is known about whether these sophisticated tools actually translate into improved patient-reported satisfaction and self-perception outcomes. Studies have highlighted the psychosocial benefits of orthodontic treatment, noting that improvements in dental aesthetics are frequently accompanied by enhanced self-confidence and social comfort. Yet, the patient journey is not determined solely by the mechanical outcome of treatment but also by the perceived transparency, control, and predictability of the process (6,7). AI-enhanced systems have been praised for providing clearer treatment visualizations and fostering patient involvement in decision-making through digital modeling (8). This added layer of technological communication could influence how patients engage with their treatment plan and how satisfied they feel throughout the process.

Recent research has shown that tools like ClinCheck® and other AI-powered platforms used in clear aligner therapy enhance patient understanding and participation, which may in turn foster greater satisfaction (9). A study noted a significant improvement in treatment adherence when patients were presented with AI-generated simulations of expected outcomes, suggesting that visual prediction tools might offer psychological reinforcement during the lengthy course of orthodontic care (10). However, while such findings are promising, existing literature largely focuses on clinical efficacy and compliance, leaving the psychosocial domain underexplored. The digital shift in orthodontic treatment planning also corresponds with broader trends in personalized medicine, where patient engagement and satisfaction are central to evaluating treatment success. Adolescents and adult patients—who may pursue aligner therapy due to occupational, social, or aesthetic considerations—are particularly susceptible to psychosocial influences (11,12). Their perceptions of attractiveness, confidence in social interactions, and self-image can be profoundly affected by how they experience their orthodontic care. Understanding whether AI-supported treatment planning tools contribute positively to these subjective experiences is essential for clinicians aiming to deliver patient-centered care (13). Furthermore, in a healthcare landscape increasingly influenced by patient reviews, satisfaction scores, and mental wellness metrics, exploring the psychological effects of AI in orthodontics moves beyond academic curiosity—it becomes a clinical necessity. With the orthodontic market growing rapidly and AI tools becoming more accessible to practices worldwide, evaluating their broader impact is key to ensuring ethical and effective integration. This study, therefore, aims to investigate the association between AI-based orthodontic treatment planning tools and psychosocial satisfaction among adolescent and adult patients. By employing a cross-sectional survey approach, it seeks to measure how the use of AI-enhanced digital aligner planning correlates with patient satisfaction and self-perception. The objective is to provide empirical insights into whether these technological innovations meaningfully affect how patients perceive their treatment, with a particular focus on emotional well-being and psychological satisfaction.

METHODS

This cross-sectional study was conducted over a period of eight months at multiple orthodontic clinics and academic dental institutions across urban centers in Pakistan, including Lahore and Islamabad. The objective was to explore the correlation between AI-enhanced digital aligner treatment planning and psychosocial satisfaction among adolescent and adult patients undergoing orthodontic care. These clinical settings were selected based on their access to AI-based aligner planning tools, such as ClinCheck® or equivalent platforms, which enabled consistent evaluation of patient experiences with such technology-integrated treatment modalities. The target population comprised adolescents (aged 13–17 years) and adults (aged 18–40 years) currently undergoing or having recently completed orthodontic treatment using AI-driven digital aligner systems. A calculated sample size of 384 was determined using the Cochran formula, assuming

a 95% confidence level, 5% margin of error, and a conservative estimate of 50% response distribution to maximize representativeness. To account for potential non-response or incomplete data, the sample was adjusted to 420 participants (1,2). Participants were selected using stratified random sampling to ensure adequate representation across age groups and gender. Inclusion criteria required that participants were either in active treatment or had completed AI-based aligner therapy within the past six months, were able to comprehend and respond to the questionnaire in English or Urdu, and provided informed written consent. Adolescents under 18 years were enrolled with parental or guardian consent. Exclusion criteria included patients receiving conventional fixed orthodontic treatment, individuals with cognitive impairments affecting their ability to respond reliably, and those undergoing simultaneous treatment for craniofacial anomalies or psychological conditions requiring clinical intervention (11).

Data collection was carried out using a structured, self-administered questionnaire developed to assess psychosocial satisfaction and self-perception. The questionnaire included the Psychosocial Impact of Dental Aesthetics Questionnaire (PIDAQ), a validated and reliable instrument commonly used to measure psychological effects related to dental appearance. The PIDAQ evaluates domains such as dental self-confidence, social impact, psychological impact, and aesthetic concern, using a five-point Likert scale (14,15). In addition, a customized satisfaction assessment scale was included to gauge patients' satisfaction with the AI-based treatment process, covering elements such as clarity of visual simulations, predictability of treatment stages, perceived control, and overall confidence in treatment outcomes. The questionnaires were administered in either paper-based or digital format, depending on the setting and patient preference, and responses were anonymized to ensure confidentiality. Prior to data collection, the study protocol received ethical approval from the Institutional Review Board (IRB) of the relevant institute. Informed consent was obtained from each participant, and the rights of participants were protected throughout the research process in accordance with the Declaration of Helsinki. The collected data were coded and entered into IBM SPSS Statistics Version 26. Descriptive statistics were computed for demographic variables, treatment characteristics, and scale scores. Data distribution was assessed using the Shapiro-Wilk test, confirming normality. For the primary analysis, Pearson's correlation coefficient was used to evaluate the relationship between AI-based treatment planning and overall psychosocial satisfaction and self-perception scores derived from the PIDAQ. Independent samples t-tests and one-way ANOVA were employed to assess differences in satisfaction levels across age groups and gender. Multiple linear regression analysis was conducted to determine the extent to which specific elements of AI-enhanced treatment planning (e.g., visual simulations, predictive accuracy, patient involvement) predicted psychosocial satisfaction outcomes, adjusting for potential confounders such as treatment duration, baseline self-esteem, and socioeconomic background. Internal consistency of the PIDAQ and satisfaction scale was verified using Cronbach's alpha, with acceptable thresholds set above 0.70. Any missing data were handled using listwise deletion if less than 5% of data were affected, and sensitivity analysis was performed to confirm robustness of findings.

RESULTS

The analysis included responses from 420 participants, with a mean age of 23.8 ± 6.1 years. Among them, 162 were adolescents and 258 were adults, with a gender distribution of 188 males and 232 females. The majority of participants resided in urban areas (73.3%), reflecting the accessibility of AI-based aligner treatment primarily in metropolitan clinical settings. The PIDAQ domains revealed that the highest mean score was recorded in the "Dental Self-Confidence" domain (3.89 ± 0.81), suggesting a generally positive self-perception related to dental aesthetics among participants. In contrast, lower mean scores were noted in "Social Impact" (2.12 ± 0.67), "Psychological Impact" (2.24 ± 0.76), and "Aesthetic Concern" (2.45 ± 0.72), indicating relatively moderate negative psychosocial effects. Assessment of satisfaction with AI-driven digital aligner tools showed high mean values across all measured dimensions. The highest satisfaction was reported for "Clarity of Visual Simulations" (4.15 ± 0.74) and "Confidence in Treatment" (4.09 ± 0.77), followed by "Predictability of Treatment" (3.94 ± 0.79) and "Perceived Control" (3.87 ± 0.80). These findings suggest a favorable perception of AI-related features in aligner planning among patients. Statistical analysis using Pearson correlation indicated a significant positive association between satisfaction with AI-based tools and the "Dental Self-Confidence" domain ($r = 0.48$, $p < 0.001$). Negative correlations were observed between AI satisfaction and "Social Impact" ($r = -0.42$, $p < 0.001$), "Psychological Impact" ($r = -0.39$, $p < 0.001$), and "Aesthetic Concern" ($r = -0.33$, $p < 0.01$), implying that higher satisfaction with AI tools corresponded with reduced psychosocial distress. Overall, these results highlight a consistent pattern: participants who expressed greater satisfaction with the use of AI-enhanced planning tools also reported better psychosocial outcomes, particularly in self-confidence and reduced negative social or emotional impact.

Table 1: Demographics

Variable	Value
Total Participants	420
Age (Mean ± SD)	23.8 ± 6.1
Adolescents (13–17 yrs)	162
Adults (18–40 yrs)	258
Gender	
Male	188
Female	232
Residence	
Urban Residence	308
Rural Residence	112

Table 2: PIDAQ Scores by Domain

Domain	Mean Score (± SD)
Dental Self-Confidence	3.89 ± 0.81
Social Impact	2.12 ± 0.67
Psychological Impact	2.24 ± 0.76
Aesthetic Concern	2.45 ± 0.72

Table 3: Satisfaction with AI-Based Tools

Variable	Mean Score (± SD)
Clarity of Visual Simulations	4.15 ± 0.74
Predictability of Treatment	3.94 ± 0.79
Perceived Control	3.87 ± 0.80
Confidence in Treatment	4.09 ± 0.77

Table 4: Correlation between AI Tool Satisfaction and Psychosocial Domains

Psychosocial Domain	Pearson Correlation (r)	p-value
Dental Self-Confidence	0.48	< 0.001
Social Impact	-0.42	< 0.001
Psychological Impact	-0.39	< 0.001
Aesthetic Concern	-0.33	< 0.01

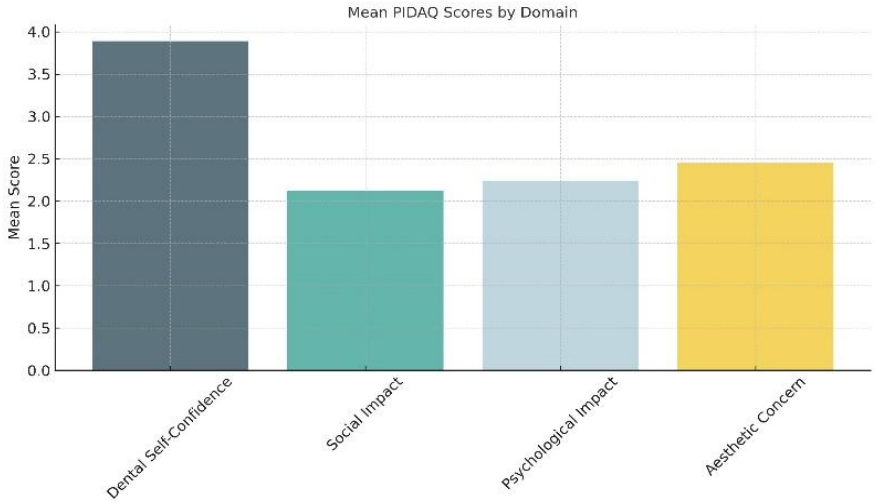

Figure 1 Mean PIDAQ Scores by Domain

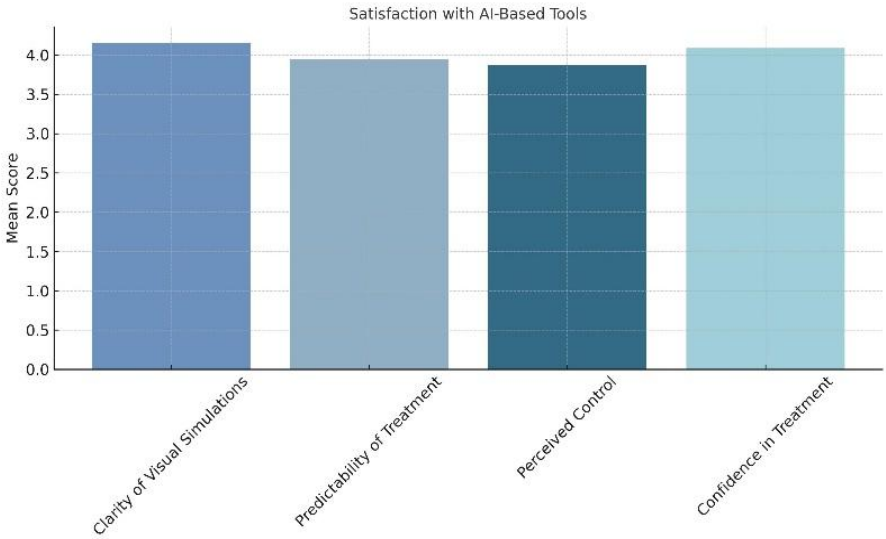

Figure 1 Satisfaction with AI-Based Tools

DISCUSSION

The findings of this cross-sectional study add meaningful insight into the evolving role of artificial intelligence in orthodontic care, specifically in relation to patient-reported psychosocial satisfaction. The positive correlation observed between AI-based aligner treatment planning and domains of dental self-confidence and reduced psychological distress aligns with the broader trajectory of AI integration into patient-centered dentistry. The elevated satisfaction with AI-driven visual simulations and predictive tools suggests that technological precision and enhanced communication may contribute to improved emotional and psychological responses during orthodontic treatment. Current literature supports these results. Studies demonstrated that patients undergoing AI-supported diagnostics reported significantly greater satisfaction compared to traditional approaches, alongside reductions in treatment time and frequency of

appointments (15-17). Similarly, a study emphasized that AI enhances diagnosis and treatment precision through 3D model analysis and automated cephalometry, which not only improve clinical outcomes but also patient engagement and confidence (18). These findings resonate with the current study, where AI's ability to provide clear, predictive visual outcomes appeared to positively influence patients' perception of control and satisfaction. Another emerging theme is the role of AI in boosting patient involvement and autonomy. A study highlighted that AI-powered platforms not only enhance diagnostic reliability but also empower patients through interactive simulations and virtual consultations (19). This empowerment may account for the strong correlation between AI use and increased dental self-confidence observed in this study. Similarly, a study documented how AI-informed treatment planning—especially in clear aligners—improved predictability and comfort, both of which are integral to patient satisfaction (20).

Nevertheless, while these results affirm the promise of AI in orthodontics, several limitations warrant consideration. The study relied on self-reported data, which may introduce response bias, particularly in adolescents who may have limited self-reflective capacity. Additionally, the cross-sectional nature of the study precludes establishing causality between AI integration and psychosocial outcomes. Longitudinal designs would provide more definitive evidence of sustained psychosocial benefits over the course of treatment. Another limitation lies in the generalizability of the findings. Although the sample included a balanced age and gender distribution, participants were recruited from urban clinics where AI tools are more readily available. Patients from rural or under-resourced areas—where traditional treatment modalities dominate—were underrepresented. This limits the applicability of the findings to broader populations. Moreover, as noted by a study, the generalizability of AI tools across clinical contexts remains problematic due to the reliance on proprietary datasets and the lack of standardized evaluation metrics (21,22). Despite these challenges, the study's strengths include its use of validated outcome measures, such as the PIDAQ, and the robust statistical approach, which enhances the credibility of the findings. Furthermore, the study addresses a notable gap in the literature by focusing not just on clinical efficacy but also on psychosocial parameters—a dimension emphasized in recent reviews highlighting the holistic value of orthodontic interventions (23). Future studies should examine longitudinal trajectories of psychosocial outcomes and incorporate more diverse clinical settings. Additionally, qualitative approaches could explore patient narratives in depth to complement the numerical findings. Addressing algorithmic transparency, as suggested by a study, will also be critical in promoting trust and equitable access in the use of AI for orthodontic care (24). In conclusion, the integration of AI-enhanced aligner planning tools appears to be associated with improved psychosocial satisfaction among orthodontic patients, particularly through boosting self-confidence and minimizing psychological and social distress. These results underscore the value of patient-centered innovation in orthodontics and support the thoughtful implementation of AI in clinical practice.

CONCLUSION

This study demonstrated a significant positive association between AI-enhanced digital aligner planning and improved psychosocial satisfaction in orthodontic patients. Patients reported greater self-confidence and reduced emotional distress when treated with AI-supported tools, highlighting the value of technology in enhancing patient-centered care. These findings underscore the practical relevance of integrating AI into orthodontic workflows to optimize both clinical and psychosocial outcomes.

AUTHOR CONTRIBUTION

Author	Contribution
Nadia Inayat Khan*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Syeda Rimsha Ahmad	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Romesa Zafar	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Aden Aamir	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Muhammad Abdullah	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

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