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Exploring dental students' attitudes and perceptions toward artificial intelligence in dentistry in Iran

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Abstract

Introduction AI has the potential to enhance diagnostics, optimize treatment planning, and improve patient care. However, concerns remain regarding professional autonomy, ethical considerations, and the need for adequate training. This research aims to address the gap in understanding how Iranian dental students perceive AI in their future practice.

Methodology A cross-sectional study was conducted among 235 dental students from different academic years who were selected through stratified sampling. A validated questionnaire with a high Cronbach's alpha coefficient (0.90) was used to assess students' attitudes toward AI. Data were analyzed via descriptive statistics, with a chi-square test examining associations between demographic factors and AI perceptions.

Results Overall, 80.4% agreed that AI would significantly advance dentistry, particularly in diagnostic applications such as radiographic analysis (75.7%) and periodontal disease detection (78.7%). However, skepticism persisted regarding AI replacing human professionals, with nearly 50% disagreeing that AI could replace dentists and with only 31.1% viewing AI as a definitive diagnostic tool. The attitudes varied by demographic factors, with female students favoring AI inclusion in education and male students exhibiting greater confidence in the diagnostic capabilities of AI. Compared with general dentistry students, specialized students were more confident in AI-assisted implant planning.

Conclusion Dental students hold a generally positive view of AI's role in dentistry while maintaining caution about its limitations. Integrating AI into dental curricula is essential for addressing knowledge gaps and preparing students for AI-enhanced practice. Future research should balance technological advancements with ethical considerations to ensure that AI effectively contributes to improved dental education and patient care.

Clinical trial number Not applicable.

Keywords Artificial intelligence, Dentistry, Dental students, Education, Attitudes, Perceptions

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Introduction

The rapid advancement of artificial intelligence (AI) has revolutionized various fields, including healthcare, where it is increasingly being integrated into clinical practice to increase patient care and professional efficiency [1, 2]. The advantages of using artificial intelligence systems include faster work and higher profits, ease of use, the ability to work without a break, the ability to solve complicated and complex problems, the ability to reduce human error (if the system is programmed correctly), and unlimited functionality [3].

Dentistry, as a vital branch of healthcare, has not remained untouched by these developments. AI applications in dentistry range from data mining and image analysis to treatment planning and patient management, offering innovative solutions that promise to transform traditional practices [1, 2]. By leveraging AI, dental professionals can achieve greater accuracy in diagnostics, optimize treatment outcomes, and streamline workflows [4–6].

Artificial intelligence is used in dentistry for numerous purposes. Some of the areas in which it is used are dental radiology (analysis of X-rays and CT scans), treatment planning, prosthodontics (fabrication of dentures), periodontics (diagnosis of periodontitis), endodontics (detection of canal morphology, lesions, or fractures), orthodontics (treatment planning), forensic dentistry, oral pathology (detection of tumor tissue), dental robotics, and others [7].

Recent studies have highlighted the potential of AI in improving diagnostic accuracy in radiographic imaging, detecting caries, and identifying periodontal diseases and oral cancers [8]. Furthermore, AI-driven innovations, such as 3D printing of aligners and personalized orthodontic care, are redefining the boundaries of dental treatment. Algorithms capable of analyzing large datasets enable precise predictions about tooth movement, pressure application, and treatment outcomes, significantly reducing treatment time and increasing patient satisfaction [4, 9, 10].

Despite these advancements, the integration of AI into dentistry presents challenges. Ethical considerations, such as data security, patient privacy, and the potential for bias in AI algorithms, are areas of concern that must be addressed [11]. Additionally, the widespread adoption of AI requires dental professionals to possess foundational knowledge and skills to utilize these technologies effectively. Studies suggest that understanding the attitudes and perceptions of dental students toward AI is essential, as they represent the next generation of practitioners who will shape the future of dentistry [12]. There are numerous studies on the application of artificial intelligence in dentistry worldwide, in which the attitudes, knowledge, and application of artificial intelligence among students, dentists, and dental assistants have been investigated [13–20].

Globally, research has shown a generally positive attitude among dental students and professionals regarding the use of AI. For example, a study conducted in Turkey revealed that the majority of dental students believed that AI would significantly impact the future of dental practice [15]. Similarly, a survey in the United Kingdom reported that 88% of medical students acknowledged AI's positive role in healthcare, although nearly half expressed concerns about the potential replacement of human professionals by AI [21]. These findings underscore the importance of evaluating and addressing the concerns of future practitioners to ensure the successful integration of AI in dental education and practice. In contrast to the growing body of international research, there is a notable gap in studies examining the perceptions and attitudes of dental students in Iran toward AI. Most existing research within the country has focused on nonmedical applications of AI, such as in the environmental sciences [22, 23]. Given the inevitability of AI integration into healthcare, it is imperative to assess the knowledge, attitudes, and preparedness of Iranian dental students to embrace this technology. Such insights are crucial for designing educational curricula that address existing gaps and foster the competencies required for effective AI utilization. This study aims to bridge this knowledge gap by evaluating the attitudes, perceptions, and readiness of dental students in Iran regarding the use of AI in dentistry. By understanding their perspectives, this research seeks to provide actionable insights for curriculum development and policy-making, ensuring that future dental practitioners are well equipped to navigate the evolving landscape of AI-driven dental care. Accordingly, we formulated the null hypothesis that there would be no significant differences in dental students' attitudes toward AI across different demographic and educational subgroups.

Methodology

Study design and setting

This descriptive and analytical cross-sectional study was conducted via stratified and convenience sampling methods with dental students from the Faculty of Dentistry, Mashhad University of Medical Sciences, in 2024. The participants were students of the Mashhad Faculty of Dentistry included in the study. Nonconsent to continue participation and incomplete questionnaire responses were considered exclusion criteria. Mashhad University of Medical Sciences is one of the best and largest state medical universities in Iran, with 7 faculties, 28 hospitals, and 16 research centers, providing health services to a population of approximately 5 million. The Faculty of Dentistry of this university is considered the largest dental faculty in the country due to its 25,000 square meters

of educational area, 3 research centers, and a specialized dental hospital. Currently, this faculty continues to work with research centers in the field of maxillofacial diseases and dental materials and various educational groups in specialties such as orthodontics, periodontics, etc., and with students from all over the country and different countries of the world. Therefore, it was selected as the faculty of interest in our study for the abovementioned reasons.

Study participants and sampling

The study population consisted of dental students from Mashhad University of Medical Sciences, Iran. Stratified sampling was performed, proportional to the number of students in each academic year (study background). The sample size was determined for estimating the score of attitudes and perceptions and the factors related to them via a multiple linear regression model, with a Type I error rate of 0.05, a test power of 90%, and 12 independent variables, resulting in a sample size of 230 participants. The sampling method was nonrandom and convenience-based. The unit of analysis was each student who met the inclusion and exclusion criteria of the study.

Data collection tool and technique

Data were collected via a standard two-part questionnaire (with a content validity of 0.90 and a Cronbach's alpha coefficient of 0.90 for reliability), which was previously used in a similar study and was completed in person by the participants [24].

The first part of the questionnaire included six questions about demographic information, such as gender, age, academic year, nationality, socioeconomic status, and academic year. The second part included fifteen questions about assessing students' attitudes and perceptions about the use of artificial intelligence in dentistry, which were scored via a three-level response format: "disagree", "no opinion", and "agree". These items covered AI's potential benefits in clinical practice (e.g., use in diagnosis, prognosis, and treatment planning), the role of AI in dental education, and views on AI potentially replacing or complementing dental professionals. The questionnaire was adapted from the study by Karan-Romero et al. [24] and was originally in English. We followed a rigorous forward–backward translation process to develop the Persian version. The English questionnaire was first translated into Persian independently by two translators, after which a third translator reconciled any discrepancies. The Persian version was then back-translated into English by two other independent translators, and the back-translation was compared with the original to ensure accuracy. This rigorous translation process was undertaken to ensure conceptual equivalence and clarity of the items in the local language. Facial validity was assessed by obtaining feedback (impact scores) from 30 dental students similar to those in the target population, confirming that the questions were clear and relevant. In addition, reliability was tested via a test–retest procedure: 30 students from the target population completed the questionnaire twice, two weeks apart, yielding a test–retest reliability coefficient of 0.8. The final Persian questionnaire demonstrated excellent internal consistency (Cronbach's $\alpha = 0.90$) and was thus considered valid and reliable for use. To collect data, the researchers explained the study's purpose to participants and obtained informed consent. The questionnaire was then administered in person, and participants completed it anonymously on paper.

Data analysis

Initially, the data were described via central tendency and dispersion indices. For univariate analysis, descriptive statistical measures such as absolute and relative frequencies were used for the main qualitative variables. To compare the relationships between the attitudes and perceptions of dental students and other independent quantitative variables regarding the attitudes and perceptions of dental students at Mashhad University of Medical Sciences, the chi-square test was used. A confidence level of 95% and a p value of less than 0.05 were considered statistically significant. All the statistical tests and models were executed via SPSS version 25 at a significance level of 0.05.

Results

The study surveyed 235 dental students from medical universities in Mashhad, Iran, to assess their demographic characteristics and attitudes toward the use of artificial intelligence (AI) in dentistry. The participants had an average age of 23.4 years, with ages ranging from 18 to 47 years, reflecting a mix of younger and older students. A slight majority of the respondents were female (54.9%), whereas 45.1% were male. Nearly all the students (97.4%) were Iranian, with only 2.6% identifying as non-Iranian. The majority (90.2%) were categorized as "General" students, likely undergraduates, whereas 9.8% were classified as "Specialized," potentially postgraduate trainees. Socioeconomically, most students came from intermediate-income backgrounds (71.9%), followed by high-income (24.3%) and low-income (3.8%) groups. The students were evenly distributed across all six years of study (15.3–18.3% per year), suggesting stable retention rates and minimal attrition (Table 1).

With respect to attitudes toward AI, the students expressed strong optimism about its potential. A significant majority (80.4%) agreed that AI would lead to major advances in dentistry and medicine, and 80.9% described its use as "exciting." The technical applications

Table 1 General characteristics of university dental students surveyed in the region of Mashhad, Iran ($n=235$)

Variable		Frequency	Percent
Age	23.4 year (18-47years)		
Gender	Male	106	45.1
	Female	129	54.9
Nationality	Iranian	229	97.4
	Non-Iranian	6	2.6
Educational level	General	212	90.2
	Specialized	23	9.8
Socioeconomic level	Low	9	3.8
	Intermediate	169	71.9
	High	57	24.3
Year of Study	1st year	42	17.9
	2nd year	37	15.7
	3rd year	36	15.3
	4th year	43	18.3
	5th year	40	17
	6th year	37	15.7

of AI received particularly high support: 85.5% endorsed its use in three-dimensional implant positioning, 78.7% agreed that it could aid in diagnosing periodontal diseases, and 75.7% supported its role in the radiographic diagnosis of dental caries. Students also favored integrating AI into education, with 71.5% agreeing that it should be part of general doctoral dental training and 67.7% supporting its inclusion in specialized programs. However, skepticism has emerged in areas involving professional autonomy. Nearly half (48.9%) disagreed that AI could replace dentists in the future, and only 31.1% viewed it as a definitive diagnostic tool, indicating reservations about overreliance on AI for critical decisions (Table 2).

Demographic comparisons revealed nuanced differences. Compared with male students, female students presented stronger support for integrating AI into general dental education (73.6% vs. 68.9%, $P=0.038$), whereas male students were more confident in the ability of AI to diagnose dental caries radiographically (87.7% vs. 65.9% females, $P<0.001$). Compared with general students, specialized students expressed greater confidence in the use of AI for implant planning (95.7% vs. 84.4%, $P=0.037$), likely reflecting advanced exposure to technology during postgraduate training. Socioeconomic disparities were evident in attitudes toward AI as a quality control tool, with intermediate-income students showing the highest agreement (75.7%), compared to low-income (66.7%) and high-income (61.4%) groups ($P=0.042$). Given the very small size of the low-income subgroup, this finding should be interpreted cautiously (Table 3). Year of study influenced perspectives on AI's diagnostic utility, with later-year students (e.g., 38.9% in the 4th year) agreeing more strongly than those in earlier years (e.g., 27.0% in the 6th year) that AI could serve as a definitive diagnostic tool ($P=0.004$). Although a small sample ($n=6$) of non-Iranian students agreed with some contentious issues, for example, 50% believed that AI could replace dentists, whereas 21% of Iranian students did, although these findings require cautious interpretation due to the limited sample size. The study also highlighted areas of uncertainty. For example, 29.8% of the students had no opinion on AI's use in diagnosing soft tissue injuries, and 28.9% were unsure about its role in forensic odontology, suggesting gaps in awareness or training (Table 4).

Table 2 Evaluation of the attitudes and perceptions of dental university students in Mashhad about the use of AI ($n=235$)

Item	Disagree *n* (%)	I have no opinion *n* (%)	Agree *n* (%)
AI will lead to great advances in dentistry and medicine	13(5.5)	33(14.0)	189(80.4)
AI may replace dentist and doctors in the future	115(48.9)	69(29.4)	51(21.7)
AI can be used as a definitive diagnostic tool in disease diagnosis	108(46)	54(23)	73(31.1)
AI can be used as a prognostic tool to predict the course of a disease and determine if there is a chance of recovery	11(4.7)	36(15.3)	188(80)
AI can be used in the three-dimensional positioning and planning of implants	3(1.3)	31(13.2)	201(85.5)
AI can be used as a treatment planning tool in the diagnosis and planning of dental treatment	22(9.4)	37(15.7)	176(74.9)
AI can be used as a quality control tool to assess the success of treatments	17(7.2)	49(20.9)	169(71.9)
AI applications should be part of general doctoral dental education	23(9.8)	44(18.7)	168(71.5)
AI applications should be part of the specialized doctorate in dentistry	26(11.1)	50(21.3)	159(67.7)
The use of AI in dentistry and medicine is exciting	14(6)	31(13.2)	190(80.9)
AI can be used for radiographic diagnosis of dental caries	21(8.9)	36(15.3)	178(75.7)
AI can be used for the diagnosis of soft tissue injuries in the oral cavity	32(13.6)	70(29.8)	133(56.6)
AI can be used for radiographic diagnosis of jaw pathologies	24(10.2)	43(18.3)	168(71.5)
AI can be used for the radiographic diagnosis of periodontal diseases	18(7.7)	32(13.6)	185(78.7)
AI can be used in forensic odontology	28(11.9)	68(28.9)	139(59.1)

Table 3 Comparison of students' attitudes and perceptions about the use of artificial intelligence in dentistry according to gender, nationality and socioeconomic level ($n=235$)

Item	answer	Gender			Nationality	Socioeconomic level		
		Male	Female	Iranian	Non-Iranian	Low	Intermediate	High
AI will lead to great advances in dentistry and medicine	Disagree n (%)	4 (3.8)	9 (7)	13 (5.68)	0 (0)	1 (11.11)	9 (5.33)	3 (5.26)
	I have No Opinion n (%)	17 (16)	16 (12.4)	32 (13.97)	1 (16.67)	0 (0)	26 (15.38)	7 (12.28)
	Agree n (%)	85 (80.2)	104 (80.6)	184 (80.35)	5 (83.33)	8 (88.89)	134 (79.29)	47 (82.46)
	P value	0.428			1	0.704		
AI may replace dentist and doctors in the future	Disagree n (%)	46 (43.4)	69 (53.49)	113 (49.34)	2 (33.33)	2 (22.22)	81 (47.93)	32 (48.94)
	I have No Opinion n (%)	31 (29.2)	38 (29.46)	68 (29.69)	1 (16.67)	5 (55.56)	51 (30.18)	13 (29.36)
	Agree n (%)	29 (27.4)	22 (17.05)	48 (20.96)	3 (50)	2 (22.22)	37 (21.89)	12 (21.7)
	P value	0.133			0.278	0.289		
AI can be used as a definitive diagnostic tool in disease diagnosis	Disagree n (%)	46 (43.4)	62 (48.06)	106 (46.29)	2 (33.33)	4 (44.44)	77 (45.56)	27 (47.37)
	I have No Opinion n (%)	23 (21.7)	31 (24.03)	52 (22.71)	2 (33.33)	3 (33.33)	37 (21.89)	14 (24.56)
	Agree n (%)	37 (34.9)	36 (27.91)	71 (31)	2 (33.33)	2 (22.22)	55 (32.54)	16 (28.07)
	P value	0.51			0.868	0.897		
AI can be used as a prognostic tool to predict the course of a disease and determine if there is a chance of recovery	Disagree n (%)	6 (5.66)	5 (3.88)	9 (3.93)	2 (33.33)	0 (0)	9 (5.33)	2 (3.51)
	I have No Opinion n (%)	17 (16.04)	19 (14.73)	35 (15.28)	1 (16.67)	2 (22.22)	24 (14.2)	10 (17.54)
	Agree n (%)	83 (78.3)	105 (81.4)	185 (80.79)	3 (50)	7 (77.78)	136 (80.47)	45 (78.95)
	P value	0.784			0.33	0.891		
AI can be used in the three-dimensional positioning and planning of implants	Disagree n (%)	3 (2.83)	0 (0)	3 (1.31)	0 (0)	0 (0)	3 (1.78)	0 (0)
	I have No Opinion n (%)	15 (14.15)	16 (12.4)	29 (12.66)	2 (33.33)	1 (11.11)	19 (11.24)	11 (19.3)
	Agree n (%)	88 (83.02)	113 (87.6)	197 (86.03)	4 (66.67)	8 (88.89)	147 (86.98)	46 (80.7)
	P value	0.153			0.245	0.414		
AI can be used as a treatment planning tool in the diagnosis and planning of dental treatment	Disagree n (%)	7 (6.6)	15 (11.63)	21 (9.17)	1 (16.67)	2 (22.22)	19 (11.24)	1 (1.75)
	I have No Opinion n (%)	17 (16.04)	20 (15.5)	34 (14.85)	3 (50)	0 (0)	26 (15.38)	11 (19.3)
	Agree n (%)	82 (77.36)	94 (72.87)	174 (75.98)	2 (33.33)	7 (77.78)	124 (73.37)	45 (78.95)
	P value	0.462			**0.042***	0.095		
AI can be used as a quality control tool to assess the success of treatments	Disagree n (%)	9 (8.49)	8 (6.2)	17 (7.42)	0 (0)	2 (22.22)	12 (7.1)	3 (5.26)
	I have No Opinion n (%)	18 (16.98)	31 (24.03)	48 (20.96)	1 (16.67)	1 (11.11)	29 (17.16)	19 (33.33)
	Agree n (%)	79 (74.53)	90 (69.77)	164 (71.62)	5 (83.33)	6 (66.67)	128 (75.74)	35 (61.4)
	P value	0.394			1	**0.042**		
AI applications should be part of general doctoral dental education	Disagree n (%)	16 (15.09)	7 (5.43)	23 (10.04)	0 (0)	0 (0)	17 (10.06)	6 (10.53)
	I have No Opinion n (%)	17 (16.04)	27 (20.93)	44 (19.21)	0 (0)	2 (22.22)	37 (21.89)	5 (8.77)
	Agree n (%)	73 (68.87)	95 (73.64)	162 (70.74)	6 (100)	7 (77.78)	115 (68.05)	46 (80.7)
	P value	**0.038***			0.316	0.196		
AI applications should be part of the specialized doctorate in dentistry	Disagree n (%)	14 (13.21)	12 (9.3)	25 (10.92)	1 (16.67)	1 (11.11)	20 (11.83)	5 (8.77)
	I have No Opinion n (%)	19 (17.92)	31 (24.03)	50 (21.83)	0 (0)	3 (33.33)	35 (20.71)	12 (21.05)
	Agree n (%)	73 (68.87)	86 (66.67)	154 (67.25)	5 (83.33)	5 (55.56)	114 (67.46)	40 (70.18)
	P value	0.406			0.428	0.903		
The use of AI in dentistry and medicine is exciting	Disagree n (%)	7 (6.6)	7 (5.43)	14 (6.11)	0 (0)	1 (11.11)	13 (7.69)	0 (0)
	I have No Opinion n (%)	15 (14.15)	16 (12.4)	30 (13.1)	1 (16.67)	1 (11.11)	24 (14.2)	6 (10.53)
	Agree n (%)	84 (79.25)	106 (82.17)	185 (80.79)	5 (83.33)	7 (77.78)	132 (78.11)	51 (89.47)
	P value	0.845			1	0.204		
AI can be used for radiographic diagnosis of dental caries	Disagree n (%)	5 (4.72)	16 (12.4)	21 (9.17)	0 (0)	0 (0)	14 (8.28)	7 (12.28)
	I have No Opinion n (%)	8 (7.55)	28 (21.71)	35 (15.28)	1 (16.67)	2 (22.22)	21 (12.43)	13 (22.81)
	Agree n (%)	93 (87.74)	85 (65.89)	173 (75.55)	5 (83.33)	7 (77.78)	134 (79.29)	37 (64.91)
	P value	**>0.001***			**0.001***	0.186		
AI can be used for the diagnosis of soft tissue injuries in the oral cavity	Disagree n (%)	12 (11.32)	20 (15.5)	32 (13.97)	0 (0)	2 (22.22)	24 (14.2)	6 (10.53)
	I have No Opinion n (%)	28 (26.42)	42 (32.56)	65 (28.38)	5 (83.33)	2 (22.22)	52 (30.77)	16 (28.07)
	Agree n (%)	66 (62.26)	67 (51.94)	132 (57.64)	1 (16.67)	5 (55.56)	93 (55.03)	35 (61.4)
	P value	0.285			**0.014***	0.836		

Table 3 (continued)

Item	answer	Gender			Nationality	Socioeconomic level		
		Male	Female	Iranian	Non-Iranian	Low	Intermediate	High
AI can be used for radiographic diagnosis of jaw pathologies	Disagree n (%)	4 (3.77)	20 (15.5)	22 (9.61)	2 (33.33)	0 (0)	15 (8.88)	9 (15.79)
	I have No Opinion n (%)	18 (16.98)	25 (19.38)	41 (17.9)	2 (33.33)	2 (22.22)	28 (16.57)	13 (22.81)
	Agree n (%)	84 (79.25)	84 (65.12)	166 (72.49)	2 (33.33)	7 (77.78)	126 (74.56)	35 (61.4)
	P value	**0.008***			**0.045***	0.277		
AI can be used for the radiographic diagnosis of periodontal diseases	Disagree n (%)	4 (3.77)	14 (10.85)	17 (7.42)	1 (16.67)	1 (11.11)	12 (7.1)	5 (8.77)
	I have No Opinion n (%)	10 (9.43)	22 (17.05)	30 (13.1)	2 (33.33)	1 (11.11)	26 (15.38)	5 (8.77)
	Agree n (%)	92 (86.79)	93 (72.09)	182 (79.48)	3 (50)	7 (77.78)	131 (77.51)	47 (82.46)
	P value	**0.017***			0.145	0.778		
AI can be used in forensic odontology	Disagree n (%)	7 (6.6)	21 (16.28)	27 (11.79)	1 (16.67)	2 (22.22)	14 (8.28)	12 (21.05)
	I have No Opinion n (%)	16 (15.09)	52 (40.31)	68 (29.69)	0 (0)	1 (11.11)	50 (29.59)	17 (29.82)
	Agree n (%)	83 (78.3)	56 (43.41)	134 (58.52)	5 (83.33)	6 (66.67)	105 (62.13)	28 (49.12)
	P value	**> 0.001***			0.303	0.059		

*: Chi-square test, $p < 0.05$

Discussion

Our findings largely refuted the null hypothesis that there would be no differences in attitudes across student subgroups. While overall sentiment toward AI was overwhelmingly positive, there were several notable demographic variations. For instance, we observed significant differences by gender, education level, and year of study in specific areas of AI perception. Nonetheless, the majority of students anticipated a beneficial role for AI in dentistry. In the following sections, we discuss the implications of these results and how they align with or diverge from existing literature.

General optimism and excitement about AI's potential in dentistry

Dental students worldwide express strong optimism about AI's role in dentistry and healthcare, with over 80% believing in its significant contributions. Studies have shown that 85–92% of Turkish students anticipate AI-driven advances [15, 25], while a multinational survey revealed that 83.9% of students expect AI to revolutionize medicine and dentistry, with 69.9% finding it an exciting field [26]. In Australia, 91% view AI as a beneficial tool [27]. Students cite AI's potential to increase diagnostic accuracy, efficiency, and treatment outcomes [27, 28]. Two systematic reviews affirm that younger dental professionals broadly support AI's role in improving dental care [12, 27]. Despite overall optimism, some studies indicate more cautious expectations. An Indian survey reported that only 52% of students "definitely" believed that AI would bring major advances [28], and 40% of Turkish students expressed concerns about AI leading to bad practices if it was misused [25]. However, positive sentiment remains dominant, aligning with the trend of dental trainees embracing digital innovations [15, 26]. Students anticipate the swift integration of AI into daily practice, particularly in imaging and diagnostics, with global consistency across regions such as India, Turkey, and Australia. Some studies highlight enthusiasm for AI in caries detection and oral pathology [29], whereas others emphasize its role in treatment planning [25]. Medical students share similar expectations for AI in radiology and pathology [30], viewing it as an exciting and inevitable step in healthcare innovation. Overall, future practitioners are eager to leverage AI for technical tasks, provided that it is accurate and reliable. The strong optimism among dental students about AI signals a transformative shift in dentistry. Despite some concerns about misuse, the global consistency of this positive outlook underscores AI's expected and desired integration into practice. To maximize its benefits in precision, efficiency, and diagnostics, dental education should incorporate AI training while addressing ethical concerns through evidence-based guidelines, ensuring responsible adoption in modern dentistry.

Support for AI in technical dental applications

Dental students strongly support AI in technical applications, particularly in radiology and implantology. Studies have shown that 85.5% of these methods favor AI for 3D implant positioning, 78.7% favor AI for diagnosing periodontal diseases, and 75.7% favor AI for detecting dental caries radiographically [27]. Radiology ranks as the top AI-assisted specialty, with 64–70% of students highlighting dental imaging as a prime application [27, 31]. Australian students (64.5%) and Indian and Korean cohorts endorse AI for radiographic diagnosis and disease detection [27, 28, 31]. Implant planning is also widely accepted, with 68% of Indian undergraduates and 64.5% of Australian respondents supporting AI for 3D implant positioning [27, 28]. AI is also useful for orthodontic analyses, periodontal disease detection, and treatment planning, with 71–75% of students agreeing that AI can aid in prognosis [25, 28]. These findings suggest broad

Table 4 Comparison of students' attitudes and perceptions about the use of artificial intelligence in dentistry according to educational level and year of study ($n=235$)

Item	answer	Educational level		Year of education					
		General	Specialized	1st year	2nd year	3rd year	4th year	5th year	6th year
AI will lead to great advances in dentistry and medicine	Disagree n (%)	10 (4.72)	3 (13.04)	3 (7.14)	5 (13.51)	3 (8.33)	2 (4.65)	0 (0)	0 (0)
	I have No Opinion n (%)	32 (15.09)	1 (4.35)	10 (23.81)	0 (0)	2 (5.56)	6 (13.95)	4 (10)	11 (29.73)
	Agree n (%)	170 (80.19)	19 (82.61)	29 (69.05)	32 (86.49)	31 (86.11)	35 (81.4)	36 (90)	26 (70.27)
	P value	0.104		0.854					
AI may replace dentist and doctors in the future	Disagree n (%)	101 (47.64)	14 (60.87)	24 (57.14)	20 (54.05)	19 (52.78)	17 (39.53)	21 (52.5)	14 (37.84)
	I have No Opinion n (%)	65 (30.66)	4 (17.39)	12 (28.57)	8 (21.62)	8 (22.22)	17 (39.53)	12 (30)	12 (32.43)
	Agree n (%)	46 (21.7)	5 (21.74)	6 (14.29)	9 (24.32)	9 (25)	9 (20.93)	7 (17.5)	11 (29.73)
	P value	0.387		0.456					
AI can be used as a definitive diagnostic tool in disease diagnosis	Disagree n (%)	94 (44.34)	14 (60.87)	20 (47.62)	15 (40.54)	17 (47.22)	22 (51.16)	18 (45)	16 (43.24)
	I have No Opinion n (%)	53 (25)	1 (4.35)	8 (19.05)	9 (24.32)	5 (13.89)	8 (18.6)	13 (32.5)	11 (29.73)
	Agree n (%)	65 (30.66)	8 (34.78)	14 (33.33)	13 (35.14)	14 (38.89)	13 (30.23)	9 (22.5)	10 (27.03)
	P value	0.081		**0.004***					
AI can be used as a prognostic tool to predict the course of a disease and determine if there is a chance of recovery	Disagree n (%)	11 (5.19)	0 (0)	1 (2.38)	1 (2.7)	2 (5.56)	0 (0)	3 (7.5)	#VALUE!
	I have No Opinion n (%)	32 (15.09)	4 (17.39)	17 (40.48)	3 (8.11)	4 (11.11)	2 (4.65)	4 (10)	6 (16.22)
	Agree n (%)	169 (79.72)	19 (82.61)	24 (57.14)	33 (89.19)	30 (83.33)	41 (95.35)	33 (82.5)	27 (72.97)
	P value	0.594		0.0685					
AI can be used in the three-dimensional positioning and planning of implants	Disagree n (%)	3 (1.42)	0 (0)	0 (0)	1 (2.7)	0 (0)	1 (2.33)	0 (0)	1 (2.7)
	I have No Opinion n (%)	30 (14.15)	1 (4.35)	13 (30.95)	4 (10.81)	2 (5.56)	1 (2.33)	3 (7.5)	8 (21.62)
	Agree n (%)	179 (84.43)	22 (95.65)	29 (69.05)	32 (86.49)	34 (94.44)	41 (95.35)	37 (92.5)	28 (75.68)
	P value	**0.0367***		0.0785					
AI can be used as a treatment planning tool in the diagnosis and planning of dental treatment	Disagree n (%)	20 (9.43)	2 (8.7)	7 (16.67)	1 (2.7)	7 (19.44)	0 (0)	1 (2.5)	6 (16.22)
	I have No Opinion n (%)	35 (16.51)	2 (8.7)	13 (30.95)	2 (5.41)	3 (8.33)	7 (16.28)	3 (7.5)	9 (24.32)
	Agree n (%)	157 (74.06)	19 (82.61)	22 (52.38)	34 (91.89)	26 (72.22)	36 (83.72)	36 (90)	22 (59.46)
	P value	0.61		0.25					
AI can be used as a quality control tool to assess the success of treatments	Disagree n (%)	17 (8.02)	0 (0)	5 (11.9)	1 (2.7)	1 (2.78)	2 (4.65)	4 (10)	4 (10.81)
	I have No Opinion n (%)	46 (21.7)	3 (13.04)	9 (21.43)	9 (24.32)	7 (19.44)	7 (16.28)	8 (20)	9 (24.32)
	Agree n (%)	149 (70.28)	20 (86.96)	28 (66.67)	27 (72.97)	28 (77.78)	34 (79.07)	28 (70)	24 (64.86)
	P value	0.165		0.773					
AI applications should be part of general doctoral dental education	Disagree n (%)	23 (10.85)	0 (0)	3 (7.14)	1 (2.7)	1 (2.78)	9 (20.93)	5 (12.5)	4 (10.81)
	I have No Opinion n (%)	39 (18.4)	5 (21.74)	11 (26.19)	2 (5.41)	8 (22.22)	4 (9.3)	7 (17.5)	12 (32.43)
	Agree n (%)	150 (70.75)	18 (78.26)	28 (66.67)	34 (91.89)	27 (75)	30 (69.77)	28 (70)	21 (56.76)
	P value	0.281		0.564					
AI applications should be part of the specialized doctorate in dentistry	Disagree n (%)	24 (11.32)	2 (8.7)	1 (2.38)	6 (16.22)	5 (13.89)	3 (6.98)	7 (17.5)	4 (10.81)
	I have No Opinion n (%)	48 (22.64)	2 (8.7)	13 (30.95)	4 (10.81)	3 (8.33)	13 (30.23)	7 (17.5)	10 (27.03)
	Agree n (%)	140 (66.04)	19 (82.61)	28 (66.67)	27 (72.97)	28 (77.78)	27 (62.79)	26 (65)	23 (62.16)
	P value	0.265		0.542					
The use of AI in dentistry and medicine is exciting	Disagree n (%)	14 (6.6)	0 (0)	5 (11.9)	0 (0)	1 (2.78)	1 (2.33)	3 (7.5)	4 (10.81)
	I have No Opinion n (%)	29 (13.68)	2 (8.7)	4 (9.52)	3 (8.11)	2 (5.56)	11 (25.58)	5 (12.5)	6 (16.22)
	Agree n (%)	169 (79.72)	21 (91.3)	33 (78.57)	34 (91.89)	33 (91.67)	31 (72.09)	32 (80)	27 (72.97)
	P value	0.328		0.854					

Table 4 (continued)

Item	answer	Educational level		Year of education					
		General	Specialized	1st year	2nd year	3rd year	4th year	5th year	6th year
AI can be used for radiographic diagnosis of dental caries	Disagree n (%)	15 (7.08)	6 (26.09)	4 (9.52)	3 (8.11)	4 (11.11)	6 (13.95)	1 (2.5)	3 (8.11)
	I have No Opinion n (%)	33 (15.57)	3 (13.04)	12 (28.57)	4 (10.81)	8 (22.22)	4 (9.3)	3 (7.5)	5 (13.51)
	Agree n (%)	164 (77.36)	14 (60.87)	26 (61.9)	30 (81.08)	24 (66.67)	33 (76.74)	36 (90)	29 (78.38)
	P value	**0.013***		0.546					
AI can be used for the diagnosis of soft tissue injuries in the oral cavity	Disagree n (%)	27 (12.74)	5 (21.74)	8 (19.05)	3 (8.11)	4 (11.11)	4 (9.3)	8 (20)	5 (13.51)
	I have No Opinion n (%)	66 (31.13)	4 (17.39)	12 (28.57)	2 (5.41)	13 (36.11)	14 (32.56)	12 (30)	17 (45.95)
	Agree n (%)	119 (56.13)	14 (60.87)	22 (52.38)	32 (86.49)	19 (52.78)	25 (58.14)	20 (50)	15 (40.54)
	P value	0.253		0.421					
AI can be used for radiographic diagnosis of jaw pathologies	Disagree n (%)	22 (10.38)	2 (8.7)	4 (9.52)	3 (8.11)	9 (25)	5 (11.63)	2 (5)	1 (2.7)
	I have No Opinion n (%)	40 (18.87)	3 (13.04)	13 (30.95)	6 (16.22)	6 (16.67)	9 (20.93)	4 (10)	5 (13.51)
	Agree n (%)	150 (70.75)	18 (78.26)	25 (59.52)	28 (75.68)	21 (58.33)	29 (67.44)	34 (85)	31 (83.78)
	P value	0.783		0.921					
AI can be used for the radiographic diagnosis of periodontal diseases	Disagree n (%)	16 (7.55)	2 (8.7)	4 (9.52)	2 (5.41)	9 (25)	1 (2.33)	1 (2.5)	1 (2.7)
	I have No Opinion n (%)	32 (15.09)	0 (0)	10 (23.81)	4 (10.81)	5 (13.89)	6 (13.95)	3 (7.5)	4 (10.81)
	Agree n (%)	164 (77.36)	21 (91.3)	28 (66.67)	31 (83.78)	22 (61.11)	36 (83.72)	36 (90)	32 (86.49)
	P value	0.117		0.266					
AI can be used in forensic odontology	Disagree n (%)	26 (12.26)	2 (8.7)	4 (9.52)	3 (8.11)	5 (13.89)	6 (13.95)	7 (17.5)	3 (8.11)
	I have No Opinion n (%)	61 (28.77)	7 (30.43)	14 (33.33)	10 (27.03)	15 (41.67)	12 (27.91)	7 (17.5)	10 (27.03)
	Agree n (%)	125 (58.96)	14 (60.87)	24 (57.14)	24 (64.86)	16 (44.44)	25 (58.14)	26 (65)	24 (64.86)
	P value	0.904		0.09					

*: Chi-square test, $p < 0.05$

student confidence in AI's ability to enhance technical, data-driven tasks where speed and objectivity are advantageous. However, AI support varies by domain. Students express less confidence in AI for complex clinical tasks such as soft tissue pathology interpretation or pediatric dentistry. One survey revealed that while 44% fully agreed that AI could assist in oral surgery and radiology, only 29% endorsed it for pediatric dentistry. Additionally, only one-third fully supported AI as a primary diagnostic tool for general disease diagnosis [25], and only ~ 63% believed that AI could independently provide final radiographic diagnoses [32]. This finding indicates that students favor AI for technical aid in structured tasks but remain cautious about its role in areas requiring nuanced clinical judgment, such as pediatric and special needs dentistry, where human expertise is considered essential [25]. Dental students widely support AI in technical tasks such as radiology and implant planning because of its speed and accuracy. However, they remain cautious about AI's role in complex clinical decision-making, emphasizing the need for human oversight. This highlights the necessity of integrating AI as a supportive tool rather than a replacement for clinical expertise.

Attitudes toward AI in dental education and training

Dental students broadly support the integration of AI into their education, with multiple studies strongly advocating for formal AI training. A 2019 Turkish survey revealed that 74.6% of students endorsed AI in undergraduate curricula, and nearly 80% endorsed AI in postgraduate programs [15]. Similarly, an international study reported that 85.6% of students and young dentists favored AI in medical/dental training [26]. In India, 55.7% supported AI in undergraduate education [28], whereas in South Korea, all surveyed dentists (100%) agreed on AI instruction in dental schools [31]. Educators have proposed AI frameworks, such as Islam et al. (2022), to integrate AI into dental curricula [33], with hands-on workshops also recommended [27]. However, some students remain hesitant due to heavy coursework, as seen in an Indian survey in which 28.5% considered AI nonessential [28]. In South Korea, only 42.5% of students explicitly supported AI programs in their schools [31]. Resource constraints and faculty expertise gaps further affect implementation [26, 28]. Despite these concerns, the overall consensus suggests that AI should be incorporated into dental training, with efforts needed to

address logistical barriers [26, 27]. AI in dental education is widely supported, with most students recognizing its future importance. Some concerns exist about course load and resource limitations, yet few students outright reject AI training. To meet expectations, dental schools must adapt, providing structured AI education while addressing logistical challenges.

Artificial intelligence and professional autonomy

While dental students are optimistic about AI, they remain cautious about surrendering professional autonomy or diagnostic authority to algorithms. A 63-country study revealed that 72.2% of students viewed AI as a "partner" rather than a "competitor" [26, 27]. Similarly, 64.2% of Korean dental students and 83% of Turkish students disagreed that AI could replace dentists [25, 31]. Most students prioritize human judgment; more than 90% would trust their own diagnosis or consult another expert over AI recommendations. Ethical concerns include AI's impact on patient relationships—61.9% of students fear reduced human interaction [26]. Additional reservations focus on AI's perceived inflexibility and inability to understand patients emotionally [27, 31]. However, the dominant view is that AI should assist dentists rather than replace them, handling routine tasks while human clinicians provide oversight and complex decision-making [28]. Dental students appreciate AI's potential but insist on preserving professional autonomy and human judgment in patient care. Concerns about ethical risks, overreliance, and loss of human interaction underline their cautious approach. Ultimately, students advocate for AI as a supportive tool, reinforcing—rather than replacing—the clinician's role.

Demographic differences in attitudes toward dental AI

Demographic factors shape attitudes toward AI in dentistry, with younger dental students generally being more optimistic than older, practicing dentists. A systematic review revealed that 72.0% of students saw AI as advancing dentistry, whereas 62.6% of dentists did [12]. Notably, male and female students differed in specific perceptions: male students reported greater confidence in AI's technical capabilities (such as interpreting radiographs for caries), whereas female students were more enthusiastic about integrating AI into their education and saw it as an assistive tool. This finding aligns with some reports in the literature. For example, a systematic review noted that male students sometimes exhibit higher confidence in AI technologies [26], whereas female students often emphasize AI's role as an adjunct and trust their clinical judgment in case of disagreement [27]. We also observed that junior (preclinical) students tended to express greater optimism about AI (e.g., higher agreement that AI could serve as a diagnostic tool) than senior (clinical) students. This could be because younger students, who are newer to clinical realities, are more receptive to emerging tech, whereas those nearing graduation have more practical experience and potentially more tempered expectations. A similar trend was reported in a South Korean study: underclassmen were more willing to use AI broadly (40.8%) compared to senior students (14.6%), although even senior students supported AI education for future cohorts [31]. Our finding that specialized (postgraduate) students were more confident in an application like implant planning suggests that advanced training or exposure can increase appreciation for AI's utility. It may be that through specialty training, students directly see AI tools (for example, digital implant planning software) in action, thereby strengthening their trust. Socioeconomic background also appeared to influence attitudes in our sample: students from intermediate-income families showed the highest overall optimism for AI. This might reflect resource availability or exposure—those from neither very low nor very high ends of the spectrum might have had sufficient exposure to technology in education but still see AI as a significant opportunity. Interestingly, a study across countries found that students from higher-income regions were more optimistic about AI's potential than those from lower-income regions, likely due to better integration of AI in their curricula or environment [26]. In our case, the small number of low-income students limits any firm conclusions, but it is an area for further inquiry. Despite these differences, it's important to note that common ground existed: across virtually all groups in our study, a majority agreed on AI's value in dentistry. Thus, while gender, level of study, and other demographics introduce variations in specific viewpoints, there is an overall consensus that AI will be a valuable adjunct in dental practice [31]. Addressing these demographic differences through education could help ensure that all student groups, regardless of background, are equally prepared and open to utilizing AI. For instance, recognizing that male and female students might have different concerns or strengths (confidence vs. caution), dental educators can tailor discussions and training to address each group's perspectives– ensuring technical training is coupled with ethical deliberation and teamwork. Likewise, the greater enthusiasm among junior students indicates an opportunity to maintain that interest through senior years by continuously integrating AI topics in the curriculum. Conversely, exposing undergraduates early to practical AI applications (as postgraduates experience) might bridge the gap between inexperienced and experienced students. An inclusive curriculum that provides hands-on AI experience and emphasizes its assistive role could help balance the varying comfort levels and ensure all future dentists, regardless of gender or year, are confident in working with AI.

Areas of uncertainty and gaps in AI awareness

Despite high interest in AI, many dental students have limited detailed knowledge of its applications, particularly in niche areas such as forensic odontology or oral pathology. In an Indian study, 51.3% of students reported only basic AI knowledge [28], whereas an Australian survey reported that 70.3% could not name a single AI software used in dentistry [27]. Most students learn about AI informally through media rather than structured education—only 8–11% receive AI instruction in school [31]. Knowledge gaps are especially pronounced in specialized applications; for example, over 40% of postgraduate students in one survey were unsure about AI's role in forensic dentistry. Even in oral pathology, postgraduate confidence is lower (53–54%) than that of undergraduates [28]. However, awareness is gradually increasing; 75% of Turkish dental students acknowledge the use of AI in dentistry, even if they lack specifics [25]. Nearly 99% of students express interest in using AI in their future practice [26], yet many feel that their curriculum does not sufficiently cover AI applications. Bridging these gaps through formal education, including lectures and hands-on training, is necessary to ensure that students are well prepared to integrate AI into dental practice [26, 28, 32]. While dental students recognize AI's importance, their knowledge remains limited, particularly regarding specialized applications. Most students rely on informal sources for AI learning and lack exposure to real-world AI tools. Expanding AI education within dental curricula through lectures and hands-on training is essential to equip students with AI-integrated practices.

Study limitations

This study has several limitations. First, it was conducted at a single dental institution (Mashhad University of Medical Sciences), which may limit the generalizability of the findings to all dental students in Iran or other countries. The attitudes observed might be influenced by local factors such as the university's curriculum or the regional prevalence of technology. Second, the sample sizes for certain subgroups were small (for example, only 6 non-Iranian students and 9 low-income students participated), which limits our ability to draw firm conclusions about those groups and may reduce the statistical power for detecting differences. Results involving these very small subgroups (e.g., the higher percentage of non-Iranian students agreeing AI could replace dentists) should be interpreted with particular caution. Third, the data on attitudes were self-reported through a questionnaire, which carries a risk of response biases. Students might respond in socially desirable ways or may overestimate their knowledge or acceptance of AI due to the survey context. Finally, as a cross-sectional survey, our study captures perceptions at one point in time; it cannot assess how attitudes might change as students' progress in their training or after they enter clinical practice. Longitudinal studies would be valuable to see if educational interventions or greater exposure to AI during training alter these perceptions. Despite these limitations, this study provides important initial insights into how future dentists in Iran view AI, and it lays the groundwork for educational enhancements and further research.

Integrating AI into dental Education– Future directions

As dental education evolves, there is a growing recognition that curricula need to adapt to emerging technologies like AI. Our findings of enthusiasm coupled with knowledge gaps suggest that dental schools should proactively integrate AI topics into their programs. Worldwide, academic and professional bodies have begun to emphasize this need. For example, the FDI World Dental Federation recently released a white paper highlighting the significance of AI in dentistry, including its implications for dental education and the need for guidelines and competency standards for AI usage [34, 35]. Experts have even called for the creation of dedicated postgraduate programs focused on AI in dentistry [36], arguing that advanced training is necessary for dentists to fully harness AI's potential in practice. In practical terms, integrating AI into dental education can take several forms. At the undergraduate level, introducing core modules or lectures on AI– covering basic concepts of machine learning, examples of current AI tools in dentistry, and discussions of ethical implications– would build foundational literacy. Hands-on experiences could further solidify understanding: for instance, students could be given opportunities to use AI-driven diagnostic software on radiographic cases or observe how an AI tool assists in treatment planning. Interdisciplinary learning, where dental students collaborate with computer science or engineering students on small projects, could also foster a deeper appreciation of how AI systems are developed and validated. At the postgraduate level, more specialized training could be offered, such as certificate programs or electives in "Digital Dentistry and AI" where interested residents learn to implement and possibly even develop AI applications in their specialty (orthodontics, radiology, etc.). There is also an urgent need for faculty development– dental educators themselves need exposure to AI advancements so they can confidently teach and supervise AI-related content. Academic leadership plays a key role in this integration [33]; schools may consider forming committees or task forces that continuously evaluate new AI technologies and update the curriculum accordingly (for example, adding a seminar on AI ethics as new issues arise). Finally, it's important that educational efforts address the demographic disparities we observed. If female students are slightly more cautious

about AI's clinical role, curricula should include open discussions about trust in AI vs. human judgment, so that these concerns are aired and addressed. If junior students are more optimistic, educators should channel that optimism into productive learning while also instilling a realistic understanding of AI's limitations. In essence, the future of dental education will likely involve a blend of teaching about AI and teaching with AI. By doing so, we prepare students not only to use current AI tools but to adapt to and critically evaluate future innovations. In fact, some institutions have already begun implementing pilot courses on AI or incorporating AI-related competencies into their graduate attributes (though this is not yet widespread). Our study supports these moves and suggests that students would welcome a more structured inclusion of AI in their training. With careful design, such educational initiatives can ensure that new generations of dentists enter the workforce with both the excitement and the expertise to effectively collaborate with AI for improved patient care [34, 35].

Conclusion

This study provides evidence that Iranian dental students generally hold positive attitudes toward AI in dentistry, especially for applications like radiographic diagnosis, implant planning, and periodontal disease detection. At the same time, students exhibit healthy skepticism about AI replacing clinicians, highlighting important concerns about professional autonomy and ethical practice. We identified specific demographic influences on these attitudes: for instance, female students were more enthusiastic about learning AI, whereas male students showed more confidence in AI's technical capabilities; specialized postgraduates had greater trust in certain AI applications than undergraduates; and students' year of study correlated with how they viewed AI's role in diagnosis. We also uncovered knowledge gaps in areas such as forensic odontology and other specialized uses of AI, underlining the need to strengthen the curriculum. Taken together, these findings suggest that dental education should evolve to meet students' interest in AI and address their uncertainties. Dental schools should consider implementing formal educational strategies—such as integrating AI-focused modules into preclinical courses, offering interdisciplinary workshops with computer science faculties, and even establishing dedicated elective courses or certificate programs on AI in dentistry—to ensure students develop competence and confidence in using AI technologies. Future efforts must prioritize structured AI training that keeps pace with technological advances, while also addressing concerns about data bias, patient privacy, and cybersecurity. Emphasizing ethical guidelines and critical thinking in the use of AI will be key to preparing students for AI-enhanced practice. In conclusion, by proactively updating curricula and fostering an environment of informed openness to innovation, academic institutions can equip the next generation of dentists to effectively collaborate with AI– improving diagnostic accuracy, treatment planning, and patient outcomes, without compromising the human elements of care. This balanced approach will ensure that AI is harnessed as a powerful tool to augment dental professionals' capabilities and improve oral healthcare delivery in Iran and beyond.

Abbreviations

AI	Artificial Intelligence
CT	Computed Tomography
3D	Three-dimensional
SPSS	Statistical Package for the Social Sciences
X-ray	X-radiation
CT scan	Computed Tomography Scan

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Author contributions

Study conception and design: A.GH, SS.T, J.M., M.S.Data collection: MR.Y, A.GH, M.S.Data analysis and interpretation: V.GHManuscript writing: SS.T, J.M., M.S., A.GH.Critical revision of the manuscript for important intellectual content: SS.T, J.M.

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Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The Ethics Committee of Mashhad University of Medical Sciences (IR.MUMS.FHMPM.REC.1402.194) reviewed and approved this study. All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional and national research committees, as well as the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. All participants received oral and written information about the study. All participants gave their written informed consent to participate. Participants were also free to withdraw during the interview at any moment during the process. Lastly, confidentiality and privacy were observed in the study. The names of the respondents were not mentioned, and audio recordings are kept on a password-protected computer.

Consent for publication

Not applicable. This manuscript does not contain any individual person's data or identifiable information requiring consent for publication.

Use of artificial intelligence

In this article, chat GPT4 is used only to edit the translation from Persian to English.

Competing interests

The authors declare no competing interests.

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