Journal of
Oral Health and Oral Epidemiology

https://johoe.kmu.ac.ir
10.34172/johoe.2403.1628
JOHOE. 2025;14:2403.1628

Original Article

Prevalence of apical periodontitis and quality of root canal among the Iranian adult population: A cross-sectional radiographic study

Ebrahim Shahdadi[1], Arash Shahravan[2*], Nima Hatami[2], Nithin Manchery[3], Farnaz Abdollahi[4], Ali Pooladi[5], Maedeh Ommani[6], Maryam Darvish[7], Amir Hossein Nekouei[8]

[1]Endodontics Department, Faculty of Dentistry, Kerman University of Medical Sciences, Kerman, Iran
[2]Endodontology Research Center, Kerman University of Medical Sciences, Kerman, Iran
[3]Department of Public Health Dentistry, School of Dentistry, University of Queensland Brisbane, Queensland, Australia
[4]Department of Restorative and Esthetic Dentistry, Faculty of Dentistry, Kerman University of Medical Sciences, Kerman, Iran
[5]Endodontics Department, Dental Faculty, Arak University of Medical Sciences, Arak, Iran
[6]Department of Pediatric Dentistry, Faculty of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran
[7]Endodontics Department, Faculty of Dentistry, Kerman University of Medical Sciences, Kerman, Iran
[8]Department of Biostatistics and Epidemiology, School of Public Health, Kerman University of Medical Sciences, Kerman, Iran

*Corresponding Author: Arash Shahravan, Email: arashahravan@gmail.com

Abstract

Background: Apical periodontitis (AP) prevalence has been reported to be very high in Iran, and endodontic treatment quality greatly affects this prevalence. This study aimed to estimate the quality of root canal fillings and AP prevalence in Iran in 2020.

Methods: This was a cross-sectional study on 1089 panoramic radiographs of people over 18 years of age with at least 10 teeth, selected from radiology clinics in different provinces of Iran. The radiographs were evaluated by two postgraduate students in endodontics. The presence or absence of AP lesions, sex, age, length of root filling, type of tooth, specific error in root canal treatments, use of post or pin restorations, and geographical region were recorded. Mixed model Logistic regression was utilized to analyze the data with SPSS software version 21.

Results: The total number of teeth examined in the radiographs was 25,247. The mean age of the participants was 30.4 ± 13.9 years. In endodontically treated and non-endodontically treated teeth, the prevalence of AP was 19% (95% CI = 18.5%–19.4%) and 1% (95% CI = 0.8%–1.1%), respectively. Teeth with definitive errors in root canal treatment had higher odds of AP than teeth without definitive errors ($P = 0.012$, OR = 1.6). The odds of AP in teeth with underfilling and overfilling were higher than in teeth with an adequate root canal obturation length ($P = 0.001$, OR = 2.8 and $P = 0.005$, OR = 4.4, respectively).

Conclusion: The prevalence of AP in endodontically treated teeth was high, and more measures are needed to increase the quality of root canal treatment in the Iranian healthcare system.

Keywords: Periapical periodontitis, Panoramic radiography, Root canal therapy

Citation: Shahdadi E, Shahravan A, Hatami N, Manchery N, Abdollahi F, Pooladi A, et al. Prevalence of apical periodontitis and quality of root canal among the Iranian adult population: a cross-sectional radiographic study. *J Oral Health Oral Epidemiol*. 2025;14:2403.1628. doi: 10.34172/johoe.2403.1628

Received: March 10, 2024, **Revised:** November 5, 2024, **Accepted:** December 28, 2024, **ePublished:** May 21, 2025

Introduction

Apical periodontitis (AP) is a chronic or acute inflammatory disease of periarticular tissues. It happens when bacterial toxins from treated, infected, or necrotic root canals leak into the root apex. In most cases, AP is clinically asymptomatic and is discovered during routine radiographic examinations. Trauma or dental caries may also contribute to this condition.[1,2]

Several studies have investigated the determinants and risk factors of apical periodontitis in the last decade. Poor quality in any procedural step of root canal treatment greatly increases the possibility of treatment failure and the progression or persistence of inflammation in periapical tissues[3]. Uncontrolled diabetes, tobacco use, and gingival health also potentially contribute to the risk of developing this disease. Additionally, the prevalence of AP depends on age and sex.[4-6] Jakovljevic et al noted that in females, endodontically treated teeth have a lower AP prevalence than in males.[7] Moreover, Kamberi et al showed that the prevalence of AP increases with age.[8]

AP could have a significant impact on population health. It affects 52% of the global population and 5% of teeth.[9] Different prevalence rates in the adult population have been reported in Europe, North America, and Japan (4%–9%), with a higher prevalence in root-canal-treated teeth (20%–65%).[10,11] The periapical consequence is the

resorption of the adjacent bone and the apex of the root. The treatment of AP is retreatment or tooth extraction. When a tooth with AP is left untreated, it may cause severe pain, and at the final stage, the patient should extract the tooth, which will lead to an impaired oral health-related quality of life.

The prevalence of apical periodontitis in Iran has been estimated in past studies, but many of these studies have small sample sizes or a long time has passed since their publication. Asgary et al studied the prevalence of AP in a selected population of Iran. They discovered that 52% of people with a history of root canal treatment had radiographic evidence of AP.[11] Esmaeili et al studied 150 cone-beam computed tomography (CBCT) images from the dentistry school of Tabriz city and found that 81% had periapical radiolucency. [12]

According to our research, no study with a large sample size based on a sample from several provinces has been recently conducted to estimate the prevalence of apical periodontitis. Therefore, the present study aimed to determine the prevalence of apical periodontitis and the quality of root canal obturation and coronal restorations in an Iranian population in 2020.

Methods

In this cross-sectional study, data were collected by examining panoramic radiographs of people referred to dental imaging centers between 2020 and 2021 in Iran. During the study, the participants' personal information was kept confidential. The study did not entail additional radiographs or participant exposure to extra radiation doses. Therefore, no ethical considerations were involved.

Sampling method

The sample size was estimated as $N = 1089$ based on the sample size formula for proportion estimation ($n = Z^2P(1\text{-}P)/d^2$) to estimate the apical periodontitis prevalence at a prevalence of 50% based on prior studies with a precision (d) and confidence level of 3% and 95%,[11] respectively. The sampling of this study was performed based on a pathfinder to maximize the geographical representativeness of the sample.[13] Panoramic radiographs were selected from the radiology clinics of four large provinces in Iran, including Tehran, Fars, Kerman, and Hormozgan, which are representative of the country's provinces. The center of the province (the largest city with the highest population) was selected in each province. Additionally, one town was randomly selected in each province. The private and public sector radiology centers were selected by convenience sampling.

Inclusion and exclusion criteria of radiographs

All panoramic radiographs were taken between 2019 and 2020. All the included subjects were > 18 years of age, with at least 10 teeth in the oral cavity. The selected panoramic radiographs had good quality and ideal density.

Radiographic assessment

The radiographs were assessed by two postgraduate endodontics students. Prior to the study, the students underwent a comprehensive examiner calibration process. The process included the evaluation of several radiographs, guided by an expert endodontist and a radiologist, to ensure consistency with established assessment standards. The estimated kappa statistic for our examiners was 97%, which confirms inter-examiner reliability.

Additionally, a detailed set of criteria was developed for scoring the radiographs. These criteria were based on established guidelines in endodontic treatment quality assessment and included indicators for bone structure changes, radiolucent areas, periodontitis, and errors in root canal treatment. This structured approach ensures a rigorous and consistent method for evaluating the radiographs. The following variables were derived from the radiographs: the absence or presence of AP (absence of apical periodontitis: normal periapical structure, presence of apical periodontitis: changes in bone structure with mineral loss, minor changes in bone structure, apical periodontitis with specific radiolucent areas, or extensive periodontitis),[14] type of tooth (molar, premolar, canine, lateral, central), definitive errors in root canal treatment (perforation, ledge, instrument breakage, missed canal),[15] the presence of a pin or post, the presence or absence of recurrent caries (apparent radiolucency adjacent to/under existing restoration),[16] and root canal obturation length (under: failed to fill the circumference of the apical foramen in one or more dimensions, over: the filling material extruded into the periapical tissues beyond the apex and adequate: root filling ending ≤ 2 mm from the radiographic apex).[17] The subjects in the current study were categorized into the following age groups: 18–25, 25–35, 35–45, 45–55, 55–65, and 65–75.

Statistical analysis

The random effects logistic regression model was used to estimate the effects of the independent variable on the prevalence of apical periodontitis. In cases where the age and sex of the subjects' radiographs were missing, the multiple imputation method with 50 iterations was used in the statistical analysis. The criterion for statistical significance was defined as $\alpha = 0.05$. The data were analyzed with SPSS (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM).

Results

Participants

In the present study, the radiographs of 1089 subjects, 34.34% of whom were females, were evaluated. Twenty-five percent of the radiographs had at least one tooth with apical periodontitis. The average age of the people

whose radiographs were examined was 41.8 ± 13.9 years. In Tehran, Kerman, Fars, and Hormozgan provinces, the percentages of patients assessed radiographically were 25.1%, 23.4%, 26.9%, and 24.5%, respectively.

Of the 25 247 teeth examined in all radiographs, periapical lesions were found in 2.5% (95% CI = 2.3–2.6) of them, 19% (95% CI = 18.5–19.4) in root-canal-treated teeth, and only 1% (95% CI = 0.8–1.1) in non-endodontically treated teeth. In addition, the prevalence of AP in root-canal-treated teeth was 19.5% in men and 11.7% in women ($P < 0.001$). The prevalence of PA was higher in towns than in cities ($P < 0.004$), and Tehran Province had a lower prevalence of PA than other cities ($P < 0.001$) (Table 1).

In univariate analysis, gender, age, and the presence or absence of a pin or post had a significant effect. However, these variables were not significant in multivariate analysis when adjusted for potential confounders. Similarly, the effect of recurrent caries was significant in univariate analysis but not in multivariate analysis. Molar teeth had higher odds of periapical lesions than central teeth ($P = 0.002$, adjusted OR = 3.12). The odds of the lesion were higher in teeth with definitive errors than in teeth without definitive errors in root canal treatment ($P = 0.012$, adjusted OR = 1.6). Furthermore, the odds of AP in teeth with underfilling and overfilling were higher than in teeth with adequate root canal obturation length ($P = 0.001$, adjusted OR = 2.8 and $P = 0.005$, adjusted OR = 4.4, respectively) (Table 2).

Discussion

In the present study, we found that in the Iranian population, 19% of root canal-treated teeth, 1% of non-root canal-treated teeth, and 2.5% of all teeth had preapical lesions. In addition, endodontically treated teeth treated in towns had a higher apical periodontitis prevalence than those treated in cities. The prevalence of periapical lesions in teeth with definitive root canal treatment errors was higher than in other teeth. In addition, teeth with overfilling and underfilling had a higher prevalence of periapical lesions than teeth with a proper filling length. It is important to extend the results to the entire Iranian population, as we used clinical radiographic data to estimate periapical lesion prevalence. People who are referred for radiographs often do not have good oral health.[8] In addition, dental check-ups are not routine in developing countries such as Iran.[18,19] Therefore, the estimated prevalence of this study may be overestimated.

In this study, the prevalence of lesions in non-endodontically treated teeth in towns was higher than in cities. This can be a sign of the difference in the quality of treatment in cities compared to towns. The sample size in our study did not allow further investigation. Therefore, more research should be done on social inequality and access to high-quality root canal treatment. On the other hand, the prevalence of lesions in endodontically treated teeth in Tehran, Kerman, Fars, and Hormozgan provinces was different. Furthermore, these differences might be attributed to inequality in access to dental services.

The prevalence of AP varies in different countries. Meirinhos and colleagues reported a 10.4% prevalence of AP based on CBCT images selected from 8 selected health centers in Portugal.[20] Al-Nazhan et al found the prevalence of AP in teeth to be 6.2% in a study of panoramic radiographs of adults in Saudi Arabia[21]; Vengerfeldt et al found the prevalence of AP to be 6.3%.[22] In a study of CBCT images of the teeth of Brazilian patients, Paes da Silva Ramos Fernandes et al showed that the prevalence of AP was 3.4%.[23] In a study on radiographic images of people from Kosovo, Kamberi et al showed that the

Table 1. Prevalence of periapical lesions in terms of gender, age, town/city, and province based on panoramic radiographs in 2020

Variable	Teeth without endodontic treatment			Teeth with Endodontic treatment		
	Category	N	Prevalence of apical periodontitis (%)	N	Prevalence of apical periodontitis (%)	*P* value[1]
Gender	Female	9007	0.8	1178	11.7	<0.001
	Male	6524	1.3	719	19.5	
Age	25–18	15500	8.0	2018	13.4	<0.001
	35–25	2927	6.0	304	15.8	
	45–35	2199	3.0	360	14.7	
	55–45	961	1.0	170	19.3	
	65–55	523	2.0	123	21.1	
	75–65	130	0	28	13.1	
City/town	Cities	16688	1.2	1984	16.11	<0.001
	Towns	9755	0.9	1487	21.1	
Province	Tehran	6479	0.9	896	16.1	<0.001
	Kerman	5719	1.1	937	18.1	
	Fars	6993	0.8	732	20.2	
	Hormozgan	6576	1.2	806	18.3	

[1] calculated for Teeth with Endodontic treatment

Table 2. Unadjusted and adjusted odds ratio (OR) values of the prevalence of apical periodontitis

Variables	Categories	Crude OR	95% CI for crude OR		Sig.	Adjusted OR	95% CI for adjusted OR		Sig.
			Lower	Upper			Lower	Upper	
Gender	Male	1.4	1.3	2.0	<0.001	1.0	0.9	1.1	0.512
	Female		1				1		
Age	18–25	0.2	0.1	0.6	0.001	1.1	0.3	3.4	0.901
	25–35	1.2	0.5	3.1	0.755	0.6	0.2	2.0	0.422
	35–45	0.9	0.4	2.7	0.972	0.8	0.2	2.7	0.761
	45–55	0.9	0.3	2.5	0.871	0.6	0.3	2.1	0.428
	55–65	0.5	0.2	1.4	0.179	0.8	0.2	2.8	0.719
	65–75		1				1		
City/town	Town	1.7	1.2	1.4	<0.001	1.9	1.8	2.2	0.034
	City		1				1		
Tooth type	Molar	2.7	1.7	4.5	<0.001	3.12	1.3	7.4	0.009
	Premolar	1.1	0.6	1.7	0.975	1.41	0.6	3.4	0.436
	Canine	0.9	0.5	1.8	0.830	1.03	0.3	3.2	0.961
	Lateral	1.85	1.0	3.3	0.042	1.84	0.7	5.2	0.251
	Central		1				1		
Definitive root canal treatment errors	With	2.1	1.7	2.7	<0.001	1.6	1.2	2.7	0.012
	Without		1						
Pin or post	With	2.1	1.68	2.6	<0.001	1.1	0.8	1.4	0.775
	Without		1				1		
Recurrent caries	With	3.2	2.6	3.9	<0.001	1.3	0.9	1.8	0.065
	Without		1				1		
Root canal obturation length	Under	2.4	1.4	4.2	0.001	2.8	1.4	5.8	0.005
	Over	4.6	3.6	5.9	<0.001	4.4	3.2	6.1	<0.001
	Adequate		1				1		

apical periodontitis prevalence was 12.3%.[8] In a study on panoramic radiographs of adult Turkish patients, Gulsahi et al showed that the apical periodontitis prevalence was 1.4%.[24] Differences in the estimation of AP in different communities might be attributed to the patients' orodental health status and clinicians' diagnostic ability. According to the results of our study, Iran is among the countries where the prevalence of AP in all teeth is low. However, 2.5% of the total teeth of the Iranian population could have apical periodontitis. It should be noted that this condition may lead to tooth extraction in the future. Therefore, it should be considered an important issue by health policymakers.

Earlier studies have reported different prevalence rates for periapical lesions in Iran. Asgary et al estimated that 52% of endodontically treated teeth of the Iranian population had apical periodontitis.[11] Ahangari et al evaluated the panoramic radiographs of Iranian patients referring to Shahid Beheshti Faculty of Dentistry, Tehran. The evaluation of 866 patients with periapical indexes showed that of 2739 teeth, 38.3% had apical periodontitis.[25] The results of all these studies are different from ours. These differences could be because of the time interval between studies and the studied populations. The time interval between our study and the study of Asgary et al, which had the same method, was ten years. Apical infection is generally asymptomatic and can remain asymptomatic for years. Therefore, longitudinal studies or repeated cross-sectional studies with short intervals are needed to track changes in prevalence.

Many studies have noted differences in apical periodontitis prevalence between men and women. Jakovljevic et al systematically reviewed apical periodontitis prevalence and risk factors. They reported that from 2012 to 2020, female patients with a history of endodontic treatment were less susceptible to AP in teeth than male patients.[7] In addition, Vengerfeldt et al evaluated 181 495 teeth in 6552 patients and reported that being male was a risk factor for AP.[22] Gulsahi et al reported a significantly higher apical periodontitis prevalence in men than in women.[24] In addition, Ahangari et al showed that the prevalence of AP in female patients (2.33%) was lower than in male patients (9.46%),[25] which is consistent with the present study results. Al-Omari et al reported a significant difference in the prevalence of AP between male and female patients in a Jordanian

population.[26] Huumonen et al evaluated the prevalence of AP in a Finnish population > 30 years of age and reported that AP was more prevalent in men than in women (31% vs. 23%).[27] In addition, López-López et al evaluated the prevalence of AP in an adult Spanish population. They reported a significantly higher prevalence of AP in men (3.42%) than in women (1.26%),[28] consistent with the present study results. The reasoning behind this finding is that women have a greater interest in dental care and prevention strategies related to periodontal conditions, resulting in decreased periapical lesions in women.[29,30]

Ahangari et al evaluated an Iranian population and reported prevalence rates of 7.40%, 9.36%, 8.38%, and 2.41% for AP in the 18–30, 31–50, 51–65, and > 65 age groups, respectively.[25] In addition, Kamberi et al reported that the prevalence of AP increased with aging, with a higher prevalence in the > 60 age group (2.20%) than in other age groups[8]. Pacs de Silva Ramos Fernandes et al reported a higher prevalence of AP in the 60–69 age group (1.73%), indicating a significant correlation between the prevalence of AP and age.[23] Undoubtedly, the extraction of teeth increases with age.[25] Therefore, it might be claimed that there are increasing odds of the extraction of teeth with lesions due to aging. At the same time, the odds of dental caries, periodontal diseases, tooth abrasion, and restorative interventions increase with aging, increasing the risk of pulp involvement and the need for root canal treatment. This could explain the increased prevalence of AP with aging, which was apparent in the present study to some extent. In a study by Oginni et al on an adult Nigerian population, the prevalence of AP in root-canal-treated teeth in different age groups was similar, which is different from the present study.[31] Jiménez-Pinzón et al evaluated an adult Spanish population and reported that AP prevalence increased with age.[30] The difference in the results of different studies might be attributed to differences in oral and dental health status and the use of different methods to detect AP.

The present study shows a significant relationship between sex and the prevalence of periapical lesions. However, in the multivariate analysis, the effect of sex was not significant in endodontically treated teeth; however, the OR of periapical lesions in all teeth was significantly higher in male patients than in female patients. An important reason for differences in the results between univariate and multivariate analyses is the presence of confounding factors.

According to the present study, of the evaluated teeth, 7.26% had pin- or post-retained restorations. Some studies have shown an increase in AP prevalence in post-retained restorations, [32, 33,34] and some have refuted this relationship.[35,36] In the present study, a significantly higher prevalence of periapical lesions was observed in teeth with pin- and post-retained restorations than in those without such restorations These findings are different from the results of the study by Tavares et al.[32] Such a relationship is suggested to be further evaluated in future studies for better understanding.

Ahangari et al evaluated the panoramic radiographs of an Iranian population and reported a prevalence of 1.2% AP in teeth with high-quality root canal obturation and 6.5% AP in teeth with unfavorable root canal obturation.[25] It has been demonstrated that the quality of root canal treatment significantly affects the prevalence of AP. In addition, Tavares et al evaluated the prevalence of AP in 1035 teeth with a history of RCT in an adult French population and reported that teeth with proper restorations exhibited a significant decrease in the prevalence of AP (29%) compared to teeth with inadequate restorations (41%).[32] In addition, Covello et al evaluated the prevalence of AP and the quality of endodontic treatments in an adult Italian population and reported a significant relationship between the periapical status and the quality of root canal treatments and root canal obturation.[37] Asgary et al reported a significantly lower prevalence (1.29%) for AP in teeth with proper root canal treatment than in teeth with unfavorable root canal treatment (8.68%).[11] Kamberi et al showed that teeth with suboptimal root canal obturation were associated with a higher risk of AP.[8] Paes a Silva Ramos Fernandes et al evaluated the CBCT images of 300 Brazilian patients and reported that teeth with inadequate root canal treatment had a high prevalence of AP (1.78%).[23] The studies above are consistent with the present study on the relationship between obturation quality and AP prevalence. Therefore, generally, it might be concluded that the prevention of AP was different depending on the adequacy and inadequacy of root canal obturation quality, and low-quality root canal obturation and coronal restoration have been considered risk factors for AP.

In the classification system of our study, AP was considered absent in cases with normal periapical structure and minor changes in bone structure, and AP was considered present in cases with changes in the bone structure associated with mineral material resorption, AP in association with definitive radiolucent areas, or extensive periodontitis.[38] In some studies, the API (apical periodontitis index) was used to determine the periodontal health status of teeth.[39] However, it has been reported that API is probably not suitable for determining the prevalence of AP in all tooth positions because the thickness of the cortical bone and the position of the tooth root apex relative to the cortex are different depending on the position of the teeth.[39] Although these considerations might lead to discussions about the validity of API, the current method will be acceptable due to the possibility of classifying periapical pathologies based on confirmatory pathological observations.

One of the most accurate methods to evaluate AP lesions is the CBCT technique; despite its high accuracy, it

is associated with high radiation doses for patients.[32] The present study used panoramic radiographs to evaluate root canal treatment quality and AP prevalence. Panoramic radiographs provide two-dimensional images of teeth and depict the whole oral cavity in one image, including the teeth and jaws. They have been used in several epidemiological studies to evaluate the periapical status of teeth.[10,40,41,42] A good correlation has been reported between panoramic and intraoral radiographs; however, overestimation has also been reported.[41,42] Therefore, it might be claimed that the diagnostic validity and accuracy of AP based on panoramic radiographs are satisfactory in the present study.

Additionally, it is not possible to use radiographs to decide whether AP lesions are healing. Based on observations made by Petersson et al, after ten years, the number of healed periapical lesions was equal to that of newly formed lesions.[40] However, it should be remembered that periapical lesions are not always diagnosed during radiographic evaluation. It was showed that diagnosing lesions confined to the spongy bone is almost impossible to view on conventional radiographs such as panoramic radiographs.[43,44] In addition, the negative diagnostic value of radiographs for AP was 0.76, indicating that when the periodontal ligament is diagnosed on radiographs, only 67% of cases will be histologically noninflammatory.[45] These findings support the validity of cross-sectional studies in deciding the long-term success of root canal treatments.

All the subjects included in the present study were > 18 years of age and had at least 10 teeth in their oral cavities. These individuals were selected because those with < 10 teeth in their oral cavities might have an unfavorable orodental health status, and due to the high prevalence of periodontitis in such individuals, evaluating the effects of ACT might pose problems in the radiographic evaluation of RCTs.[46,47]

The main limitations of our study were the sampling method and sample size. Our sampling technique was not ideal for estimating the prevalence of AP in Iran. For this reason, it is crucial to be careful when making generalizations. Considering the importance of cross-sectional studies in the prevalence of periapical lesions in different communities and to provide proper treatment and guidelines for prevention, it is suggested that such a study be periodically repeated in the coming years to decide whether changes occur in the prevalence of these lesions and their risk factors. If the prevalence of these lesions decreases, it might be reasoned that the quality of root canal treatments has increased. Otherwise, measures should be taken to further educate dentists to take the necessary precautions in this regard.

Conclusion

Apical periodontitis was detected in 19% of root-canal-treated teeth in the Iranian population evaluated in this study, which is higher than earlier studies. Generally, the prevalence of periapical lesions was higher in men than in women, in obturations with more errors than those with fewer errors, in teeth with pin- or post-retained restorations than teeth without these restorations, in teeth with recurrent caries than teeth without recurrent caries, and in teeth with proper root canal obturation length than in teeth with inadequate root canal obturation length. The present study emphasizes the need for further improvements in the quality of root canal treatments.

Acknowledgments

The authors would like to thank and appreciate everyone who contributed to this research.

Authors' Contribution

Conceptualization: Arash Shahravan.
Data curation: Ebrahim Shahdadi, Nima Hatami, Nithin Manchery, Farnaz Abdollahi, Ali Pooladi, Maedeh Ommani, Maryam Darvish.
Formal analysis: Arash Shahravan, Amir Hossein Nekouei.
Investigation: Arash Shahravan.
Methodology: Arash Shahravan.
Project administration: Arash Shahravan.
Supervision: Arash Shahravan.
Writing-original draft: All authors.
Writing-review & editing: All authors.

Competing Interests

The authors declare that they have no conflicts of interest.

Data Availability Statement

The data will be available from the corresponding author upon reasonable request.

Ethical Approval

This study has been conducted as a research project with the support of the Vice Chancellor for Research and Technology of the Kerman University of Medical Sciences. The ethics approval code is IR.KMU.REC.1399.631.

Funding

The research reported in this manuscript was partially funded by Kerman University of Medical Sciences (grant No.: 99000709).

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