



The Rationality to Requesting in-ward Magnetic Resonance Imaging Investigation

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ABSTRACT

Background: Magnetic Resonance imaging (MRI) is a valuable diagnostic tool by its non-invasive/non-ionizing nature.

Objective: This study aims to determine justification of MRI in hospitalized patients at a tertiary provincial referent medical center in a one-year period.

Material and Methods: In the present retrospective and descriptive cross-sectional study, 438 admitted patients referred for MRI during 2017 were selected using systematic random sampling. The age, gender, investigated organ, the specialty of requesting physician, MRI with and without contrast, MRI diagnostic outcome were collected using checklists. Descriptive statistics and chi-square test were used for data analysis.

Results: The mean age of the patients was 42±26 years-old and female represented 53% of enrolled patients. The most and less prevalent investigated organs were the cerebrum and the orbit. After excluding cancer diagnosis, cancer staging, and therapeutic follow-up exams, MRI request was oriented in 64.3% and 77.2% of positive results was concordant with aforementioned diagnostic orientation ($P<0.001$). Oriented diagnostic MRI requesting is influenced by age, medical specialists and, investigated organ ($P<0.001$). The positive MRI is influenced significantly by oriented MRI request, gender, medical specialists and investigated organ ($P<0.001$). The diagnosis concordance of MRI is influenced significantly by oriented MRI request, medical specialists and investigated organ ($P<0.001$).

Conclusion: Appropriate implementation of medical imaging requires boosting employed rationality by the concerned physicians. The current suboptimal results to requesting MRI rationality should mandate supplementary educational programs as to incite the medical corpus more closely implementing the published medical practice guidelines.

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Keywords

Magnetic Resonance Imaging; Rational Use; Admitted Patient; Diagnostic Imaging; Appropriateness; Cross Sectional Study; Data Analysis

Introduction

Magnetic resonance imaging (MRI) is a valuable expansive medical imaging tool, experiencing an increasing generalization worldwide [1-6]. Although the diagnostic accuracy of MRI in many challenging clinical situations does afford resource-saving

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features by establishing a prompt diagnosis and triggering an earlier target-directed treatment [7-9], generalization to MRI requesting mandates its periodic analysis to investigate MRI rationality [10]. Therefore, the latter serves to periodically boost rationalized medical imaging practice and feed further meta-analyses or practice guidelines. By the way, such a periodic analytic approach is a powerful reflective and incentive process to establish medical imaging priorities and resource planning. The present study sought to investigate the rationality to MRI requesting over a one-year period among the in-ward patients in the university hospital complex, covering the Charmahal & Bakhtiari Province in Iran.

Material and Methods

Study feature

This retrospective cross-sectional study has been carried out during from August 2017 to July 2018 to investigate demographic and clinical data in the inward patients who underwent at least one MRI exam.

Study environment

The referral hospitals belong to the university hospital complex of the Shahrekord University of Medical Sciences (SKUMS) with more than 1200 active hospital beds and encompassing all medical and surgical specialties, which is in charge to providing health more than one million population of Charmahal & Bakhtiari Province.

Sampling

The total number of MRI exams performed during the study period for inward patients was 1313. Sampling method according to the formula $n = (z^2 p(1-p)) / d^2$, with a 95% confidence level and 5% margin of error was used to determine the number of patients enrolled in the study. Accordingly, the sample size was estimated as 400 patients. The systematic

random sampling was used to select sample size from a total of 1313 that performed MRI exams.

Study conduct

The data was extracted using a checklist from electronically achieved patient charts. Patients' the demographic data such as the age and sex, the prevalence of investigated organ, the specialty of requesting physician, MRI request orientation, cancer patients, cancer staging MRI, therapeutic follow-up MRI, contrast MRI, MRI diagnostic outcome, and MRI report conclusion as clinical data were collected. The data was analyzed by SPSS analytic software (Version 16, SPSS Inc., Chicago, IL, USA).

MRI request orientation was defined as a request heading, a defined disease and classified as oriented and non-oriented exam request. MRI diagnostic outcome was defined as an exam with a specified diagnosis and classified as positive or negative. The conclusions of a MRI report would be classified as concordant if the advanced positive diagnostic was in line with the aforementioned clinical orientation to requesting MRI, and a discordant report was attributed in the contrary. The MRI report was considered as being incidental if the positive MRI diagnostic was fortuity.

Statistical analysis

The obtained data were analyzed using SPSS software version 16 (SPSS Inc., Chicago, IL, USA) based on descriptive statistics (sums, frequencies, percentages, means, and standard deviations) and chi-square test.

Ethical issues

This study was registered at research and innovation SKUMS deputyship, and it was ethically approved.

Results

The mean age of the sample was 42 ± 26

years-old (from 1 to 91) and female sex represented 53% of enrolled patients, as seen in Figure 1. The patients below 20 and above 60 years old accounted for 60% of the selected cases (Figure 1a). The most and less prevalent investigated organs were the cerebrum (56.2%) and the orbit (0.2%), as seen in Figure 1c. The contrast material was used in 9.1% of performed exams (Figure 1d). 5.7 and 1.4% of the undertaken MRI accounted for the cancer diagnosis or cancer staging, respectively, Figure 1e. MRI requested for therapeutic follow-up represented 16.7% of the total cases, Figure 1f.

After excluding cancer diagnosis, cancer staging and therapeutic follow-up exams in which MRI was actually labeled as oriented, MRI request was oriented in 64.3% of 345 remaining cases (Figure 2a). The departments of medical emergency (24.3%) and pediatrics

(23.5%) were the two most frequent medical specialties when it came to requesting MRI, Figure 2b. Only in 47% of performed MRI, a positive diagnosis was reported, Figure 2c. Among the latter, 77.2% of positive results were in consistent with aforementioned diagnostic orientation, and incidental positive diagnosis was found to be 20.4% of the cases ($P<0.001$), Figure 2d.

When it came to oriented diagnostic MRI requesting, age classes significantly influenced the prevalence of diagnostic oriented MRI requesting ($P<0.001$), favoring age-class below 20 years-old, Figure 3a. The percentage of diagnostic oriented MRI requesting differs significantly among clinical physicians ($P<0.001$), favoring pediatric (23.4%) and medical emergency (23%) physicians, Figure 3b. The prevalence of oriented diagnostic MRI requesting significantly differs in

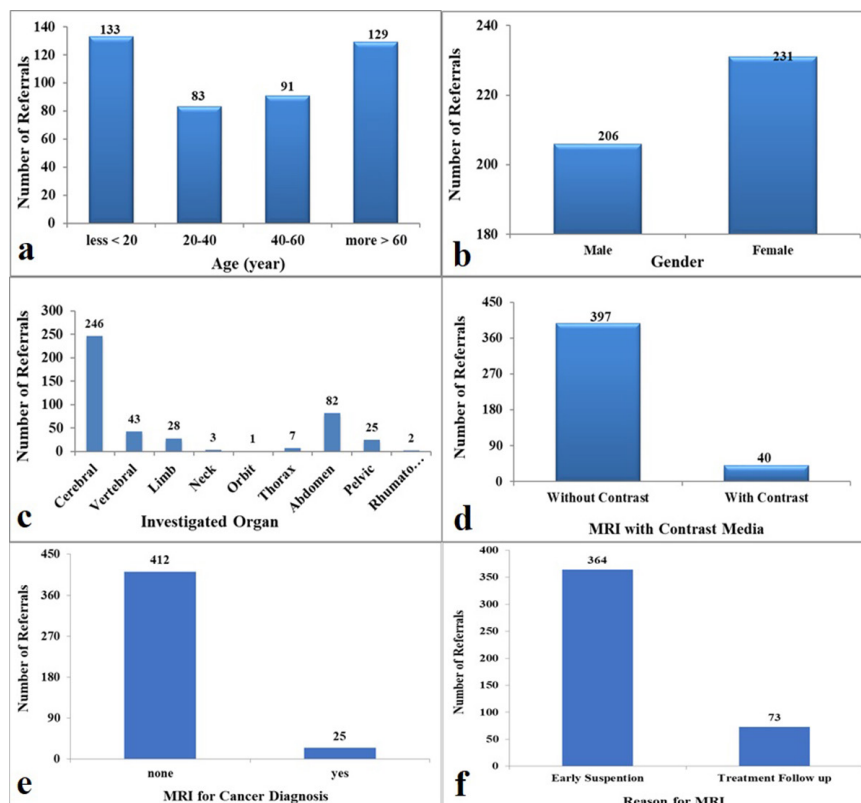


Figure 1: Number of Magnetic Resonance imaging (MRI) referrals on admitted patients by (a) age, (b) gender, (c) investigated organs, (d) MRI contrast agent, (e) cancer diagnosis and cancer staging and (f) therapeutic follow-up MRI in 2017-2018.

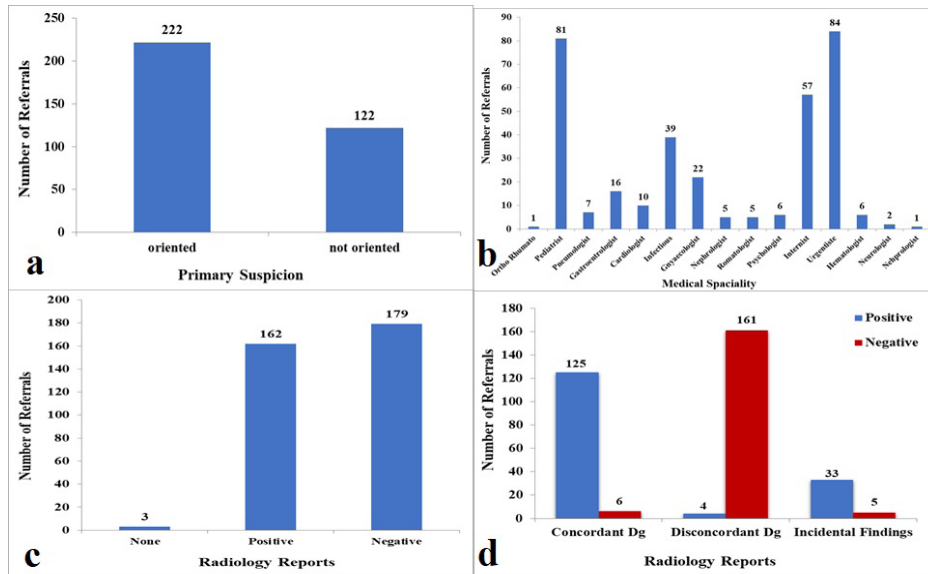


Figure 2: Number of Magnetic Resonance imaging (MRI) referrals, excluding cancer diagnosis, cancer staging, and therapeutic follow-up exams, on admitted patients by (a) oriented MRI request, (b) medical specialists, (c) radiology reports in 2017-2018, and (d) the relationship between oriented MRI request and radiology report.

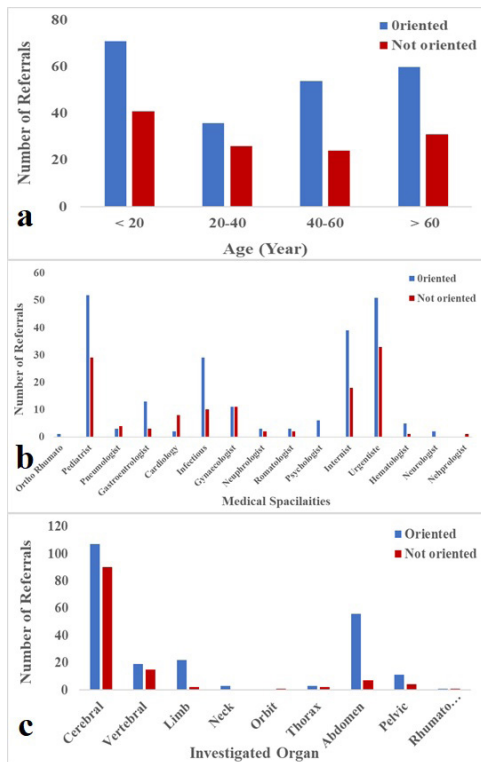


Figure 3: The oriented Magnetic Resonance imaging (MRI) request is influenced significantly by (a) age, (b) medical specialists and (c) investigated organ on admitted patients in 2017-2018.

respect to the investigated organ ($P<0.001$), favoring cerebral (48%) then followed by abdominal (25%) investigation, Figure 3c. The cerebrum was also the most significantly prevalent non-oriented requests to MRI (74% of non-oriented requests, $P<0.001$), Figure 3c.

The overall rate of a positive diagnostic was 47%. The proportion of positive diagnostic was significantly influenced by oriented MRI requesting ($P<0.001$), Figure 4a. The prevalence of a positive MRI report differed significantly in relation to the gender favoring females ($P<0.001$), Figure 4b. The category of physician specialty significantly influenced the prevalence of a positive diagnosis ($P<0.001$), favoring medical emergency physicians (27.8%); while pediatricians (33%) sustained the most prevalent physician category to negative diagnosing ($P<0.001$), Figure 4c. The prevalence of a positive diagnosis significantly differed among investigated organs ($P<0.001$), favoring the cerebrum (40.1%) followed by the abdomen (31.5%), Figure 4d.

MRI Rationality among Admitted Patients

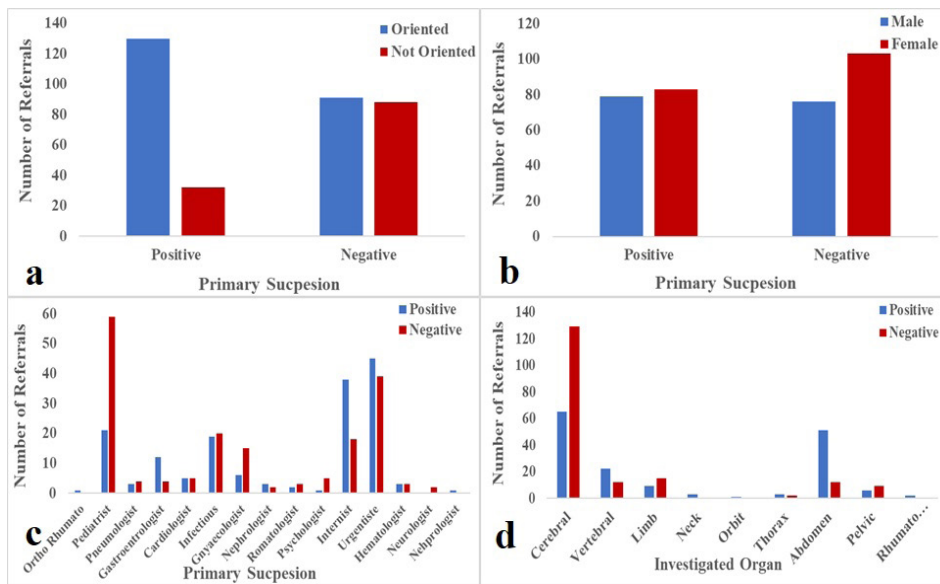


Figure 4: The positive diagnosis Magnetic Resonance imaging (MRI) is influenced significantly by (a) oriented MRI request, (b) gender, (c) medical specialists and (d) investigated organ on admitted patients in 2017-2018.

In regard to diagnostic concordance of the performed MRI, a concordance diagnostic was noticed just in 38% of the cases. Diagnostic orientation significantly influenced diagnostic concordance (56 vs. 4.9%, $P < 0.001$), Figure 5a. The medical emergency physicians significantly marked the most diagnostic concordant requesting physicians (29.8% of positive reports; $P < 0.001$). Pediatricians represented the most prevalent category of discordant positive diagnosis (21.1%), $P < 0.001$, Figure 5b. The prevalence of concordance positive diagnosis significantly varied among different investigated organs ($P < 0.001$), favoring the abdomen (37.4%), Figure 5c. The most discordant positive diagnosis came to the cerebrum (72.6%). The prevalence of incidental diagnostic finding was significant in favor of the cerebrum (71%, $P < 0.001$).

Discussion

Magnetic resonance imaging is a valuable diagnostic tool by its multi-planner feature as well non-invasive/non-ionizing nature [1, 3, 4, 11]. In many challenging clinical situ-

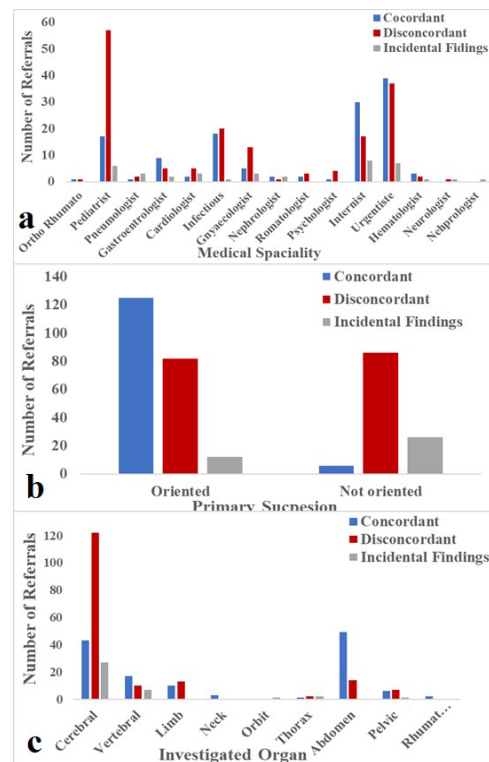


Figure 5: The diagnosis concordance of Magnetic Resonance imaging (MRI) is significantly influenced by (a) oriented MRI request, (b) medical specialists and, (d) investigated organ on admitted patients in 2017-2018.

ations, MRI represents the last resort non-invasive diagnostic method [2, 7-9]. By providing accurate diagnosis and enabling earlier disease management, MRI can be considered as a health-resource saving tool in many medical situations to the specific diseases. Nevertheless, the ongoing increasing number of MRI centers, the practitioners a safer environment to their medical practice, as well the fact the patient requirement as to obtain a faster diagnosis have led to increasing unjustified number of performed MRI. The latter does inflict an additional health-resource expenditure [8]. Outranging to resort on MRI investigation was alarmed by previously reported studies [12-17]. Smith et al. reported a threefold increase in requesting MRI over a ten years period from 1997 to 2006 in their investigated target health system comprising two general hospitals, 28 family medical centers, and 5 specialty medical centers at Washington State [18].

Performing MRI seems to widely differ, depending on various factors such as the expertise level of the requesting physician, the investigated organ, underlying disease, the resorted imaging protocol and diagnostic environment. Oikarinen et al. investigated the appropriateness of 150 performed common MRI (upper abdomen, lumbar spine, knee, and head) in an academic center in Finland, reporting a 93% appropriateness of performed MRI [19]. Bouette et al. reported an appropriateness rate of 79% to 330 performed MRI in medical imaging centers of Luxembourg. The authors found a significant difference in appropriateness rate favoring medical specialists compared to general physicians (82 vs.58, $P<0.001$). The authors estimated that an inappropriateness rate of 21% to performed MRI was unsatisfactory [20]. In line, Jahanmehr et al. reported a rate of 39% of unjustified MRI over 614 patients based on a multi-centric study comprising four private and academic Iranian hospitals in Tehran, finding a significant statistical relation be-

tween age or sex of the patients and the MRI appropriateness [21]. Similarly, Sadeghi et al. found a rate of 25% to inconclusive performed MRI at Chamran University Hospital in Fars Province in Iran, founding a significant difference between the investigated organ or using contrast material and the diagnostic MRI performance [22]. In addition, Saadat et al. found that 17% of performed MRI at an outpatient facility was unnecessary in Tehran [23].

When considering the MRI rationality in respect to investigated organs, Sherman et al. reported a rate of 13% to unjustified undertaken MRI in patients, suffering from advanced knee joint osteoarthritis and standing as a candidate for surgery [24]. In contrast, Vejdani et al. reported an inappropriateness rate of 51% in 150 performed knee MRI in the frame of pain workup at an academic center in South Khorasan Province [25]. The appropriateness rate of performing lumbar spine and cerebral MRI displayed different patterns in reported studies. Emery et al. concluded that only 55% of performed lumbar spine MRI was inappropriate or uncertain, while the appropriateness rate to cerebral MRI sustained by headache reached 83%. The latter authors found that there was significant difference in lumbar spine MRI appropriateness according to ordering medical specialist in favor or disfavor of neurosurgeons and family physicians respectively [26]. Zargar et al. found a rate of 46.5% to unjustified performed MRI due to low back pain in 391 patients at four Tehran MRI centers. Barzin et al. reported the diagnostic MRI performance to headache workup during a 2 years-period and at an academic center in Mazandaran Province, reporting a rate of 18.2% conclusive findings [27]. Sedaghat et al. reported a rate of 20% of justified performed lumbar spine MRI according to the database of an insurance company in Tehran [23]. Khoury et al. investigated CT and MRI appropriateness to lobar pain and headache

in an academic Canadian center. The authors found an inappropriateness rate of 12% and incompleteness (non-oriented) rate of 36.3% to requested imaging exams [28].

Increasing the appropriateness to requesting MRI can be enhanced through educative programs based on meta-analyses and best-practice guidelines [28]. Wang et al. reported a significant increase in appropriateness of indicating lumbar spine MRI in patients, complaining low-back pain by implementing a joint supplementary educational program affected at three different primary care facilities in Texas State [29]. Xu et al. in a tertiary Canadian hospital found a significant increase in the appropriateness to requesting MRI by implementing a conceived checklist, resulting in a 16% and 80% increase in efficiency as to appropriately indicating MRI in the cases of moderate and severe knee osteoarthritis, respectively [30].

In the present study, it was attempted to investigate the global outcome and diagnostic performance of MRI practice in inpatient patients over a one-year period at an Iranian university hospital complex. The global performance in appropriately requesting MRI was defined by physician clinical diagnostic orientation, the diagnostic positivity of MRI, and the diagnostic concordance between the physician clinical orientation and ensued MRI diagnostic. 64% of MRI request was found to be oriented or completed. Pediatricians as well as medical emergency specialists were the two most performant physician categories to observe completeness of MRI requesting. The completeness to MRI requesting significantly varied in regards to the investigated organ with the highest rates sustained by requesting cerebral and abdominal MRI. Cerebral MRI emerged as the most significant non-oriented requesting; thereby, reflecting a considerable proportion of unjustified performed exams.

The MRI performance in concluding a di-

agnosis was significantly influenced by the female gender. The highest rate of diagnostic positivity was observed by medical emergency specialists that does reflect natural pathway to patient and disease selection. The less performant diagnostic positivity came to pediatricians accounting for 33% of negative diagnostic cases. The diagnostic positivity to performed MRI differed according to the investigated organs with the cerebrum and abdomen providing the highest rate of diagnostic positivity.

Taking into account for the diagnostic concordance, the highest rate of positively diagnostic concordance was afforded by medical emergency specialists; while, pediatricians (who represented one of two most performant physicians in completeness of oriented MRI requesting) resulted in the highest rate of diagnostic discordance. The diagnostic concordance rate differed among investigated organ with the abdomen resulting in the highest scores. Cerebral MRI resulted in the highest rate of discordant diagnosis. Similarly, the rate of incidental finding was significantly the highest by the performed cerebral MRI.

Overall, a diagnostic orientation rate approaching 64% in parallel with a positive diagnostic rate of 47% that was sustained by a rate of 38% of diagnostic concordance does highlight an alarming unsatisfactory level of rationality to requesting MRI at SKUMS university hospital complex. Nevertheless, the current data indicated the intricate influence of diagnostic orientation on the performance level to diagnostic positivity and concordance.

Conclusion

Appropriate implementation of medical imaging requires boosting employed rationality by the concerned physicians. The observed suboptimal results in this study in respect to a rationalized approach to requesting an MRI investigation highlight the importance of need

to boost the continuous medical education programs for the radiologist and all medical specialties to conform their practice paralleling the recommendations of published medical practice guidelines.

Authors' Contribution

E. Raeisi and V. Kermanian did the Conceptualization. Data curation was carried out by E. Raeisi and V. Kermanian, and A. Taheri. Formal Analysis was done by E. Raeisi and V. Kermanian, and MA. Dayani. E. Raeisi and V. Kermanian, A. Taheri did the Investigation. The Methodology was written by E. Raeisi and V. Kermanian, and MA. Dayani. Project administration was carried out by E. Raeisi and V. Kermanian. Resources were provided by E. Raeisi and V. Kermanian. Supervision was done by E. Raeisi, A. Taheri and MA. Dayani, and MH. Aazami. Visualization was done by E. Raeisi, V. Kermanian, and A. Taheri. V. Kermanian, A. Taheri, E. Raeisi, MH. Aazami, MA. Dayani, D. Shahbazi-Gahrouei wrote the original draft. Writing review & editing were done by V. Kermanian, A. Taheri, E. Raeisi, MH. Aazami, MA. Dayani, and D. Shahbazi-Gahrouei. All the authors read, modified, and approved the final version of the manuscript.

Ethical Approval

The Shahrekord University of Medical Sciences Ethics Committee approved the study's protocol (Ethic code: IR.SKUMS.REC.1397.213).

Informed Consent

The informed consent letter was prepared confirmed by "The Shahrekord University of Medical Sciences Ethics Committee" and signed by the contributed patients.

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Conflict of Interest

None

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