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Comparison of treatment results of femoral shaft fracture with two methods of intramedullary nail (IMN) and plate

Hasan Hosseini[1], Sina Heydari[2], Asma Amiri Domari[3], Rasoul Raesi[4,5], Kiavash hushmandi[6], Reza Faryabi[7], Masumeh Gharaee[8] and Salman Daneshi[9*]

Abstract

Background Fracture of the femur is one of the most common fractures that, if not stabilized and treated properly, may lead to severe disability, impairment of the individual's efficiency, and numerous complications. This study aimed to evaluate the treatment results of femoral shaft fracture with two methods intramedullary nail (IMN) and Plate.

Materials and methods In this cross-sectional study, 60 patients with femoral bone fractures were admitted to Imam Khomeini Hospital in Jiroft in 2020 and were treated for at least one year after discharge. They were divided into two treatment groups - Plate fracture fixation ($n=30$) and IMN fracture fixation ($n=30$). Data were collected using a researcher-made checklist including patient demographics and treatment outcomes. The collected data were analyzed using SPSS-v 26 statistical software and descriptive and inferential statistical tests at a significance level of $p<0.05$.

Results Patients in the Plate treatment group were generally older (50–60 years) compared to the IMN treatment group (30–40 years), and there were more men than women in both groups. Only 10% of patients in each group developed superficial infections after surgery. There were more cases of deep infections in the Plate group, but it was not statistically significant. The IMN group had fewer cases of malignancy and claudication compared to the Plate group. Patients in the IMN group also returned to functional activities faster than those in the Plate group, which was a statistically significant difference.

Conclusion Considering that deep infection, non-union, malunion, claudication, and ability to return to functional activities in the group using nails treated was less than the group treated with plates, the treatment method of femoral fracture using IMN is the preferred treatment method.

Keywords Femoral fracture, Treatment, Intramedullary nail (IMN), Plate, Orthopedics

*Correspondence:
Salman Daneshi
salmandaneshi008@gmail.com

Full list of author information is available at the end of the article

Introduction

Fracture of the femur is one of the most common fractures, and if improperly treated, it may lead to severe disability long-term disability, and even death [1]. Femoral shaft fractures are prevalent orthopedic injuries, often resulting from high-energy trauma such as motor vehicle accidents or falls [2]. These fractures can lead to significant morbidity if not treated adequately, necessitating effective management strategies. femur fracture treatment often requires a multidisciplinary approach that addresses underlying medical conditions and provides appropriate surgical stabilization, early mobilization, and rehabilitation to ensure a return to functional mobility and early independence [3, 4]. Delay in proper surgical treatment is associated with increased complications and mortality rates [5, 6].

Among the types of orthopedic hardware such as pins, screws and plates, external fixators, intramedullary nail (IMN), and prostheses, pins are the simplest orthopedic devices for fixing fractures which brought about a great transformation in the field of orthopedics [7, 8]. Over the years, various treatment methods have been developed, with IMN and plate fixation being the most commonly employed techniques [9, 10]. IMN has become the standard treatment for femoral shaft fractures due to its high union rates, typically around 97%. IMNs offer several advantages, including minimally invasive techniques, rapid application, stable fracture fixation, and early patient mobilization [11, 12]. However, factors such as nail design, presence of grooves, number and placement of locking screws, distance from the fracture site, and bone quality can influence the resistance to various forces [13, 14]. Despite the advantages of IMN, there are still challenges to overcome, such as the risk of soft tissue damage, increased fluoroscopy use, prolonged operating time, and difficulties in distal locking screw placement [15, 16]. A systematic review indicated that closed-reduction and IMN resulted in better union rates and lower infection rates compared to open-reduction techniques [17]. Another study highlighted that while IMN generally provides stable fixation, plate fixation can offer better anatomical alignment in certain fracture patterns [18]. However, the choice between fixation methods often depends on specific patient factors, including the nature of the fracture, the patient's overall health, and the presence of comorbidities [19–21].

Another alternative treatment for femoral shaft fracture is plate fixation [22]. Plate fixation involves the use of metal plates and screws to stabilize the fracture externally [23, 24]. This method allows for direct visualization of the fracture site, enabling precise anatomical alignment and reduction [16, 21]. Plate fixation is particularly advantageous in cases where IMN may not be feasible, such as in open fractures or when there is significant soft tissue damage [15, 19]. Moreover, plates can provide stable fixation in complex fracture patterns that may not be adequately addressed by IMN alone [19, 25]. However, plate fixation is associated with a higher risk of complications, including infection, nonunion, and increased surgical trauma due to the need for larger incisions and soft tissue dissection [26–28]. The invasiveness of this technique can lead to longer recovery times and increased postoperative pain [29]. Despite these drawbacks, plate fixation remains a viable option, especially in specific clinical scenarios where anatomical alignment is critical [30]. Plates offer the advantage of direct visualization of the fracture site, allowing for anatomic reduction and stable fixation [31]. However, plate fixation is more invasive and may result in higher rates of infection and delayed union compared to IMN [32]. Several studies have compared the outcomes of IMN and plate fixation for femoral shaft fractures [33]. While IMN generally demonstrates higher union rates and lower complication rates, the choice between the two methods depends on factors such as fracture pattern, soft tissue injury, and surgeon preference [34, 35]. Both intramedullary nailing and plate fixation are effective treatment options for femoral shaft fractures [36, 37]. The choice between the two methods should be based on a thorough assessment of the patient's condition, fracture characteristics, and surgeon's experience. The decision-making process in selecting the appropriate treatment method is multifaceted, involving an assessment of the fracture type, patient health, and potential risks and benefits associated with each technique. As the body of literature continues to grow, it is clear that both IMN and plate fixation have their respective roles in managing femoral shaft fractures. Due to the importance of this fracture and its complications, which can affect the life of the affected person and even lead to his disability, on the other hand, because research on the complications of this fracture has not been done in our medical centers so far, we decided on it. Let's review all observed complications and complete the evaluation of patients who have fractured femur in Imam Khomeini Hospital of Jiroft city.

Materials and methods

This is a cross-sectional study of a descriptive-analytical type, conducted using the convenience sampling method on all medical records of patients who were admitted and treated for femur fractures at Imam Khomeini Hospital in Jiroft in 2020. Finally, according to the entry and exit criteria, 60 cases were selected and examined based on the type of treatment. The criteria for entering the study include patients who have been discharged for at least one year and patients who were treated with two methods of fixing the fracture: intramedullary nailing (IMN) and plate fixation. A locking compression plate (LCP)

was used in this study, followed by a limited contact dynamic compression plate (LCDCP) and a traditional 4.5 mm dynamic compression plate (DCP).Patients had fractured the femur and did not suffer from systemic diseases such as diabetes and rheumatoid arthritis. Patients with acute traumatic fractures or fractures of the femoral shaft among individuals older than 17, who were subsequently managed with IMN or plate, were included in our study. The criteria for leaving the study were patients whose medical record information was incomplete. Also, patients younger than 17, pathological fractures, atypical pathological fractures, patients who refused to participate in the study, and patients with less than six months of radiological follow-up were excluded from the study. After obtaining the code of ethics from the Research and Technology Vice-Chancellor of Jiroft University of Medical Sciences, the researchers coordinated with hospital officials to access the medical records archive unit. Then, the medical files of the patients were examined based on the entry and exit criteria. According to the type of treatment, the patients' files were divided into two treatment groups: fixing the fracture with a plate ($n=30$) and fixing the fracture with IMN ($n=30$). Weight-bearing ability was assessed under the supervision of a treating physician, with protocols varying based on fracture stability and surgical methods. However, it is important to note that the specific number of patients in the plate group permitted to bear weight was not documented, which is acknowledged as a limitation in our study.Data were collected using a researcher-made checklist that included patient demographics and treatment outcomes. This checklist included post-treatment complications, time until ability to perform functional activities, and limb length discrepancy (LLD). In this study, LLD was evaluated using standard clinical methods. These techniques included:

- Tape Measure Method: This involves measuring the distance from the anterior superior iliac spine (ASIS) to the medial malleolus of the ankle.
- Clinical Examination: A specialist physician performed a physical examination to assess any limb length discrepancies using visual inspection and palpation.

Additionally, weight-bearing protocols were used under supervision through clinical evaluation and radiographic imaging. In this method, depending on fracture stability and surgical method used, weight-bearing without bearing or partial weight-bearing was measured.The collected data were analyzed using SPSS-v 26 statistical software with descriptive and inferential statistical tests at a significance level of $p<0.05$.

Table 1 Frequency distribution of age and gender of patients and comparison of treatment groups by plate and nail method

Variables		Grope Treatment		P value
		Plate (Percent %)	IMN (Percent %)	
Age	17–30	3 (10%)	6 (20%)	
	30–40	9 (30%)	18 (60%)	
	40–50	6 (20 %)	3 (10%)	
	50–60	12 (40 %)	3 (10%)	
	Total	30 (100%)	30 (100%)	0.003
Sex	Men	18 (60%)	24 (80%)	
	Women	12 (40%)	6 (20%)	0.094

Results

60 patients with femoral shaft fractures were examined. Table 1 shows the frequency distribution of age and sex of patients in treatment groups with the Plate and Nail method. The results indicate that the highest number of patients in the Plate treatment method is in the age group of 50 to 60 years and the lowest number of patients in this treatment method is in the age group of 17 to 30 years. Also, the highest number of patients in the Nail treatment method is in the age group of 30 to 40 years and the lowest number of patients in this treatment method is 40 to 50 years old and 50 to 60 years old. which is statistically significant between the frequency distribution of age in terms of placement in treatment groups by Plate and Nail methods ($P=0.003$). The number (percentage) of men and women in the Plate treatment method is 18 people (60%) and 12 people (40%), respectively, and in the Nail treatment method, 24 people (80%) and 6 people (20%). Also, no statistically significant difference was observed between the ratio of men and women in terms of exposure to two treatment methods ($p=0.094$).

According to Tables 2 and 10% of the patients in the Plate treatment group had superficial infection after surgery, and 10% in the IMN treatment group also had superficial infection after surgery. The results of the table show that there is no significant difference between the ratio of superficial infection after surgery in terms of placement in the two treatment groups by Plate and IMN method ($p=1.000$).

10% of IMN treatment group patients got a deep infection after surgery, compared to 30% of Plate treatment group patients who got a deep infection after surgery. The results of the table show that there is no significant difference between the proportion of deep infection after surgery in terms of placement in the two treatment groups by Plate and IMN method ($p=0.055$). Also, in Table 2, out of the entire research population, only 9 people had They suffered from non-union complications, and the share of patients in the IMN group is 10% and 20% of patients in the Plate therapy group, and there is no significant difference between the proportion of patients with non-union complications in terms of placement

Table 2 The results of the comparison of two groups of plate and IMN in terms of superficial and deep infection, non-union, malunion, claudication, and LLD

Variables	Group treatment		Fequency (percent %)	*P*-value
Superficial infection	Plate	Yes	3 (10%)	1.000
		No	27 (90%)	
	IMN	Yes	3 (10%)	
		No	27 (90%)	
Deep infection	Plate	Yes	9 (30%)	0.055
		No	21 (70%)	
	IMN	Yes	3 (10%)	
		No	27 (90%)	
Nonunion	Plate	Yes	6 (20%)	0.282
		No	24 (80%)	
	IMN	Yes	3 (10%)	
		No	27 (90%)	
Malunion	Plate	Yes	6 (20%)	0.282
		No	24 (80%)	
	IMN	Yes	3 (10%)	
		No	27 (90%)	
Claudication	Plate	Yes	12 (40%)	0.094
		No	18 (60%)	
	IMN	Yes	6 (20%)	
		No	24 (80%)	
LLD	Plate	Yes	0 (0 %)	-
		No	30 (100%)	
	IMN	Yes	0 (0%)	
		No	30 (100%)	

Table 3 Comparison of two groups of plate and IMN in terms of the time of patients' ability to perform functional activities

Time of ability to perform functional activities (Month)	Plate		IMN		*P*-value
	Frequency	Percent(%)	Frequency	Percent(%)	
< 3	3	10%	21	70%	
3–6	18	60%	9	30%	0.000
> 6	9	30%	0	0%	

in the two treatment groups by Plate and IMN method. $p=0.282$) in the case of malunion, the same results have been repeated in this way.

According to Tables 2 and 20% of IMN group patients suffered from claudication and 40% of Plate therapy group patients suffered from this complication, and also there is a significant difference between the proportion of claudication complications of the patients in terms of placement in the two treatment groups by Plate and IMN method. None ($p=0.094$) According to Table No. 2, no patient suffered from the complication of limb shortening in the two treatment groups by the Plate and IMN method.

According to Table 3, the time of ability of functional activities in Plate therapy group patients is 3 to 6 months, and in IMN group patients, it is such that most patients started their functional activities under 3 months. Also, there is a significant difference between the ratio of time to perform functional activities in terms of being placed in the two treatment groups by Plate and IMN method ($p<0.001$).

Discussion

This study aimed to compare the side effects of Plate and IMN treatment groups in femur fractures in 60 patients who were admitted to Imam Khomeini Hospital in Jiroft in 2020 with femur fractures and were treated, and at least one year had passed since the patients were discharged. The results of this research showed that in the Plate treatment group, the largest number of patients were in the age group of 50 to 60 years, and in the IMN treatment method, the largest number of patients were in the age group of 30 to 40 years, and this difference was significant; The number of men is more than women in both Plate and IMN treatment groups, but this difference was not statistically significant. In the research of Mehdi Nesab et al., the investigated patients included 12 women and 94 men, and most of the patients were in the age group of 15–35 in the IMN group [38]. Also, in the research of Sharifi et al., of the 40 patients studied, 75% were men and 25% were women, and 78% of the patients with the interlock method and 72% of the patients with the Plate method were men [39]. In Dehghan's study, the average age in the plate group was 28.9 years and in the rod group inside the bone canal was 29.7 years, and out of 42 patients in the plate group, 29 were men and out of 43 patients in the rod group inside the bone canal, 32 were men [40]. In the study of Mousavi et al., in the first group (intraosseous rod) there were 17 men and 7 women with an age range of 17 to 53 years, with an average age of 25 years, and in the second group (screws and plates) there were 20 men and 4 women with an age range of 16–48 years, whose average age was 26 years [41]. All the research reviewed was consistent with the results of the present study.

Among other findings, only 10% of patients from each treatment group had superficial infection after surgery. In Rahim Nia et al.'s study, 8 patients had a superficial infection at the pin site and one patient had osteomyelitis, which is relatively significant, and also in their study, there was a significant relationship between the duration of screw and plate use and the occurrence of pin site infection [42], which is contrary to the findings of the present study. In the study of Handolin et al., 44 patients were treated with retrograde intramedullary IMNs (distal femoral) and were followed up retrospectively for 9 months, three cases of wound superficial infection were

observed, all of which were successfully treated with intravenous antibiotics without the need to revise the wound infection [43].

The number of patients in the IMN group with non-union complications is less than the patients in the Plate treatment group, but this difference was not statistically significant. Metaizaeu's study was conducted at the Belle Isle Hospital in France and it was concluded that fusion of the fracture site can be done in the right position and at a reasonable time [44]. In the study of Kocaoglu et al., 2 patients (4.8%) in the intracanal rod group suffered from delayed bone fusion, which was treated with bone grafting [45]. In Alexa et al.'s study, it was reported that the use of Plate requires large incisions, which is associated with a high rate of non-union or poor bone union [46]. In the study of Leggon et al., 19 patients with IMN were followed up for an average period of 19.3 months, and the rate of healing was 100% without infection or bad bone healing [47]. In the study of Qara Daghi et al., in which 136 cases of femur fractures (81 cases of open fractures and 55 cases of closed nailing) were performed and were followed up for two years, the complication of non-union occurred in 41.4% of the cases, two cases in the closed method and 4 in the closed method. The case happened in the open method and this difference was significant; This significance can be due to the higher sample size in this study compared to our study [48]. In Phipatanakul et al.'s study, 50 patients with femur fractures were examined using the IMN technique. People have been followed up for 52 weeks. No cases of non-union have been observed. The average range of motion of the knee joint was 125 degrees [49]. In the study of Hontzsch and colleagues in Finland, 44 patients who had previously suffered from distal femur fractures (46 fractures) were studied. All these patients have been operated on by the IMN method. The complete healing rate was 95%, which lasted 13.5 weeks on average. In 2 cases, deformity occurred along the limb. One case of non-union and 2 cases of broken screws were also observed [50]. In the study of Cieslik et al., 74 patients with femur fractures referred to a trauma center were studied and 39 patients were treated with the IMN method, in 36 patients (93%) complete bone fusion occurred 4 months after surgery.

The authors of this study considered the appropriate amount of union and that the patients were able to bear weight from about 2 to 6 months, they evaluated the IMN technique as suitable for compound fractures of the femur [51]. In a retrospective study, 43 femoral fractures were evaluated in 43 patients who underwent screw and lid surgery. In this study, the rate of complete healing was 91% and the average time to achieve complete union was 17.5 weeks. The observed complications included: three wound infections (which were treated with washing, debridement, and antibiotics). 3 patients had a severe decrease in range of motion, 3 patients had nonunion with initial treatment, and 14 patients required reoperation [52].

The results show that in the Plate treatment group, the number of those who suffered from deep infection complications after surgery is more than in the IMN group, which is not statistically significant. This suggests that while there may be a trend towards increased infections with plate fixation, the evidence does not support a definitive conclusion regarding the superiority of one method over the other in terms of infection rates. In the study of Paley et al., only one person had a deep infection in the screw and plate treatment method [53]. Also, the findings from the comparison of IMN and plate fixation treatments for femoral shaft fractures align with existing literature that suggests IMN may offer advantages in terms of infection rates and overall outcomes [54, 55]. In the study of Qara Daghi et al., out of 136 cases investigated, 2 cases suffered from deep infection, one case occurred after nailing and one case occurred in polytrauma with an open fracture, which improved after canal reaming treatment and antibiotic administration [48]. The results of all similar studies confirm the results of the present study. In the study of Hontzsch and colleagues in Finland, 44 patients who had previously suffered from distal femur fracture (46 fractures) were studied, and no case of deep infection was observed, but 3 cases of superficial infection were observed. The authors of this study Neil's operation have been considered an acceptable operation for femur fractures [50] in a retrospective study conducted by Ricci et al., 43 femur fractures in 43 patients who were operated by the screw and lid method were evaluated. In this study, the rate of complete healing was 91% and the average time to achieve complete union was 17.5 weeks. The observed complications included: three wound infections (which were treated with washing, debridement, and antibiotics) [52]. A broader meta-analysis suggested that augmentative plating generally leads to better outcomes in terms of union rates and fewer complications when compared to traditional plate fixation methods, particularly in cases of non-union following intramedullary nailing [56].

The number of patients in the IMN group with bad fusion complications is less than the patients in the Plate therapy group. In the study conducted by Shab and his colleagues at the Alabama Hospital, they concluded that the use of IMN therapy in femur fractures causes fewer complications, including poor appetite [57]. Also, in the studies conducted by Reevese et al. [58], Henderson et al. [59], and Kirby et al. [60] it was shown that the use of the IMN treatment method in pediatric femoral shaft fractures has a lower rate of morbidity. The reasons for the occurrence of lower fractures in the IMN group can be due to the high stability in the axis and twisting [61], the

possibility of little movement at the fracture site and as a result speeding up the repair, the lack of damage to the physics and blood vessels to the femur [62] and prevent the two ends of the fracture site from overlapping and the initial angulation after passing both IMNs from the fracture site. The number of patients in the IMN group with claudication is less than the patients in the Plate therapy group, while this difference was not statistically significant. In the study of Azarbal et al., they concluded that if the follow-up period was longer, the analysis of changes in limb shortness and claudication would be more valuable [63].

The results of the present study showed that patients in the IMN treatment group returned to their functional activities faster than those in the Plate treatment group.This aligns with findings from multiple studies that emphasize the benefits of IMN, particularly in facilitating quicker returns to functional activities and reducing the likelihood of complications associated with traditional plate fixation methods. Studies indicate that IMN allows for earlier weight-bearing and functional recovery compared to plate fixation. For instance, a study noted that the operation duration, intraoperative blood loss, hospitalization duration, and fracture healing time were significantly shorter in patients treated with IMN than those treated with plate fixation [64]. IMN has been associated with lower rates of nonunion and complications. A retrospective analysis found that patients who underwent IMN had a significantly lower nonunion frequency than those treated with plate fixation [65]. This is attributed to the stability and mechanical advantages provided by the intramedullary nail, which aligns with the physiological axis of the femur and minimizes soft tissue disruption [18]. Research has shown that IMN leads to improved functional outcomes. For example, a study involving 398 patients found that early stabilization through IMN was linked to better functional recovery and fewer complications compared to open-plating techniques [66]. In Flynn's study in Philadelphia, they concluded that compared to screws and plates, the complications, the length of hospitalization, and the recovery period are less [67]. Also, in another study, it was reported that IMN is an effective method in the treatment of femur fractures, that 12 months or more after surgery, in 80% of femur fractures, the normal range of motion of the knee joint was present. There was no limitation in knee extension [68]. In the study of Dehghan et al., patients treated with a IMN, the time to return to work was 3 months [40].

The advantage of the present study compared to most similar studies is that in this study we did not limit ourselves to the descriptive report of the difference between the two groups, but the difference between the two groups was also analyzed in terms of statistical significance and was evaluated analytically, whereas in most similar studies, only the report The description of the prevalence of each of the variables in two groups is enough (except for those that are significant).

Conclusion

Considering that deep infection, non-union, malunion, claudication, and ability to return to functional activities in the group using IMNs treated was less than the group treated with plates, the treatment method of the femoral fracture using IMNs is the preferred treatment method. These findings suggest that the treatment method of femoral fractures using plates is more effective in promoting better overall outcomes and reducing complications post-treatment. The superiority of plate fixation over IMN fixation in femoral fractures is supported by the study's results. The lower incidence of deep infections, non-union, malunion, and improved ability to return to functional activities in the plate group highlights the importance of considering this treatment approach for femoral fractures.

Limitations of the study

This study was hampered by several limitations. One of the restrictions was the exclusion of some patients from the study because the files did not contain all of the necessary information. Another limitation of this study was the non-homogeneous distribution of age and gender in the studied groups, which can reduce the reliability of the study. Additionally, this study only included patients hospitalized in the Imam Khomeini Hospital in Jiroft. As a result, caution should be exercised when extrapolating the findings. To improve the precision and accuracy, it is advisable to conduct comprehensive and prolonged studies. This research was done cross-sectional, which makes it difficult to conclude causality. Considering the mentioned limitations, it is suggested that future studies be conducted with a larger sample size and in different hospitals so that the findings are more reliable. It is suggested that the results of subsequent studies be analyzed and checked using relevant tests to remove confounding factors. It is also suggested to conduct a study by examining the influencing variables such as physical exercises and physiotherapy in the two study groups.

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Author contributions

SH, MG, AAD, and KH analyzed and interpreted the data. RR, SD, HH, and RF contributors in writing the manuscript. All authors read and approved the final manuscript.

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Data availability
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1975 Helsinki Declaration and its later amendments or comparable ethical standards. In order to comply with the ethical considerations in this research, the information of the participants was kept confidential and other people were not able to access this information. The names and surnames of the participants were not used for data collection, and data collection was done after obtaining the code of ethics from Jiroft University of Medical Sciences. This article reports the results of a research project approved by Jiroft University of Medical Sciences with the code of ethics IR.JMU.REC.1400.005.

Consent to participate
Not applicable. In this research, after receiving the code of ethics from Jiroft University's Research Vice-Chancellor, the data was extracted from the patients' medical files. Therefore, since the data was not directly collected from the patients themselves, there was no need to obtain informed consent from the Participate.

Human and animal rights
No animals were used for the studies that are the basis of this research. All human procedures followed were per the guidelines of the Helsinki Declaration of 1975.

Consent for publication
Not applicable.

Standards of reporting
STROBE guideline has been followed.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Orthopedics, Mashhad University of Medical Sciences, Mashhad, Iran
[2]Department of Orthopedics, School of Medicine, Imam Khomeini Hospital, Jiroft University of Medical Science, Jiroft, Iran
[3]Department of Surgery, School of Medicine, Imam Khomeini Hospital Jiroft University of Medical Sciences, Jiroft, Iran
[4]Department of Nursing, Torbat Jam Faculty of Medical Sciences, Torbat Jam, Iran
[5]Department of Health Services Management, School of Health, Mashhad University of Medical Sciences, Mashhad, Iran
[6]Nephrology and Urology Research Center, Clinical Sciences Institute, Baqiyatallah University of Medical Sciences, Tehran, Iran
[7]Health Education & Promotion, Department of Public Health, School of Public Health, Jiroft University of Medical Sciences, Jiroft, Iran
[8]Epidemiology, School of Medical Sciences Esfarayen Faculty of Medical Sciences, Esfarayen, Iran
[9]Department of Public Health, School of Health, Jiroft University of Medical Sciences, Jiroft, Iran

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