ORIGINAL ARTICLE

DOI: 10.4274/nkmj.galenos.2025.93798
Nam Kem Med J 2026;14(1):52-57

Evaluating The Learning Curve in Suprapatellar Nailing of Tibial Shaft Fractures

Tibial Şaft Kırıklarının Suprapatellar Çivilenmesinde Öğrenme Eğrisinin Değerlendirilmesi

Ömer POLAT, Alper DÜNKİ, Bahattin KEMAH, Çağrı ÖZCAN, Sefa Giray BATIBAY

University of Health Sciences Türkiye, Ümraniye Training and Research Hospital, Clinic of Orthopeadics and Traumatology, İstanbul, Türkiye

ABSTRACT

Aim: Tibial shaft fractures constitute approximately 2% of all fractures. Intramedullary nails are considered the gold standard in their treatment due to less soft tissue damage and biomechanical superiority. The learning curve is an expression of how quickly and efficiently a person learns a skill or process in a certain period. Our aim in this study is to analyze the suprapatellar nailing learning curve, using operative time and total fluoroscopy time as outcome measures.

Materials and Methods: Between January 2021 and December 2021, patients aged 18-65 with fresh tibial shaft fractures, no open fractures, who underwent surgery with a senior physician and had complete records, were included in the study. Forty-seven patients met the inclusion criteria. Demographic data of the patients, fracture types, side, surgical duration and total fluoroscopy dose were examined.

Results: Surgeon-1 operated on 23 patients (48.9%) and surgeon-2 on 24 patients (51.1%). The study included 34 males (72.3%) and 13 females (27.7%), with a mean age of 36.11±12.92 years (range: 19-64). Mean operative time was 64.89±10.41 minutes (range: 48-90), and the number of fluoroscopy shots averaged 54.09±13.46 (range: 30-78). No significant differences were observed regarding gender, age, side, or operative time ($p>0.05$). Over time, both surgeons showed a significant decrease in operative duration, with surgeon-1 reducing time by 1.557 minutes per case [beta (ß)=-1.557; $p=0.001$] and surgeon-2 by 0.847 minutes (ß=-0.847; $p=0.001$). No significant learning curve was found for fluoroscopy usage ($p>0.05$).

Conclusion: Our study showed that the suprapatellar intramedullary nailing technique resulted in a significant reduction in operative time and a significant regression curve.

Keywords: Tibia shaft fracture, intramedullary nailing, suprapatellar technique, learning curve

ÖZ

Amaç: Tibial şaft kırıkları tüm kırıkların yaklaşık %2'sini oluşturur. İntramedüller çiviler, daha az yumuşak doku hasarı ve biyomekanik üstünlük nedeniyle tedavilerinde altın standart olarak kabul edilir. Öğrenme eğrisi, bir kişinin belirli bir sürede bir beceriyi veya işlemi ne kadar hızlı ve verimli bir şekilde öğrendiğinin bir ifadesidir. Bu çalışmadaki amacımız, sonuç ölçütleri olarak operasyon süresi ve toplam floroskopi süresini kullanarak suprapatellar çivileme öğrenme eğrisini analiz etmektir.

Gereç ve Yöntem: Ocak 2021 ile Aralık 2021 tarihleri arasında, açık kırığı olmayan, kıdemli bir hekim tarafından ameliyat edilen ve kayıtları tam olan, 18-65 yaş aralığındaki taze tibial şaft kırığı olan hastalar çalışmaya dahil edildi. Kırk yedi hasta dahil etme kriterlerini karşıladı. Hastaların demografik verileri, kırık tipleri, taraf, cerrahi süresi ve toplam floroskopi dozu incelendi.

Bulgular: Cerrah-1 23 hastayı (%48,9) ve cerrah-2 24 hastayı (%51,1) ameliyat etti. Çalışmaya 34 erkek (%72,3) ve 13 kadın (%27,7) dahil edildi ve ortalama yaşları 36,11±12,92 yıldı (aralığı: 19-64). Ortalama ameliyat süresi 64,89±10,41 dakikaydı (aralığı: 48-90) ve floroskopi çekim sayı ortalaması 54,09±13,46'ydı (aralığı: 30-78). Cinsiyet, yaş, taraf veya ameliyat süresi açısından anlamlı bir fark gözlenmedi ($p>0,05$). Zamanla, her iki cerrah da

Address for Correspondence: Ömer POLAT MD, University of Health Sciences Türkiye, Ümraniye Training and Research Hospital, Clinic of Orthopeadics and Traumatology, İstanbul, Türkiye
E-mail: dromer.polat@gmail.com **ORCID ID:** orcid.org/0000-0002-6847-3555
Received: 11.04.2025 **Accepted:** 23.12.2025 **Publication Date:** 04.03.2026

Cite this article as: Polat Ö, Dünki A, Kemah B, Özcan Ç, Batıbay SG. Evaluating the learning curve in suprapatellar nailing of tibial shaft fractures. Nam Kem Med J. 2026;14(1):52-57

operasyon süresinde önemli bir azalma gösterdi; cerrah-1 olgu başına süreyi 1,557 dakika [beta (ß)=-1,557; p=0,001] ve cerrah-2 0,847 dakika (ß=-0,847; p=0,001) azalttı. Floroskopi kullanımında önemli bir öğrenme eğrisi bulunamadı (p>0,05).

Sonuç: Çalışmamız, suprapatellar intramedüller çivileme tekniğinin ameliyat süresinde anlamlı azalma ve belirgin regresyon eğrisi ile sonuçlandığını göstermiştir.

Anahtar Kelimeler: Tibia şaft kırığı, intramedüller çivileme, suprapatellar teknik, öğrenme eğrisi

INTRODUCTION

Tibial shaft fractures constitute approximately 2% of all fractures[1]. Surgical treatment methods such as external fixation osteosynthesis, plate-screw osteosynthesis, and intramedullary nail and screw fixation are available for tibial shaft fractures. Studies and experience have shown that intramedullary fixation methods are more advantageous in terms of success and complications[2,3]. It is accepted as the gold standard due to less soft tissue damage and being biomechanically superior[4]. In addition, fewer wound complications and higher union rates have been reported in the literature with intramedullary nailing[5].

Intramedullary nailing technique for tibial shaft fractures is performed by passing the skin with an infrapatellar incision opened from the inferior part of the patella in knee flexion and passing the patellar tendon with a transverse or parapatellar technique. This method has reported serious union and satisfaction rates in tibial shaft fractures. However, it has been experienced over time that anterior knee pain and joint stiffness complaints affect the quality of life in these patients and are the main source of problems for clinicians during follow-ups[6]. For this reason, it is noteworthy in the literature that the use of the suprapatellar technique is becoming more widespread with the aim of fewer knee joint problems and ease of surgical application[7,8].

Learning an orthopedic surgical procedure requires theoretical knowledge, intraoperative decision-making skill, mastery of fluoroscopy, and technical application that respects soft tissue. In this context, orthopedic surgery includes a certain learning curve and many parameters, such as complication rates, surgical duration, and radiation exposure, are evaluated as an indicator of this process. The learning curve is an expression that indicates how quickly and efficiently a person learns a skill or process in a certain period. The learning curve represents a graphical result between the learning effort and the learning result[9]. Defining a new technique's learning curve is important for instructors and practitioners. It provides information about the surgeon's experience and also provides confidence in the management of complications that may occur. When the suprapatellar nailing method is compared with the infrapatellar method, which is known and whose treatment adequacy is sufficiently proven, it is important to investigate the existence of a learning curve. This study aims to analyze the suprapatellar nailing learning curve by taking the surgery time and the total number of fluoroscopy shots as the outcome measures.

MATERIALS AND METHODS

This retrospective, single-center study was conducted at the Orthopedics and Traumatology Clinic of University of Health Sciences Türkiye, Ümraniye Training and Research Hospital between January and December 2021. Ethical approval was obtained from the University of Health Sciences Türkiye, Ümraniye Training and Research Hospital Ethics Committee (decision number: 50, date: 13.03.2025) in accordance with the Declaration of Helsinki. Two senior orthopedic specialists who had successfully treated at least 30 tibial shaft fractures with intramedullary nailing in the last two years and attended the necessary training and courses [Turkish Orthopedic Association and Arbeitsgemeinschaft für Osteosynthesefragen (AO)] courses were determined. Tibial shaft fractures were operated on randomly by two surgeons. The surgical technique was standardized using the same order in each case. The patient was in the supine position and elevated with a specially prepared sponge pillow under the leg (Figure 1). Trigen, Metanail, semi-extended (Smith & Nephew, London, UK) nails suitable for suprapatellar access were used in all cases. Demographic data of the patients, fracture types, side, surgical time, and total number of fluoroscopy shots were examined.

Inclusion criteria were determined as patients with fresh tibial shaft fractures between the ages of 18-65, no open fracture, operated by a senior physician, and appropriate records kept. Exclusion criteria were determined as cases with open fracture, another surgical team, insufficient records, and cases without appropriate equipment.

Between January and December 2021, 84 patients underwent intramedullary nailing for tibial shaft fractures. After excluding 18 open fractures, 12 cases operated on by another team, 3 treated with different implants, and 4 with incomplete data, 47 patients were included. Of these, 23 were operated on by surgeon-1 and 24 by surgeon-2. The total number of fluoroscopy shots was recorded for all procedures examined. A single X-ray image intensifier (Philips Zenition 50) was used for all procedures examined. Surgical times were determined as the time from the initial incision to the final suture after

Figure 1. Surgical position and incision line

appropriate alignment and fixation of the fracture.

This was a retrospective study using consecutive patients treated during the surgeons' initial experience with the suprapatellar technique. No formal a priori sample-size calculation was performed. Post-hoc power analysis based on the observed effect sizes demonstrated >0.95 power for detecting the learning-curve effect on operative time; however, the power for detecting a moderate learning effect on the number of fluoroscopy shots was only approximately 0.20-0.30. Therefore, the absence of a significant learning curve for the number of fluoroscopy shots should be interpreted with caution, as the study may have been underpowered for this secondary outcome.

Statistical Analysis

Statistical analysis were performed using SPSS 27 (IBM Corp., Armonk, NY, USA). Quantitative variables were expressed as mean ± standard deviation, median, and range (min-max). Qualitative variables were summarized using descriptive statistics, including frequencies and percentages.

Normality of distribution was assessed using the Shapiro-Wilk test and Box-Plot visualizations. For normally distributed data comparing two groups, the independent Student's t-test was applied. Categorical variables were analyzed with the Pearson chi-square test.

To evaluate the learning curve of surgeons, linear regression analysis was conducted for operating time and the number of fluoroscopy shots. All results were interpreted within a 95% confidence interval, and statistical significance was set at $p<0.05$.

RESULTS

A total of 47 patients who underwent suprapatellar intramedullary nailing for tibial shaft fractures between January and December 2021 were included in this study. Surgeries were performed randomly by two senior surgeons: surgeon-1 operated on 23 patients (48.9%) and surgeon-2 on 24 patients (51.1%). The cohort consisted of 34 males (72.3%) and 13 females (27.7%), with a mean age of 36.11±12.92 years (range: 19-64). Fractures involved the right side in 27 patients (57.4%) and the left in 20 patients (42.6%). The mean operative time was 64.89±10.41 minutes (range: 48-90), and the mean number of fluoroscopy shots was 54.09±13.46 shots (range: 30-78) (Table 1).

Fracture types of the patients were determined according to AO/Orthopaedic Trauma Association classification[10]. No statistically significant difference was found between gender, side, and age of the patients according to surgeons ($p>0.05$). No statistically significant difference was found between surgery times according to surgeons ($p>0.05$). The number of fluoroscopy shots of surgeon-2 was found to be statistically significantly longer than surgeon-1($p=0.002$; $p<0.01$) (Table 2).

Table 1. Demographic characteristics

		n (%)
Gender	**Male**	34 (72.3)
	Female	13 (27.7)
Age	Mean ± SD	36.11±12.92
	Median (mini-maximum)	31 (19-64)
Side	**Right**	27 (57.4)
	Left	20 (42.6)
Fracture type	**42A1**	13 (27.6)
	42A2	7 (14.9)
	42A3	8 (17.0)
	42B1	6 (12.8)
	42B2	8 (17.0)
	42B3	5 (10.6)
Duration of surgery (minimum)	Mean ± SD	64.89±10.41
	Median (mini-maximum)	62 (48-90)
Number of fluoroscopy shots	Mean ± SD	54.09±13.46
	Median (mini-maximum)	55 (30-78)
Surgeons	**Senior surgeon-1**	23 (48.9)
	Senior surgeon-2	24 (51.1)

SD: Standard deviation

Table 2. Comparison of data according to surgeons

		Surgeon-1	Surgeon-2	p-value
Gender	**Male**	14 (60.9)	20 (83.3)	0.085
	Famale	9 (39.1)	4 (16.7)	
Age	Mean ± SD	39.39±15.63	32.96±8.88	0.088
	Median (mini-maximum)	33 (19-64)	31 (20-51)	
Side	**Right**	9 (39.1)	18 (75.0)	0.013*
	Left	14 (60.9)	6 (25.0)	
Duration of surgery (minimum)	Mean ± SD	64.17±12.51	65.58±8.12	0.132
	Median (mini-maximum)	60 (48-90)	63.5 (56-90)	
Number of fluoroscopy shots	Mean ± SD	47.74±11.72	60.17±12.34	**0.002****
	Median (mini-maximum)	49 (30-66)	62 (30-78)	

*p<0,05, **p<0,01, Pearson chi-square test, Student's t-test, SD: Standard deviation

Table 3. Learning curve statistical analysis

Dependent variable	Independent variable	ß	SE	%95 CI	p-value	R2
Duration of surgery	Surgeon-1	-1.577	0.209	-2.011/-1.143	0.001**	0.731
	Surgeon-2	-0.847	0.165	-1.190/-0.504	0.001**	0.543
Number of fluoroscopy shots	Surgeon-1	0.197	0.375	-0.540/0.935	0.603	0.040
	Surgeon-2	0.050	0.372	-0.684/0.785	0.893	0.010

**p<0,01, ß: Beta, SE: Standard error, CI: Confidence interval

When the learning outcomes of the surgery duration in surgeons are examined, the surgery duration decreased significantly over time. Surgeon-1 shortened the surgery duration faster than surgeon-2. While the surgery duration of surgeon-1 decreased by an average of 1.557 minutes [beta (ß):-1.557; p=0.001; p<0.01] with each case, this decrease was 0.847 (ß:-0.847; p=0.001; p<0.01) minutes for surgeon-2. These results show that surgeon-1 adapted to the suprapatellar technique faster and reduced the surgery duration more effectively (Table 3). When the regression curve is drawn as a figure, it is seen that there is a significant decrease and that it intersects after approximately 10 cases. After the intersection, it is seen that the duration starts to plateau and the curves tend to be parallel (Figure 2).

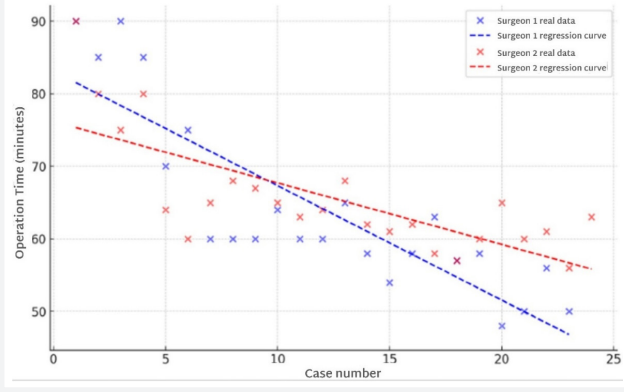

Figure 2. Regression curve of operation time and number of cases

There was no significant learning curve in terms of number of fluoroscopy shots (p>0.05). It was observed that there was no significant decrease in the number of fluoroscopy shots over time. This was the result for both surgeons. As shown in the figure, there is a more parallel curve (Figure 3).

DISCUSSION

The results of this study show that there can be a learning curve in terms of surgery time during the recognition phase of the suprapatellar nailing technique performed by two senior surgeons. After approximately 10 cases, an intersection in the regression curve in terms of surgery time and then a parallel course are shown graphically. It has been shown that there is no significant change in terms of the number of fluoroscopy shots. This shows us that there is no decrease or increase in intraoperative radiation exposure with learning.

In our study, surgery time was determined as the time during which skin-to-skin alignment and fixation were achieved. The first studies conducted with the suprapatellar technique showed that surgery time did not create a significant difference when compared to the infrapatellar technique[11,12]. As the technique developed, studies conducted showed that surgery

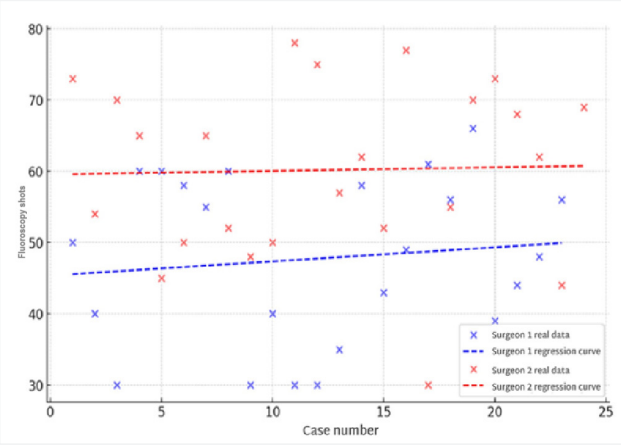

Figure 3. Regression plateau of the number of fluoroscopy shots and the number of cases

times were stated to be much shorter than the infrapatellar technique[7,13]. In the infrapatellar technique, the knee must be in a flexed position. This situation causes reduction problems and entry site problems, especially in proximal fractures, and causes a loss of time. This problem is minimal in the suprapatellar method. Since the entry point is proximal to the patella and the patient is in the supine position, it has been observed that there is less time loss with reduction because the leg is extended. In addition, it is thought that the time loss between the flexion position and the supine position in distal screw locking is due to the less time spent in favor of the supine position. There are many studies indicating patellar tendon and infrapatellar tendon damage with the infrapatellar technique[12,14,15]. Due to the increase in anterior knee pain and pain complaints in patients followed with the infrapatellar technique, the suprapatellar technique has been tried to be developed. However, there is a risk of chondral damage in the patellofemoral joint with this technique[16,17]. Since the studies on this subject are not sufficient, it is open to investigation. With the replacement of open surgeries with minimally invasive and intramedullary techniques, X-ray exposure for fracture reduction and stabilization status control has increased. This poses a risk for people in the operating room during surgery[18]. The potential for increased neoplastic activity, even in the low-dose range used at the time of fluoroscopy, has been known for many years[19]. It has been shown that the risk of cataract increases in people exposed to low-dose ionizing radiation for a long time[20]. Studies have shown that the surgeon's hand faces the highest radiation exposure. The thyroid and eyes are sensitive to radiation and can be affected even at low doses[18].

Although segmental comminuted fractures and open fractures were not included in our study in order to standardize the sample group as much as possible, the results showed that the fluoroscopy period was not included in the learning curve. When we investigated the reason for this, no organic problem was found. However, we think that differences in the surgeons' habits may have caused this. In the first cases, it was observed that surgeons were more meticulous during the entry site problems and the medullary canal during nailing and followed the canal path step by step. It was observed that this habit did not decrease over time and continued. This shows us that fluoroscopy is needed in cases regardless of the number of cases.

Allen et al.[13] mentioned a significant decrease in the number of fluoroscopy shots in their study comparing the suprapatellar technique with the infrapatellar technique. They stated that there was a significant decrease in the duration of surgery and the number of fluoroscopy shots between the two groups. In contrast to these data, recent studies have indicated that no significant difference was observed in terms of the number of fluoroscopy shots[11,21]. We thought that the comparison would not be useful for us in the learning curve during the planning phase. Because we think that comparisons made with the curve of the infrapatellar technique, which has been a successful and proven method for a long time, will not yield significant results.

Study Limitations

Our study has some limitations. Although we standardized the fracture pattern and surgeon experience as much as possible, surgical skill was an uncontrolled variable. Another limitation was the surgeons' habits. The average time between the two surgeons was significantly different ($p=0.002$; $p<0.01$). Although all other conditions were tried to be standardized, there was no standardization of the surgical team (anesthesia team, assistant surgical team, radiology technician).

CONCLUSION

Our study demonstrated that the suprapatellar intramedullary nailing technique was associated with a significant reduction in operative time, accompanied by a distinct regression curve indicative of a measurable learning process. Surgeons adapted rapidly to this technique, showing improved ability in fracture reduction and fixation over time. However, no significant decrease in the number of fluoroscopy shots was observed, nor was there evidence of a corresponding regression curve for this parameter. These findings suggest that while the suprapatellar approach facilitates quicker technical adaptation and enhanced intraoperative efficiency, further prospective studies with larger cohorts and longer follow-up periods are necessary to validate and generalize these results.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the University of Health Sciences Türkiye, Ümraniye Training and Research Hospital Ethics Committee (decision number: 50, date: 13.03.2025) in accordance with the Declaration of Helsinki.

Informed Consent: This is retrospective, single-center study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: B.K., Ç.Ö., Concept: Ö.P., Ç.Ö., Design: Ö.P., B.K., S.G.B., Data Collection or Processing: Ö.P., S.G.B., Analysis or Interpretation: Ö.P., A.D., Ç.Ö., Literature Search: Ö.P., A.D., Writing: Ö.P., A.D., B.K., Ç.Ö., S.G.B.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. Injury. 2006;37:691-7.
2. Blachut PA, O'Brien PJ, Meek RN, Broekhuyse HM. Interlocking intramedullary nailing with and without reaming for the treatment of closed fractures of the tibial shaft. a prospective, randomized study. J Bone Joint Surg Am. 1997;79:640-6.
3. Donegan DJ, Akinleye S, Taylor RM, Baldwin K, Mehta S. Intramedullary nailing of tibial shaft fractures: size matters. J Orthop Trauma. 2016;30:377-80.
4. Bhandari M, Guyatt GH, Tong D, Adili A, Shaughnessy SG. Reamed versus nonreamed intramedullary nailing of lower extremity long bone fractures: a systematic overview and meta-analysis. J Orthop Trauma. 2000;14:2-9.
5. Foote CJ, Guyatt GH, Vignesh KN, Mundi R, Chaudhry H, Heels-Ansdell D, et al. Which surgical treatment for open tibial shaft fractures results in the fewest reoperations? A network meta-analysis. Clin Orthop Relat Res. 2015;473:2179-92.
6. Nyland J, Bealle DP, Kaufer H, Johnson DL. Long-term quadriceps femoris functional deficits following intramedullary nailing of isolated tibial fractures. Int Orthop. 2001;24:342-6.
7. Cepni SK, Kemah B, Karataş ME, Oruç MM, Batar S, Söylemez MS. Comparison of clinical and radiological results after a minimum one-year follow-up of tibial fractures operated via suprapatellar or infrapatellar intramedullary nailing: a retrospective study. Jt Dis Relat Surg. 2023;34:679-86.
8. Parikh S, Marsh L, Anderson M, Scott J, Patel A, Hendrix C, et al. Anterior knee pain and knee functional scores following common approaches to tibial shaft fractures: a systematic review. JB JS Open Access. 2025;10:e24.00119.
9. Pusic MV, Kessler D, Szyld D, Kalet A, Pecaric M, Boutis K. Experience curves as an organizing framework for deliberate practice in emergency medicine learning. Acad Emerg Med. 2012;19:1476-80.
10. Meinberg EG, Agel J, Roberts CS, Karam MD, Kellam JF. Fracture and dislocation classification compendium-2018. J Orthop Trauma. 2018;32 Suppl 1:S1-170.
11. Wang C, Chen E, Ye C, Pan Z. Suprapatellar versus infrapatellar approach for tibia intramedullary nailing: a meta-analysis. Int J Surg. 2018;51:133-9.
12. Ozcan C, Turkmen I, Sokucu S. Comparison of three different approaches for anterior knee pain after tibia intramedullary nailing. Eur J Trauma Emerg Surg. 2020;46:99-105.
13. Allen JD, Matuszewski PE, Comadoll SM, Hamilton DA, Abbenhaus EJ, Aneja A, et al. The learning curve of suprapatellar nailing: adoption over time can decrease operative time and radiation exposure. J Orthop Trauma. 2020;34:370-5.
14. Fu B. Locked META intramedullary nailing fixation for tibial fractures via a suprapatellar approach. Indian J Orthop. 2016;50:283-9.
15. Ponugoti N, Rudran B, Selim A, Nahas S, Magill H. Infrapatellar versus suprapatellar approach for intramedullary nailing of the tibia: a systematic review and meta-analysis. J Orthop Surg Res. 2021;16:94.
16. Sanders RW, DiPasquale TG, Jordan CJ, Arrington JA, Sagi HC. Semi-extended intramedullary nailing of the tibia using a suprapatellar approach: radiographic results and clinical outcomes at a minimum of 12 months follow-up. J Orthop Trauma. 2014;28:245-55.
17. Chan DS, Serrano-Riera R, Griffing R, Steverson B, Infante A, Watson D, et al. Suprapatellar versus ınfrapatellar tibial nail ınsertion: a prospective randomized controlled pilot study. J Orthop Trauma. 2016;30:130-4.
18. Matityahu A, Duffy RK, Goldhahn S, Joeris A, Richter PH, Gebhard F. The great unknown-a systematic literature review about risk associated with intraoperative imaging during orthopaedic surgeries. Injury. 2017;48:1727-34.
19. Frankenberg D, Kelnhofer K, Bär K, Frankenberg-Schwager M. Enhanced neoplastic transformation by mammography X rays relative to 200 kVp X rays: indication for a strong dependence on photon energy of the RBE(M) for various end points. Radiat Res. 2002;157:99-105.
20. Chodick G, Bekiroglu N, Hauptmann M, Alexander BH, Freedman DM, Doody MM, et al. Risk of cataract after exposure to low doses of ionizing radiation: a 20-year prospective cohort study among US radiologic technologists. Am J Epidemiol. 2008;168:620-31.
21. van de Pol GJ, Axelrod DE, Conyard C, Tetsworth KD. A suprapatellar approach, when compared with an ınfrapatellar approach, yields less anterior knee pain and better patellofemoral joint function, for ıntramedullary nailing of diaphyseal tibial fractures: results of a randomized controlled trial. J Orthop Trauma. 2024;38:235-9.