



Suprapatellar approach for fractures of the tibia: Does the fracture level matter?

Tibia kırıklarında suprapatellar yaklaşım: Kırık düzeyinin önemi var mı?

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ABSTRACT

Objectives: This study aims to evaluate proximal, shaft, and distal tibial fractures treated with suprapatellar (SP) tibial intramedullary nailing (IMN) in terms of alignment, healing, and patellofemoral (PF) pain.

Patients and methods: The study included 58 patients (41 males, 17 females; mean age 42.9 years; range, 18 to 75 years) treated via the SP approach in semiextension. Suprapatellar IMN surgeries were performed by two surgeons. After a minimum of 12 months of follow-up, patients' genders, ages, limb sides, fracture types, and classifications were recorded. Fracture reduction accuracy, angulation, PF arthritis, healing time, complications, and nonunions were analyzed. Anterior knee pain, visual analog scale (VAS), and Lysholm knee scoring scale were used as clinical measurements.

Results: Seventeen fractures were in the proximal third, while 22 were in the middle third and 19 were in the distal third of the tibia. The mean healing time was 7.14 months (range, 4 to 13 months); differences in healing time between fracture locations were not statistically significant ($p=0.83$). The mean follow-up duration was 19.83 months (range, 12 to 30 months); there were no statistically significant differences in follow-up times in terms of fracture sites ($p=0.51$). The VAS score for the knee was 0 in 49 patients (84.5%) and <3 in nine patients (15.5%). The Lysholm score differences between the fracture location groups were not statistically significant ($p=0.33$).

Conclusion: Suprapatellar tibial IMN can be applicable to extra-articular tibial fractures in all locations. Providing easy anatomic reduction in semiextension, convenient fluoroscopic imaging, safety for the PF joint, acceptable anterior knee pain, and satisfactory functional outcomes render SP approach more feasible.

Keywords: Anterior knee pain, patellofemoral joint, suprapatellar nailing, tibial fractures.

ÖZ

Amaç: Bu çalışmada suprapatellar (SP) tibia intramedüller çivileme (İMÇ) yöntemi ile tedavi edilen tibia proksimal, cisim ve distal kırıkları dizilim, kaynama ve patellofemoral (PF) ağrı yönünden değerlendirildi.

Hastalar ve yöntemler: Çalışmaya semiekstansiyonda suprapatellar yaklaşım ile tedavi edilen 58 hasta (41 erkek, 17 kadın; ort. yaş 42.9 yıl; dağılım, 18-75 yıl) dahil edildi. Suprapatellar İMÇ cerrahileri iki cerrah tarafından yapıldı. En az 12 aylık takip sonrası hastaların cinsiyeti, yaşı, uzuv tarafı, kırık tipi ve sınıflandırması kaydedildi. Kırık redüksiyonu doğruluğu, açılanma, PF artrit, iyileşme zamanı, komplikasyonlar ve kaynamama analiz edildi. Klinik ölçümlerde diz önu ağrısı, görsel analog ölçeği (GAÖ) ve Lysholm diz skorlama ölçeği kullanıldı.

Bulgular: On yedi kırık tibianın proksimal 1/3'ünde, 22 kırık orta 1/3'ünde ve 19 kırık distal 1/3'ünde idi. Ortalama iyileşme zamanı 7.14 ay (dağılım, 4-13 ay) idi; kırık yerleşimleri arasında iyileşme zamanı açısından farklılıklar istatistiksel olarak anlamlı değildi ($p=0.83$). Ortalama takip süresi 19.83 ay (dağılım, 12-30 ay) idi; takip sürelerinde kırık yerleşimleri açısından istatistiksel olarak anlamlı farklılık yoktu ($p=0.51$). Diz için GAÖ skoru 49 hastada (%84.5) 0 ve dokuz hastada (%15.5) <3 idi. Kırık yerleşimi grupları arasında Lysholm skoru farklılıkları istatistiksel olarak anlamlı değildi ($p=0.33$).

Sonuç: Suprapatellar tibia İMÇ tüm yerleşimlerdeki eklem dışı tibia kırıklarında uygulanabilir. Semiekstansiyonda kolay anatomik redüksiyon, elverişli floroskopik görüntüleme, PF eklemden güvenlilik, kabul edilebilir diz önu ağrısı ve iyi fonksiyonel sonuçlar sağlaması SP yaklaşımı daha kullanışlı kılmaktadır.

Anahtar sözcükler: Diz önu ağrısı, patellofemoral eklem, suprapatellar çivileme, tibia kırıkları.

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Tibial fractures are among the most common long bone fractures observed in the body.^[1,2] Most tibial fractures are caused by either high-energy trauma, such as motor vehicle accidents, in young patients or low-energy trauma, such as falls, among older adults. Surgical treatment of tibial fractures via intramedullary nailing (IMN) is a common practice.^[1,3-5] Intramedullary nailing is a biomechanical load-sharing device that has the potential advantages of early rehabilitation and weight bearing.^[1,3,5] Intramedullary nailing also possesses other major benefits such as minimal soft tissue damage and preservation of extraosseous blood supply.^[6,7]

Recently, several techniques have been described for IMN of the tibia, including the medial parapatellar, lateral parapatellar, and transpatellar routes. All of these techniques are traditionally infrapatellar (IP) approaches.^[7-10] Although the IP approach is a well-known technique, high rates of malunion, malreduction, and fixation failure of the proximal fragment are still reported in proximal tibial fractures treated via the IP approach.^[7,11,12] In standard IP technique, the knee is usually flexed or hyperflexed during surgery.^[4,7,9,10,13] In the hyperflexed position, sagittal dislocating forces caused by the quadriceps tendon on the proximal part of the tibia can lead to malreduction in apex anterior angulation.^[3,7,8,10,14,15] Additional tools, such as plates, external fixators, and blocking screws might be required to avoid malalignment after IMN. To overcome these drawbacks, the semiextended nailing technique, using a medial parapatellar entry route after lateral subluxation of patella, was described by Tornetta and Collins.^[11] Moreover, the suprapatellar (SP) approach using the midline quadriceps tendon has been recently proposed.^[7,13,16]

The SP approach facilitates fracture reduction, prevents malalignment, and simplifies intraoperative imaging.^[6,7,10] Although there are many potential advantages of the SP approach, implant removal, anterior knee pain and patellofemoral (PF) joint damage remain highly controversial. There have been many studies on proximal tibial fractures, but studies on distal and tibial shaft fractures are limited. In this study, we aimed to evaluate proximal, shaft, and distal tibial fractures treated with SP tibial IMN in terms of alignment, healing, and PF pain.

PATIENTS AND METHODS

Between July 2014 and October 2016, 105 tibial shaft fractures were treated with tibial IMN at Sakarya University Training and Research Hospital. Vast majority of tibial fractures were treated

via semiextended approach without any special indication except immobile PF joint, grade IV arthrosis, and nightshift surgeries. All of SP tibial IMN surgeries were performed by two surgeons. This nonrandomized retrospective study included 58 patients (41 males, 17 females; mean age 42.9 years; range, 18 to 75 years) treated via the semiextended approach through the SP route. Remaining 47 patients were treated via IP approach. Inclusion criteria were skeletally mature patients, type 1 and 2 open or closed tibial fractures operated via SP route, with a minimum of 12-month follow-up. Exclusion criteria were skeletally immature patients, fractures of intra-articular extension, type 3 open fractures or nailing for tibial pseudarthrosis. Patient data on gender, age, limb side, and fracture type and classification were recorded. The Arbeitsgemeinschaft für Osteosynthesefragen (AO)/Orthopaedic Trauma Association (OTA) system was used for fracture classification. The study protocol was approved by the Sakarya University Ethics Committee (No. 71522473/050.01.04/51). A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

All fractures were treated with SP route tibial IMN within 48 hours after registration in the emergency room. First, spinal anesthesia was applied to the patients. A pneumatic tourniquet was not inflated prior to surgery. Then, the leg was prepared in a semiextended position with a towel under the knee in 15 degrees of flexion (Figure 1a, b). A SP midline incision was made 3 cm from the superior to proximal pole of the patella. The quadriceps tendon was sharply split along the midline to enter the SP pouch (Figure 1c). A trocar was inserted into the anterosuperior edge of the tibia via the SP portal in order to protect the PF joint (Figure 1d). Subsequently, a K-wire was inserted through the trocar under fluoroscopic guidance to identify the nail starting point (Figure 1e, f). The starting point was determined, according to the method of McConnell et al.,^[17] as the medial to lateral intercondylar tubercle in the coronal plane and just anterior to ventral edge of the joint surface on the sagittal plane (Figure 1g, h). The position of the K-wire was checked with a biplanar fluoroscopy system (Figure 1e, f). The tibial fracture was minimized, and reduction maintenance was achieved in the semiextended position during surgery. After proximal reaming, the guide-wire was inserted into the intramedullary canal to prepare for nail insertion (Figure 1i). Then, the nail was placed in the intramedullary canal (Figure 1j, k).



Figure 1. (a, b) Semiextended position. (c) Midline quadriceps splitting. (d) Protective trocar placement. (e, f) K-wire placement under fluoroscopy (g, h) starting point under fluoroscopic guidance. (i) Reaming intramedullary canal (j, k) nail insertion.

Distal and proximal locking screws were implanted with fluoroscopic guidance. Finally, the end-cap was inserted, and fluoroscopic images were checked. Patients were encouraged to bear weight progressively after surgery. Knee and ankle range of motion (ROM) were supported. Moreover, quadriceps were gradually strengthened by physical therapy.

Radiographs of the entire tibia and knee were checked after surgery in the coronal and sagittal planes (Figure 2). Patellar sunrise (merchant) images were also taken to evaluate the PF joint (Figure 2). Radiological measurements on X-rays were examined as follows: fracture reduction accuracy, angulation, PF arthritis, and fracture healing. Kellgren-Lawrence (KL) classification was used for radiologic evidence of PF osteoarthritis.^[18] This classification system was based on severity of osteoarthritis which assigned a grade from 0 to IV, grade 0 signifying no presence of osteoarthritis while grade IV signifying severe osteoarthritis.

Patellofemoral pain was measured by visual analog scale (VAS) after fracture healing. The Lysholm knee scoring scale was used for clinical measurements. Those measurements were obtained from patients at

the last follow-up examination. Fracture healing time, complications, and nonunions were noted.

Statistical analysis

Statistical analyses were performed with the SPSS version 15.0 software (SPSS Inc., Chicago, IL, USA). Descriptive statistics were reported as the mean \pm standard deviation (SD), minimum-maximum, number, and percentage. The t-test was used to compare the measured data of the binary groups, whereas the chi-square test was used to compare count data. One-way analysis of variance was conducted to determine the significant differences among the groups. A *p* value of <0.05 was considered to be statistically significant.

RESULTS

The mean age of the male patients was 40.1 years (range, 18 to 75 years), and females had a mean age of 45.0 years (range, 18 to 68 years). Fractured limb side, open fractures, and additional fractures are presented in Table I. According to AO classification, fractures were as follows: 30 42A, 16 42B, and 12 42C. Seventeen fractures were in the proximal third of the tibia, while 22 were in the middle third, and 19

were in the distal third. Patient demographics and fracture variables are presented in Table I.

Fracture reduction was achieved in anatomic lines in all patients with the exception of a five-degree valgus in the coronal plane for one proximal fracture. The mean fracture healing time was 7.14 months (range, 4 to 13 months). The difference

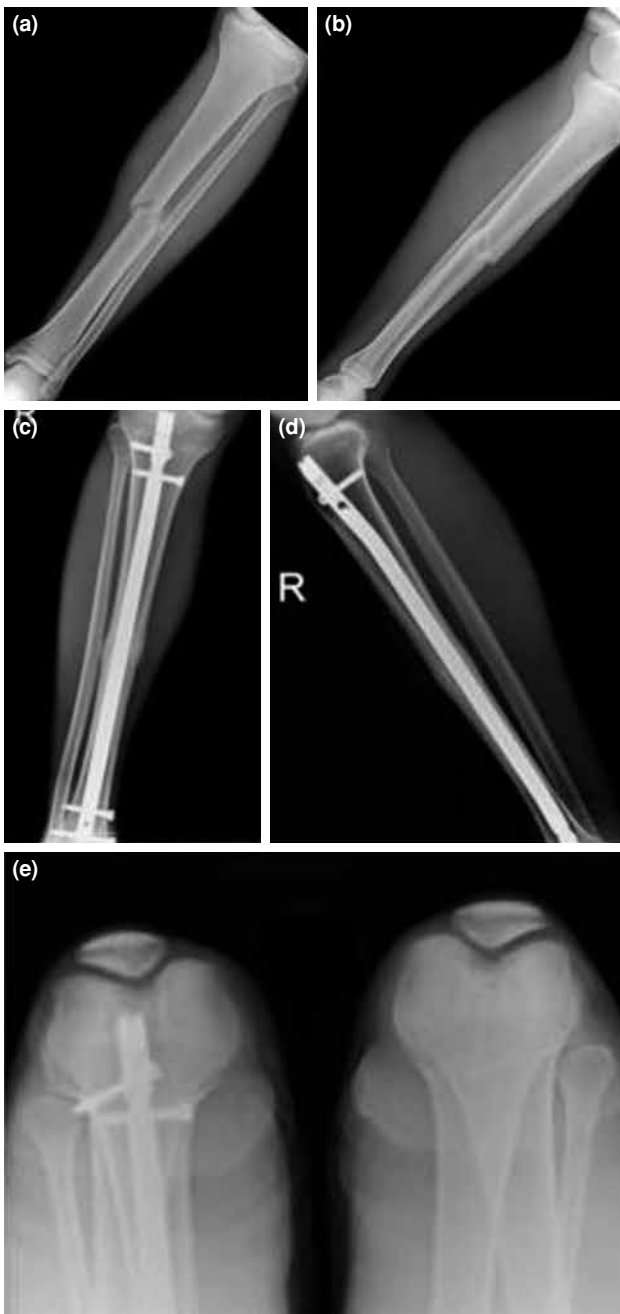


Figure 2. Right tibial shaft fracture of a 20-year-old male patient. Preoperative (a) anteroposterior and (b) lateral radiographs. After 13 months of follow-up, (c) anteroposterior and (d) lateral radiographs. (e) Merchant patella radiography.

in fracture healing time between fracture locations was statistically insignificant ($p=0.83$). The mean follow-up time was 19.83 months (range, 12 to 30). The difference in fracture healing times between males and females was statistically insignificant ($p=0.90$). Differences in follow-up times by gender and fracture site were not statistically significant ($p=0.63$ and $p=0.51$, respectively).

Anterior knee pain was mild in nine patients (15.5%) ($VAS<3$) and painless in 49 patients (84.5%) ($VAS=0$). The mean Lysholm knee score was 90.88 ± 9.30 . Differences in Lysholm knee scores among the proximal, shaft, and distal fracture groups were statistically insignificant with p values of 0.33 (Table II). Similarly, differences in Lysholm knee scores between males and females were not significant ($p=0.88$) (Table III).

Patellofemoral cartilage changes were observed in seven knees (12%). According to KL classification, three patients had grade II, three had grade III, and one patient had grade IV PF osteoarthritis. Flexion limitations ranged between 5° and 10° in 10 patients (17.2%) compared to that in the contralateral knee. The outcomes of the fractures and functional scores are given in Tables 2 and 3.

Nonunions were observed in three patients after five months and treated with nail dynamization. All of these patients had distracted fractures (more than 2 mm radiological) and atrophic fracture site. None of the patients required grafting or implant exchange.

Mild hemarthrosis occurred in one patient and was treated conservatively without sequelae. Superficial

TABLE I
Demographic data and fracture variables

	n	%
Gender		
Male	41	70.7
Female	17	29.3
Limb		
Right	36	62
Left	22	38
Localization		
Proximal	17	29.3
Shaft	22	37.9
Distal	19	32.8
Wound		
Open	5	8.6
Close	53	91.4
Additional fractures		
Rib fractures	3	5.2
Radius distal fractures	4	6.9
Proximal humerus fractures	2	3.4

TABLE II
Outcomes of patients according to fracture location

	Proximal	Shaft	Distal	<i>p</i> *
	Mean±SD	Mean±SD	Mean±SD	
Fracture healing time (month)	7.33±3.01	6.40±3.53	7.40±4.27	0.83
Follow-up time (month)	15.29±5.85	15.90±4.72	12.86±5.78	0.51
Lysholm score	87.71±8.69	94.20±6.46	89.29±12.67	0.33

SD: Standard deviation; * *P*<0.05 is significant.

TABLE III
Outcomes of patients according to gender

	Male	Female	<i>p</i> *
	Mean±SD	Mean±SD	
Fracture healing time (month)	7.69±4.29	7.00±3.15	0.90
Follow-up time (month)	20.18±9.05	19.00±7.59	0.63
Lysholm score	91.06±10.59	90.43±5.68	0.88

SD: Standard deviation; * *P*<0.05 is significant.

infection was detected and treated by debridement and antimicrobial therapy in two patients. No heterotrophic ossification occurred in the knee joints.

DISCUSSION

Tibial IMN is an effective treatment, and good outcomes have been reported for shaft fractures.^[10,16] Although promising results, including anatomic reduction, union rates and increased mobility, have been documented for shaft fractures, troublesome outcomes have been reported in proximal and distal tibial fractures.^[2,10,14-16] To overcome malalignment, SP entry semiextended nailing has been described and used successfully in previous studies.^[2,10,11,16,19] Nevertheless, there are debates on SP technique for PF injury and extensive application. Good union rates with anatomic reduction were achieved via SP tibial IMN in the vast majority of patients in this study.^[20] Similar fracture healing outcomes were acquired in proximal, shaft, and distal fractures. Distal fracture reduction was also successfully attained. Likewise, Avilucea et al.^[9] reported successful outcomes in distal third fractures by SP IMN. A more anatomical starting point and better alignment makes the semiextended technique favorable.^[19] Our study supported the recent literature.^[21]

Anterior knee pain remains controversial in the treatment of tibial fracture with IMN. After a minimum of 12 months of follow-up, only nine patients declared mild pain in our study. The vast majority of patients were painless. Prevalence

of anterior knee pain after tibial IMN has been reported as up to 56%.^[8,22] However, the etiology of anterior knee pain is still unclear.^[23] Anterior knee pain is usually associated with nail insertion.^[8] Damage to intra-articular structures, injury to the infrapatellar branch of the saphenous nerve, patellar chondromalacia, and damage to retropatellar structures in the transtendinous and paratendinous approach were among the proposed reasons for anterior knee pain.^[23] All of these proposed mechanisms were associated with IP IMN. In a study with a minimum of 12 months of follow-up, Sanders et al.^[16] stated that no patients complained of anterior knee pain. Although none of the patients treated with SP IMN complained of anterior knee pain, two patients with IP IMN complained of anterior knee pain according to a recent study.^[8] The authors claimed that the absence of dissection or incision around the IP area protects the infrapatellar branches of the saphenous nerve, resulting in no anterior knee pain.^[8,16] Tornetta and Collins^[11] also reported the same numbers of patients suffering from anterior knee pain between IMN with hyperflexion and IMN with extension groups. Moreover, Jones et al.^[23] found no significant difference in anterior knee pain between IP and SP IMN groups. Zelle et al.^[3] claimed that SP IMN is a safe procedure for anterior knee pain. Knee pain frequency after semiextended nailing was similar with IP IMN according to Ryan et al.^[19] In that study, mild pain was reported in nine patients (11%) in the SP IMN group and in 12 patients (12%) in the IP group.

Patellofemoral joint injury persists as a fundamental concern of the SP approach. Although many cadaveric studies demonstrated SP portal safety for PF cartilage, Zamora et al.^[24] reported cartilage injury in one third of specimens.^[10,13] While PF contact pressure increased in SP nailing, chondral damage did not occur in a cadaveric model.^[13] In pre-nail and post-nail arthroscopic examinations, 87% of patients were free of PF cartilage change, while two knees showed grade II chondromalacia in the trochlear groove.^[16] Cartilage changes in three of 11 patients were shown arthroscopically, but all of those patients were clinically free of pain after one-year follow-up according to a recent study comparing IP and SP IMN.^[8] Yasuda et al.^[4] investigated a patella eversion technique to overcome PF cartilage damage, particularly in narrow joint articulation. We demonstrated compatible results of PF damage with previous studies. Additional attention should be given to using a soft protective trocar during the operation to avoid cartilage damage.

Although good union rates were achieved with IMN, patients still complained of insufficient function. Functional limitations in the affected knee continued in 44% of patients after a one-year follow-up study.^[3,25] Another study reported work-related disability after one-year follow-up in up to 47% of patients.^[26] In long-term follow-up studies, the percent of patients still complaining of functional disability was not less than 20%.^[21,27] In our study, functional assessment of the knee was crucial, not only for pain rating but also for the management of everyday life. Statistically, no significant differences in knee function, as evaluated by the Lysholm knee scoring scale, were observed between gender groups or fracture site, which was an important outcome. Our results indicate that anatomic reduction and PF joint preservation play a more important role for knee function than fracture level and gender. Sanders et al.^[16] reported mainly good outcomes for 37 knees following SP tibial IMN. These authors claimed that poor outcomes originated from preexisting arthritis and polytrauma in these patients.^[16] Poor outcomes in our study were due to preexisting type 3 PF arthritis. Chan et al.^[8] reported no significant differences in Lysholm knee scoring scale outcomes between SP and IP techniques.

In addition, postoperative decreased ROM can accompany tibial IMN.^[8,21] In a long-term follow-up infrapatellar tibial IMN study, equivalent knee ROM was found between the affected and contralateral sides.^[27] Chan et al.^[8] reported similar findings for both IP and SP patients in a study with an average

15.55 months of follow-up. Similarly, only three patients from each group of IP and SP had problems in kneeling in a recent study.^[23] Sanders et al.^[16] reported up to 86% full knee flexion while only two patients had limitation to 110 degrees. Decreased knee ROM in 17.2% of SP patients in our study was in good agreement with those studies. All patients with decreased ROM could perform kneeling, which was important in our population.

Nonunion, infection, and heterotrophic ossification were not at substantially important rates in our study. There was no statistically significant difference for venous thromboembolism, infection or nail exchange between SP and IP groups in a recent study.^[8] Differences in postoperative deep infection, nonunion rate, and secondary operation between SP and IP were not statistically significant in a recent meta-analysis.^[21]

There were a few limitations in this study. The PF joint was evaluated by X-rays and might need further investigation with magnetic resonance imaging or intraoperative and postoperative arthroscopic assessment. This study was intended to evaluate the feasibility and safety of the SP technique. Longer follow-up time is needed to compare IP and SP techniques. Moreover, our study was retrospective and not blinded. Future research may be improved with more patient groups in randomized and blinded studies to strengthen our results. Even though we had these limitations, this study successfully demonstrated mid-term results after union of tibial fracture. Suprapatellar tibial IMN was evaluated as applicable in all parts of tibial fractures.

In conclusion, suprapatellar tibial IMN may be applicable to all extra-articular tibial fractures. Providing easy anatomic reduction in the semiextended position, convenient fluoroscopic imaging, safety for the PF joint, acceptable anterior knee pain, and satisfactory functional outcomes render the SP technique more feasible.

Declaration of conflicting interests

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REFERENCES

1. Fu B. Locked META intramedullary nailing fixation for tibial fractures via a suprapatellar approach. *Indian J Orthop* 2016;50:283-9.

2. Larsen P, Elsoe R, Hansen SH, Graven-Nielsen T, Laessoe U, Rasmussen S. Incidence and epidemiology of tibial shaft fractures. *Injury* 2015;46:746-50.
3. Zelle BA, Boni G. Safe surgical technique: intramedullary nail fixation of tibial shaft fractures. *Patient Saf Surg* 2015;9:40.
4. Yasuda T, Obara S, Hayashi J, Arai M, Sato K. Semiextended approach for intramedullary nailing via a patellar eversion technique for tibial-shaft fractures: Evaluation of the patellofemoral joint. *Injury* 2017;48:1264-8.
5. Stinner DJ, Mir H. Techniques for intramedullary nailing of proximal tibia fractures. *Orthop Clin North Am* 2014;45:33-45.
6. Franke J, Homeier A, Metz L, Wedel T, Alt V, Spät S, et al. Infrapatellar vs. suprapatellar approach to obtain an optimal insertion angle for intramedullary nailing of tibial fractures. *Eur J Trauma Emerg Surg* 2018;44:927-38.
7. Franke J, Hohendorff B, Alt V, Thormann U, Schnettler R. Suprapatellar nailing of tibial fractures-Indications and technique. *Injury* 2016;47:495-501.
8. Chan DS, Serrano-Riera R, Griffing R, Steverson B, Infante A, Watson D, et al. Suprapatellar Versus Infrapatellar Tibial Nail Insertion: A Prospective Randomized Control Pilot Study. *J Orthop Trauma* 2016;30:130-4.
9. Avilucea FR, Triantafillou K, Whiting PS, Perez EA, Mir HR. Suprapatellar Intramedullary Nail Technique Lowers Rate of Malalignment of Distal Tibia Fractures. *J Orthop Trauma* 2016;30:557-60.
10. Eastman J, Tseng S, Lo E, Li CS, Yoo B, Lee M. Retropatellar technique for intramedullary nailing of proximal tibia fractures: a cadaveric assessment. *J Orthop Trauma* 2010;24:672-6.
11. Tornetta P, Collins E. Semiextended position of intramedullary nailing of the proximal tibia. *Clin Orthop Relat Res* 1996;328:185-9.
12. Freedman EL, Johnson EE. Radiographic analysis of tibial fracture malalignment following intramedullary nailing. *Clin Orthop Relat Res* 1995;315:25-33.
13. Gelbke MK, Coombs D, Powell S, DiPasquale TG. Suprapatellar versus infra-patellar intramedullary nail insertion of the tibia: a cadaveric model for comparison of patellofemoral contact pressures and forces. *J Orthop Trauma* 2010;24:665-71.
14. Lang GJ, Cohen BE, Bosse MJ, Kellam JF. Proximal third tibial shaft fractures. Should they be nailed? *Clin Orthop Relat Res* 1995;315:64-74.
15. Vidyadhara S, Sharath KR. Prospective study of the clinico-radiological outcome of interlocked nailing in proximal third tibial shaft fractures. *Injury* 2006;37:536-42.
16. Sanders RW, DiPasquale TG, Jordan CJ, Arrington JA, Sagi HC. Semiextended 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. McConnell T, Tornetta P III, Tilzey J, Casey D. Tibial portal placement: The radiographic correlate of the anatomic safe zone. *J Orthop Trauma*. 2001;15:207-9.
18. Tokgöz MA, Atik OŞ, Esendağlı G, Ögüt B, Bozkurt HH. Is it possible that the pathogenesis of osteoarthritis could start with subchondral trabecular bone loss like osteoporosis? *Eklem Hastalik Cerrahisi* 2018;29:152-8.
19. Ryan SP, Steen B, Tornetta P. Semi-extended nailing of metaphyseal tibia fractures: alignment and incidence of postoperative knee pain. *J Orthop Trauma* 2014;28:263-9.
20. Atik OŞ. Are all case reports worth publishing? *Eklem Hastalik Cerrahisi* 2016;27:61.
21. 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.
22. Keating JF, O'Brien PI, Blachut PA, Meek RN, Broekhuysen HM. Reamed interlocking intramedullary nailing of open fractures of the tibia. *Clin Orthop Relat Res* 1997;338:182-91.
23. Jones M, Parry M, Whitehouse M, Mitchell S. Radiologic outcome and patient-reported function after intramedullary nailing: a comparison of the retropatellar and infrapatellar approach. *J Orthop Trauma* 2014;28:256-62.
24. Zamora R, Wright C, Short A, Seligson D. Comparison between suprapatellar and parapatellar approaches for intramedullary nailing of the tibia. Cadaveric study. *Injury* 2016;47:2087-90.
25. Skoog A, Söderqvist A, Törnkvist H, Ponzer S. One-year outcome after tibial shaft fractures: results of a prospective fracture registry. *J Orthop Trauma* 2001;15:210-5.
26. Ferguson M, Brand C, Lowe A, Gabbe B, Dowrick A, Hart M, et al. Outcomes of isolated tibial shaft fractures treated at level 1 trauma centres. *Injury* 2008;39:187-95.
27. Lefaivre KA, Guy P, Chan H, Blachut PA. Long-term follow-up of tibial shaft fractures treated with intramedullary nailing. *J Orthop Trauma* 2008;22:525-9.