

# Suprapatellar versus infrapatellar approach for intramedullary nail fixation of tibial shaft fractures: a review of the literature

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## Abstract

Semi-extended suprapatellar intramedullary nail fixation of tibial fractures has recently been gaining popularity. Several recent studies and meta-analyses compare the outcomes of the suprapatellar approach with the traditional infrapatellar approach. Despite concerns with intra-articular placement of instruments, studies show the suprapatellar approach to be a safe alternative. Several articles conclude that the suprapatellar approach may be superior to the infrapatellar approach. This review discusses recent findings comparing suprapatellar and infrapatellar approaches for nail insertion.

**Keywords:** infrapatellar, intramedullary, suprapatellar, tibial shaft

## 1. Introduction

Intramedullary nail fixation is standard operative treatment for diaphyseal tibial fractures in adults. Traditionally, an infrapatellar (IP) approach has been used, either through a midline transtendinous or a medial or lateral paratendinous incision. Despite overall excellent results of the approach, well-documented complications include chronic anterior knee pain (47%), malalignment (58–85%), and malunion (30%).<sup>[1]</sup> In 1996, Tornetta and Collins<sup>[2]</sup> introduced a new technique for proximal tibia fractures using a semi-extended approach. The approach was developed to reduce the force of the quadriceps tendon on the proximal fragment and mitigate the valgus and apex anterior deformities typically seen in this fracture pattern.

Several studies, including recent meta-analyses, demonstrate that the suprapatellar (SP) approach may be superior to the IP approach and allow for easier reduction, decreased fluoroscopy time, and reduced rates of malunion and anterior knee pain.<sup>[3–10]</sup> Concerns with the SP approach, however, stem from introducing instruments directly into the knee joint.<sup>[11–15]</sup> Patellofemoral damage is a major concern with the SP approach. The authors

also question an increased risk of knee sepsis, particularly with use in open tibial shaft fractures.<sup>[16,17]</sup>

This article reviews the reported differences between the suprapatellar and infrapatellar approaches regarding fluoroscopy time, operative time, radiographic alignment, intra-articular damage, anterior knee pain, outcome scores, and knee sepsis.

## 2. Intraoperative fluoroscopy

Multiple studies show reduced fluoroscopy time and radiation dose with the SP technique. Factors favoring reduced fluoroscopy time with the SP approach include easier reduction and maintenance of reduction, a more anatomical entry point, and better positioning for anteroposterior and lateral radiographs.<sup>[9,18]</sup> The SP approach allows for the knee to remain in a semi-extended position, relaxing the quadriceps tendon and allowing for easier reduction and maintenance of reduction.<sup>[9,18,19]</sup> Several studies confirm that the SP approach allows for easier fluoroscopic imaging with less need for repositioning of the leg to obtain adequate AP and lateral radiographs.<sup>[9,12,13,18,19]</sup> Williamson et al<sup>[9]</sup> compared fluoroscopy time and radiation dose between the SP and IP techniques. The mean fluoroscopy time for the SP group was  $94.4 \pm 47.9$  s versus  $129.7 \pm 56.6$  s in the IP group ( $P = .002$ ). The mean radiation dose was  $38.2 \pm 26.7$  cGY cm<sup>2</sup> in the SP group versus  $53.6 \pm 34.2$  cGY cm<sup>2</sup> in the IP group ( $P = .02$ ). Sun et al<sup>[7]</sup> discovered a decrease in fluoroscopy time with a mean of  $80.61 \pm 37.23$  s in the SP group compared to  $118.68 \pm 40.23$  s in the IP group ( $P = .009$ ). Recent meta-analyses comparing the SP and IP approaches confirm significant reduction in fluoroscopy time with the SP approach.<sup>[3,7,8,10,20]</sup> MacDonald et al,<sup>[6]</sup> in a multicenter clinical trial, noted there to be no significant difference between operating or fluoroscopic time between the 2 groups. An easier reduction, maintenance of reduction, anatomical entry point, and intraoperative leg position with the use of the SP approach allows for less fluoroscopy time and radiation dose compared to the IP approach.

## 3. Operative time

Evaluating differences in operative times between the 2 approaches yields less compelling conclusions. Two recent meta-analyses show a decreased operative time with the SP

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approach.<sup>[3,10]</sup> Xu et al,<sup>[10]</sup> comparing 7 studies (3 randomized; 4 clinical controlled trials), found the IP approach to be more time consuming than the SP approach ( $P=.01$ ). Chen et al<sup>[3]</sup> evaluated 7 randomized controlled trials (RCT) and originally found no significant difference in operative time ( $P=.88$ ); however, sensitivity analysis excluding an outlier study did show a significant reduction in operative time with the SP approach ( $P=.002$ ). Gao et al,<sup>[4]</sup> evaluating 4 RCTs, and Wang et al,<sup>[8]</sup> evaluating 2 RCTs and 6 retrospective cohort trials, found no significant difference in operative times ( $P=.344$  and  $P=.68$ , respectively). Cui et al,<sup>[21]</sup> in a retrospective cohort study of 50 patients, found no significant difference in operative time ( $P=.794$ ) with mean times of 66.38 min (SP) and 65.69 min (IP). Similarly, Sun et al,<sup>[7]</sup> in a randomized prospective study of 162 patients, found no significant difference in operative time ( $P=.183$ ) with mean times of  $71.01 \pm 5.98$  min (SP) and  $73.26 \pm 4.03$  (IP). The SP approach does not significantly reduce the operative time compared to the IP approach.

#### 4. Radiographic alignment

Several studies have evaluated the radiographic alignment following fixation of tibial shaft fractures and compared the SP and IP approach. Avilucea et al,<sup>[22]</sup> in a retrospective cohort study, reviewed 132 SP and 134 IP patients with distal tibial shaft fractures. Coronal plane ( $P<.001$ ) and sagittal plane ( $P<.001$ ) deformity were decreased in the SP group. Primary angular malalignment  $> 5$  degrees occurred in 26.1% of IP patients versus 3.8% of SP patients ( $P<.001$ ). Johnstone et al,<sup>[5]</sup> in a multicenter randomized control trial, discovered improved overall coronal ( $P=.006$ ) and sagittal ( $P=.003$ ) alignment of the tibial nail and improved final position of the proximal end of the nail in the sagittal plane ( $P=0.029$ ) in the SP approach. Jones et al<sup>[23]</sup> performed a retrospective review of 2 consecutive sets of 38 patients with tibial nailing and showed improved alignment of the fracture in the coronal plane to both angulation ( $P=.003$ ) and translation ( $P=.010$ ) in the SP group, as well as more accurate nail insertion points in the sagittal ( $P=.011$ ) and coronal ( $P=.014$ ) planes. Several recent meta-analyses<sup>[3,8,10]</sup> all showed the SP approach to have a significant improvement in sagittal alignment, but no significant difference in coronal alignment. The use of the SP approach shows improved postoperative fracture alignment compared to the IP approach.

#### 5. Intra-articular damage

One of the major concerns with the suprapatellar approach is iatrogenic damage from either canal preparation, nail insertion, or increased contact pressures on the patella and femoral condyles. Several studies have used pre- and postoperative MRI or arthroscopy to evaluate for potential intra-articular cartilage damage following SP tibial nails.

Serbest et al<sup>[24]</sup> used pre- and postoperative arthroscopy after SP tibial nailing and reported 17 of 21 patients (80.95%) had normal (grade 0) patellar and femoral articular surfaces pre-nail and post-nail. Of the remaining 4 patients starting with grade 0 chondromalacia, 2 patients had grade 1 and 2 patients had grade 2 patellar chondral damage post-nail.

Sanders et al<sup>[15]</sup> treated 56 patients with the SP approach and evaluated 15 of them postoperatively with arthroscopy. Thirteen of the patients (86.7%) had no postoperative cartilage changes on arthroscopic images and 2 patients (13.3%) had grade 2 chondromalacia limited to the trochlear groove. Thirty-three

patients underwent MRI scans at 1 year. One patient had grade 2 patellofemoral changes and 1 patient had grade 3 patellofemoral changes. The 2 patients with grade 2 cartilage changes on arthroscopic images had MRI findings at 1 year which were read as normal. They found no correlation between the arthroscopic images, MRI findings, or patient outcomes.

Chan et al<sup>[25]</sup> evaluated 11 SP patients with pre-nailing and post-nailing arthroscopy and found that 3 of the patients had a change in the degree or location of chondromalacia, one of which had preexisting disease. The other 2 patients resulted in a change from grade 0 to grade 2 trochlea chondral damage and from a grade 0 to grade 4 patella chondromalacia. Both patients were clinically symptom-free with full return to normal activities at 1 year. They also performed 1-year follow-up MRI and found 5 patients with patellofemoral chondromalacia. None of these findings correlated with either pre-nail or post-nail arthroscopy, and no patient complained of patellofemoral joint pain. Despite intra-articular placement of instruments, the SP approach shows to be a safe alternative to the IP approach for nail fixation of tibial shaft fractures.

#### 6. Cadaveric studies

Several other studies have evaluated intra-articular damage with the SP approach using cadaveric specimens. Zamora et al<sup>[26]</sup> compared suprapatellar and parapatellar approaches in the semi-extended position and found that patellar cartilage or trochlea cartilage damage occurred in one-third (3/10) of the cadavers in the SP approach. The patellar cartilage was damaged in 2 specimens and measured  $< 1$  cm, and the intercondylar notch was damaged in 1 specimen and measured more than 1 cm. Only 1 cartilage injury occurred in the parapatellar group and was measuring less than 5 mm. There was partial laceration of the intermeniscal ligament in 3 of the 10 knees with both approaches. One ACL injury was found in the SP group but mean distance from the entry point to major structures was not significantly different between approaches.

Eastman et al<sup>[12]</sup> also performed a cadaveric study evaluating spatial relationships and injury to major structures with the SP approach. They discovered the mean distance from the nail entry site to the medial and lateral menisci was  $6.6 \pm 3.2$  mm and  $6.4 \pm 4.4$  mm, respectively. The distance to the medial and lateral articular surfaces was  $5.6 \pm 3.6$  mm and  $7.4 \pm 4.2$  mm, respectively. Mean distance to the ACL footprint was  $7.5 \pm 3.5$  mm. The lateral meniscus and ACL were not injured in any specimens. The medial meniscus was injured in 12.5% of specimens and the intermeniscal ligament was injured in 81.2% of specimens, although damage was never more than 1 to 2 mm.

Gelbke et al<sup>[13]</sup> evaluated the contact pressures of SP and IP techniques and found SP pressures (3.83 MPa) were  $> 3$  times higher than IP pressures (1.26 MPa). However, prior studies have shown that a minimum of 4.5 MPa is needed to induce chondrocyte death. Peak contact pressure with knee flexion alone can reach pressures as high as 4 to 5 MPa. These investigators concluded that the SP entry portal does not pose any significant risk to the viability or structural integrity of the articular cartilage.

#### 7. Anterior knee pain

One of the major concerns following intramedullary nailing of tibia fractures is the development of chronic anterior knee pain. Various reports show as little as 10% of patients complaining of

knee pain to as high as 86%.<sup>[3,6]</sup> Multiple etiologies of postoperative anterior knee pain exist, including implant prominence, injury to intra-articular structures, patellar tendon or fat pad injury, damage to the infrapatellar branch of the saphenous nerve, and altered biomechanics.<sup>[11]</sup> The suprapatellar approach avoids the branches of the saphenous nerve and also spares the patellar tendon, potentially lowering the risk for anterior knee pain.<sup>[2,14]</sup>

Several studies have evaluated outcomes of anterior knee pain following SP and IP approaches. All 5 recent meta-analyses showed significantly lower postoperative pain scores in the SP group.<sup>[3,4,8,10,20]</sup> Sun et al<sup>[7]</sup> found no significant difference in VAS score between the SP and IP groups at 1 and 3 months postoperatively, but found significantly lower VAS scores in the SP group at 6, 12, and 24 months. Sanders et al<sup>[15]</sup> evaluated 41 patients at 12 months after suprapatellar nailing and documented that no patients had anterior knee pain. MacDonald et al<sup>[6]</sup> discovered no significant difference in VAS scores, although patients treated with the SP approach were found to be able to transmit greater mean proportion of weight through the injured leg compared to the uninjured leg when kneeling at all postoperative time points.

Chan et al,<sup>[25]</sup> in a prospective randomized control pilot study, found no significant difference in postoperative knee pain ( $P > .05$ ). Of the 41 patients enrolled, 25 were available at a minimum of 12 months. Two of the patients in the IP group complained of anterior knee pain and no patients in the SP group complained of pain. Cui et al<sup>[21]</sup> found no significant difference in the pain component of HSS scores between SP and IP groups ( $P = .57$ ). In a retrospective cohort study by Isaac et al<sup>[27]</sup> evaluating knee pain beyond 1 year, there was reported to be no significant difference between SP and IP in knee pain with kneeling ( $P = .90$ ), resting ( $P = 1.00$ ), walking ( $P = .51$ ), or within the last 24 hours ( $P = .45$ ). The study identified a significantly higher proportion of proximal 1/3 tibial fractures in the SP group (33% vs 14%) which they mention could mask the benefits of the SP approach in more distal patterns. The SP approach shows similar to improved postoperative pain scores compared to the IP approach.

## 8. Outcome scores

Other comparative outcome scores have been explored. Chan et al<sup>[25]</sup> showed no significant difference in Lysholm knee scores, with mean scores of 98 in the SP group and 86 in the IP group. The SP group had significantly superior bodily pain scores (46 vs 36,  $P = .035$ ) suggesting less pain and disability. Sun et al<sup>[7]</sup> found significantly improved Lysholm knee scores in the SP group at 6 and 24 months postoperative but comparable scores at the remaining follow-ups. There was no significant difference between the groups in overall SF-36 or ROM, although the physical component of SF-36 showed significant improvement in the SP group compared to the IP group at all follow-ups except for 6 months. Cui et al<sup>[21]</sup> found HSS scores of 97.21 in the SP group and 97.27 in the IP group ( $P = .62$ ). Subanalysis of the HSS components showed no difference in the pain component ( $P = .57$ ) or stand and walk component ( $P = .54$ ). Muscle force, flexion deformity, and stability components also showed no difference with full scores in both groups. Range of motion was superior in the IP group ( $P = .041$ ).

Meta-analyses demonstrate mixed results. Chen et al<sup>[3]</sup> reviewed 4 studies with outcome ratings and reported that “excellent” and “good” ratings were more frequent in the SP group at last follow-up ( $P < .001$ ). The SP group also showed

significant improvement in HHS, Lysholm knee scores, SF-36, and ROM. Yang et al<sup>[20]</sup> and Gao et al<sup>[4]</sup> both reviewed 3 RCTs providing outcome scores and found significantly improved Lysholm knee scores in the SP approach ( $P < .001$ ) but no significant difference in range of motion ( $P = .180$ ). Wang et al<sup>[8]</sup> discovered no significant difference in final follow-up knee functional scores ( $P = .05$ ). During subgroup analysis, unlike the retrospective studies which showed no significant difference ( $P = .40$ ), the RCT studies showed higher knee functional scores in the SP group ( $P < .001$ ). Xu et al<sup>[10]</sup> reviewed 2 studies that reported Lysholm and SF-36 scores and 2 studies that reported Kujala scale, SF-12 scores, and Oxford knee scores. They reported no significant difference between the 2 approaches in any of the functional outcome scores ( $P = .35$ ). The SP approach shows similar to improved outcome scores compared to the IP approach.

## 9. Knee sepsis

One concern with use of instrumentation through the knee joint is development of postoperative knee sepsis, particularly in cases of open tibial shaft fractures. Mitchell et al<sup>[17]</sup> evaluated 139 open fractures treated with a SP nail, of which 87% were Gustilo and Anderson type II or III. Although 18% of patients had either a local infection at the open fracture site or an infected nonunion, they found no cases of acute knee sepsis.

Maracek et al<sup>[16]</sup> also compared infection rates. Of the 142 fractures treated with the IP approach, 20 total infections (14.1%) ensued with no cases of septic knee arthritis. Of the 147 fractures treated with the SP approach there were 24 infections (14.7%) with 2 cases of septic knee arthritis (1.4%). They concluded that consideration should be given to a small, but present, risk of septic arthritis with the SP approach.

## 10. Discussion

As the semi-extended suprapatellar approach becomes more popular in the treatment of tibial shaft fractures, surgeons must understand the technique and its risks and benefits. Recent meta-analyses comparing the outcomes of the SP approach to the traditional IP approach conclude that the SP is a safe alternative and may be superior to the IP approach in several outcome measurements. This literature review summarizes the findings in the recent studies and meta-analyses comparing the SP and IP approach for intramedullary nail fixation of tibial shaft fractures.

Multiple studies reported a reduced fluoroscopy time and radiation dose with the suprapatellar technique due to its easier reduction and maintenance of reduction, a more anatomical entry point, and better positioning for anteroposterior and lateral radiographs. The operative time, radiographic alignment, incidence of anterior knee pain, and outcome scores were all shown to have similar or superior results with the SP approach in nearly every study.

Although concerns remain for potential complications with the SP approach, none of the recent meta-analyses report a significant difference in complication rates between the 2 approaches. Several studies evaluating prenailing and postnailing arthroscopy and MRI found minimal patellofemoral chondral damage. Cadaveric studies have also shown that the SP instrumentation likely will not induce chondrocyte death and can be used safely compared to the traditional IP approach. Although there may be a risk of knee sepsis, particularly with open tibial shaft fractures, this has been reported to occur at a very low rate.

Despite the SP approach showing excellent results without increased complication rates, recent meta-analyses concluded that there was significant heterogeneity in the studies reviewed and most of the studies had small sample size, short follow-ups, and little subgroup analysis. A recent systematic review looking at the quality of randomized controlled trials regarding IP versus SP approach for tibia intramedullary nails found that the RCTs were considered poor using the Modified Coleman and CONSORT systems.<sup>[28]</sup> They found that half of articles supported suprapatellar tibial nailing over the infrapatellar approach, whereas the other half demonstrated equivocal results. Additional randomized clinical trials with longer follow-ups are needed to further evaluate the benefits of the SP approach and determine the long-term outcomes compared to the traditional IP approach. Based on these short-term results, however, the SP technique seems to be a safe alternative with potentially better outcomes.

## References

- Maslow JI, Joseph HL, Hong DY, et al. Radiographic evaluation of the tibial intramedullary nail entry point. *J Am Acad Orthop Surg.* 2020;28:e810–e814.
- Tornetta P, Collins E. Semiextended position of intramedullary nailing of the proximal tibia. *Clin Orthop Relat Res.* 1996;328:185–189.
- Chen X, Xu HT, Zhang HJ, et al. Suprapatellar versus infrapatellar intramedullary nailing for treatment of tibial shaft fractures in adults. *Medicine (Baltimore).* 2018;97:e11799.
- Gao Z, Han W, Jia H. Suprapatellar versus infrapatellar intramedullary nailing for tibial shaft fractures: a meta-analysis of randomized controlled trials. *Medicine (Baltimore).* 2018;97:e10917.
- Johnstone A, Munro C, Caba P, et al. The suprapatellar variant of the semi-extended surgical approach improves intramedullary nail position compared with the conventional medial parapatellar surgical approach. *ACE Report.* 2015;4:25.
- MacDonald DR, Caba-Doussoux P, Carnegie CA, et al. Tibial nailing using a suprapatellar rather than an infrapatellar approach significantly reduces anterior knee pain postoperatively: a multicentre clinical trial. *Bone Joint J.* 2019;101-B:1138–1143.
- Sun Q, Nie XY, Gong JP, et al. The outcome comparison of the suprapatellar approach and infrapatellar approach for tibia intramedullary nailing. *Int Orthop.* 2016;40:2611–2617.
- Wang C, Chen E, Ye C, et al. Suprapatellar versus infrapatellar approach for tibia intramedullary nailing: a meta-analysis. *Int J Surg.* 2018;51:133–139.
- Williamson M, Iliopoulos E, Williams R, et al. Intra-operative fluoroscopy time and radiation dose during suprapatellar tibial nailing versus infrapatellar tibial nailing. *Injury.* 2018;49:1891–1894.
- Xu H, Gu F, Xin J, et al. A meta-analysis of suprapatellar versus infrapatellar intramedullary nailing for the treatment of tibial shaft fractures. *Heliyon.* 2019;5:e02199.
- Bishop JA, Campbell ST, Eno JT, et al. Knee pain after intramedullary nailing of tibia fractures: prevalence, etiology, and treatment. *J Am Acad Orthop Surg.* 2018;26:e381–e387.
- Eastman JG, Tseng SS, Lee MA, et al. The retropatellar portal as an alternative site for tibial nail insertion: a cadaveric study. *J Orthop Trauma.* 2010;24:659–664.
- Gelbke MK, Coombs D, Powell S, et al. Suprapatellar versus infrapatellar intramedullary nail insertion of the tibia: a cadaveric model for comparison of patellofemoral contact pressure and forces. *J Orthop Trauma.* 2010;24:665–671.
- Hessmann MH, Buhl M, Finkemeier C, et al. Suprapatellar nailing of fractures of the tibia. *Oper Orthop Traumatol.* 2020;32:440–454.
- Sanders RW, DiPasquale TG, Jordan CJ, et al. 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;28:245–255.
- Marecek GS, Nicholson LT, Broghammer FH, et al. Risk of knee sepsis after treatment of open tibia fractures: a multicenter comparison of suprapatellar and infrapatellar approaches. *J Orthop Trauma.* 2018;32:88–92.
- Mitchell PM, Weisenthal BM, Collinge CA. No incidence of postoperative knee sepsis with suprapatellar nailing of open tibia fractures. *J Orthop Trauma.* 2017;31:85–89.
- Franke J, Homeier A, Metz L, et al. Infrapatellar vs. suprapatellar approach to obtain an optimal insertion angle for intramedullary nailing of tibial fractures. *Eur J Trauma Emerg Surg.* 2018;44:927–938.
- Zelle BA. Intramedullary nailing of tibial shaft fractures in the semi-extended position using a suprapatellar portal technique. *Int Orthop.* 2017;41:1909–1914.
- Yang L, Sun Y, Li G. Comparison of suprapatellar and infrapatellar intramedullary nailing for tibial shaft fractures: a systematic review and meta-analysis. *J Orthop Surg Res.* 2018;13:146.
- Cui Y, Hua X, Schmidutz F, et al. Suprapatellar versus infrapatellar approaches in the treatment of tibia intramedullary nailing: a retrospective cohort study. *BMC Musculoskelet Disord.* 2019;20:573.
- Avilucea FR, Triantafyllou K, Whiting PS, et al. Suprapatellar intramedullary nail technique lowers rate of malalignment of distal tibia fractures. *J Orthop Trauma.* 2016;30:557–560.
- Jones M, Parry M, Whitehouse M, et al. Radiological outcome and patient-reported function after intramedullary nailing: a comparison of the retropatellar and infrapatellar approach. *J Orthop Trauma.* 2014;28:256–262.
- Serbest S, Tiftikci U, Coban M, et al. Knee pain and functional scores after intramedullary nailing of tibial shaft fractures using a suprapatellar approach. *J Orthop Trauma.* 2019;33:37–41.
- Chan DS, Serrano-Riera R, Griffing R, et al. Suprapatellar versus infrapatellar tibial nail insertion: a prospective randomized control pilot study. *J Orthop Trauma.* 2016;30:130–134.
- Zamora R, Wright C, Short A, et al. Comparison between suprapatellar and parapatellar approaches for intramedullary nailing of the tibia. *Cadaveric study. Injury.* 2016;47:2087–2090.
- Isaac M, O'Toole RB, Udogwu U, et al. Incidence of knee pain beyond 1 year: suprapatellar versus infrapatellar approach for intramedullary nailing of the tibia. *J Orthop Trauma.* 2019;33:438–442.
- Chan A, Pisciopy J, Piscoya A, et al. A systematic review and analysis of the quality of randomized controlled trials comparing infrapatellar and suprapatellar approach for nailing of tibial fractures. *J Orthop Trauma.* 2021;35:506–511.