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EVIDENCE-BASED SYSTEMATIC REVIEWS

Anterior Knee Pain and Knee Functional Scores Following Common Approaches to Tibial Shaft Fractures

A Systematic Review

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Background: Tibial shaft fractures are common, causing substantial morbidity. Intramedullary nailing offers advantages but often leads to anterior knee pain and functional issues.

Methods: Following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, we conducted a systematic review on outcomes for different surgical approaches—suprapatellar (SP), infrapatellar (IP), medial parapatellar (MPP), and lateral parapatellar (LPP). Searches across Ovid, Embase, and PubMed identified studies from 2000 to 2023, including retrospective and prospective studies, randomized controlled trials, and case series on anterior knee pain and functional outcomes postsurgery. Bias was assessed using Cochrane's RoB2.

Results: Of 27 studies, 8 were noncomparative (3 SP, 3 IP, 1 MPP, 1 LPP), showing varied anterior knee pain and function outcomes. Comparative studies (12 SP vs. IP, 5 MPP vs. IP) indicated better patient-reported outcomes for SP over IP in anterior knee pain and knee function. Comparative data for MPP and LPP remain limited. Overall RoB was low.

Conclusion: SP has better patient-reported outcomes and lower anterior knee pain than IP. MPP and LPP approaches are promising but lack robust comparative data. Further large, prospective trials are needed to clarify optimal approaches for tibial shaft fractures.

Level of Evidence: Level III. See Instructions for Authors for a complete description of levels of evidence.

Introduction

Tibial shaft fractures are common long bone injuries, accounting for 4% of fractures in Medicare-insured patients and 17% of lower extremity fractures[1,2]. These fractures represent 2% of all fractures and 37% of long bone fractures in adults, with an annual incidence of 12 to 21 per 100,000 people[3]. Typically resulting from high-energy trauma, these fractures can lead to prolonged disability due to soft tissue damage, affecting both young patients (high-energy injuries) and geriatric patients (low-energy injuries)[1,2].

Intramedullary nailing, associated with earlier union and fewer complications, is frequently used[1]. However, anterior knee pain and stiffness often impair range of motion and quality of life[1,4,5]. Contributing factors include surgical approach, transtendinous techniques, anterior cortex nail protrusion, patellar tendon dissection, and the incision site[6-10]. Even with proper healing, many patients continue to experience pain and functional deficits[11].

Historically, the infrapatellar (IP) approach with a flexed knee was standard but often resulted in procurvatum deformity,

All articles and data are accessible via databases previously mentioned.

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSOA/A722).

especially in proximal tibial fractures, due to the gastrocnemius muscle's pull. In addition, pull from the patellar tendon and quadriceps can extend the proximal fracture fragment. Consequently, semi-extended approaches, including the suprapatellar (SP), medial parapatellar (MPP), and lateral parapatellar (LPP), have become more common[12-14]. The LPP approach, introduced by Tornetta et al. in 1996, has gained traction due to improved positioning, reduction, and imaging; however, concerns about articular damage, quadriceps function, and anterior knee pain remain[15,16].

Although parapatellar approaches are increasingly studied, no comprehensive review compares all 4 major approaches (IP, SP, MPP, LPP) for tibial shaft fractures. As orthopaedic techniques advance, examining these methods and their patient outcomes is essential. The aim of this systematic review was to compare outcomes related to anterior knee pain and knee function across these approaches. We hypothesize that the LPP approach yields lower anterior knee pain incidence and better knee function scores than SP and IP.

Methods

This systematic review adhered to PRISMA 2020 guidelines (see Appendices A and B), with no preregistered or prepublished protocol. Searches were conducted on Ovid, Embase, and PubMed on February 20, 2023, using terms such as (Tibial Shaft) AND ([IP] OR [SP] OR [LPP] OR [Medial] OR [Semiextended] OR [Arthrotomy] OR [Extra-articular] OR [Retropatellar])[17]. Rayyan.ai was used for organization, inclusion, and exclusion[17]. Artificial intelligence was not used in any other manner.

Inclusion criteria encompassed retrospective and prospective reviews, randomized controlled trials, and case series reporting on anterior knee pain following IP, SP, MPP, and LPP approaches for tibial shaft fractures published after 2000. Exclusions included case

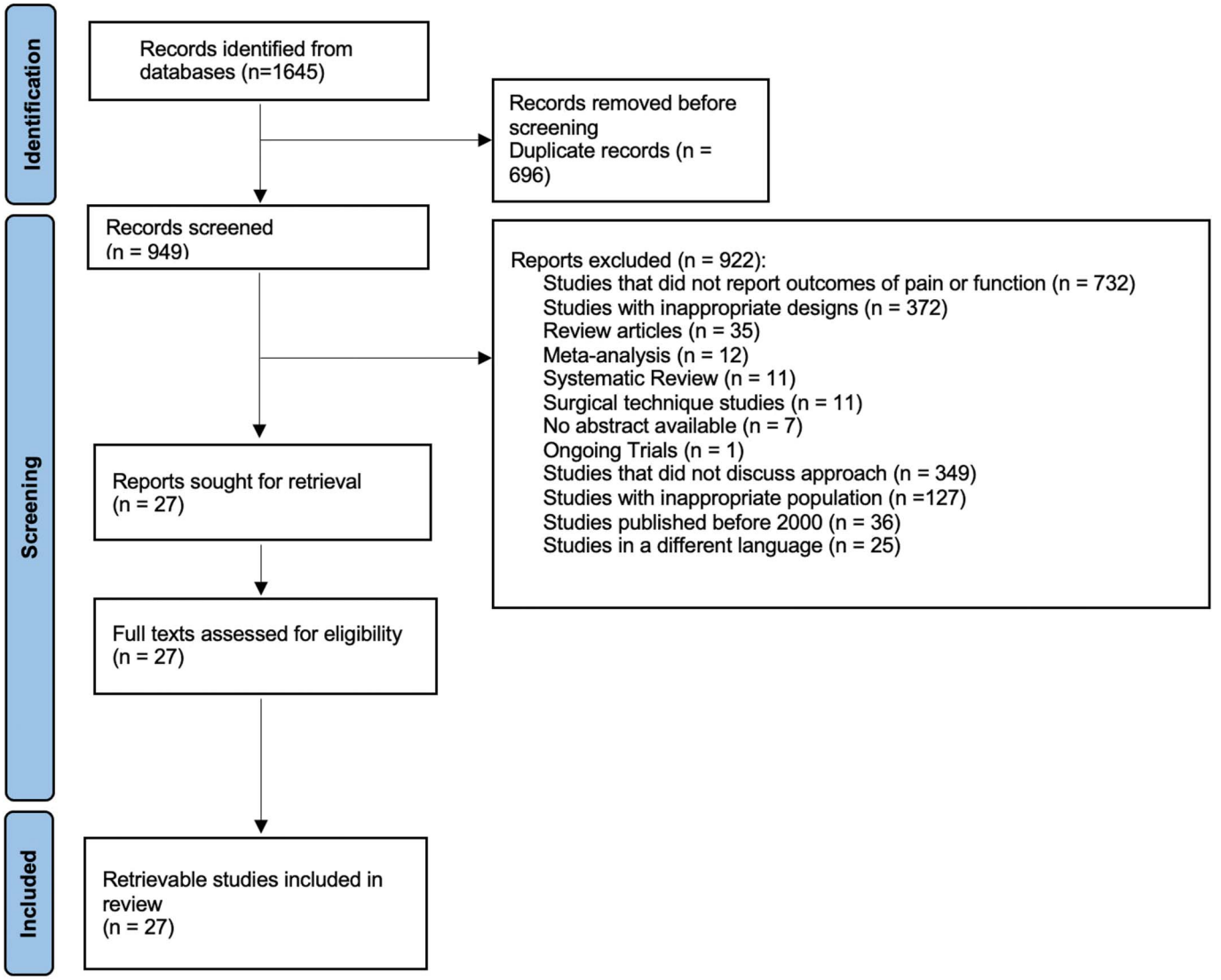

Fig. 1

Flow diagram depicting the process of identifying studies and the reasons for exclusion.

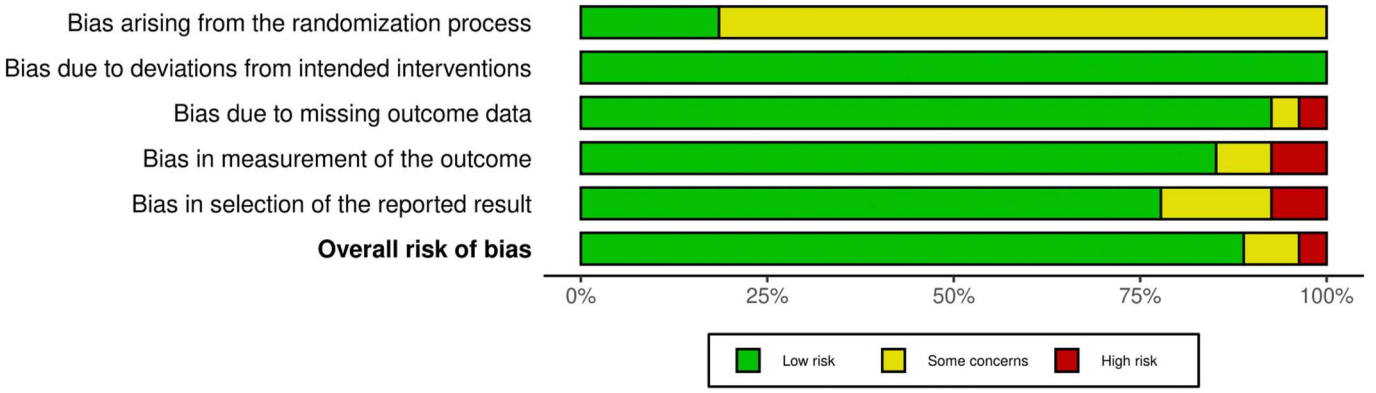

Fig. 2
Summarization and the overall risk of bias using the RoB2 tool.

reports, systematic reviews, meta-analyses, studies on patients aged younger than 18 years, non-English articles, abstracts only, or ongoing trials. Two blinded reviewers screened articles, with discrepancies resolved by a third reviewer. Of 949 articles screened (Fig. 1), 27 met inclusion criteria.

The 27 studies were categorized by surgical approach (SP, IP, MPP, LPP) and study type (comparative vs. noncomparative). Among the noncomparative studies, 3 analyzed the SP approach, 3 focused on IP, one examined MPP, and one investigated LPP. Comparative studies included 12 SP vs. IP and 5 MPP vs. IP or transtendinous approach studies. Outcomes were analyzed for trends and patterns, but meta-analysis was not feasible due to significant variability across studies in reporting methods, measurement tools, and patient-reported outcomes.

Specifically, the included studies used diverse scales to measure anterior knee pain and functional outcomes, such as the visual analog scale (VAS), Knee injury and Osteoarthritis Outcome Score, and Tegner-Lysholm Knee Scores (TLKS). This lack of standardized outcome measures and differing follow-up periods prevented direct comparison across studies, limiting the ability to pool data quantitatively. Consequently, a narrative synthesis was performed instead. Cochrane's RoB2 tool assessed bias (Figs. 2 and 3), and data were organized in Microsoft Excel 2024.

Results

Noncomparative Studies

Suprapatellar Approach

Three articles analyzed long-term outcomes of the SP approach for tibial shaft fractures (Table I)[18-20]. A total of 101 patients were included, with follow-up periods ranging from 15.6 to 60 months and average ages between 31 and 45 years. Various metrics assessed anterior knee pain and functional outcomes, including the VAS[21], TLKS[22], and the short form (36) health survey (SF-36)[23].

Çiçekli et al. reported an average TLKS of 90.88, with 18% of patients experiencing mild anterior knee pain (VAS <3)[18]. Flexion limitations ranged from 5° to 10° in 17.2% of patients compared with the contralateral limb. Daley-Lindo et al. found an average TLKS of 98, with 68% of patients achieving excellent results, 80% ambulated without assistance, and 63% were pain-free[19]. Serbest et al. reported a TLKS of 95.76, with a VAS score of 1.0, and knee range of motion (ROM) of 133.1° on the affected side[20]. Notably, 4 patients developed chondromalacia postsurgery, classified as grades 1 and 2.

Overall, the SP approach resulted in fair-to-excellent functional outcomes, with comparable ROM with the contralateral limb. However, anterior knee pain was noted in 18% to 37% of patients[18,20]. Variations in pain quantification hindered direct comparison across studies.

Infrapatellar Approach

Three studies examined factors contributing to anterior knee pain following the IP approach (Table II)[7,24]. Erinc et al. found greater thickness (3.4 vs. 2.6 mm, $p = 0.007$) and width (31.0 vs. 26.5 mm, $p = 0.009$) in the operative patellar tendon among pain-free patients compared with their nonoperative side[24]. The median VAS score for those with knee pain was 31.0.

Leliveld et al. compared transverse incisions (TI) with longitudinal incisions, reporting 31.1% of patients experienced anterior knee pain; TI resulted in lower sensory nerve disturbances (18% vs. 54%, $p < 0.001$)[7]. A third study comparing semi-extended (SEIP) to hyper-flexed IP positions found lower rates of moderate anterior knee pain in the SEIP group (5% vs. 25%, $p = 0.03$), alongside higher TLKS scores (92 vs. 88, $p = 0.01$)[25].

Outcomes suggest that larger tendon dimensions correlate with reduced anterior knee pain, though these dimensions were only assessed postoperatively[24]. The TI incision minimizes nerve damage, and the SEIP approach associates with lower pain rates and better functional scores compared with hip flexion impairment profile[25].

Medial Parapatellar Approach

One study assessed anterior knee pain following a fat-pad–preserving MPP approach in 60 patients (Table III)[26]. Persistent anterior knee pain occurred in 35.5% of cases, with mild (VAS 1-3) in 19.4% and moderate pain (VAS 4-6) in 16.1%. Patients without pain had a higher average TLKS (90.8) compared with those with mild (88.4) and moderate pain (79.9, $p = 0.012$)[26]. The study concluded that atraumatic mobilization of the Hoffa fat pad may reduce anterior knee pain, but its limited sample size and lack of a control group restrict the generalizability.

Fig. 3

Risk of bias by included article using the RoB2 tool.

TABLE I Summary of Outcomes Reported by Articles Discussing Outcomes Following the Suprapatellar Approach to Tibial Shaft Fractures

Author	Sample	Average Follow-up Time (mo)	Average Age (yr)	Results	
Çiçekli et al.[18]	50	19.83	40.1	VAS scale*	ROM
				9 patients (VAS <3; mild)	Flexion limitation of 5º-10° in 10 patients
				41 patients (VAS 0; no pain)	
				Average TLKS score†	
				90.88	
Daley-lindo et al.[19]	37	60	31 (TLKS ≥85)	Average TLKS: 98	General functional findings
			45 (TLKS <85)	24 (68%): excellent	• 28 (80%) did not have limp
				3 (9%): good	• 32 (91%) ambulated without assistance
				3 (9%) fair	• 22 (63%) were pain free
				5 (14%): poor	• 29 (83%) had no knee instability
					• 30 (86%) had no catching or locking
					• 27 (77%) could climb stairs without issues
					• 24 (69%) had no problem with squatting
Serbest et al.[20]	21	15.62	35.4	VAS scale (average)	Chondromalacia§
				At 3 mo: 1.75	Grade 0 prenail: 21
				At 6 mo: 1.12	Grade 0 postnail: 17
				At 12 mo: 1.0	Grade 1 postnail: 2
				Average TLKS: 95.76	Grade 2 postnail: 2
				18 (85.7%): excellent	ROM
				3 (14.3%): good	Average affected side
				SF-36 physical score (average)†	Full extension-133.1°
				At 3 mo: 36.25	Average unaffected side
				At 6 mo: 40.14	Full extension-134.05°
				At 12 mo: 45.10	
				SF-36 mental score (average)†	
				At 3 mo: 38.45	
				At 6 mo: 42.54	
				At 12 mo: 51.7	

*VAS scale is a patient-reported pain rating scale between 0 (no pain) and 10 (most pain). †Tegner-Lysholm knee score is a patient-reported instrument that consists of subscales for pain, instability, locking, swelling, limp, stair climbing, squatting, and the need for support: >90 (excellent), 85 to 90 (good), 65 to 84 (fair), <65 (poor). ‡SF-36 physical and mental score is a self-reported survey used to evaluate health status and quality of life scored on a scale of 0 to 100, with 100 representing the highest level of functioning possible. Authors did not discuss SF-36 findings. §The Outerbridge Classification is an articular cartilage grading systems based on direct visualization of the joint. Grade 0 (normal cartilage) to Grade 5 (exposed subchondral bone). ROM = range of motion, SF-36 = short form (36) health survey, TLKS = Tegner-Lysholm knee scores, and VAS = visual analog scale.

Lateral Parapatellar Approach

Three studies discussed outcomes after the LPP approach (Table IV)[27-29]. Weil et al. examined 50 patients and reported 18% incidence of knee pain, associated with more open fractures[27]. Stella et al. noted that 94% of patients reported minimal to no pain, with full ROM achieved[28]. Alwadi et al. followed 9 patients, achieving similar ROM and minimal complications[29].

The LPP approach exhibited low rates of anterior knee pain (18% to 30%) and favorable functional outcomes, but prospective studies with larger samples are necessary for confirmation. Careful fat pad dissection may further mitigate pain[27].

Comparative Studies

Suprapatellar vs. Infrapatellar

Twelve studies comparing outcomes of SP and IP approaches for tibial shaft fractures included a total of 1,128 patients (590 IP, 538 SP)[30-41]. Various outcome measures were used to assess knee pain and function, including the VAS, TLKS, SF-36, and Hospital for Special Surgery (HSS) knee score.

The SP approach demonstrated significantly superior TLKS scores at 6 months ([SP] 78.92 vs. [IP] 68.33, $p < 0.001$), 1 year ([SP] 93 vs. [IP] 84, $p = 0.02$), and 2 years ([SP] 88.91 vs. [IP] 83.44, $p = 0.034$) in 3 studies. Other studies reported better TLKS values for the SP group, although these were not statistically significant[34,35,41].

TABLE II Summary of Outcomes Reported by Articles Discussing Outcomes Following the Infrapatellar Approach to Tibial Shaft Fractures

Author	Sample	Average Follow-up Time (mo)	Average Age (yr)	Results		
Erinc et al.[24]	32	38.3	33	Compared with nonoperated side in patients without pain Statistically different Tendon width: 31.0 vs 26.5 mm (p = 0.009) Tendon thickness 3.4 vs 2.6 mm (p = 0.007) Not statistically different Tendon length Compared with nonoperated side in patients' pain Statistically different None Not statistically different Tendon length Tendon width Tendon thickness	VAS score Median: 31* Rest: 1.0 Walking: 2.0 Running: 4.0 Squatting: 5.0 Kneeling: 4.5 Stairs down: 4.5 Stairs up: 5.0 After long-term sitting: 3.0	
Leliveld et al.[7]	136	12	38 (TI group) 32 (LI group)	Pain and functional outcomes at 12 mo EMM Kneeling† TI group: 2.4 LI group: 3.7 (p = 0.018) LEFS TI group: 85 LI group: 83 SFMA TI group: 8 LI group: 10 EQ-US TI group: 0.87 LI group: 0.82 EQ-VAS TI group: 81 LI group: 80	Clinical outcomes at 12 mo Median knee flexion TI group: 133° LI group: 130° (p = 0.594) All patients reached full extension (0°) Median ankle flexion TI group: 10° LI group: 10° Median ankle extension TI group: 50° LI group: 50°	Sensory disturbance of the infrapatellar nerve at 12 mo TI group: 11/62 (18%) LI group: 32/59 (54%) p < 0.001
Lu et al.[25]	80	40: SEIP 40: HFIP	36.7	Rate of moderate anterior knee pain SEIP: 5% HFIP: 25% s p < 0.03 Median VAS score SEIP: 0 HFIP: 0 p = 0.03	Median TLKS SEIP: 92 HFIP: 88 p = 0.01 Median SF-36 mental SEIP: 48 HFIP: 48 p = 0.30 Median SF-36 physical score SEIP: 48 HFIP: 45 p = 0.14	

*VAS score was not defined by the manuscript.[22] †This difference did not persist in the linear mixed-effects regression models, in which pain scores were similar between the groups overtime for all daily activities. EMM = estimated marginal mean, EQ-US = EuroQol 5-Dimensions Utility Score, HFIP = hip flexion impairment profile, LEFS = lower extremity functional scale, SEIP = study comparing semi-extended, SF-36 = short form (36) health survey, SFMA = selective functional movement assessment, TLKS = Tegner-Lysholm knee scores, and VAS = visual analog scale.

Average VAS scores were also significantly lower in the SP group at multiple time points: at 6 months ([SP] 0.63 vs. [IP] 1.5, p <0 .001), 12 months ([SP] 0.37 vs. [IP] 1.09, p = 0.011), and 24 months ([SP] 0.21 vs. [IP] 0.84, p = 0.048). The SP group achieved significantly higher mean abnormal walking test-knee scores and HSS knee scores ([SP] 90.91% vs. [IP] 76.36%, p = 0.038),

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TABLE III Summary of Outcomes Reported by Articles Discussing Outcomes Following the Medial Parapatellar Approach to Tibial Shaft Fractures*

Author	Sample	Average Follow-up Time (mo)	Average Age (yr)	Results		
Jankovic et al.[26]	62 tibial shaft fractures	38.9	49.4	Anterior knee pain (AKP) 22 pts had persistent AKP (35.5%) 12 mild (VAS 1-4) (19.4%) 10 moderate (VAS 4-6) (16.1%) Average knee ROM 137.2° Without AKP: 139.8° Mild AKP: 139° Moderate AKP: 135.1° p = 0.381	Return to preinjury level of activity Without AKP: 92.3% Mild AKP: 61.9% Moderate AKP: 50.0% p = 0.011	Average TLKS: 84.6 Without AKP: 90.8 Mild AKP: 88.4 Moderate AKP: 79.9 p = 0.012

*ROM = range of motion, TLKS = Tegner-Lysholm knee scores, and VAS = visual analog scale.

as well as SF-36 physical scores ([SP] 48.19 vs. [IP] 40.98, p <0 .001) and mental scores ([SP] 45.23 vs. [IP] 49.22, p < 0.001)[35,41].

Radiographically, the SP approach showed better nail insertion point accuracy (p < 0.0001) and more precise entry points on anterior-posterior ([SP] ±2.1 mm vs. [IP] ±3.5 mm, p <0 .01) and lateral radiographs ([SP] ±5.2 mm vs. [IP] ±7.6 mm, P <0 .04). In addition, the SP group demonstrated improved ROM ([SP] 55.34° vs. [IP] 46.09°, p < 0.001)[35].

Overall, 7 studies concluded that the SP approach provided superior outcomes regarding anterior knee pain and patient-reported functional measures, while 5 studies reported comparable results. No studies indicated the superiority of the IP approach. Four of the 5 studies showing no significant differences had

TABLE IV Summary of Outcomes Reported by Articles Discussing Outcomes Following the Lateral Parapatellar Approach to Tibial Shaft Fractures

Author	Sample	Average Follow-up Time (mo)	Average Age (yr)	Results		
Weil et al.[27]	50	12	45	Average ROM Knee flexion: 130° All patients achieved full extension	Knee pain 9 patients (18%)	Average TLKS: 86.3 31 (62%): excellent 15 (30%): good 4 (8%): fair 46 (92%) had good results
Stella et al.[28]	70	41.2	47	Average ROM Injured knee: 130.6° Contralateral knee: 131.6° All patients achieved full extension Average VAS score: 0.6	Knee pain 49 no pain 17 inconstant and slight pain with exertion 4 marked pain with exertion Strength Oxford scale* 5/5 in 62 patients	Average TLKS: 96.1 57: excellent 11: good 2: fair (1 polytrauma)
Alwadi et al.[29]	9	6	28.7	Average surgical time 63.78 minutes Average Intraoperative Images 94	Anterior knee pain Average Kajula score: 90.9% ROM All patients regained a comparable range of motion in their knees and ankles	Time to fracture union 8 wk

*Numerical rating scale used to quantify muscle strength: 0 (no strength)–5 (maximum strength). Kajula score is a self-reported questionnaire assessing anterior knee pain: 0 (worst knee function and worse pain)-100 (better knee function and less pain). ROM = range of motion, TLKS = Tegner-Lysholm knee scores, and VAS = visual analog scale.

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TABLE V Summary of Outcomes Reported by Articles Discussing Outcomes Following the Medial Parapatellar and IP Approach to Tibial Shaft Fractures*

Author	Sample Size	Average Age (yr)	Average Follow-up (mo)	Results		
Rothberg et al.[43]	MPP: 24 IP: 23	39.9	12.8	Hardware removal PP: 3 (12%) IP: 11 (48%) p = 0.008 KLOA score ∝ SS-IKDC Coefficient: 3.83 p = 0.026	Mean for difference SS-IKDC 0.29 (90% CI: 4.16-4.75) PP: 25.25 IP: 24.96 (Equivalent) Difference in pain scores 0.20 [90% CI: 3.18–3.59] PP: 15.29 IP: 15.09 (Equivalent)	
Ahmad et al.[42]	MPP: 30 IP: 30	MPP: 28.4 IP: 34.63	MPP: 28.87 IP: 34.63	Anterior knee pain PP: 2.5 IP: 4.4 p = 0.000		
Toivanen et al.[44]	MPP: 21 IP: 21	MPP: 44 IP: 43	MPP: 3.1 y IP: 3.3 y	Anterior knee pain before nail removal MPP: 17/21 IP: 18/21 RR: 1.06 p = 1.000 Anterior knee pain during movement MPP: 15/21 (71%) IP: 14/21 (67%) RR: 1.07 p = 1.000 Tegner score before vs after injury MPP: decreased 0.19 IP: decreased 0.52 p = 0.301	Mean lysholm activity score MPP: 92.1 IP: 90.4 p = 0.698 IOWA knee score MPP: 96.1 IP: 95.4 p = 0.765 Mean functional score MPP: 10 IP: 9.8 p = 0.883 ROM MPP: 142° IP: 138° p = 0.168	Mean peak torque deficit at 60°/s Quadriceps MPP: 14% IP: 16% p = 0.651 Hamstrings MPP: 7% IP: 12% p = 0.275 Mean peak torque deficit at 180°/s Quadriceps MPP: 11% IP: 14% p = 0.625 Hamstring MPP: 2% IP: 11% p = 0.2755
Kekec and Bozgeyik[46]	MPP: 20 IP: 27	33	12 mo	Mean VAS MPP: 132 IP: 136.5 p = 0.927	Knee pain No pain MPP: 8 IP: 10 Mild pain MPP: 8 IP: 13	Moderate pain MPP: 3 IP: 3 Severe pain MPP: 1 IP: 1

continued

TABLE V (*continued*)

Author	Sample Size	Average Age (yr)	Average Follow-up (mo)	Results		
Vaisto et al.	At 3 yr MPP: 21 IP: 21 At 8 yr MPP: 14 IP: 14	MPP: 48 IP: 42.5	3 and 8 yr	Anterior knee pain (VAS score) Never MPP: 3 IP: 4 Vanished MPP: 7 IP: 6 Still MPP: 4 IP: 4 p = 0.800 Mean ROM MPP: 140° IP: 139° p = 0.850	Tegner knee score 3 yr MPP: 4.07 IP: 3.64 p = 0.538 8 yr MPP: 4.29 IP: 4.21 p = 0.887 Iowa knee score 3 yr MPP: 498.4 IP: 98.8 p = 0.924 8 yr MPP: 98.4 TT: 98.8 p = 0.694	Lysholm knee score 3 yr MPP: 88.9 IP: 93.6 p = 0.317 8 yr MPP: 93.0 IP: 97.5 p = 0.564 Mean peak torque deficit at 60°/s at 8 m Quadriceps MPP: 1.6% IP: 1.7% p = 0.890 Mean peak torque deficit at 180°/s Quadriceps MPP: 1.8% PT: 0.5% p = 0.625 Hamstring MPP: 2% IP: 11% p = 0.2755

*CI = confidence interval; IKD = International Knee Documentation Committee, IOWA = Iowa level of assistance scale, IP = infrapatellar, KLOA = Kellgren-Lawrence osteoarthritis, MPP = medial parapatellar, PP = per protocol (analysis), PT = physical therapy, ROM = range of motion, SS = statistical significance, TT = tibial tuberosity, and VAS = visual analog scale.

relatively small sample sizes (58, 41, 50, 40, 102), potentially limiting their statistical power[30-32,38,39]. The fifth study noted lower rates of anterior knee pain in the SP group (67.9% vs. 53.7%), although this difference was not statistically significant[38].

Medial Parapatellar vs. Transtendinous

Five studies compared outcomes of the MPP and transtendinous (IP) approaches, involving 196 patients (95 MPP, 101 IP) (Table V)[42-46]. Ahmad et al. reported lower anterior knee pain incidence in the MPP group ([MPP] 2.5 vs. [IP] 4.4, p = 0.000)[42]. Other studies found no significant differences in pain scores or functional metrics between the groups[43-46].

Discussion

This systematic review compiled and analyzed articles discussing anterior knee pain following various surgical approaches to tibial shaft fractures. We focused exclusively on original studies that reported anterior knee pain outcomes, deliberately excluding research centered on unrelated factors such as radiation dose, surgical time, complications, intraoperative imaging, time-to-fracture union, and hardware removal, as these fell outside the scope of our review. Polytrauma patients were not separately categorized within the different cohorts. In total, 27 studies were included: 3 focused on the SP approach, 3 on the IP approach, one on the MPP approach, and one on the LPP approach. In addition, 12 studies compared anterior knee pain outcomes between the SP and IP approaches, while 5 studies compared the MPP and IP approaches.

Given the use of over 18 different scores and scales for reporting anterior knee pain and functional outcomes, performing a comprehensive statistical analysis proved unfeasible. Nevertheless, the results indicated that the SP approach yielded better patient-reported outcomes and lower instances of anterior knee pain compared with the IP approach. This finding aligns with 2 recent meta-analyses published in 2023, which also concluded that the SP

approach may offer greater advantages than the IP approach[47,48]. Both studies reported statistically better results for the SP group in terms of radiographic accuracy, alignment, fluoroscopic time, TLKS, VAS pain score, and surgical time.

Notably, a prospective, parallel group randomized controlled trial published in February 2024 by Pol et al. compared anterior knee pain and patellofemoral function between the SP and IP approaches in 95 patients (44 SP, 46 IP) treated with intramedullary nailing[49]. Their findings indicated superior results for the SP group, which achieved higher Kujala scores at 6 weeks ([SP] 53.0 vs. [IP] 43.2, $p < 0.01$) and 12 months ([SP] 92.0 vs. [IP] 81.3, $p < 0.01$) postoperatively, alongside reduced anterior knee pain at 12 weeks ([SP] 0.7 vs. [IP] 2.9, $p < 0.01$).

This systematic review is the first to include and analyze the MPP and LPP approaches concerning tibial shaft fractures. Although both approaches are present in the literature, the reported results were sporadic. Noncomparative studies showed varying rates of anterior knee pain and functional outcomes that were comparable with those observed with other approaches. Comparative studies between the MPP and IP approaches indicated little statistical difference in anterior knee pain and functional outcomes, which may be attributed to limited sample sizes or the absence of significant differences between the groups. Nonetheless, the MPP and LPP approaches present viable surgical options for managing tibial shaft fractures, although no comparative studies exist between the MPP approach and the SP approach. Future research with larger samples should aim to compare these approaches to elucidate any potential benefits of the MPP technique.

This review acknowledges several limitations. The variability in patient-reported outcomes posed challenges for conducting a robust statistical analysis, necessitating the exclusion of relevant articles for such analyses. Consequently, our conclusions rely on the authors' interpretations, which may introduce bias. In addition, cross-comparison between articles involves uncontrolled variables that could confound results. However, we adhered to PRISMA guidelines, a recognized and reliable protocol for conducting systematic reviews, which enhances the methodological rigor of our work. Our review is also more comprehensive than recent meta-analyses, thereby providing a broader understanding of the current literature. RoB was assessed using the Risk Of Bias VISualization (ROBVIS) 2 tool[50], and while few studies were randomized, the overall RoB was deemed low (Figs. 2 and 3).

In conclusion, most articles comparing the SP approach to the IP approach indicate favorable patient-reported outcomes in terms of anterior knee pain and knee function scores. Both the MPP and LPP approaches are also feasible surgical options for tibial shaft fractures, with rates of anterior knee pain and functional outcomes following the LPP approach comparable with those of the SP and IP approaches. However, little evidence supports the superiority of the MPP approach over the IP approach.

Appendix

eA Supporting material provided by the author is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJSOA/A723). This content has not been copyedited or verified. ■

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