




Anterior knee pain and functional outcome following different surgical techniques for tibial nailing: a systematic review

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Abstract

Purpose The aim of this systematic review was to compare knee pain and function after tibial nail insertion through an infrapatellar, semi-extended and suprapatellar technique.

Methods A search was carried out to identify articles with an exact description of the method used for insertion of the tibial nail and description of the outcome parameters (knee pain or function). Data on study design, population, rate and severity of anterior knee pain and function scores were extracted. Pooled rates and scores were calculated.

Results 67 studies with 3,499 patients were included. The pooled rate of patients with anterior knee pain was 38% (95% CI 32–44) after nail insertion through an infrapatellar approach and 10% (95% CI 1–26) after insertion through a suprapatellar approach. Pooled analysis was not possible for the semi-extended technique. Knee pain scores as measured by visual analogue score (0–10) ranged from 0.2 (95% CI – 0.1–0.5) for general knee pain to 3.7 (95% CI 1.3–6.1) for pain during kneeling. Pooled estimates for the Lysholm score were 87 points (range 77–97) for the infrapatellar technique and 85 points (range 82–85) for the suprapatellar technique. Iowa Knee scores were 94 (range 86–96) and Anterior Knee Pain Scale scores were 76 (range 75–80) after infrapatellar nail insertion.

Discussion Depending on the technique used, the proportion of patients with knee pain after tibial nailing varied between 10 and 38%. The actual measured knee pain scores were, however, surprisingly low. Knee function was good for both the infra- and suprapatellar technique.

Keywords Infrapatellar tibial nailing · Suprapatellar tibial nailing · Outcome

Introduction

Diaphyseal fractures of the tibia are commonly treated with an intramedullary nail. The infrapatellar approach is most commonly used. However, hyperflexion of the knee during this procedure is associated with an increased risk of valgus and procurvatum deformities in proximal third tibial shaft fractures. In an attempt to address this problem, a semi-extended technique has been developed [1, 2], of which

also a subcutaneous variant exists [3]. For the same reasons, the suprapatellar approach has been introduced [4–6]. For this approach, an incision is made just proximal to the superior pole of the patella and the nail is inserted through the patellofemoral joint. The first clinical studies have suggested favorable outcomes associated with a suprapatellar approach [4, 5, 7–9]. The concern of potential damage to the cartilage of the patellofemoral joint remains a significant drawback, although rates of anterior knee pain after this procedure seem lower than seen after the infrapatellar approach [5, 7, 9].

Although all techniques for nail insertion have been proven feasible, a comparison of their rates of anterior knee pain and functional outcome is lacking. The aim of this systematic review and pooled analysis was, therefore, to compare these parameters between different techniques for tibial nail insertion. This information gives perspective to the patient's rehabilitation after tibial nailing and can aid

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surgeons in their decision to choose between these surgical techniques.

Patients and methods

The following databases were searched on December 19, 2018: Embase, Medline (OvidSP), Web of Science, Cochrane Central Register of Controlled Trials (CENTRAL), and Google Scholar. Searched items consisted of terms related to tibia shaft, intramedullary nailing and terms related to pain and function (for full search strategy, see Supplementary data).

Titles and abstracts were screened independently by three reviewers (MSL, JVH, and EAVB). Inconsistencies were resolved by consensus. Studies were included if they met the following inclusion criteria: (1) tibial shaft fracture treated with intramedullary nailing, (2) description of the surgical method used for insertion of the tibial nail (infrapatellar, (subcutaneous) semi-extended or suprapatellar; insertion through patellar tendon, medial or lateral to patellar tendon; use of longitudinal or transverse incision) and (3) primary data for at least one of the outcome parameters (knee pain, function). No limitations on language were considered and only studies from 1990 onwards were included. Studies were excluded if no full-text version was available after contacting corresponding authors. Studies encompassing patients with intra-articular fractures (*i.e.*, tibia plateau or pilon fracture) or only patients with ipsilateral fractures (*i.e.*, patients with a floating knee), studies that described only pathological fractures or those with a population aged < 18 years, were excluded. Case reports and letters to or from the editor were also excluded. Reference lists of review articles and eligible studies were examined for additional studies that may have been missed.

Randomized controlled trials (RCTs) and cohort studies were found to be eligible. Patient groups of comparative studies that were treated with the same incision were taken together; the pooled study population was considered one cohort over which knee pain rate, pain and functional scores were calculated.

Two reviewers (MSL and EAVB) independently assessed the methodological quality of the studies using the MINORS (Methodological Index for Non-Randomized Studies) scale [10] (see Supplementary Materials), the global ideal score being 16 for non-comparative studies and 24 for comparative studies.

Data were independently extracted in duplicate by three reviewers (MSL, JVH, and EAVB) using a standardized data sheet. Discrepancies were resolved by consensus. The following data were extracted for each publication: name of first author, publication year, population size and

age, percentage of polytrauma patients and patients with ipsilateral fractures, the approach used, the rate of anterior knee pain, the pain scores, functional outcome scores, and the moment at which these measurements were done. When measurements were done at different time points, the scores at 12 months were used for calculation.

Analyses were performed using MedCalc Statistical Software (version 17.6; MedCalc Software bvba, Ostend, Belgium; <https://www.medcalc.org>; 2017). The rates of anterior knee pain were computed for each study and expressed as percentage. Visual Analog Scales (VAS) with a scale 0–100 were divided by 10 to compare them with 10 cm VAS and 10-point Numeric Rating Scales (NRS). Heterogeneity of the data was assessed using the Cochrane χ^2 Q -test (significance set at $p < 0.10$) and I^2 statistic. Outcomes for cohorts with the same surgical approach were pooled if data were available for at least two groups. A random effects model was used if the I^2 statistic was > 40%; a fixed-effect model was used if it was < 40%. For comparative studies, the relative risk ($RR_{\text{transpatellar/parapatellar medial}}$ and $RR_{\text{infrapatellar/suprapatellar}}$) was determined for binomial variables and a mean difference for continuous variables. Pooled estimates and relative risks are reported with their 95% confidence interval.

Results

The literature search identified 6184 potentially eligible studies. After removal of the duplicates (2737 studies) and applying the inclusion and exclusion criteria, 77 studies remained for analysis (Fig. 1).

In the majority of the studies, the infrapatellar approach was described [4, 7–9, 11–78]). Six studies reported on the suprapatellar approach [4, 5, 7–9, 79–83] and one on the semi-extended technique [66]. There were 17 randomized trials [7, 9, 19, 23, 26, 30, 48, 49, 52, 54, 57, 59–61, 64, 68, 71] of which five compared different methods for tibial nailing [7, 9, 26, 49, 71], 14 prospective studies [5, 11, 14, 28, 31, 34, 37, 39, 46, 55, 70, 72, 73, 83] and 45 retrospective studies [4, 8, 12, 13, 15–18, 20–22, 24, 25, 27, 29, 32, 33, 35, 36, 38, 40–45, 47, 50, 51, 53, 56, 58, 62, 63, 66, 67, 69, 74, 76, 78–82, 84]. The mean follow-up ranged from 8 [63] to 94 [28] months. In the majority of the papers, it was clearly stated that the study population did not comprise any polytrauma patients [7–9, 22–26, 28, 32, 33, 36, 43, 44, 48, 51, 53, 55, 60, 63, 64, 66, 68, 71, 74, 79, 81, 84]. However, 23 studies included multiple injured patients in their population [5, 11–14, 16, 18, 19, 27, 30, 34, 35, 37–39, 41, 52, 54, 62, 65, 72, 80, 82], ranging from 4% [38] to 100% [80]. In those articles that included patients with ipsilateral fractures [5, 12, 19, 30, 32, 34, 35, 46, 52, 54, 62, 67, 80, 82], the proportion of ipsilateral fractures was between 3% [19] and 56% [80]. These patients were excluded in 29 studies [7–9,

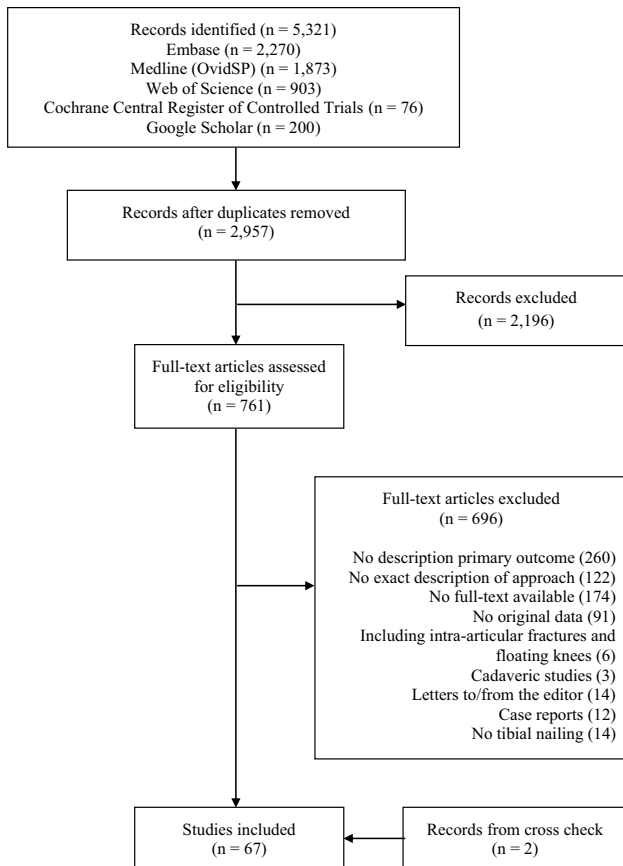


Fig. 1 Study flowchart

22–26, 28, 33, 36, 38, 43–45, 48, 51, 53, 55, 60, 64, 66, 68, 71–73, 77, 79, 81]. The moment at which data on anterior knee pain or function were conveyed, was documented in 28 studies [4, 5, 7, 9, 18–20, 25, 26, 28, 30, 42, 45, 49, 51, 53, 54, 56, 58, 60, 66, 70–73, 81, 83] and ranged from 3 months [71] to 94 months [28].

Anterior knee pain

Pain rate

The pooled percentage of patients with anterior knee pain after intramedullary nailing was 36% (95% CI 31–42) after

use of the infrapatellar approach and 10% (95% CI 2–22) after the suprapatellar approach (Table 1). The relative risk of anterior knee pain after tibial nailing was 1.3 (95% CI 0.9–2.0) when comparing the infrapatellar and suprapatellar techniques [4, 7, 9, 81].

Pain scores

Six different scales were used for measuring the severity of anterior knee pain (Table 2). For the majority of the studies, it was not documented on how data on knee pain were retrieved. Pooled estimates for knee pain (VAS 0–10) were 2.5 (95% CI 1.5–3.4) for the infrapatellar technique and 0.4 (95% CI 0.0–0.7) for the suprapatellar technique (Fig. 2a, b). Pain scores for specific (daily) activities could only be pooled for the infrapatellar technique. Kneeling was reported as most painful (VAS 3.7; 95% CI 1.3–6.1) [26, 53, 58]. Pain scores for other activities were described in two studies [26, 53]: 0.3 (95% CI – 0.1–0.7) in rest, 0.6 (95% CI – 0.0–1.1) for prolonged sitting with knees bend, 0.5 (95% CI 0.01–1.0) during walking, 1.0 (95% CI 0.0–2.1) for running, 1.6 (95% CI 0.5–2.7) while squatting, 1.1 (95% CI 0.2–2.1) for ascending stairs and 0.9 (95% CI – 0.1–1.9) for descending stairs.

Table 2 Different instruments used for measuring knee pain

Instrument used to measure knee pain	N studies
Unspecified [11–16, 19–23, 25, 27, 29, 30, 32, 34–37, 40, 41, 44, 47, 50, 52, 59, 62, 64, 65, 69, 71]	32
VAS 0–10 [5, 7, 9, 24, 38, 46, 49, 55, 56, 63, 70]	11
VAS 0–100 [26, 33, 53, 58, 60]	5
Direct questioning [20, 28, 45, 51, 54]	5
NRS 0–10 [17, 42, 67]	3
Oxford Knee Score (pain component) [8]	1
Lysholm Knee Score (pain component) [72]	1
Kujala or Anterior Knee Pain Scale (pain component) [4]	1

Table 1 Pooled pain rates per (sub)group

Parameter	(Sub)group	Studies (N)	Population (N)	Q (p-value)	I ² (95% CI)	Pooled estimate (95% CI)
Pain (%)	Infrapatellar technique	51	2853	612.3 (<0.0001)	92 (90–93)	38 (32–44)
	Suprapatellar technique	5	174			

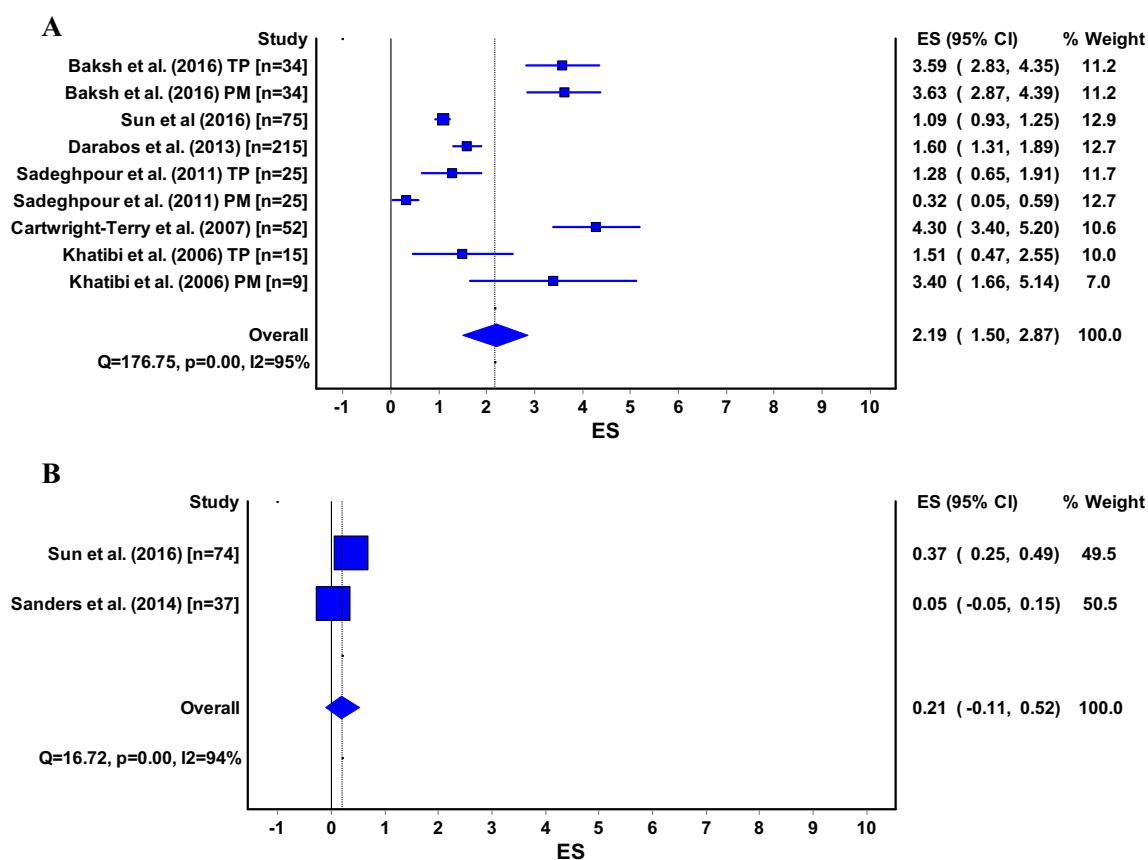


Fig. 2 a, b ES, effect size (pooled estimate for Visual Analogue Score); 95% CI, 95% Confidence Interval; Q, Cochran's Q-statistic for study heterogeneity; I2, statistic for study heterogeneity; numbers

indicate the number of patients in each study or subgroup; TP, transpatellar approach; PM, parapatellar medial approach

Function

General function lower extremity

To measure the lower extremity function in general, the Tegner Activity Score [14, 23, 26, 53, 77], Lower Extremity Functional Score [35], and Musculoskeletal Function Assessment [54] were used. The pooled analysis for the Tegner Activity score was 3.9 (95% C.I. 3.6–4.2) for the infrapatellar technique [53].

Knee function

The Lysholm Scale [5, 9, 26, 45, 53, 56, 66, 73, 75, 77, 79–81, 83, 84], Iowa Knee Score [24, 26, 33, 48], (Kujala) Anterior Knee Pain Scale (AKPS) [4, 51, 80, 81], Functional Anterior Knee Pain Score [38, 75, 80], Oxford Knee Score [8, 80] and International Knee Documentation Committee (IKDC Questionnaire) [80] were used for measuring the knee function after tibial nailing. Pooled estimates for the Lysholm Scale were 87 points (95% CI 81–94) for

the infrapatellar technique and 85 points (95% CI 83–87) for the suprapatellar technique (Fig. 3a, b). Pooled analysis for the Iowa Knee Score (Fig. 4) was only possible for the infrapatellar technique and was 94 points (95% CI 91–97) (Fig. 4). Pooled estimates for the Anterior Knee Pain Scale (or Kujala) were 79 points (95% CI 76–83) for the infrapatellar technique and 79 points (95% CI 71–86) for the suprapatellar technique (Fig. 5a, b).

Ankle function

To measure ankle function, the following instruments were used: AOFAS ankle–hindfoot scoring system [67, 77, 78, 82], Iowa Ankle Score (also known as Merchant and Dietz Ankle Function Score) [24, 31, 33, 36, 48], Olerud and Molander Ankle Score [36, 76, 82], Mazur Ankle Score [59], and Foot Function Index [54]. Pooled estimates for the AOFAS ankle–hindfoot scoring system and Iowa Ankle Score were 91 (95% CI 87–93) and 92 (95% CI 89–96) for the infrapatellar and suprapatellar technique, respectively.

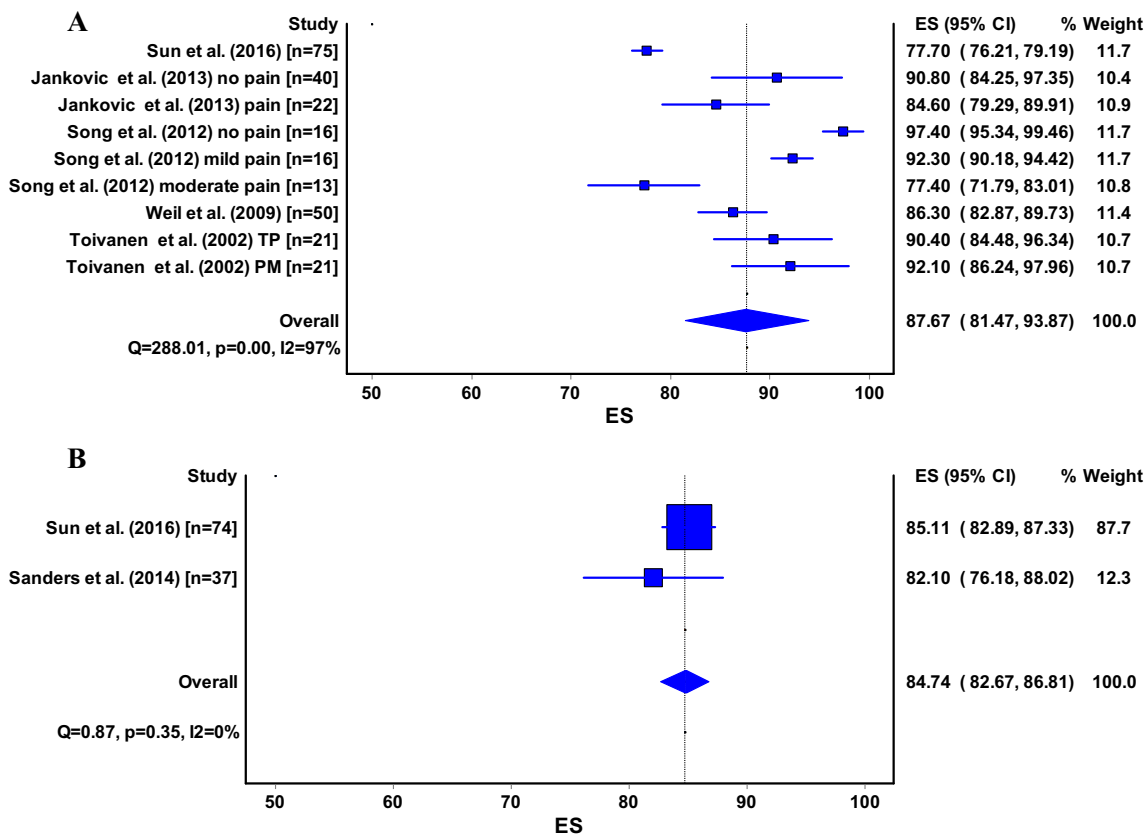


Fig. 3 a, b ES, effect size (pooled estimate for Lysholm score); 95% CI, 95% Confidence Interval; Q, Cochran’s Q-statistic for study heterogeneity; I2, statistic for study heterogeneity; numbers indicate

the number of patients in each study or subgroup; TP, transpatellar approach; PM, parapatellar medial approach Pooled estimates for the other surgical methods could not be calculated and are thus not shown

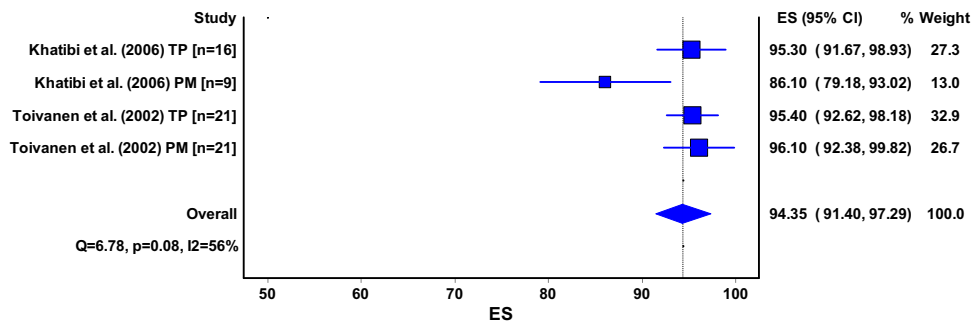


Fig. 4 ES, effect size (pooled estimate for Iowa knee score); 95% CI, 95% Confidence Interval; Q, Cochran’s Q-statistic for study heterogeneity; I2, statistic for study heterogeneity; numbers indicate the num-

ber of patients in each study or subgroup; TP, transpatellar approach; PM, parapatellar medial approach Pooled estimates for the other surgical methods could not be calculated and are thus not shown

Quality of life

The Short Form-36 (SF-36) [5, 7, 9, 24, 43, 48, 51, 61, 67, 80, 83], SF-12 [4], EQ5D [60], and the Nottingham Health Profile [23, 60] were used to measure quality of life after tibial nailing. The pooled estimates could only

be calculated for the physical and mental component score (PCS and MCS) of the SF-36. The PCS was 42 (95% CI 40–44) for the infrapatellar technique and 46 (95% CI 41–51) for the suprapatellar technique (Fig. 6a, b). The pooled estimate for the MCS was 44 (95% CI 43–45) for the infrapatellar technique and 48 (95% CI 44–52) for the suprapatellar technique (Fig. 7a, b).

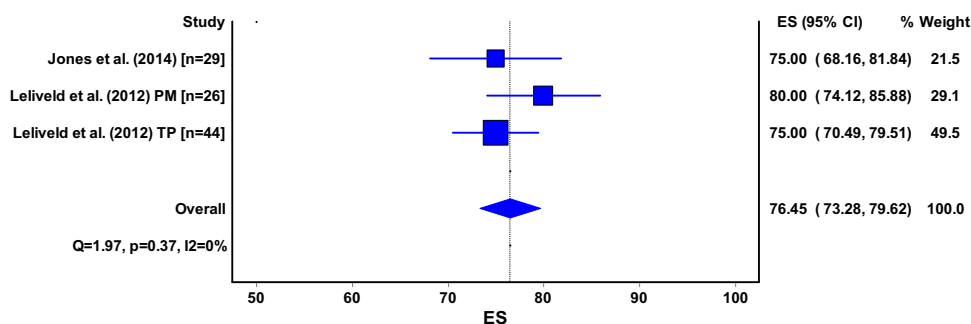
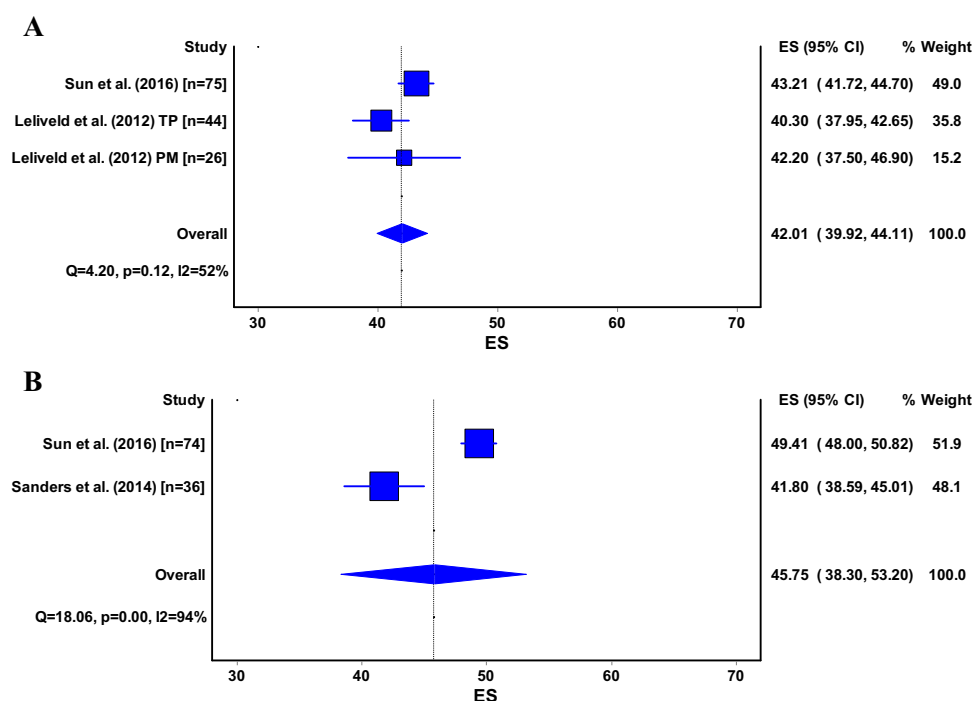


Fig. 5 ES, effect size (pooled estimate for Anterior Knee Pain Scale); 95% CI, 95% Confidence Interval; Q, Cochran's Q-statistic for study heterogeneity; I2, statistic for study heterogeneity; numbers indicate the number of patients in each study or subgroup; TP, transpatellar

approach; PM, parapatellar medial approach. Pooled estimates for semi-extended technique could not be calculated and are thus not shown

Fig. 6 a, b SF-36, Short Form-36; PCS, physical component score; ES, effect size (pooled estimate for PCS); 95% CI, 95% Confidence Interval; Q, Cochran's Q-statistic for study heterogeneity; I2, statistic for study heterogeneity; numbers indicate the number of patients in each study or subgroup; TP, transpatellar approach; PM, parapatellar medial approach. Pooled estimates for the semi-extended technique could not be calculated and are thus not shown



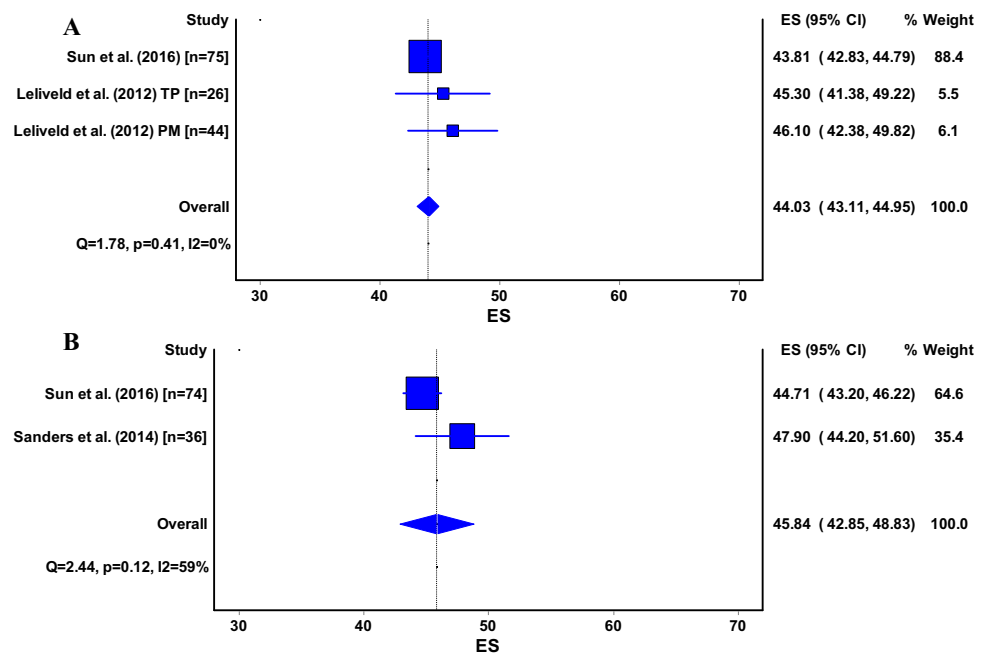
Discussion

The aim of this systematic review was to compare knee pain and function after tibial nail insertion through different surgical methods. For the infrapatellar approach, the proportion of patients with anterior knee pain in the current review was 36%. The percentage found for the suprapatellar technique was 10%. The documented general knee pain scores (VAS/NRS 0–10) were, however, surprisingly low for both techniques (2.5 for the infrapatellar technique and 0.4 for the suprapatellar technique). For the infrapatellar technique, pain scores during common daily activities were also low, except for kneeling (range 3.2–4.7). Knee

function was good for both the infra- and suprapatellar techniques.

The pooled proportion of 36% of patients with knee pain is lower than the much quoted percentage of 47.4% from the systematic review by Katsoulis et al. [85], but it is still a substantial percentage. Although many patients report pain, pooled estimates were high for the Lysholm score, Iowa Knee score and AKPS. The scope of most knee function scores is limited to patients with osteoarthritis or those receiving total knee replacements. For fractures around the knee, there is currently no validated, reliable, and reproducible outcome measure. For patients with tibia fractures only, the disease-specific Short Musculoskeletal Function Assessment (SMFA) and the generic measure SF-36 have

Fig. 7 a, b SF-36, Short Form-36; MCS, mental component score; ES, effect size (pooled estimate for MCS); 95% CI, 95% Confidence Interval; Q, Cochran's Q-statistic for study heterogeneity; I², statistic for study heterogeneity; numbers indicate the number of patients in each study or subgroup; TP, transpatellar approach; PM, parapatellar medial approach. Pooled estimates for the semi-extended technique could not be calculated and are thus not shown



been demonstrated responsive and valid [86]. Both assess the general functional status of patients and how bothered they are by functional problems without focus on knee function and knee pain. Since outcome scoring is vital in the accurate evaluation and comparison of interventions, what knee scoring system should we use to measure knee pain and/or function after tibial nailing? The Lysholm Score and Iowa Knee Score [24, 26, 33, 48] are the most commonly used for this cause, but neither is validated for this specific patient population. Validation of (at least one of) these questionnaires in a patient population that include tibial fractures is, therefore, needed.

One limitation of this systematic review is the lack of randomized controlled trials (RCT) comparing different methods in tibial nailing. Only two RCTs compared nail insertion through the patellar tendon with insertion medial to the patellar tendon [26, 49] and two other RCTs compared an infrapatellar and suprapatellar technique [7, 9]. Furthermore, most studies lack information on how pain as an outcome parameter was acquired, as did information at the point of time at which the parameter was measured. The proportion of patients with knee pain might well be higher within the first months after surgery than years later. This should be taken into account when interpreting such percentages. Pain scores and functional outcome measurements can additionally be affected by the presence of other injuries. Therefore, outcome measures from studies that included multiple injured patients or patients with ipsilateral fractures must also be interpreted with caution.

Overall, adequate reporting of outcome measures was poor. Besides, the previously mentioned lack of how and when measurements were taken, the standard deviation for mean pain or functional scores was not always provided. Furthermore, some authors chose to report scores only in terms of excellent, good, fair etc., without mentioning an overall score. The quality of a systematic review, such as the current review, depends on the quality of the underlying studies and although it is the authors' responsibility to report their data adequate and complete, it would be helpful if journal reviewers and editors would ask for any missing information.

Conclusion

The question whether one surgical approach for tibial nailing is superior to another cannot be answered due to limited availability of adequate data. One can conclude though that in terms of anterior knee pain, the suprapatellar technique has the lowest proportion (10.0%) of patients with this complaint. Overall, general knee pain scores are low (range 0.2–2.7). Knee function was good for both the infra- and suprapatellar techniques.

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Compliance with ethical standards

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Consent to participate Not applicable.

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Availability of data and material Not applicable.

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