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# Surgical Outcomes and Complications of Fixation Strategies for Distal Tibial Fractures: A Systematic Review and Network Meta-analysis

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**ADMINISTRATIVE INFORMATION**

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**Conflicts of interest -** None declared.

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**Amendments -** This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 16 December 2025 and was last updated on 16 December 2025.

## INTRODUCTION

**Review question / Objective** P (Population): Adults (≥18 years) with distal tibial fractures treated surgically. I (Interventions): Open reduction and internal fixation (ORIF); minimally invasive plate osteosynthesis (MIPO); external fixation combined with limited open reduction and internal fixation (EF+LORIF); intramedullary nailing via suprapatellar approach (IMN-SP); intramedullary nailing via infrapatellar approach (IMN-IP); retrograde tibial nailing (RTN). C (Comparators): Any of the above fixation strategies compared with another, including direct head-to-head comparisons and indirect comparisons within a connected treatment network. O (Outcomes): Operative time; time to fracture union (healing time); postoperative infection; malunion; delayed union and nonunion. Effect measures will be risk ratios (RRs) for dichotomous outcomes and mean differences (MDs) for continuous outcomes, both with 95% confidence intervals. S (Study design): Randomized controlled trials and comparative observational studies (prospective or retrospective cohort studies).

**Rationale** Most existing meta-analyses provide only limited evidence, as they mainly compare two surgical techniques at a time, and traditional pairwise meta-analyses cannot comprehensively evaluate multiple operative strategies simultaneously. Network meta-analysis (NMA) allows comparison of multiple interventions within a single analytical framework.Therefore, in this study we performed an NMA comparing ORIF, MIPO, EF+LORIF, IMN（IP）, IMN-SP and RTN for the treatment of distal tibial fractures, to assess the relative efficacy and safety of these procedures and to provide evidence to inform clinical decision-making.

**Condition being studied** Distal tibial fractures refer to fractures involving the distal third of the tibia. In this review, we focus on extra-articular

distal tibial fractures located 4–11 cm proximal to the tibial plafond. These injuries are clinically challenging because the distal tibia has limited soft-tissue coverage and relatively compromised blood supply, and high-energy trauma is common. As a result, patients are at increased risk of wound complications and infection, as well as delayed union/nonunion, malunion, and prolonged time to union. The primary goals of surgical management are to restore alignment and stability, promote timely fracture healing, and minimize soft-tissue disruption. Several fixation strategies are widely used, including open reduction and internal fixation (ORIF), minimally invasive plate osteosynthesis (MIPO), external fixation combined with limited open reduction and internal fixation (EF+LORIF), intramedullary nailing via suprapatellar or infrapatellar approaches, and retrograde tibial nailing. However, the optimal surgical strategy remains controversial because each technique involves trade-offs in surgical exposure, fixation stability, and complication profiles. Therefore, comparative evidence integrating both direct and indirect comparisons is needed to inform decision-making for extra-articular distal tibial fractures.

## METHODS

**Participant or population** 1) patients were over age 18 years withextra-articular distal tibial fractures located 4–11 cm fromthe tibial plafond; 2)at least one of five surgical methods described (ORIF,MIPO,EF+LORIF,IMN-SP,IMN-IP and RTN); 3)outcomes included operation time,healing time,malunion,delayed union,nonunion and wound infection;4)randomized controlled trials or cohort studies;5)minimum follow-up of 12 months.

**Intervention** The interventions of interest were surgical fixation strategies for extra-articular distal tibial fractures, including open reduction and internal fixation (ORIF), minimally invasive plate osteosynthesis (MIPO), external fixation combined with limited open reduction and internal fixation (EF+LORIF), intramedullary nailing via a suprapatellar approach (IMN-SP), intramedullary nailing via an infrapatellar approach (IMN-IP), and retrograde tibial nailing (RTN).

**Comparator** Comparators were any of the other eligible fixation strategies listed above. Studies directly comparing at least two of these interventions were eligible, and indirect comparisons were performed within a connected network of treatments.

**Study designs to be included** Randomized controlled trials and comparative cohort studies (prospective or retrospective) evaluating at least two eligible fixation strategies for extra-articular distal tibial fractures will be included. Non-comparative designs (e.g., case reports/series), reviews, letters, abstracts, biomechanical/cadaveric studies, and animal studies will be excluded.

**Eligibility criteria** The inclusion criteria were as follows：minimum follow-up of 12 months.The exclusion criteria were as follows:1)animal study, study on cadavers,or biomechanical study; 2) pathologic fractures;3)valid data could not be extracted or converted;4)abstracts, letters, or casereports and reviews.

**Information sources** Electronic databases including PubMed, Embase, Web of Science, and the Cochrane Library will be searched from inception to September 23, 2025. In addition, reference lists of relevant reviews and included studies will be manually screened to identify additional eligible articles. When necessary, study authors will be contacted to clarify unclear information or to obtain missing data. No trial registries or other grey-literature sources will be systematically searched.

**Main outcome(s)** All prespecified outcomes were considered main outcomes. These included operative time and time to fracture union (healing time), as well as postoperative complications: malunion, delayed union and nonunion, and wound infection. Operative time and time to union were analyzed as continuous outcomes and summarized using mean differences (MDs) with 95% confidence intervals (CIs). Malunion, delayed union/nonunion, and infection were analyzed as dichotomous outcomes and summarized using risk ratios (RRs) with 95% CIs. Outcomes were extracted as reported in the original studies and, when multiple time points were available, data at the latest follow-up were used (minimum follow-up of 12 months).

**Quality assessment / Risk of bias analysis** Risk of bias/quality will be assessed independently by two reviewers. Randomized controlled trials will be evaluated using the Cochrane Risk of Bias 2 tool (RoB 2). Cohort studies will be assessed using the Newcastle–Ottawa Scale (NOS). Any discrepancies will be resolved through discussion, with arbitration by a third reviewer if necessary. The results of risk-of-bias/quality assessment will be considered in the interpretation of findings and explored in sensitivity analyses where applicable.

**Strategy of data synthesis** Data will be synthesized using a frequentist network meta-analysis (NMA) to combine direct and indirect evidence across all eligible fixation strategies within a connected network. For dichotomous outcomes (infection, malunion, delayed union/nonunion), treatment effects will be summarized as risk ratios (RRs) with 95% confidence intervals (CIs). For continuous outcomes (operative time and time to union), effects will be summarized as mean differences (MDs) with 95% CIs. Random-effects models will be applied as the primary approach. Statistical heterogeneity will be assessed using the between-study variance ($\tau^2$) and $I^2$ where applicable. Consistency will be evaluated using both global (design-by-treatment interaction model) and local approaches (node-splitting), and results will be interpreted with caution if inconsistency is detected. Treatments will be ranked using P-scores. Where feasible, sensitivity analyses will be performed to examine the robustness of findings (e.g., excluding studies at high risk of bias). All analyses will be conducted in R (version 4.5.1).

**Subgroup analysis** No subgroup analyses were prespecified. Subgroup analyses were not performed because key clinical modifiers (e.g., open vs. closed fractures, AO/OTA fracture classification, soft-tissue status, fibular fixation, and follow-up duration) were inconsistently reported across included studies, which precluded reliable stratifiedanalyses.

**Sensitivity analysis** Leave-one-out sensitivity analyses were performed for each outcome (operative time, time to union, malunion, delayed union/nonunion, and infection) by removing one study at a time and re-running the network meta-analysis. Robustness was assessed by evaluating whether pooled effect estimates, treatment rankings (P-scores), and heterogeneity statistics ($\tau^2$ and $I^2$) changed materially after exclusion of any single study. Overall, the conclusions were not driven by any individual study.

**Country(ies) involved** China.

**Keywords** Distal tibial fracture;Fracture fixation;Meta-Analysis.

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