



COMPARISON OF MINIMALLY INVASIVE PLATE OSTEOSYNTHESIS AND INTRAMEDULLARY NAILING FOR TIBIAL SHAFT FRACTURE: A SYSTEMATIC REVIEW AND META-ANALYSIS

I Wayan Subawa¹, Anak Agung Ngurah Bagus Surya Dharma^{2*}

¹Consultant of Department of Orthopaedic and Traumatology, Faculty of Medicine, Universitas Udayana, Jl. Raya Kampus Unud, Jimbaran, Badung, Bali 80361, Indonesia

²Resident of Department of Orthopaedic and Traumatology, Faculty of Medicine, Universitas Udayana, Jl. Raya Kampus Unud, Jimbaran, Badung, Bali 80361, Indonesia

*suryadarma63@yahoo.com

ABSTRACT

Tibia shaft fractures are thought to affect 4% of the elderly population. Both low energy and high energy mechanisms have the potential to damage the tibia. Two frequently utilized surgical procedures that are superior to other available choices (external fixation and conventional plate fixation) for the treatment of tibia shaft fractures are intramedullary nailing (IMN) and minimally invasive plate osteosynthesis (MIPO). We compare minimally invasive plate osteosynthesis versus intramedullary nailing for tibia shaft fracture in terms of return to work, hospital stay, and complications over the duration of 1-2 years of follow-up. Methods: A PRISMA guided systematic review was done. A comprehensive literature search was performed to find study in English comparing between MIPO and IMN for tibia shaft fracture from January 2017 until August 2022. PubMed, Google Scholar, and Cochrane Library. The focus in this systematic review and meta-analysis is to compare outcome between MIPO and IMN for tibia shaft fracture. (“Minimally Invasive Plate Osteosynthesis”, “Intramedullary Nailing”), AND (“Tibia Shaft Fracture”), AND (“Outcome Measure”) were utilized in the search. Results: This meta-analysis included a total number of 214 patients with 91 patients undergoing MIPO and 123 patients undergoing IMN. The follow-up period was 1-2 years after the treatment. There were found no significant differences statistically in terms of hospital stay, return to work, infection, malunion, and non union. Conclusion: Our investigations show that both IMN and MIPO are safe and effective methods in treating tibia shaft fractures, and our results show that both methods provide similar outcomes in length of stay, return to work, infection, malunion, and non-union aspects.

Keywords: intramedullary nailing; minimally invasive plate osteosynthesis; tibia shaft fracture

How to cite (in APA style)

Subawa, I. W., & Dharma, A. A. N. B. S. (2025). Comparison of Minimally Invasive Plate Osteosynthesis and Intramedullary Nailing for Tibial Shaft Fracture: A Systematic Review and Meta-Analysis. *Indonesian Journal of Global Health Research*, 7(2), 271-278. <https://doi.org/10.37287/ijghr.v7i2.5130>.

INTRODUCTION

One of the most frequent long-bone fractures and the second-most frequent open sport-related injury, tibia shaft fractures are thought to affect 4% of the elderly population (Tian et al., 2020). Both low energy and high energy mechanisms have the potential to damage the tibia (Bauwens et al., 2021). Low energy impacts typically resulted in spiral fractures at various levels with little soft tissue damage due to transitional forces and indirect trauma (Mahajan, Kumar and Gupta, 2021). Two frequently utilized surgical procedures that are superior to other available choices (external fixation and conventional plate fixation) for the treatment of tibia shaft fractures are intramedullary nailing (IMN) and minimally invasive plate osteosynthesis (MIPO) (Bleeker et al., 2022). Due to these encouraging results, the IMN procedure's indications have been expanded to include fractures that are closer to joints. In both proximal and distal tibia shaft fractures, the minimally intrusive plate osteosynthesis (MIPO) approach is preferable than IMN due to higher union rates and fewer angular deformities (Behlmer et al., 2021).

In order to get the greatest results and prevent complications, particularly when discussing the most frequent long bone fractures, management of tibial fractures has been updated (Wang and Ji, 2024). Less invasive fixation methods are preferred in order to lessen damage to the soft tissues around the wound, accelerate healing, and limit problems. (Marazzi et al., 2020). The least invasive and most widely employed techniques nowadays are intramedullary nailing (IMN) and minimally invasive percutaneous plate osteosynthesis (MIPO) (Kim et al., 2023). Tibial shaft fractures are among the most common long-bone fractures encountered in clinical practice, often leading to significant morbidity. Highlighting their prevalence, particularly in active and elderly populations, underscores the importance of optimizing treatment strategies to minimize complications and improve functional outcomes. Hereby, we compare minimally invasive plate osteosynthesis versus intramedullary nailing for tibial shaft fracture in terms of return to work, hospital stay, and complications over the duration of 1-2 years of follow-up through the utilization of systematic review and meta analysis (Upfill-Brown et al., 2021).

METHOD

Search Strategy

A systematic review was conducted in accordance to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Figure 1) (Liberati *et al.*, 2009). A comprehensive literature search was performed to gather a full-length, peer-reviewed paper in English on comparison between MIPO and IMN for tibial shaft fracture from January 2017 until August 2022. We searched PubMed, Google Scholar, and Cochrane Library. The focus in this systematic review and meta-analysis is to compare outcome between MIPO and IMN for tibial shaft fracture. Keywords in the search matched the MeSH rule and term used are ((“Minimally Invasive Plate Osteosynthesis”, “Intramedullary Nailing”), AND (“Tibial Shaft Fracture”), AND (“Outcome Measure”)).

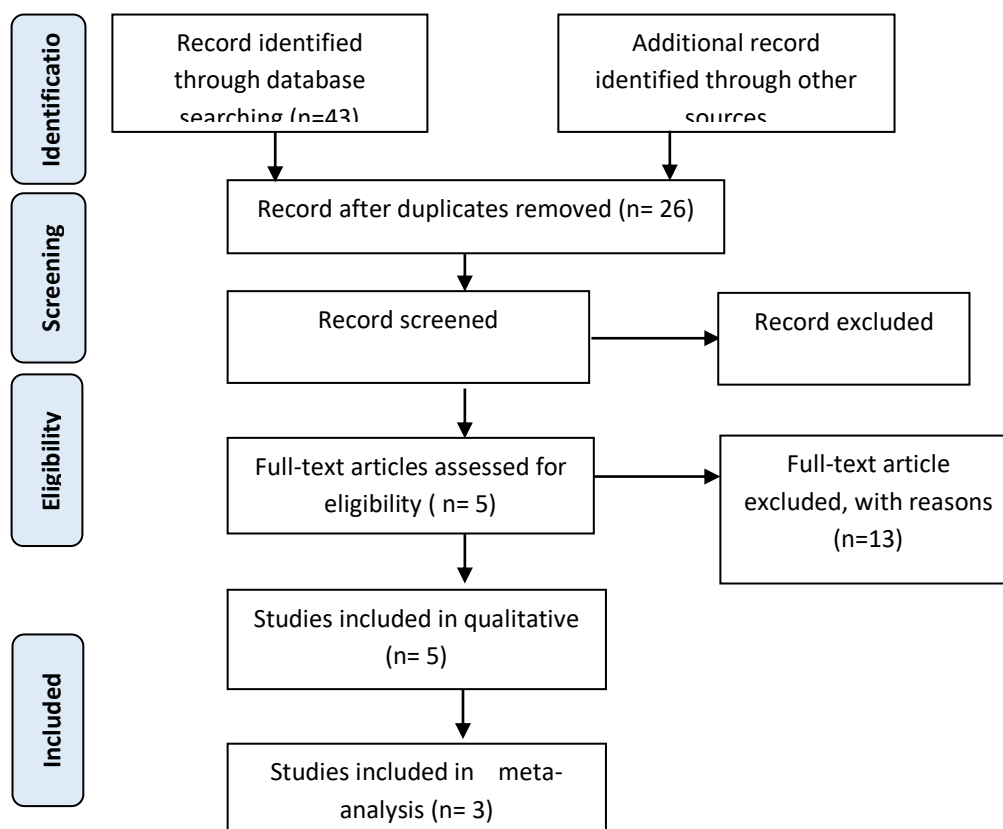


Figure 1. Flow chart of study selection

Study Selection

The inclusion criteria were any studies about the outcome MIPO and IMN for tibial shaft fracture. The exclusion criteria were case reports, letters, editorials, review articles, nonhuman studies, inaccessible fulltext, and studies not published in English. The outcome assessed includes return to work, hospital stay, and complications include malunion, non-union, and infection.

Quality Assessment

Assessment of study quality and risk of bias assessed using criteria developed by the Oxford Center for Evidence-based Medicine, perspicacity defined by the Grades of Recommendation Assessment, Development and Evaluation (GRADE) Working Group, and sanction made by the Agency for Healthcare Research and Quality (AHRQ). While the class of evidence is categorized into "class I" for good quality RCT, "class II" for moderate to poor quality RCT and good quality cohort, "class III" for moderate or poor-quality cohorts and case-control studies, "class IV" for the case series.

RESULT

Literature Search, Study Selection and Study Characteristics

The electronic research resulted in 43 records from various databases. After the process of identification, screening, eligibility, duplication elimination, and exclusion, the remaining 3 studies were included in qualitative and quantitative synthesis. The remaining articles were excluded due to lack of mean and standard deviation data and did not meet the inclusion and exclusion criteria.

Table 1.
Studies included in the analysis

Reference	Journal	Study Design	Level of Evidence
Kati et al, 2020	Joint Disease and Related Surgery	Retrospective Cohort study	III
Kang et al, 2021	Elsevier	Retrospective Cohort study	III
Radaideh et al, 2022	Research Gate	Retrospective Cohort study	III

Statistical Analysis

We utilized the Review Manager version 5.4 software (RevMan; The Cochrane collaboration Oxford, England) to perform all statistical analyses. Based on heterogeneity of the current study, we performed a sensitivity analysis to further assess the overall results. The heterogeneity across studies was examined through the I² statistic describing as follows: low, 25% to 50%; moderate 50% to 75%; or high >75%. We applied the fixed-effect models to calculate the total MDs/ORs when low heterogeneity was seen in studies. In other cases, we used the random effects model. Studies with a P values less than 0.05 were thought to have statistical significance. Forest plots showed the findings of out meta-analysis.

Outcome Analysis

This meta-analysis included a total number of 214 patients with 91 patients undergoing MIPO and 123 patients undergoing IMN. The follow-up period was 1-2 years after the treatment. The main characteristic of include studies (Table 2).

Table 4.
Risk of bias graph of all studies included

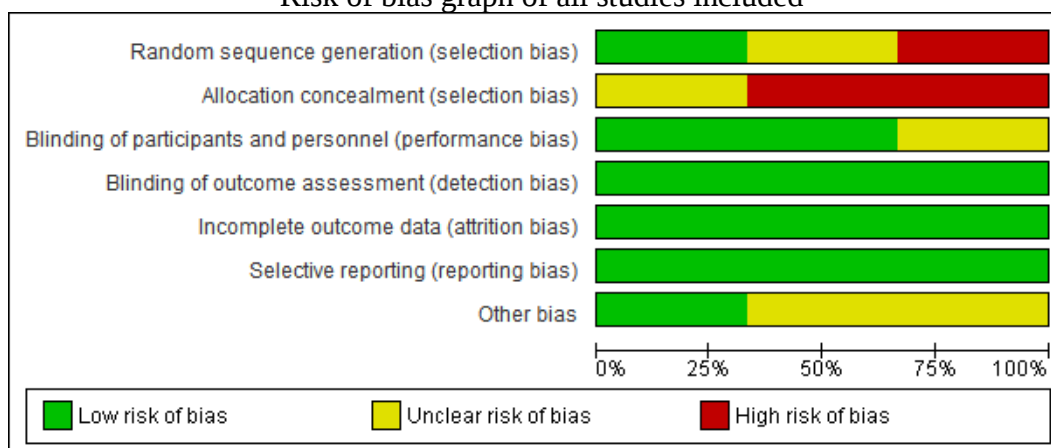


Table 5.
Risk of bias summary of all studies included

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Kang 2021	+	?	?	+	+	+	?
Kati 2020	?	-	+	+	+	+	?
Radaideh 2022	-	-	+	+	+	+	+

Hospital Stay

We performed a subgroup analysis to evaluate hospital stay outcome between MIPO versus IMN in tibial shaft fracture patient. We found that there is no significant difference statistically between these two groups (Mean difference 0.75; 95% CI -0.70 to 2.20; $p > 0.05$).

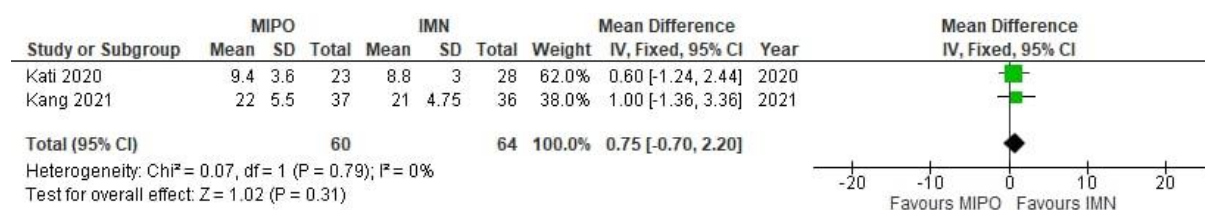


Figure 2. Pooled analysis of Hospital Stay outcome

Return to Work

We performed a subgroup analysis to evaluate return to work outcome between MIPO versus IMN in tibial shaft fracture patient. We found that there is no significant difference statistically between these two groups (Mean difference 0.26; 95% CI -0.68 to 1.21; $p > 0.05$).

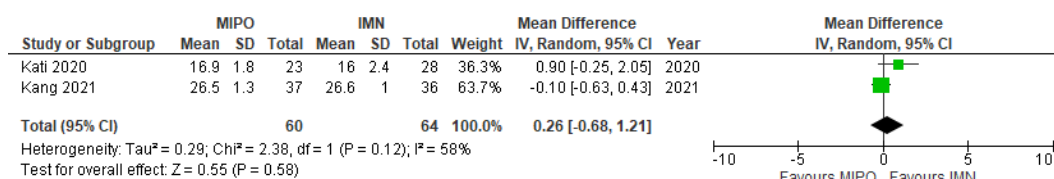


Figure 3. Pooled analysis of Return-to-Work outcome

Infection

We performed a subgroup analysis to evaluate infection outcome between MIPO versus IMN in tibial shaft fracture patient. We found that there is no significant difference statistically between these two groups (Mean difference 0.77; 95% CI 0.26 to 2.25; $p > 0.05$).

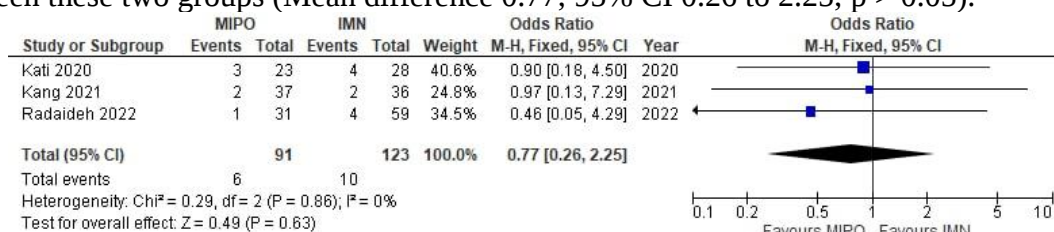


Figure 4. Pooled analysis of Infection outcome

Malunion

We performed a subgroup analysis to evaluate malunion outcome between MIPO versus IMN in tibial shaft fracture patient. We found that there is no significant difference statistically between these two groups (Mean difference 1.15; 95% CI 0.49 to 2.67; $p > 0.05$).

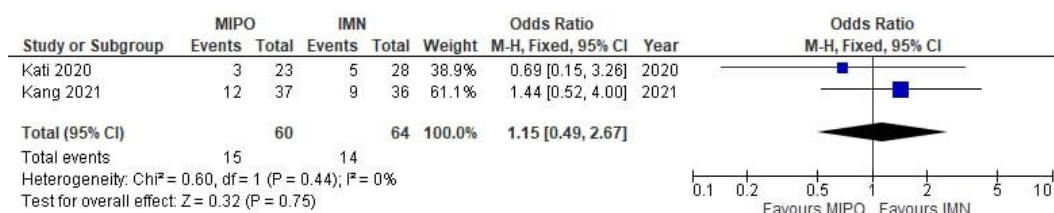


Figure 5. Pooled analysis of Malunion outcome

Non Union

We performed a subgroup analysis to evaluate non union outcome between MIPO versus IMN in tibial shaft fracture patient. We found that there is no significant difference statistically between these two groups (Mean difference 0.43; 95% CI 0.08 to 2.22; $p > 0.05$).

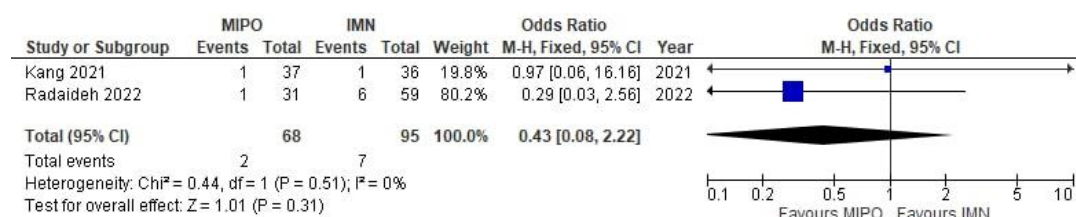


Figure 6. Pooled analysis of Non Union outcome

DISCUSSION

The goal of this analysis was to determine which one between IMN or MIPO is the superior minimally invasive therapy for tibial shaft fractures across 3 studies. This meta-analysis revealed that there is no difference in the term of hospital stay, return to work, infection, malunion, and nonunion between IMN and MIPO. This showed that both IMN and MIPO are comparable. Study by Kati et al investigating 51 patient with spiral oblique and spiral wedge tibial shaft fracture in a retrospective cohort, 28 patients were treated with IMN while 23 patients treated with MIPO. The results showed that there is no difference between IMN and MIPO in the terms of union time, return to work, infection, malunion, hospital stay, and Lower Extremity Functional Scale (LEFS) values (Kati et al., 2020). The same results were found in the study by Kang et al which included 36 patients undergo IMN and 37 patients treated with MIPO. There was no difference in the terms of operation time, hospital stay, bone healing, and complication rate (Kang et al., 2021). Radaideh et al in his study investigating 90 patients which consist of 59 patients treated with IMN and 31 patient treated with MIPO. The outcome assessed were complication which is consist of blood loss, infection, non-union, re-operation, and fracture. That study revealed that MIPO has lower complication rate compared to IMN, but it was not statistically significant (Radaideh et al., 2022). According to Kang et al., similar outcome in hospital stay is due to comparable in VAS and ROM during observation in the hospital after the surgery, indeed the patient might be discharged in the same time (Turley, 2023).

Another meta analysis by Wang et al investigate IMN and MIPO for distal tibial fractures in 13 RCTs studies with 924 patients. The study revealed that IMN has slightly better advantages compared to MIPO. IMN was related to a shorter surgery duration and time to union compared to MIPO. IMN also has lower surgical wound complication, whereas the rates of deep infections and union complications were comparable between the two groups. Similar functional outcomes also were found based on AOFAS and FFI evaluation. However, meta analysis by Wang et al only evaluating distal tibial fractures while this meta analysis evaluating tibial shaft fractures which is wider (Wang et al., 2019). According to Kati et al., no significant difference in return-to-work aspects between those two procedures because of similar in union time (Kati et al., 2020). IMN and MIPO also gave out similar amount of callus formation (Kang et al., 2021).

Meta analysis by Goh et al included 5 RCTs with 497 patients. It stated that MIPO was associated with longer union time and higher rate of wound complication. There is no difference in functional outcome, malunion rate, and non-union rate (Goh et al., 2018). Meta analysis by Liu et al included 10 RCTs involving 911 patients, with results which showed that MIPO had lower rate of malunion but higher rate of surgical wound complication. There is no difference in union time, re-operation, nonunion rate, between two groups (Naude et al., 2021). Infection rate might correlate with operation duration, which results in higher infection rate. Fortunately, according to Liu et al., no significant difference was found between those two procedures regarding the operation duration aspect (Liu et al., 2019). Intramedullary nails had been used widely in recent years for the treatment of tibial shaft fracture. It has advantages of high successful rate and minimal damage to surrounding tissue. However, it also has the risk of several complication such as malunion, infection, and reoperation. As the advancement of technology especially in minimally invasive surgery, MIPO was developed and started to be widely used in tibial shaft fracture (Miao and Miao, 2023).

It might be viewed primarily as an alternate fixation technique in polytrauma patients to prevent pulmonary problems. Additionally, it might be seen as a permanent fixation rather

than the transient fracture fixation provided by external fixators. If the blocking screw, distal locking screw, and percutaneous reduction method are not available in IMN practice, minimally invasive plate osteosynthesis may be an option (Bhanushali et al., 2022). Regardless of the procedures were preferred, no significant differences were found in non-union and malunion complications (Pollard et al., 2023). These results were found because from patients treated with MIPO had lower incidence of malunion, while IMN seemed to have lower surgical incision complications whether in closed or opening fractures (Liu et al., 2019). The limitation of this study are small number of study and all of the studies are consist of retrospective study. The characteristics of patients such as age, sex, fracture severity, and fracture pattern between study are also different. Therefore, randomized control trial is needed for stronger evidence of comparison between IMN and MIPO for tibial shaft fractures

CONCLUSION

In conclusion, both IMN and MIPO are safe and effective methods in treating tibial shaft fractures, and our results show that both methods provide similar outcomes in length of stay, return to work, infection, malunion, and non-union aspects. The similar results from both methods allowing surgeons to base their choice of technique on patient-specific factors and surgical expertise.

REFERENCES

- Bauwens, P.H. et al. (2021) 'Risk factors for complications after primary intramedullary nailing to treat tibial shaft fractures: A cohort study of 184 consecutive patients', *Orthopaedics and Traumatology: Surgery and Research*, 107(3). Available at: <https://doi.org/10.1016/j.otsr.2021.102877>.
- Behlmer, R.J. et al. (2021) 'Reduction techniques for intramedullary nailing of tibial shaft fractures: a comparative study', *OTA International*, 4(1), p. E095. Available at: <https://doi.org/10.1097/OI9.0000000000000095>.
- Bhanushali, A. et al. (2022) 'Outcomes of early versus delayed weight - bearing with intramedullary nailing of tibial shaft fractures : a systematic review and meta - analysis', *European Journal of Trauma and Emergency Surgery*, 48(5), pp. 3521–3527. Available at: <https://doi.org/10.1007/s00068-022-01919-w>.
- Bleeker, N.J. et al. (2022) 'MIPO vs. intra-medullary nailing for extra-articular distal tibia fractures and the efficacy of intra-operative alignment control: a retrospective cohort of 135 patients', *European Journal of Trauma and Emergency Surgery*, 48(5), pp. 3683–3691. Available at: <https://doi.org/10.1007/s00068-021-01836-4>.
- Goh, E.L. et al. (2018) 'Minimally invasive percutaneous plate osteosynthesis versus intramedullary nail fixation for closed distal tibial fractures: A meta-analysis of the clinical outcomes', *Sicot-J*, 4. Available at: <https://doi.org/10.1051/sicotj/2018055>.
- Kang, H. et al. (2021) 'Comparison between intramedullary nailing and minimally invasive plate osteosynthesis for tibial shaft fractures', *Injury*, 52(4), pp. 1011–1016. Available at: <https://doi.org/10.1016/j.injury.2021.01.038>.
- Kati, Y.A. et al. (2020) 'May minimally invasive plate osteosynthesis be an alternative to intramedullary nailing in selected spiral oblique and spiral wedge tibial shaft fractures?', *Joint Diseases and Related Surgery*, 31(3), pp. 494–501. Available at: <https://doi.org/10.5606/ehc.2020.75052>.
- Kim, K. et al. (2023) 'Intramedullary Nailing versus Minimally Invasive Plate Osteosynthesis for Distal Tibia Shaft Fractures: Retrospective Comparison of Functional and Cosmetic

- Outcomes', *Journal of Korean Foot and Ankle Society*, 27(3), pp. 93–98. Available at: <https://doi.org/10.14193/jkfas.2023.27.3.93>.
- Liberati, A. et al. (2009) 'The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration', in *Journal of clinical epidemiology*. Available at: <https://doi.org/10.1016/j.jclinepi.2009.06.006>.
- Liu, X. kai et al. (2019) 'Intramedullary Nailing Versus Minimally Invasive Plate Osteosynthesis for Distal Tibial Fractures: A Systematic Review and Meta-Analysis', *Orthopaedic Surgery*, 11(6), pp. 954–965. Available at: <https://doi.org/10.1111/os.12575>.
- Mahajan, A., Kumar, N. and Gupta, B. (2021) 'Delayed Tibial Shaft Fracture Healing Associated with Smoking : A Systematic Review and Meta-Analysis of Observational Studies Conducted Worldwide'.
- Marazzi, C. et al. (2020) 'Minimally invasive plate osteosynthesis (MIPO) versus open reduction and internal fixation (ORIF) in the treatment of distal fibula Danis-Weber types B and C fractures', *Journal of Orthopaedic Surgery and Research*, 15(1), pp. 1–9. Available at: <https://doi.org/10.1186/s13018-020-02018-5>.
- Miao, K.H. and Miao, J.H. (2023) 'Radiological Diagnosis and Imaging of Femoral Shaft Fractures', pp. 282–299.
- Naude, J.J. et al. (2021) 'Functional Outcomes and Quality of Life Following Complex Tibial Fractures Treated with Circular External Fixation : A Comparison between Proximal , Midshaft , and Distal Tibial Fractures'.
- Pollard, T.G. et al. (2023) 'Mortality and morbidity following operative management of tibial shaft fractures in octogenarians', *European Journal of Orthopaedic Surgery & Traumatology*, 33(2), pp. 299–304. Available at: <https://doi.org/10.1007/s00590-021-03180-0>.
- Radaideh, A. et al. (2022) 'Outcomes of Treating Tibial Shaft Fractures Using Intramedullary Nailing (IMN) versus Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO)', *Medical archives (Sarajevo, Bosnia and Herzegovina)*, 76(1), pp. 55–61. Available at: <https://doi.org/10.5455/medarh.2022.76.55-61>.
- Tian, R. et al. (2020) 'Prevalence and influencing factors of nonunion in patients with tibial fracture : systematic review and meta-analysis', 2, pp. 1–16.
- Turley, L. (2023) 'Frequency of complications in intramedullary nailing of open tibial shaft fractures : a systematic review', *EFORT Open Reviews*, 8(2), pp. 90–99.
- Upfill-Brown, A. et al. (2021) 'Rates and timing of short-term complications following operative treatment of tibial shaft fractures', *OTA International*, 4(4), p. E158. Available at: <https://doi.org/10.1097/OI9.0000000000000158>.
- Wang, B. et al. (2019) 'Minimally invasive percutaneous plate osteosynthesis versus intramedullary nail fixation for distal tibial fractures: a systematic review and meta-analysis', *Journal of orthopaedic surgery and research*. Department of Orthopaedic Surgery, HongHui Hospital, Xi'an Jiaotong University, Xi'an, Shaan'xi Province, China., p. 456. Available at: <https://doi.org/10.1186/s13018-019-1479-0>.
- Wang, S.F. and Ji, Q.L. (2024) 'Wound infection and healing in minimally invasive plate osteosynthesis compared with intramedullary nail for distal tibial fractures: A meta-analysis', *International Wound Journal*, 21(3), pp. 1–9. Available at: <https://doi.org/10.1111/iwj.14715>.