

Selected topics

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Screws versus plate with screws for osteosynthesis of the posterior malleolus: a systematic review and meta-analysis

Tornillos frente a placa con tornillos para la osteosíntesis del maléolo posterior: una revisión sistemática y meta-análisis

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ABSTRACT. Introduction: fractures involving the posterior malleolus (PM) of the ankle can have significant functional and clinical implications if not properly treated. The optimal treatment approach for these fractures remains uncertain. This review aims to compare the use of cannulated screws versus plate with screw fixation in terms of their impact on the development of postoperative ankle osteoarthritis and functional outcomes in patients with PM fractures. **Material and methods:** a comprehensive search was conducted in PubMed, EMBASE, and Cochrane Library databases to identify studies directly comparing cannulated screws versus plate with screw fixation for PM fractures and their association with the development of postoperative osteoarthritis and functional outcomes. The quality of the included studies was assessed using appropriate assessment tools. The data on osteoarthritis development and functional outcomes were extracted and analyzed. **Results:** a total of 691 articles were screened, and several studies were included for analysis. The findings revealed no statistically significant difference in the development of postoperative ankle osteoarthritis between the cannulated screws and plate with screw fixation groups. Similarly, there was no

RESUMEN. Introducción: las fracturas que involucran el maléolo posterior (MP) del tobillo pueden tener importantes implicaciones funcionales y clínicas si no se tratan adecuadamente. El enfoque de tratamiento óptimo para estas fracturas sigue siendo incierto. El objetivo de esta revisión es comparar el uso de tornillos canulados versus placa con fijación de tornillos en cuanto a su impacto en el desarrollo de la osteoartrosis de tobillo postoperatoria y los resultados funcionales en pacientes con fracturas del MP. **Material y métodos:** se realizó una búsqueda exhaustiva en las bases de datos de PubMed, EMBASE y Cochrane Library para identificar estudios que compararan directamente tornillos canulados versus placa con fijación de tornillos para fracturas de MP y su asociación con el desarrollo de osteoartrosis postoperatoria y los resultados funcionales. La calidad de los estudios incluidos se evaluó utilizando herramientas de evaluación adecuadas. Los datos sobre el desarrollo de osteoartrosis y los resultados funcionales se extrajeron y analizaron. **Resultados:** se revisaron un total de 691 artículos y se incluyeron varios estudios para su análisis. Los hallazgos revelaron que no hay una diferencia estadísticamente significativa en el desarrollo

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significant difference in functional outcomes between the two treatment approaches. **Conclusion:** based on the available evidence, there is no significant difference in the development of postoperative ankle osteoarthritis or functional outcomes between cannulated screws and plate with screw fixation for PM fractures. However, further research is needed to strengthen these findings and provide more conclusive evidence.

Keywords: posterior malleolar fixation, screws, posterior plate, osteoarthritis, functional outcomes.

de osteoartrosis de tobillo postoperatoria entre los grupos de tornillos canulados y placa con fijación de tornillos. Del mismo modo, no hubo una diferencia significativa en los resultados funcionales entre los dos enfoques de tratamiento. **Conclusión:** según la evidencia disponible, no hay una diferencia significativa en el desarrollo de osteoartrosis de tobillo postoperatoria o en los resultados funcionales entre los tornillos canulados y la placa con fijación de tornillos para las fracturas del MP. Sin embargo, se necesita más investigación para fortalecer estos hallazgos y proporcionar evidencia más concluyente.

Palabras clave: fijación del maléolo posterior, tornillos, placa posterior, osteoartrosis, resultados funcionales.

Introduction

Ankle fractures are among the most common fractures.^{1,2,3} They are most prevalent in young men and older women.⁴ Between 7 to 44% of all ankle and foot fractures involve the posterior malleolus (PM), which is a bony prominence formed by the posterior inferior margin of the tibia's articulating surface.^{5,6} The PM is located between the fibular notch and the medial malleolus and serves as an insertion surface for the syndesmotic ligament complex.⁶ Fractures involving more than 33% of the articular surface are likely to result in an unfavorable functional outcome for the patient.⁷ However, there has been recent interest in the relevance of the posterior ligamentous complex and its role in syndesmosis stabilization, which may have radiological and functional consequences.^{4,8,9} While the initial injury itself can impact the functional and radiological outcome, the treatment used can also be a modifiable factor.^{6,10}

Currently, there is controversy regarding the most optimal treatment option for ankle fractures involving the PM,^{6,11,12,13} although conservative management has traditionally been described.^{1,14} Osteosynthesis using plates with screws has gained importance as a fixation method, not only for the PM fragment but also for the ligamentous complex of the syndesmosis.^{11,12,15,16,17} The compression provided by screws for PM fixation may be sufficient.¹⁸ However, stabilization with posterior plates and screws, either posteromedially or posterolaterally, may offer improved functional outcomes and potentially play a role in preventing osteoarthritis.¹²

The objective of this study is to compare the use of cannulated screws versus plate with screw fixation in relation to the development of ankle osteoarthritis in the postoperative period of ankle fractures involving the posterior malleolus.

Material and methods

The systematic review was conducted following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) checklist¹⁹ and the guidelines outlined

in the Cochrane Handbook for Systematic Reviews of Interventions.²⁰ The study was registered in the International Prospective Register of Systematic Reviews (PROSPERO) with the ID number CRD42022322139.

Eligibility criteria

Prospective or retrospective cohorts, case-control studies, or randomized clinical trials involving human participants were included if they directly compared the use of plates alone versus plates with screws for osteosynthesis of posterior malleolus fractures. Studies that did not report the method of osteosynthesis or the development of osteoarthritis in the postoperative period were excluded. Additionally, studies that lacked demographic information or a clear diagnosis were excluded. No studies were excluded based on the risk of bias assessment.

Search strategy

The search strategy was developed by an expert reference librarian and included a combination of keywords and MeSH terms related to the population, intervention, comparison, and outcomes of interest. The search was performed in several electronic databases, including MEDLINE, Scopus, Web of Science, and EMBASE. The search timeframe covered the period from 2005 to February 2022. For detailed information, please refer to Supplementary Material.¹

Selection and data collection

Three independent reviewers conducted a duplicate assessment of each manuscript's title, abstract, and full text to determine eligibility. Studies that were included by at least one reviewer during the abstract screening phase were considered for full-text screening. The level of agreement between the reviewers was assessed using the Kappa statistic to account for chance agreement.²¹ Any disagreements were discussed and resolved through mutual

consensus among the authors. If disagreements persisted, a third author made the final decision.

Data collection process

Two reviewers independently and in duplicate extracted data on study characteristics, quality of evidence, and outcomes using a web-based data extraction form. Conflicts during this phase were resolved through consensus or by involving a third, experienced reviewer for arbitration.

Quality assessment of included studies

Two reviewers independently and in duplicate conducted a methodological quality assessment of each study included in the qualitative analysis. The assessment was performed using the Newcastle-Ottawa Quality Assessment Scale for Cohort Studies and Case-Control Studies, as presented in Supplementary (Table 1).²² This scale evaluates three domains: Selection, Comparability, and Outcome/Exposure. The maximum scores considered were 8 stars for Cohort Studies and 9 stars for Case-Control Studies.

Statistical analysis

To assess the effectiveness of the interventions, we calculated the mean difference (MD) and standardized mean difference (SMD) using Cohen's d method.²³ The DerSimonian-Laird random-effects model was used to pool the SMD values from the included studies.²⁴ Heterogeneity

was evaluated using the I2 statistic, which measures the percentage of variability in the effect estimate that is due to heterogeneity rather than chance. A value greater than 50% indicates substantial heterogeneity.²⁵ Due to the limited number of studies included, a test for publication bias was not performed as it is typically done when at least 10 studies are available for meta-analysis.²⁰ All statistical analyses were conducted using RevMan (version 5.4; The Cochrane Collaboration, 2020) and the meta package in R (version 3.4.3; R Project for Statistical Computing).

Certainty of evidence

The certainty of evidence was assessed using the GRADE approach for complex interventions.²⁶ The certainty of evidence from non-randomized trials starts at a low level and can be further downgraded based on methodological limitations, imprecision, indirectness, inconsistency, or publication bias.²⁷

Results

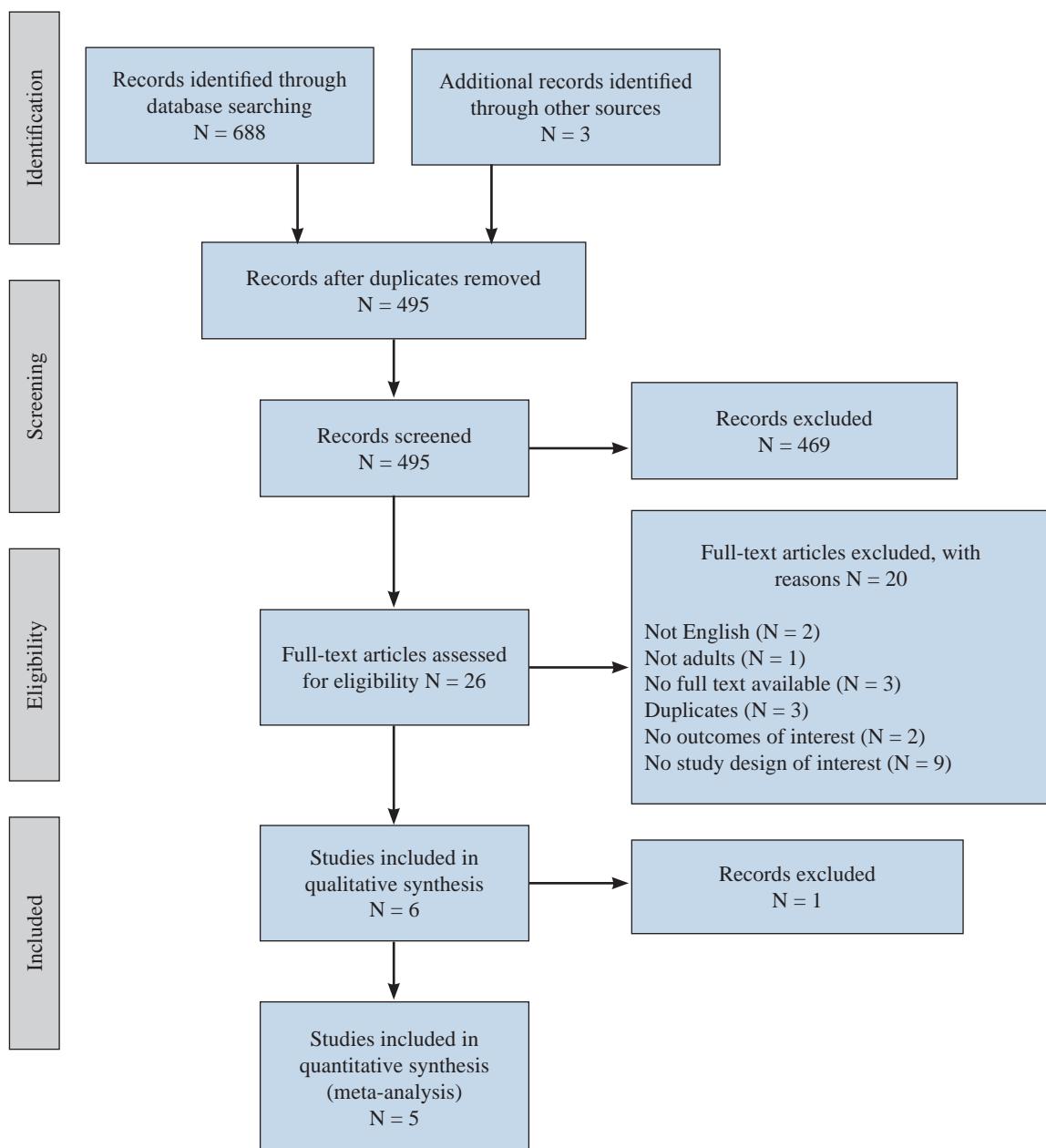
The search strategy initially identified 688 articles, and an additional three references were found through a snowball strategy, resulting in a total of 691 articles. After removing duplicates, 495 articles remained. During the title and abstract screening phase, 469 articles were excluded, leaving 26 articles for full-text screening. Among these, 20 articles were excluded for various reasons. Finally, six articles were included in the qualitative analysis^{18,28,29,30,31,32}

Table 1: Demographics of studies included for posterior malleolus fracture fixation.

| Author | Country and year | Groups | Total n | Mean age (years) | Percentage male | Classification on functional | Reported* | Follow-up (months)* |
|--------------------------------|------------------|----------------------------------|----------------|----------------------|--------------------|------------------------------|---|--|
| Erdem, et al. ³⁰ | Turkey, 2014 | Screw PL | 20 20 | 47.6 50.2 | 55 45 | AOFAS | 94.5 ± 3.25 93.5 ± 2.75 | 37.2 ± 6.8 39.2 ± 5.5 |
| O'Connor, et al. ³¹ | USA, 2015 | PL AP Screw | 16 11 | 47.8 45.5 | 43.8 36.3 | SMFA | 20.2 ± 16.8 9.4 ± 9.0 | 54.9 ± 20 32.0 ± 8.5 |
| Kalem, et al. ¹⁹ | Turkey, 2018 | AP Screw PA Screw PL | 20 13 34 | 43.4 48.3 40.8 | 60 38.5 29.4 | AOFAS | 86.4 ± 8.0 93.8 ± 4.05 94.7 ± 5.3 | 14.4 ± 2.2 16.3 ± 2.6 17.1 ± 3.0 |
| K. Zhang, et al. ³² | China, 2020 | Screw PL | 24 24 | 42.7 41.4 | 54.2 58.3 | AOFAS | 92.5 ± 5.3 94.7 ± 5.6 | 29.5 ± 4.3 30.4 ± 4.1 |
| Yang, et al. ³³ | China, 2020 | Plates & screws | 22 | 61.5 | 45.5 | AOFAS | 85.4 ± 5.5 | 30.0 ± 10.0 |
| Neumann, et al. ³⁴ | Germany, 2021 | AP Screw PA Screw PL | 14 13 36 | 60 | 31 | AOFAS | 89.7 ± 15.2 88.0 ± 20.4 86.6 ± 22.3 | 83.6 ± 34.5 |

* mean ± standard deviation. AOFAS = American Orthopedic Foot and Ankle Society scale. SMFA = Short Musculoskeletal Function Assessment. PL = plate.
AP = anterior-to-posterior. PA = posterior-to-anterior.

PRISMA 2009 Flow Diagram

**Figure 1:** Prisma 2009 Flow Diagram.

One study³² was excluded from the meta-analysis because it did not provide information on the type of surgical approach. The flow diagram of the study selection process is presented in *Figure 1*³³ according to the PRISMA guidelines.

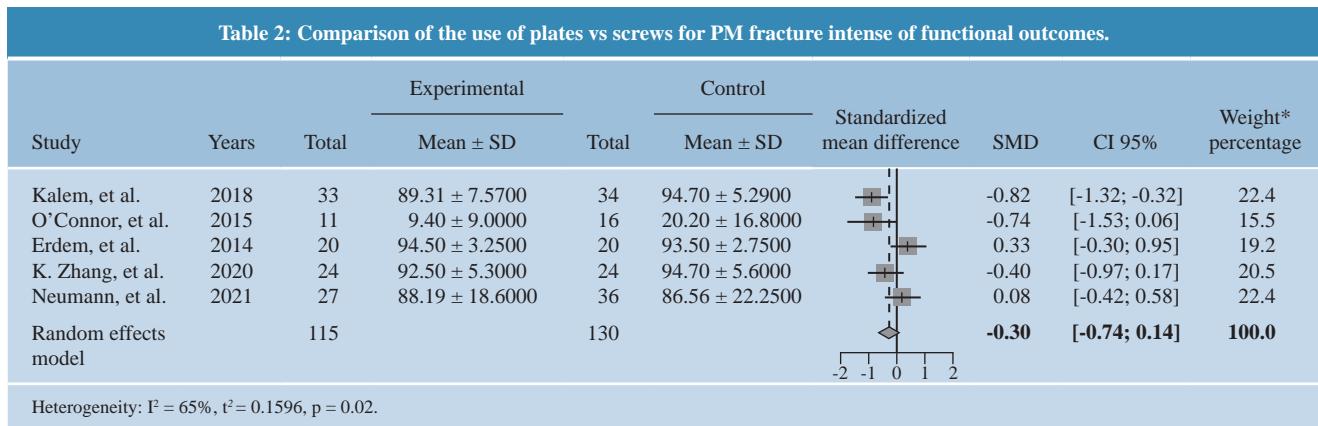
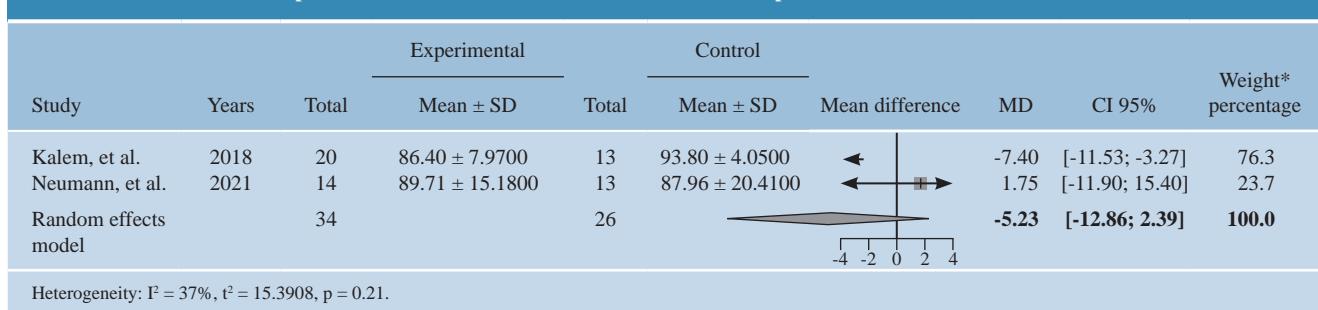
Patient demographics

Data from a total of 267 procedures were extracted from the six included retrospective cohorts. The studies were published between 2014 and 2021, with two studies conducted in Taiwan,^{18,28} two in China,^{31,32} one in the United

States,³⁰ and one in Germany³ (*Table 1*). The mean age of the patients was 48.1 ± 6.9 years, and 43.1% (115 out of 267 patients) were male. The mean follow-up duration was 42.7 ± 31.7 months. Among the procedures, 115 involved anterior-to-posterior (AP) or posterior-to-anterior (PA) screw fixation, while 130 utilized plates.

Functional scale

Five studies^{28,29,30,31} included in the analysis reported data on functional scales such as the AOFAS (American

Table 2: Comparison of the use of plates vs screws for PM fracture intense of functional outcomes.**Table 3: Comparisson between AP direction vs PA direction screw placement intense of functional outcomes.**

Orthopaedic Foot and Ankle Society scale) or SMFA (Short Musculoskeletal Function Assessment). A meta-analysis was conducted to compare the use of plates versus screws for PM fracture in terms of functional outcomes. The results showed no statistical difference between the two groups ($n = 5$, SMD -0.30, CI 95% -0.74 to 0.14, $p = 0.02$, $I^2 = 65\%$) (Table 2).

Additionally, an exploratory meta-analysis was performed to investigate whether there was a difference in functional outcomes between an anterior-to-posterior (AP) direction versus posterior-to-anterior (PA) screw placement. Two studies^{8,29} provided data for this analysis. However, no statistical difference was found between the two approaches ($n = 2$, SMD -5.23, CI 95% -12.86 to 2.39, $p = 0.21$, $I^2 = 37\%$) (Table 3).

Osteosynthesis sequelae

Quantitative analysis of osteoarthritis was not feasible due to limited data availability. Only two studies, O'Connor et al.³⁰ and Zhang et al.,³¹ provided information on the proportions of osteoarthritis using the Bargon Criteria for Grading Posttraumatic Arthritis, with rates of 28.75 and 20.8%, respectively.

Risk of bias

The methodological quality of all included studies was assessed using the Newcastle-Ottawa Quality Scale. Five

studies were classified as having good quality, while one study³² was deemed to have poor quality. The study with poor quality did not include a control group, making it impossible to evaluate the comparability domain (Table 4).

Discussion

Our findings indicate that both cannulated screws and plates provide good to excellent clinical results when used for osteosynthesis of the posterior malleolus (PM). However, the measurement of osteoarthritis was not feasible due to variations in reporting methods. Nevertheless, both techniques appear to be suitable options, as there was no statistical difference in postoperative function as assessed by the AOFAS scale.

Radiological evaluation of PM fractures includes assessing the extent of the fracture, location of the fragment, and involvement of the articular surface.^{12,34} Initial assessment is typically done using anteroposterior, lateral, and mortise radiographic views. The presence of a double contour of the medial malleolus and bony discontinuity may indicate a PM fracture.¹ Computed tomography scans and magnetic resonance imaging can provide more detailed information about fracture size, displacement, and syndesmotic injury.

Treatment criteria for fractures of the medial and lateral malleolus are well-established, but the criteria for PM fixation are still a subject of debate. Some authors suggest

Table 4: Newcastle-Ottawa quality assessment scale cohort studies.

| Autor, year | Representativeness of the exposed cohort | Selection | | Comparability | | Outcome | |
|-----------------------|--|---------------------------------|---------------------------|--|--|-----------------------|---------------------|
| | | Selection of non-exposed cohort | Ascertainment of exposure | Demonstration that the outcome was not present at the start of the study | Comparability of cohorts on the basis of design and analysis | Assessment of outcome | Length of follow-up |
| Kalem, et al. 2018 | — | * | * | * | * | * | — |
| O'Connor, et al. 2014 | — | * | * | * | * | * | — |
| Erdem, et al. 2014 | — | * | * | * | * | * | — |
| Zhang, et al. 2020 | — | — | — | — | — | — | — |
| Yang, et al. 2020 | — | — | — | — | — | — | — |
| Neumann, et al. 2021 | — | — | — | — | — | — | — |

Maximum score for «Selection» domain: ***; Maximum score for «Comparability» domain: **; Maximum score for «Outcome» domain: **.

fixation for fractures involving 25% to 33% of the PM, while others report better clinical and functional outcomes with fixation for fractures involving less than 25% of the PM using cannulated screws, especially within the first 6 months after surgery.^{35,36,37} However, PM fractures are often accompanied by other complications such as syndesmotic or ligament injuries, as well as bimalleolar or trimalleolar fractures. Therefore, the treatment approach for PM fractures should be individualized based on factors such as the type of fracture, size, displacement, syndesmotic stability, involvement of intercalary joint fragments, and presence of associated fractures.^{4,31}

The three surgical approaches achieve an anatomical reduction of the PM fracture. However, according to biomechanical principles, the choice of fixation method could provide greater stability to the tibiotalar and tibiofibular joints through ligament stabilization in avulsion fractures with a rotational component.⁹

The selection of surgical approaches is mainly based on the surgeon's preference, experience, and the availability of resources in the healthcare setting. Our results suggest good clinical and radiographic outcomes when performing osteosynthesis of the PM using either cannulated screws or a posterior plate, as evaluated through various clinical and radiographic scales. The statistical test for heterogeneity was significant, indicating variability among the included studies, with 65% of the observed variance being real. Subgroup analysis was not possible due to limitations in the available data.

Unfortunately, we could not separately analyze deep and superficial infections as specific details were not provided in the enrolled studies. Additionally, the compared groups in the included studies had different preoperative grades of osteoarthritis, which may have influenced preoperative pain levels, functional status, and the extent of osteoarthritis. These factors could potentially confound the results of surgical outcomes and clinical scores.

Considering the surgical approach position, recent reports indicate a greater residual instability of the syndesmosis in the supine position (AP, 2.1%) compared to the prone position (PA, 48%).^{31,37,38} However, a meta-analysis was not possible due to the lack of information in the reports. Further prospective and comparative trials are needed to provide more evidence in this regard.

When choosing surgical techniques, other parameters such as postoperative complications (e.g., fixation failure, infection, wound dehiscence, need for hardware removal) and relative surgical cost should be considered. Furthermore, comparing the learning curve, resource requirements, time, and training needed to master the surgical skills for each technique among orthopedic residents is important.^{39,40}

Evidence suggests that syndesmal stabilization with direct fixation of the posterior malleolus should be performed in a prone position for a posterior-to-anterior (PA) approach.^{17,37,38} The results did not show statistically significant differences when comparing anterior-to-posterior

(AP) versus PA screw fixation. However, it is important to note the direction of the effect in the confidence interval and consider the possible low statistical power due to the small sample size of the included studies.^{18,29} Further prospective studies with homogeneous functional scales are still required to support these findings.

Limitations:

The present study has several limitations that should be acknowledged. Firstly, the limited number of included studies is a significant weakness, which affects the generalizability of the findings. Additionally, most of the studies included in this analysis had a retrospective design, which introduces potential biases and limitations in data collection and analysis. However, these limitations are inherent to the available published literature on surgical strategies for PM fractures, as high-quality evidence in this area is lacking.

Efforts were made to obtain additional data for meta-analysis by contacting the authors, but unfortunately, it was not possible to obtain the required information. This further highlights the challenge of data availability and accessibility in the field.

It is important to note that future prospective and comparative studies with longer follow-up periods are needed. These studies should not only focus on comparing different surgical procedures but also strive for a consensus on the functional scales used for evaluation and the reporting of osteoarthritis.

Conclusion

Based on the available evidence, there is no statistical difference in terms of functionality between the use of cannulated screws, plating, or a combination of both for PM fixation. However, the comparison of osteoarthritis was not feasible. The choice of screw placement approach, whether anterior-to-posterior (AP) or posterior-to-anterior (PA), did not show a statistical difference, although the limited sample size may have influenced the results. Further studies are warranted to address these limitations and provide more conclusive evidence in the field of PM fracture fixation.

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