REVIEW ARTICLE

CONTENTS

Tibiofibular stabilization in patients with ankle and posterior malleolus fractures: A systematic review and meta-analysis

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ABSTRACT

Aim: To compare the functional outcomes and the frequency of use of distal tibiofibular stabilization (TFS) in patients with ankle fractures involving the posterior malleolus (PM).

Materials and Methods: A systematic literature search was conducted in MEDLINE (PubMed), Scopus and the Cochrane Library databases in accordance with the PICOS and PRISMA guidelines. Studies included in the meta-analysis were analyzed using the Cochrane RevMan software. 20 studies were selected for qualitative analysis and 18 for quantitative analysis, and included 2179 patients. Functional outcomes according to the AOFAS scale in patients with ankle fractures and PM fractures treated with TFS were not statistically different from the control group (MD = 1.00; 95% CI [-4.70, 6.70]; $p = .073$, $I^2=87\%$). A significant decrease in the use of TFS was found in patients after fixation of the PM (OR = 3.77; 95% CI [2.13, 6.69]; $p < 0.00001$, $I^2=78\%$) and in patients who had PM fixation with a buttress plate (OR = 0.44; 95% CI [0.25, 0.79]; $p = 0.006$, $I^2=0\%$).

Conclusions: The use of additional TFS after fixation of the PM does not affect the functional outcomes of treatment of patients with ankle fractures. Fixation of the PM fragment significantly reduces the need for TFS. Open repositioning and osteosynthesis of the PM by a buttress plate reduces the need for TFS as compared to screws.

KEYWORDS: ankle fracture, posterior malleolus, distal tibiofibular syndesmosis, osteosynthesis, meta-analysis

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INTRODUCTION

Distal tibiofibular syndesmosis (DTFS) injury occurs in 20% of malleoli fractures [1] and is a component of complex ankle joint (AJ) injuries. Over the past decades, a number of studies have demonstrated the involvement of the posterior malleolus (PM) in ensuring congruence, restoring of anatomy and stability of the DTFS, which are important conditions for the successful treatment of ankle fractures [2]. At the same time, there is controversial data regarding the need for additional stabilization of the DTFS after full restoration of the skeletal anatomy of the AJ. Thus, some authors emphasize that fixation of broken malleoli and the PM fragment may be sufficient to ensure proper stability of the DTFS [3,4], while others argue for the need for routine use of additional tibiofibular stabilization (TFS), taking into account the nature of the injury [5,6].

There are controversial studies on the use of TFS for PM fractures. Some authors emphasize the mandatory use of TFS, justifying this by the need to restore the syndesmosis and prevent its instability [7,8]. Others are critical for TFS due to a number of complications: implant instability and associated osteolysis and infection, implant fractures, tibiofibular synostosis, insufficient restoration of syndesmotic anatomy, the need for repeat operation in a case of complication [9,10]. Another part of the authors believe that TFS does not affect the outcome of surgical treatment of malleoli fractures at all [11,12]. At the same time, as noted by Kocan et al, despite the relatively stable level of fixation of the PMF, the frequency of TFS has increased significantly over the past 10 years [13].

Thus, there is a need for a study comparing the necessity and effectiveness of TFS in patiens with malleoli and PM fractures, which was the basis of this systematic review and meta-analysis.

AIM

The aim is to compare the functional outcomes and the frequency of use of distal tibiofibular stabilization (TFS) in patients with ankle fractures involving the posterior malleolus (PM).

MATERIALS AND METHODS

The systematic literature review and meta-analysis were prepared in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines [14]. A search for original studies was conducted in the MEDLINE (PubMed), Scopus, and Cochrane Library databases/registers: Cochrane reviews published from the beginning to May 2025. The search strategy was developed for MEDLINE (PubMed) and adapted for other search systems (databases), respectively. Search strategy for PubMed (search formula): ("Ankle Fractures"[MeSH Terms] OR "posterior malleolus*"[All Fields] OR "trimalleolar*"[All Fields] OR "Volkmann's triangle"[All Fields] OR "posterior pilon"[All Fields] OR "posterior ankle"[All Fields]) AND ("Ankle Joint"[MeSH Terms] OR "syndesmos*"[All Fields] OR "tibiofibular syndesmosis"[All Fields] OR "syndesmotic injury"[All Fields] OR "syndesmotic screw"[All Fields] OR "distal tibiofibular joint"[All Fields] OR "distal tibiofibular syndesmosis"[All Fields] OR "positioning screw"[All Fields] OR "syndesmotic fixation"[All Fields]) AND ("Patient Reported Outcome Measures"[MeSH Terms] OR "Treatment Outcome"[MeSH Terms]). We also reviewed the "gray literature", references to bibliographies, reviews, and studies that may have been missed during the systematic search. Relevant articles were added after reading the full text and identifying the necessary parameters. The inclusion criteria for the review were developed in accordance with the PICOS criteria [15] and are listed in Table 1.

Exclusion criteria: 1) isolated PMF, fractures of the ankle without the involvement of the PM and "pylon" type fractures; 2) reviews, abstracts, or articles that did not include sufficient data; 3) biomechanical, anatomical, or computer modeling studies; 4) studies with fewer than 20 patients; 5) articles published in non-English language.

DATA EXTRACTION

Each database was searched separately; the datasets were exported to Mendeley Reference Manager (version 1.12.1; Elsevier) and duplicates were subsequently removed. Two independent experts (T.M.O., O.A.T. – scientific degree of doctor of medical sciences in the specialty of "traumatology and orthopedics", more than 15 years of experience as an orthopedic surgeon) independently checked the search results by title and/or abstract and full text. Any contradictions or discrepancies were resolved by consensus or by the fourth author (A.P.L. – scientific degree of doctor of medical sciences in the specialty of "traumatology and orthopedics", 40 years of experience as an orthopedic surgeon). Each article included in the review was entered into a standardized data extraction table. The data obtained included: author, year of publication, study design, demographic data, classification of ankle injury, classification of PM fractures, size and type of PM fixation, type of TFS, and mean follow-up time.

QUALITY ASSESSMENT OF INCLUDED STUDIES

The risk of bias in the publications included in the analysis was assessed using the tool Newcastle-Ottawa Quality Assessment Scale for Cohort Studies and Case-Control Studies (NOS) [16]. This scale assesses three domains: Selection, Comparability, and Outcome/Exposure. The maximum score is 8 for cohort studies and 9 for case-control studies. Studies with a score of 8 to 9 are considered to be of high quality, those with a score of 7 to 5 are of moderate quality, and those with a score below 4 are of low quality. The methodological quality of publications was assessed using the "funnel plot" tool. The symmetrical distribution of studies assessing the pooled effect indicates a low publication bias.

DATA SYNTHESIS AND ANALYSIS

The publications included in the review were analyzed for comparability and combined into the final database. In case 3 or more studies had sufficient comparability (inclusion criteria, outcome parameters), a meta-analysis was performed. In the case of insufficient comparability but similarity of groups and outcome parameters, a quantitative analysis was performed to illustrate the current trend of results. The meta-analysis was performed using the Cochrane RevMan software (version 5.4.1; The Cochrane Collaboration, 2020). The method of inverse variance was used for continuous data (assessment of functional outcomes - PROMs) based on the calculation of mean differences (MD); to estimate the frequency of use of TFS, a dichotomous analysis model (OR - odds ratio) with 95% confidence intervals (CI) was used. The I^2 method was used to test the heterogeneity of the results of each study. When $I^2 \leq 50\%$, which indicates a small heterogeneity among studies, a meta-analysis with a fixed effects model was used; when $I^2 > 50\%$, which indicates a large heterogeneity among studies, a meta-analysis with a random effects model was used.

ETHICS

All sources used in this literature review are publicly available.

AI STATEMENT

The author states that no AI tools were used in writing this article.

Table 1. PICOS Criteria

Participants	Patients (>18 years) with malleoli and posterior malleolus fractures (OTA/AO types 44 - B and 44 - C)
Intervention	Using of distal tibiofibular stabilization (positional screw(s), elastic systems)
Comparison	The absence of distal tibiofibular stabilization
Outcomes	Patient reported outcome measurements (PROMs); frequency of TFS
Study design	Original articles, cohort studies (retrospective and prospective)

Source: compiled by the authors of this study

Table 2. Characteristic data of the study

Author, year	Countries	Design	Total subjects	Male/ Female	Age,years- mean (range)
Neumann AP, Rammelt S, 2022 [29]	Germany	Retrospective	100	31\69	60 (20-83)
*Saygılı et al., 2017 [17]	Turkey	Retrospective cohort	73	34\39	(18-75)
*Erdem et al., 2014 [18]	Turkey	Prospective case series	40	20\20	(24-77)
Behery et al.,2021 [24]	USA	Retrospective	85	32\53	51
Li et al.,2017 [34]	USA	Retrospective rewiev	97	42\55	48.0 ± 15.47
Tosun et al.,2018 [33]	Turkey	Retrospective rewiev	49	21\28	47 (20-82)
*Bingol et al.,2023 [19]	Turkey	Retrospective	55	29\26	(18-83)
Marques Ribeiro et al., 2021 [4]	Portugal	Retrospective comparative study	64	20\44	58.6 ± 17.8 (23–75)
Aravindan et al.,2023 [5]	USA	Retrospective review	79	30\49	44 (IQR: 28–56)
Mertens et al., 2020 [32]	Belgium	Coparative prospective cohort vs retrospective cohort	135	60\75	(21–84)
Baumbach et al., 2019 [25]	Germany	Retrospective registry study	236	99\137	53.0 ± 18.3 (18-100)
*Miller et al., 2018 [20]	USA	Retrospective comparative series	198	69\129	(18-92)
Karaismailoglu et al., 2023 [30]	Turkey	Prospective randomized controlled study	40	20\20	(18-65)
Stringfellow et al., 2021 [31]	UK	Retrospective	160	57\103	50.2 (19–92)
Pilskog et al.,2020 [26]	Norway	Retrospective comparative study	86	23\63	57 (IQR 41-67)
*O'Connor et al.,2015 [21]	USA	Retrospective case series	27	11\16	(21.1-67.1)
*Kalem et al.,2018 [22]	Turkey	Retrospective-multicenter comparative	67	27\40	(40.8-48.3)
Miller et al.,2010 [9]	USA	Prospective	31	11\20	48 (21–83)
*Cho et al., 2025 [23]	Republic of Korea	Retrospective	472	182\290	45.8 ± 14.1 (18–70)
Liu et al., 2020 [35]	China	Retrospective cohort study	85	38\47	(42.92±12.26)
Total 20			2179	856\1323	

*Notes: * - calculated using data from original article*
Source: compiled by the authors based on [4, 5, 9, 17-26, 29-35]

REVIEW AND DISCUSSION

The process of selecting studies in accordance with PRISMA recommendations is presented in Fig. 1. The results of the systematic review and the characteristics of each study are summarized in Table 2 and Table 3.

20 studies met the criteria and were included for qualitative and 18 for quantitative analysis with 2179 patients. The studies were published between 2010 and 2025. Fractures of the PM were presented as a component of trimalleolar or equivalent ankle injuries

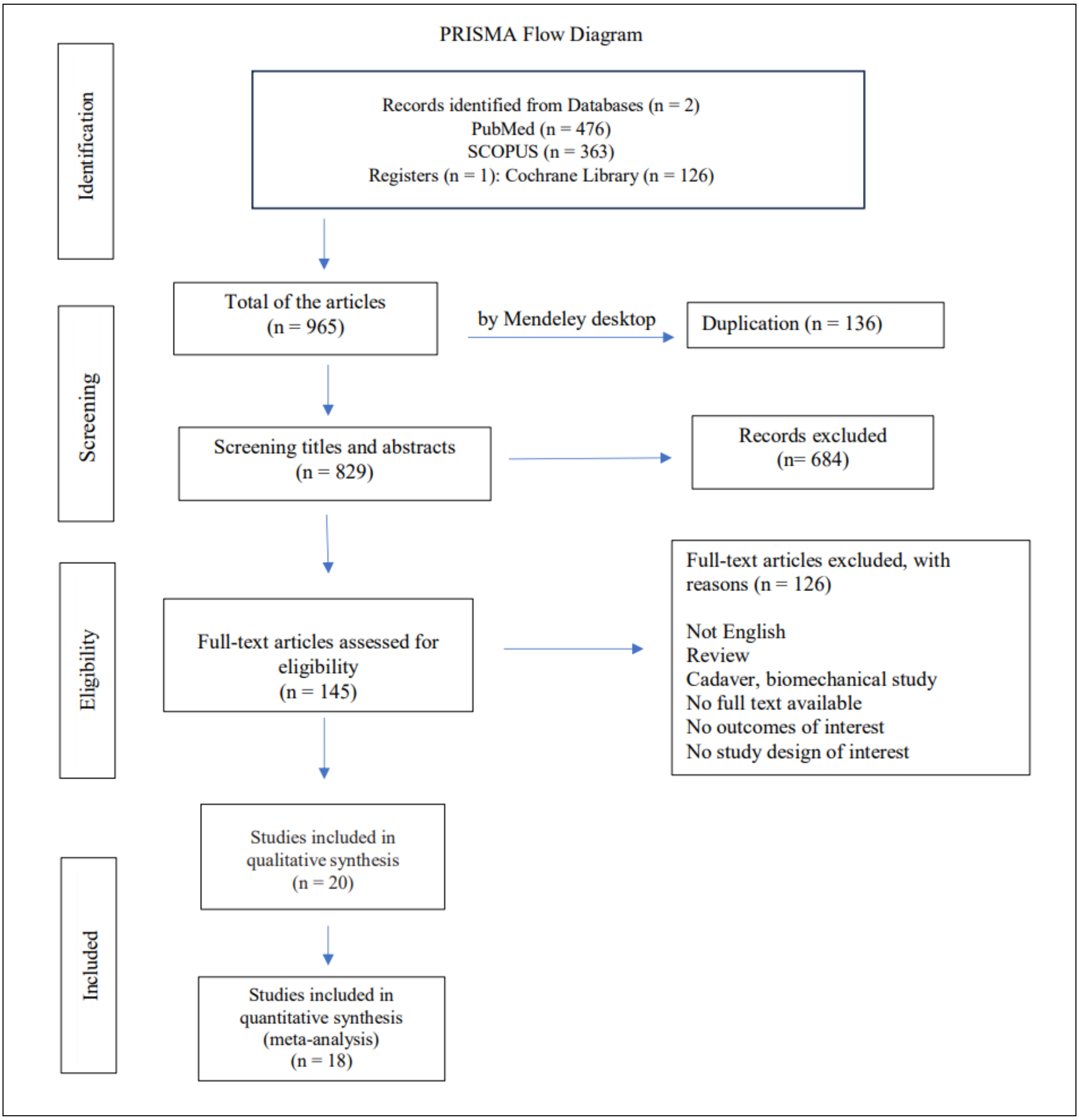

Fig. 1. The PRISMA flow diagram
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(single malleolus and bimalleolar fractures involving the posterior malleolus). Retrospective study design was performed in 16 studies, prospective in 3 studies (1 case series; 2 randomized controlled studies) and 1 comparative prospective-retrospective cohort study. Quantitative indicators in 7 studies [17-23] were obtained by self-reported calculations, as they provided data for each patient or group separately.

The most frequent method of intraoperative determination of DTFS instability in the analyzed publications was the external rotation stress test and hook test or their combination. TFS was performed using one or two positioning screws tri- and quadricortically in 12 publications, in 4 studies [23-26] TFS was performed using positioning screws or elastic systems (suture button, tight rope, internal brace) in 3 studies [5,20,21] the specific method of TFS was not specified. Miller et al. [9] performed TFS using two blocked quadricortical positioning screws through a 1\3 tubular plate to prevent excessive compression of the DTFS.

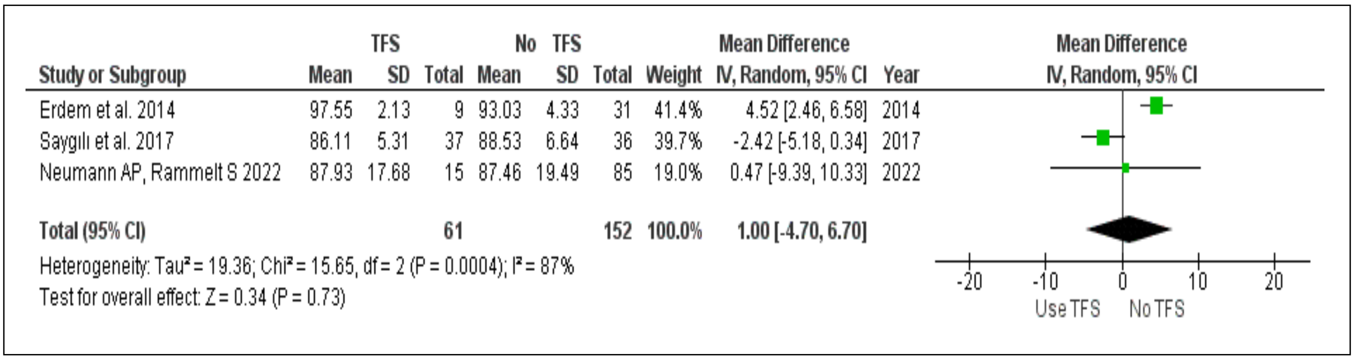

Fig. 2. Forest plot showing AOFAS scores for malleoli and PM fractures treated with and without TFS
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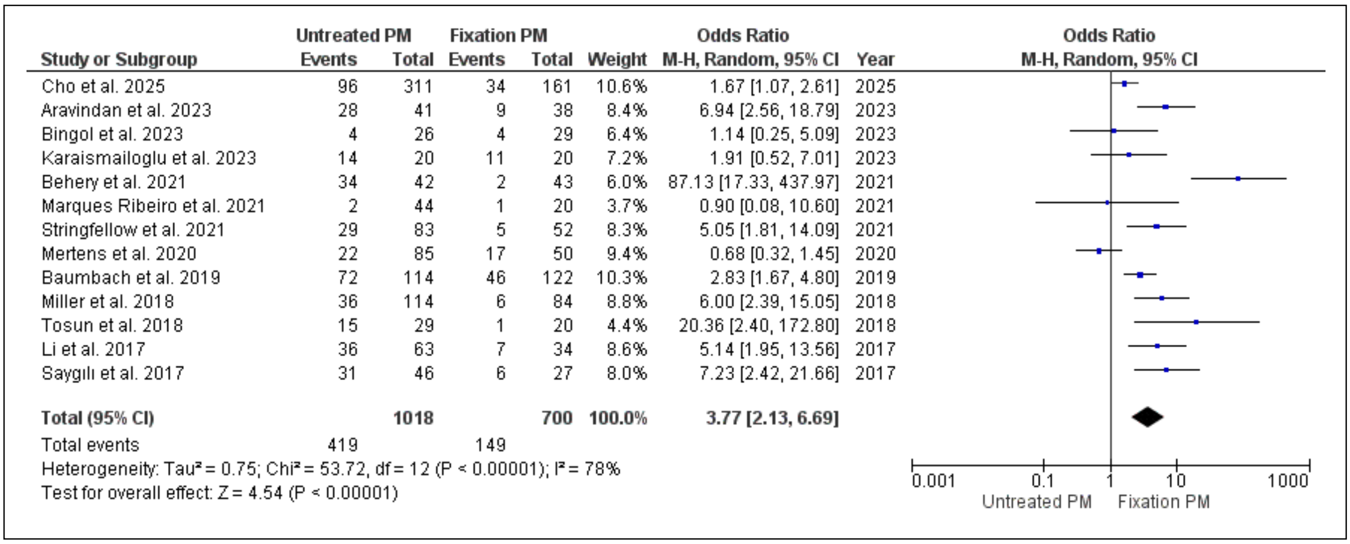

Fig. 3. Forest plot comparing the frequency of TFS use after osteosynthesis versus untreated PM fractures
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In order to determine the morphology of the PM fractures, the Bartoníček-Rammelt [27] and Haraguchi [28] classifications were used in the publications found. Morphologic verification of the PM fractures was used only in 9 studies found (47%), while the size of the fractured PM was reported in 14 studies (74%). In all these studies, osteosynthesis of the PM was performed by 3 methods (posterior-to-anterior (PA) screws; anterior-to-posterior (AP) screws, buttress plate), and the restoration of the lateral and medial malleolus was performed in accordance with the principles of the Arbeitsgemeinschaft für Osteosynthesefragen (AO).

FUNCTIONAL RESULTS

Three studies [17,18,29] included in the systematic review reported data assessing functional outcomes of patient-reported outcome measures (PROMs). The AOFAS scale, in comparison with other PROMs, was the only objective measure of quality of life that was defined in the same way in all studies, which was used for the cumulative analysis. A meta-analysis was performed in terms of functional outcomes in patients who received TFS after malleoli and PM osteosynthesis and patients who did not receive TFS. The results of the meta-analysis showed no statistical difference between the two groups (MD = 1.00; 95% CI [-4.70, 6.70]; p = .073). A high level of heterogeneity was found in this comparison (I^2 = 87%, p = 0.0004) (Fig. 2).

PMF FIXATION VS UNTREATED

13 studies [4,5,17,19,20,23–25,30–34] included in the analysis compared the frequency of TFS use in patients who underwent PM fixation and patients who had their PM injuries treated conservatively. In a quantitative analysis, the results of 1018 patients treated conservatively were compared with 700 patients who underwent PM osteosynthesis. The results of the meta-analysis demonstrate that fixation of the PM significantly reduces the need for additional use of TFS (OR = 3.77; 95% CI [2.13, 6.69]; p < 0.00001). The

Table 3. Publication outcome measurement

Author, year	Syndesmosis test	TFS	Size of PM,%	PM classification	Type of PM fixation	Danis–Weber \AO classification	Lauge–Hansen classification	Time of follow up (months)
Neumann AP, Rammelt S, 2022 [29]	hook test	syndesmotic screw	N\R	Bartoníček-Rammelt classification Type 1 - 7%, Type 2 - 35%, Type 3- 35%, Type 4- 23%	No fixation - 37%, AP screw- 14%, PA screw- 13%, Plate - 36%	Weber B- 76%; C - 24%	SE 3 type - 4%, SE 4 type - 26%, PA 3 type - 46%, PE 4 type - 24%	83,6 (33-171)
*Saygılı et al., 2017 [17]	fluoroscopic external rotation stress test	syndesmotic screw	PMF no fix: 19.8% ± 4.54% (10-25) PMF fix: : 20% ± 4.66% (15-25)	Haraguchi classification Type 1 -57 %; Type 2 - 38 %; Type 3 - 5%	No fixation - 46 (63%) Posterior plate - 17 (63%) Percutaneous screw - 10 (34%)	44B3 - 70 %; 44C1 - 20.5%; 44C2 -9.5 %.	N\A	< 24
*Erdem et al., 2014 [18]	fluoroscopy control	syndesmotic screw	>20%	Haraguchi classification Type 1 -70%; Type 2 - 25 %; Type 3 - 5%	Reconstruction locking plates with either 4 or 5 screw holes - 20 (50%) 1 or 2 or 3 screws -20 (50%)	44B3 - 90 %; 44C 1.3 - 5%; 44C 2.3 -5%.	N\A	38,2 (24-51)
Behery et al., 2021 [24]	external rotation stress test under fluoroscopy	screws - 94% suture button - 6%	PMF no fix: 19% ± 8% PMF fix: : 27% ± 9%	N\R	T or 1/3 tubular plates -39 (91%) AP screws - 4 (9%)	N\R	N\R	N\R
Li et al.,2017 [34]	external rotation stress test under fluoroscopy	2 trans-syndesmotic screws	27% - AP screw group 27.67% - plate group	N\R	AP screw -15 Posterolateral plating - 19	N\A	SER 97 (67.8) PER 35 (24.5) PAB 6 (4.2) SAD 2 (1.4) Not classifiable or previous fracture 3 (2.0)	5.47 ± 3.87
Tosun et al., 2018 [33]	lateral translation stress test and external rotation stress	3.5 mm cortical or 4.5 mm malleolar screw tricortically	PMF no fix : 21.3+7.5 (6-32) PMF fix : 28.9+ 10.5 (12-45)	N\R	Screw -9 Plate - 11	N\A	44-B/SER - 67.3% 44-C/PER - 32.7%	15 (12-51)
*Bingol et al., 2023 [19]	hook test	syndesmotic screws	N\R	Haraguchi classification Type 1 -34,6%; Type 2 - 23,6 %; Type 3 - 41,8%	Posterior buttress plating AP one or two 4.0-mm cannulated screws	N\R	N\R	12-42
Marques Ribeiro et al., 2021 [4]	manual external rotation test	trans-syndesmotic screw	14.7 ± 5.3% (5–24)	N\R	70% plate and screws 25% AP screw 5% PA screw.	44-B - 87% (B3.2: 39%; B3.3: 48%) 44-C - 13% (C1: 2%; C2: 8% C3: 3%).	N\A	43.1 ± 22.2 (24–96)

Table 3. Cont.

Aravindan et al., 2023 [5]	external rotation stress test	N\R	PMF no fix: 16.50% (25.6–32.1%) PMF fix: : 28.90% (25.6–32.1%)	Haraguchi classification Type 1 -50,6%; Type 2 - 31,6 %; Type 3 - 17,8%	48.1% ORIF 48.1% no fixation 3.8% percutaneous screw fxation	N\R	N\R	> 3
Mertens et al., 2020 [32]	hook test	syndesmotic screw	N\R	Bartoníček-Rammelt classification Type 1 - 2, Type 2 - 17, Type 3- 13, Type 4- 14	No fixation - 76 2.7 mm plate -50 AP screw -9	N\R	N\R	> 12
Baumbach et al., 2019 [25]	hook test or external rotation test	trans-syndesmotic screw (56.8%) tight rope (36.4%) internal brace (6.8%)	21.4 ± 10.4% (2.7-55.9%)	Haraguchi classification Type 1 -47,9%; Type 2 - 33,9 %; Type 3 - 18,2%	No fixation - 48,3% CRIF using AP screws - 18.6% ORIF using a plate or screw(s) - 33.1%	1.7% - 44-A (A2: 0.4%; A3: 1.3%) 77.5% - 44-B (B1: 0.8%; B2: 0.4%; B3.1: 20.3%; B3.2: 19.5%; B3.3: 36.4%) 11.9% - 44-C fracture (C1: 1.3%; C2: 6.8% C3: 3.8%) 8.9% - not classified	N\A	N\R
*Miller et al., 2018 [20]	hook test	N\R	PMF fix : 22.2 ± 10.2 PMF no fix : 15.2 ± 7.4	N\R	Plate fixation - 48 Other - 36	Weber A - 1 B -159 C - 36	Maissoneuve - 2 ISO - 2 PER - 22 PAB - 13 SER - 159	N\R
Karaismailoglu et al., 2023 [30]	external rotation stress or hook test	one or two trans-syndesmotic screws	25.8% ± 5.9% X-ray 19.1% ± 5.2% CT	Haraguchi classification Type 1 -60%; Type 2 - 40%	buttress plate or screws	Weber B - 72,5% C -27,5%	SER - 72,5% PER - 27,5%	>24
Stringfellow et al., 2021 [31]	N\R	cortical screws	17.8% X-ray 24.5% CT	N\R	42 (80.7%) plate fixation 4 cortical and 6 cancellous screw	N\R	N\R	N\R
Pilskog et al., 2020 [26]	cotton test or external rotation test	1 quadricortical screw 2 tricortical 3.5-mm screws or a suture button	17% (12%-24%)	N\R	3.5-mm screws with or without a one-third tubular plate AP partially threaded, 3.5-mm cancellous screws	Weber B - 30 C - 56	SER - 55 PER - 31	26 (IQR 19-35)
*O'Connor et al., 2015 [21]	N\R	N\R	12.8-41.2%	N\R	AP 1 or 2 percutaneous 3.5-mm lag screws – 41% T plate or 1/3 tubular plate – 59%	N\R	N\R	Plate - 54.9 (19.5–99.5) AP screws - 32 (14.9–48.8)

Table 3. Cont.

*Kalem et al., 2018 [22]	N\R	one screw	<10% - 25 10-25% - 31 >25% - 11	N\R	20 AP\ 13 PA - one or two partially threaded 4.5 mm canullated screws 35 plate (3.5 mm. 1/3 tubular plate)	N\A	SER - 32.8% PER - 11.9% PA - 47.8% SA - 7.5%	12-24
Miller et al.,2010 [9]	placing a narrow Hohmann retractor in the interosseous space to apply an external rotation stressor	two locked quadricortical syndesmotic screws through a separate three-hole one-third tubular plate	N\R	N\R	six-hole 2.0 or 2.4 reconstruction or T-plate	N\A	SER 4 - 80% PER 4 - 10% Unclassifiable - 10%	15 (12–31)
*Cho et al., 2025 [23]	external rotation or hook test	trans-syndesmotic screw or suture button	N\A	Haraguchi classification Type 1 -50.2 %; Type 2 - 42.2 %; Type 3 - 7.6%	one or two 3.5-mm screws -134 (83,2%) or a posterior buttress plate - 27 (16,8%)	Weber B -335 C - 137	PER - 132 PAB - 19 SER - 321	51 (36–120)
Liu et al., 2020 [35]	cotton test	tricortical screw	≥25%	N\R	Plate fixation – 47 Screws - 38	N\A	SER 4 – 100%	(13.11±1.12) months

Notes : * - calculated using data from original article; N\A - not applicable; N\R- not reported.
PM – posterior malleolus; TFS – distal tibiofibular stabilization; SAD - Supination – Adduction; SER - Supination - External Rotation; PER - Pronation - External Rotation; PAB - Pronation – Abduction; PA – posterior-to-anterior screws; AP – anterior-to-posterior screws ; ORIF – open reduction and internal fixation; CRIF – closed reduction and internal fixation.
Source: compiled by the authors based on [4, 5, 9, 17-26, 29-35]

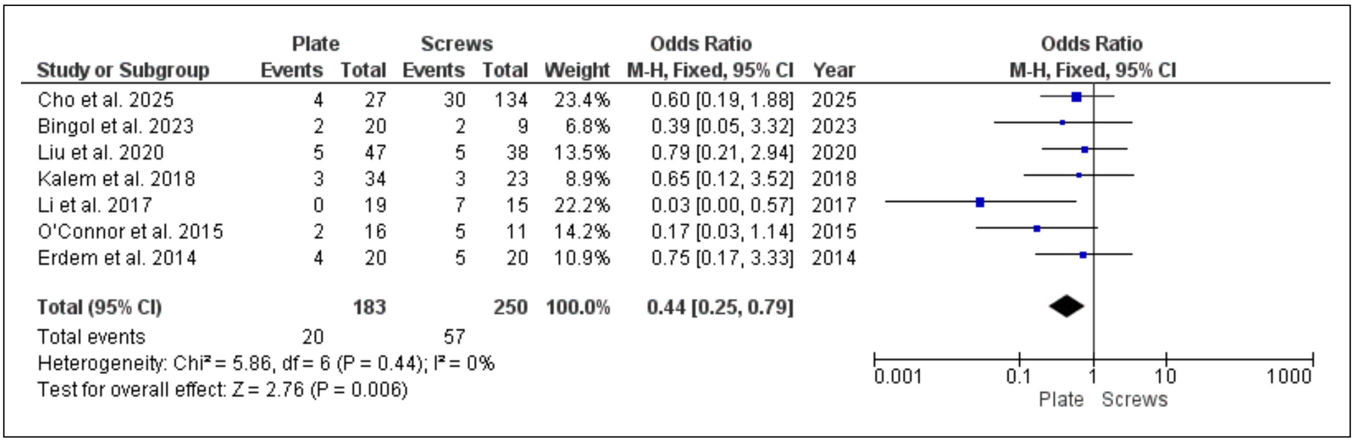

Fig. 4. Forest plot showing the frequency of TFS application after PM fixation with a buttress plate compared to screws
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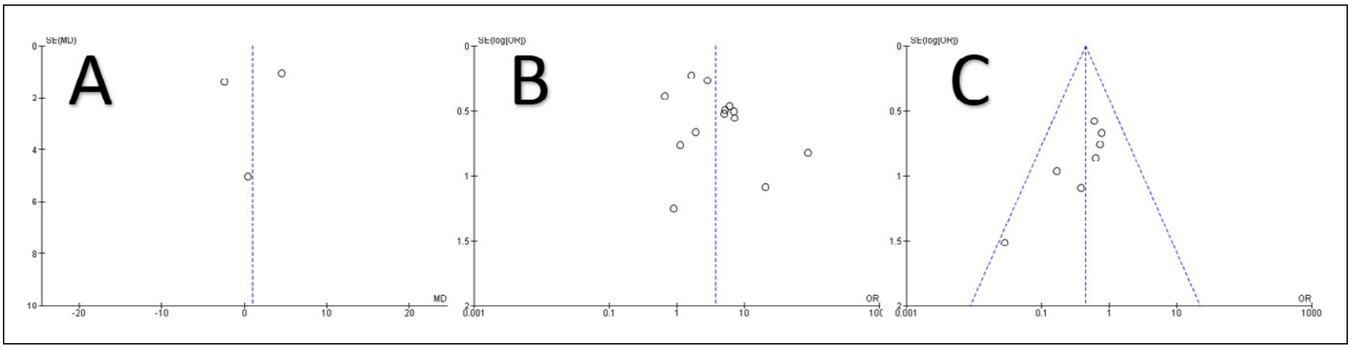

Fig. 5. Funnel plots showing: A — comparison of AOFAS scores with versus without TFS use; B — frequency of TFS use after osteosynthesis versus untreated PM fractures; C — frequency of TFS use after osteosynthesis of the PM with a buttress plate versus screws
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analysis revealed a high level of heterogeneity (I^2=78%; p<.00001) (Fig. 3).

PLATE VS SCREWS

In 7 studies [18,19,21–23,34,35], data are presented that demonstrate the frequency of TFS use after osteosynthesis of the PM with a buttress plate and after the use of screws in the anterior-to-posterior (AP) and posterior-to-anterior (PA) directions. The results of the quantitative analysis demonstrate that fixation of the PM with a buttess plate significantly reduces the need for additional TFS (OR = 0.44; 95 % CI [0.25, 0.79]; p = 0.006). The model showed a low level of heterogeneity (I^2 = 0%; p = 0.44) (Fig. 4).

PUBLICATION BIAS

The methodological quality of all included studies was assessed using the Newcastle-Ottawa Quality Assessment Scale. 9 studies were classified as having high quality, and 11 studies were classified as having moderate quality (Table 4). The funnel plots show some asymmetry, which may indicate the presence of publication bias (Fig. 5).

In our study, we comprehensively collected the relevant literature and analyzed the clinical efficacy and frequency of TFS use in patients with ankle fractures involving PM. The results of our systematic literature review and meta-analysis demonstrate that restoration of the bone anatomy of the AJ reduces the frequency of TFS use, and its additional use may not affect the functional outcomes of treatment.

From an anatomical point of view, the modern principle of treatment of AJ injuries is "directly fix what is broken and repair what is torn" [36]. The advantages of fixation of the posterior malleolus are to ensure anatomical repair of the incisura fibularis tibiae and the posterior part of the DTFS, which may reduce the need for stabilization of the syndesmosis or be its equivalent[37]. This is probably due to the extensive attachment of the posterior inferior tibiofibular ligament to the posterior malleolus, which provides up to 42% of the stability of the DTFS [38]. Miller et al [20] showed that open reduction and internal fixation (ORIF) of PM fracture restores syndesmosis stability in

Table 4. Risk of Bias Assessment per the Newcastle-Ottawa Quality Assessment Scale

Author,year	Selection				Comparability	Outcome			Total	Quality
	Representativeness of the exposed cohort	Selection of the non exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study		Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts		
Neumann AP, Rammelt S, 2022	1	0	1	1	2	1	1	1	8	High
Saygılı et al., 2017	1	1	1	1	1	1	1	0	7	Moderate
Erdem et al., 2014	1	1	1	1	1	1	1	1	8	High
Behery et al.,2021	1	1	1	1	2	1	1	0	8	High
Li et al.,2017	1	1	1	1	2	1	1	0	8	High
Tosun et al.,2018	1	1	1	1	1	1	1	1	8	High
Bingol et al.,2023	1	1	1	1	1	1	1	0	7	Moderate
Marques Ribeiro et al., 2021	1	1	1	1	2	1	0	1	8	High
Aravindan et al.,2023	1	1	1	1	1	1	0	1	7	Moderate
Mertens et al., 2020	1	1	1	1	1	1	0	1	7	Moderate
Baumbach et al., 2019	1	1	1	1	2	1	1	0	8	High
Miller et al., 2018	1	1	1	1	1	1	1	0	7	Moderate
Karaismailoglu et al., 2023	1	1	1	1	2	1	1	1	9	High
Stringfellow et al., 2021	1	1	1	1	1	1	1	0	7	Moderate
Pilskog et al.,2020	1	1	1	1	1	1	0	1	7	Moderate
O'Connor et al.,2015	1	1	1	1	1	1	1	1	8	High
Kalem et al.,2018	1	1	1	1	1	1	1	1	8	High
Miller et al.,2010	1	1	1	1	1	1	1	0	7	Moderate
Cho et al., 2025	1	1	1	1	1	1	1	0	7	Moderate
Liu et al., 2020	1	0	1	1	2	1	1	1	9	High

*High quality: 8-9 stars, Moderate quality: 7-5 stars, Low quality: < 4 stars

Source: compiled by the authors of this study more than 97% of cases. Neumann and Rammelt [29] report the use of TFS after osteosynthesis of the PM in only 15% of cases, mainly with pronation - external rotation 4 type injuries, Weber C and Bartonicek-Rammelt type 2 injuries. Saygili et al [17] noted that TFS was necessary in 22% of patients after fixation of PM, while in the group of conservative treatment of PM fractures, TFS was 68%. The authors did not note a correlation between the frequency of TFS and the morphology of the PM. Çağlar et al [3] showed that anatomical repair of the PM provides high stability of the syndesmosis, which is confirmed by the radiological parameters of the AJ after 1 year of observation, and does not require additional fixation of the syndesmosis with screws.

On the other hand, other studies emphasize that fixation of the PM may not be sufficient to fully restore the stability of the DTFS. For example, Erdem et al [18] reported that the presence of TFS led to better results on the AOFAS scale regardless of the type of fixation of the PM at 6 and 24 months after surgery and at the final follow-up. The authors attribute this phenomenon to possible undiagnosed intraoperative damage to the DTFS ligaments, which affected clinical outcomes in this cohort of patients. Aravindan et al [5] emphasize that fixation of the PM reduces (23.7% vs. 68.3%) but does not completely eliminate the need for TFS, especially in the case of small PM fragment, where 40% of patients still required TFS after fixation of the PM. Baumbach et al [25] found that TFS was required in 50% of cases, despite a significant reduction in its use after ORIF of the PM fragment. TFS was required significantly less frequently in patients who underwent ORIF of the PM fragment (25%) compared with closed reduction and osteosynthesis (61%) and the group of conservative treatment of PM fracture (63%). The authors emphasize that the size of the fragment of the PM did not have a significant effect on the incidence of TFS in all three groups. J. Bartoníček and S. Rammelt[27] and L.W. Mason[39] recommend TFS as an alternative to fixation of the PM fragment, for a certain type of PM fragment, given the lack of advantages of surgical fixation of avulsive (type 1 - extraincisional) fragments of the PM, and the existing damage to the DTFS.

Although anatomical repositioning and fixation of the PM fragment may sufficiently stabilize the DTFS, residual instability is due to concomitant damage to other structures of the DTFS, including the interosseous ligament and the anterior inferior tibiofibular ligament, which may require additional use of TFS. Intraoperative verification of residual instability of the DTFS after fixation of malleoli fractures should remain a necessary criterion for the use of TFS. However, its routine use, in our opinion, may not have additional benefits, given the potential risks and the need for a second visit to the operating room for removal of hardware in static scenario of stabilizing the DTFS.

One of the results obtained in our study is a decrease in the use of TFS when using a buttress plate. The probable reason that may explain this phenomenon is that ORIF of the PM with the help of a buttress plate not only promotes anatomical restoration of the articular surface of the ankle joint and stable fixation of the PM fragment, but also can provide (compared to AP and PA screws) reapproximation of the posterior inferior tibiofibular ligament, given its wide attachment to the posterior part of the distal tibial plateau, especially in rotationally unstable ankle fractures where damage (delamination) of the ligament can manifest itself as its detachment without visible tearing [40].

LIMITATIONS

This meta-analysis has certain limitations. Firstly, the use of TFS is a common technique in the treatment of Maisonneuve fractures and complex "logsplitter injuries" of the AJ, where restoration of the DTFS is a recommended procedure, interpreted by the nature of the injury, which makes it difficult to assess the need for TFS in this group of patients. Secondly, we did not separately evaluate the difference between TFS in fixation of PM with PA and AP screws. Thirdly, we did not analyze the complication rate in patients treated with TFS, which may be the basis for future studies. Methodological and clinical heterogeneity in the included studies limited the conclusions drawn from this analysis. Thus, our results should be interpreted with caution, as we believe that large and rigorous RCTs are needed to improve the evidence.

CONCLUSIONS

A systematic review of the literature and meta-analysis revealed that fixation of the PM in the treatment of patients with ankle fractures reduces the frequency of TFS use. No effect of additional TFS on functional outcomes was found. Osteosynthesis of PM with a buttress plate reduces the frequency of TFS use compared to AP and PA screws.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

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