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ORIGINAL ARTICLE

Plates versus headless screws for fixation of Mason Type 3 radial head fractures: A systematic review

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ABSTRACT

Objectives: In this review, we discuss the clinical outcomes of plates and headless screws (HSs) for Mason Type 3 radial head fractures to determine the superior approach.

Materials and methods: A comprehensive literature search was conducted across multiple databases for studies on internal fixation of Mason Type 3 radial head fractures, covering publications from inception to December 2024. Literature was screened, and data were extracted according to predefined inclusion criteria. The quality of randomized-controlled trials (RCTs) was assessed using the Cochrane Handbook for Systematic Reviews of Interventions, while the Methodological Index for Non-Randomized Studies (MINORS) recommended by the Cochrane Collaboration was used for non-RCT studies. Systematic review was performed using *RevMan* version 5.1 software provided by the Cochrane Collaboration.

Results: A total of five studies were included in the systematic review, comparing 89 cases treated with plate fixation and 136 cases treated with HS fixation. The systematic review revealed that plate fixation increased the time to bone union (mean difference [MD]=26.89; 95% confidence interval [CI]: 18.84-34.93; p<0.0001) without significant heterogeneity (p=0.51, I^2=0%). Plate fixation was also associated with a decrease in the postoperative Mayo Elbow Performance Score (MEPS) (MD=–5.86; 95% CI: –9.11 to –2.61; p=0.0004) with no significant heterogeneity (p=0.34, I^2=6%), although the result was not clinically significant. Plate fixation resulted in reduced postoperative pronation (MD=–8.82; 95% CI: –13.02 to –4.63; p=0.0001) and supination (MD=–8.79; 95% CI: –12.09 to –5.49; p=0.0001). No significant differences were found between the two methods in terms of operation time, length of hospital stay, postoperative flexion-extension, flexion, extension, complications, or postoperative Disabilities of the Shoulder, Arm, and Hand (DASH) scores.

Conclusion: The results of our systematic review indicate that HSs offer a faster bone union time and better functional outcomes in terms of pronation and supination, compared to plate fixation. However, the clinical significance of differences in MEPS and DASH scores is questionable, as they still remain below the minimal clinically important difference thresholds. Given the varying fracture configurations, further studies with larger sample sizes are needed to confirm these findings and determine the most clinically relevant treatment approach.

Keywords: Elbow, internal fixation, Mason classification, proximal radius, radial head fracture.

Radial head fractures are the most common type of elbow fracture in adults, with an incidence of 12.4 per 100,000 individuals. These fractures occur more frequently in women, likely due to the higher prevalence of osteoporosis in this population.[1-3] The typical mechanism of injury involves a fall on an outstretched arm with the forearm pronated and the elbow slightly flexed, causing the radial head to strike the capitellum and transmit axial force.[1-3] Radial head fractures may also present as part of complex elbow dislocations.[4]

The radial head plays a critical role in transmitting forces across the elbow joint and stabilizing it against valgus stress, second only to the medial collateral ligament (MCL). When the elbow is extended, and the forearm is fully

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pronated, the radial head can bear up to 90% of body weight.[2,5] The classification of radial head fractures was initially introduced by Mason[6] in 1954 and has since been modified by Broberg and Morrey[7] (to include displacement and fragment percentage), Johnston[8] (to add Type 4 fractures), and Hotchkiss[9] (to suggest treatment strategies). Non-displaced or minimally displaced fractures (<2 mm) without a mechanical block to forearm rotation are classified as Type 1. Displaced (>2 mm) or angulated fractures with potential mechanical block to forearm rotation are classified as Type 2. Displaced and comminuted fractures with a mechanical block to forearm rotation are classified as Type 3, while Type 3 fractures with associated elbow dislocation are classified as Type 4.[8]

Treatment approaches for radial head fractures primarily depend on the fracture type. Conservative management is generally effective for minimally displaced fractures,[10] while internal fixation is commonly used for Mason Type 2 fractures.[6] However, there is no consensus on the optimal treatment for Mason Types 3 and 4 fractures. Both internal fixation and radial head arthroplasty have been recommended by different authors.[11-13] Radial head arthroplasty is typically reserved for patients with severe, comminuted, and irreparable fractures, particularly those with concomitant ligamentous injury, as it often yields unsatisfactory results in other cases.[14-16]

For Mason Type 3 fractures, both plates and headless screws (HSs) are widely used for internal fixation, offering favorable outcomes but with distinct advantages and disadvantages.[17] A network meta-analysis study by Su et al.[18] showed that plates and screws fixation for radial neck fractures might exhibit enhanced biomechanical strength in axial and bending directions, while cross screws reduced torsional stability compared to parallel screws. There are also some biomechanical studies suggest that fixation with locked plates provides superior stabilization.[19] Therefore, plate fixation is more commonly employed for Mason Type 3 radial head fractures, particularly when the fracture extends to the radial neck or when the fragments are too numerous or too small to be adequately stabilized with screws. However, plates may lead to increased complications due to the larger dissection required and the prominence of metal in subcutaneous locations.[20] In contrast, HS fixation is associated with faster bone union and lower complication rates.[21]

To date, no systematic review has specifically compared the advantages and disadvantages of these two fixation methods. In this review, we discuss the clinical outcomes of plates and HSs for Mason Type 3 radial head fractures to determine the superior approach.

MATERIALS AND METHODS

Literature search strategy

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Systematic searches were performed following the Cochrane Collaboration's recommendations. Relevant articles were identified from PubMed, Embase, and the Cochrane Library using the following keywords: "radial head fracture," "internal fixation," "plate screws", "plate" and "headless screws." Studies in English language published from the inception of the databases to December 2024 were included. The initial search yielded 186 results. A review of reference lists from all retrieved articles was also conducted to identify additional studies.

Two independent researchers evaluated the articles for inclusion based on predefined criteria. Disagreements were resolved through discussion.

The study protocol was approved by the Tianjin Medical University General Hospital , Ethics Committee (date: 24.02.2023, no: IRB2023-DWFL-090). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Selection criteria

The inclusion criteria for this systematic review were as follows: *(i)* studies involving skeletally mature patients with acute, closed, isolated Mason Type 3 radial head fractures, classified using the Mason and Johnston system as modified by Broberg and Morrey;[7] *(ii)* studies comparing clinical outcomes of plate fixation versus HS fixation for Type 3 radial head fractures; and *(iii)* studies reporting measurable clinical outcomes, including operation time, hospital stay, time to bone union, Disabilities of the Shoulder, Arm, and Hand (DASH) score, Mayo Elbow Performance Score (MEPS), range of motion, and postoperative complications. Titles, abstracts, and keywords of identified articles were screened independently by two researchers to assess eligibility. Articles meeting inclusion criteria underwent full-text evaluation. Disagreements were resolved through discussion, until a consensus was reached.

Methodological quality assessment

The quality of randomized-controlled trials (RCTs) was assessed using the Cochrane Handbook for Systematic Reviews of Interventions (Figure 1). For non-RCTs, the Methodological Index for Non-Randomized Studies (MINORS), recommended by the Cochrane Collaboration, was applied.

Data extractions

Two independent researchers extracted data from the included studies. Extracted information included the first author's name, publication year, sample size, patient baseline characteristics, fracture type, number of fracture fragments and clinical outcomes (e.g., operation time, hospital stay, bone union time, DASH score, MEPS, range of motion, and complications).

Statistical analysis

Statistical analysis was performed using the *RevMan* version 5.1 software (The Cochrane Collaboration). Standardized mean differences (SMDs) with 95% confidence intervals (CIs) were calculated for continuous variables. Odds ratios (ORs) with 95% CIs were used for dichotomous variables. Heterogeneity among studies was assessed using the chi-squared test and a quantitative p-value. A fixed-effects model was applied, when heterogeneity was low ($p>0.01$, $I^2<50\%$); otherwise, a random-effects model was used. A *p* value of <0.05 was considered statistically significant.

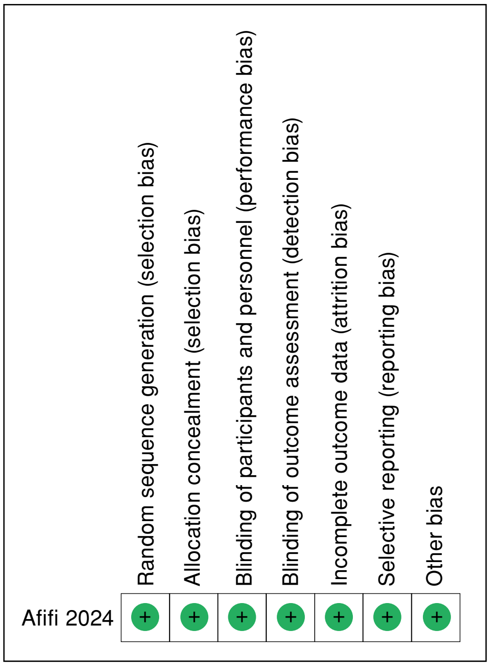

FIGURE 1. The summary of bias risk of randomized controlled trials.

RESULTS

Search results and quality assessment

A total of 186 potential studies were identified online. After removing duplicates (n=134), the remaining 52 studies were assessed by reviewing titles and abstracts for further screening. Following this process, 29 studies were excluded, leaving 23 eligible studies. No new articles were found during manual searches of the reference lists from all included studies. After reviewing the literature, 18 additional articles were excluded. Ultimately, one RCT and four non-RCTs were included for data extraction and systematic review. The search process is displayed in Figure 2.

The quality of the RCT was assessed based on the Cochrane Handbook for Systematic Reviews of Interventions (Figure 1). The MINORS scores for non-RCTs were all 20, and the methodological quality assessment of these studies is presented in Table I.

Study characteristics

Table II summarizes the demographic characteristics and other details of the included studies. In all studies, the baseline characteristics of the two groups were similar. However, detailed information regarding fracture characteristics was limited. All five studies reported the number of fracture fragments, which was comparable between the two groups and ranged from 2 to 4 fragments in four of the studies. Notably, in Müller's study,[1] screw fixation was applied exclusively to simple two-part fractures, while multi-fragment Mason Type 3 radial head fractures were treated with plate fixation. Unfortunately, none of the included studies provided information on the size of the fracture fragments, leaving potential heterogeneity in our analysis unresolved. Despite this heterogeneity, Müller's study was incorporated only once, minimizing its impact on the overall analysis. A total of 225 patients were analyzed across the five studies, comprising 89 cases with plate fixation and 136 cases with HS fixation. The MINORS scores of the non-RCTs suggested that the included studies were of acceptable methodological quality.

Outcomes of systematic review

Operation time

Only two studies reported the operation time (in min) for both groups, with a comparable number

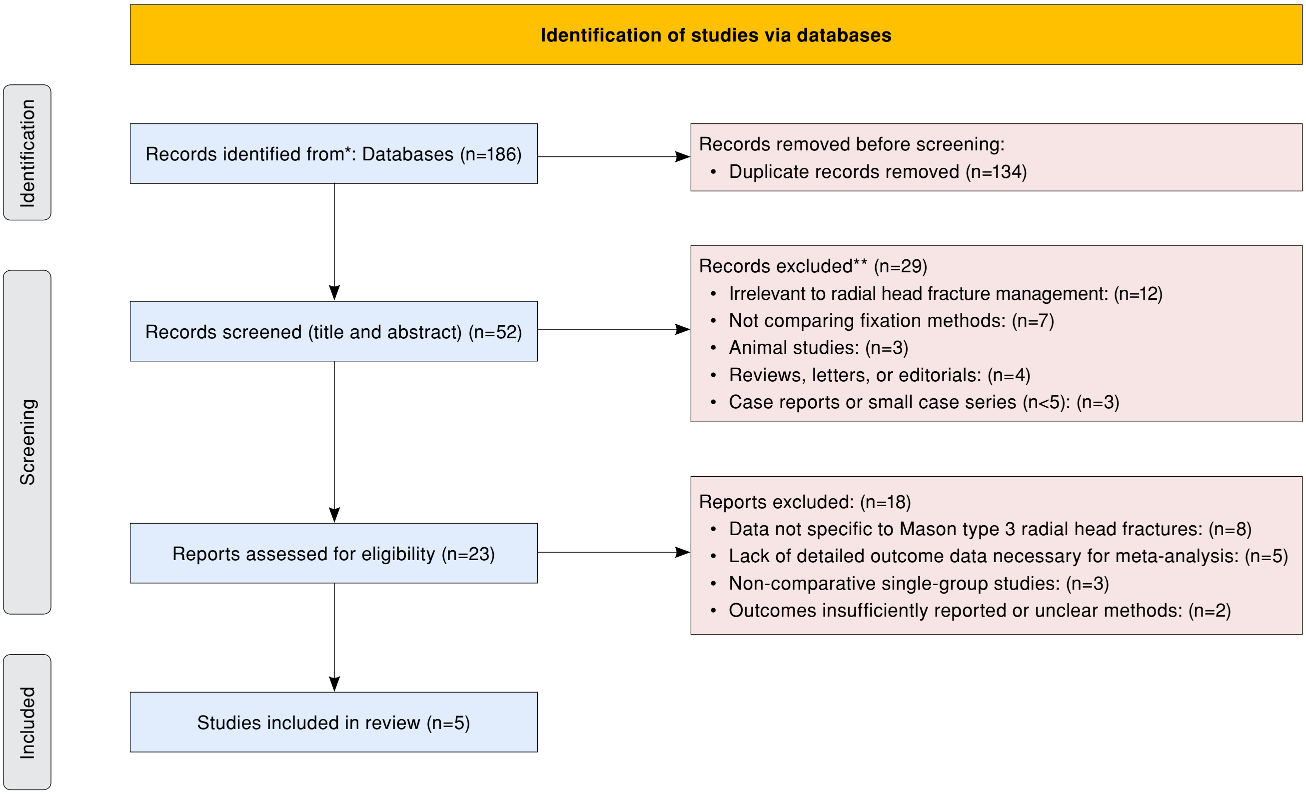

FIGURE 2. Flowchart of the study selection process.

of fracture fragments between them. Pooled results showed that there was no significant difference on operation time between two methods (MD=4.92; 95% CI: –12.26-22.09; p=0.57) without significant heterogeneity (p=0.61, I^2=0%) (Figure 3).

Length of hospital stay

Two studies reported the length of hospital stay (in days). Pooled results indicated that plates did not increase hospital stay duration compared

TABLE I
Quality assessment for non-randomized trials

Quality assessment for non-randomized trials	Adıgüzel et al.[5] 2023	Müller et al.[1] 2023	Wu et al.[20] 2016	Yano et al.[26] 2022
A clearly stated aim	2	2	2	2
Inclusion of consecutive patients	2	2	2	2
Prospective data collection	0	0	0	0
Endpoints appropriate to the aim of the study	2	2	2	2
Unbiased assessment of the study endpoint	2	2	2	2
A follow-up period appropriate to the aims of study	2	2	2	2
Less than 5% loss to follow-up	2	2	2	2
Prospective calculation of the sample size	0	0	0	0
An adequate control group	2	2	2	2
Contemporary groups	2	2	2	2
Baseline equivalence of groups	2	2	2	2
Adequate statistical analyses	2	2	2	2
Total score	20	20	20	20

TABLE II
Characteristics of included studies

Study	Design	Intervention	Case	Mean age	Male	Follow-up
Adıgüzel et al.[5] 2023	RCS	P	15	44.5	8	18 m
		HS	12	44.2	8	18 m
Afifi et al.[27] 2025	RCT	P	30	35.5	18	18 m
		HS	30	32.8	25	18 m
Müller et al.[1] 2023	RCS	P	20	NS	NS	49.9 m
		HS	67	NS	NS	49.9 m
Wu et al.[20] 2016	RCS	P	12	45	6	NS
		HS	16	40	9	NS
Yano et al.[26] 2022	RCS	P	12	43.5	8	18 m
		HS	11	42.8	6	18 m

HS: Headless screw; P: Plate; RCS: Retrospective controlled trial; RCT: Randomized controlled trial; M: Month; NS: Not state.

to HSs (MD=0.66; 95% CI: –1.44-2.76; p=0.66) with significant heterogeneity (p=0.02, I^2=82%) (Figure 4).

Time to bone union

Two studies analyzed time to bone union (in days). The union of the fracture was defined as bony bridging across the fracture site. Pooled results revealed that plates increased time to bone union compared to HSs (MD=26.89; 95% CI: 18.84-34.93; p<0.0001) without significant heterogeneity (p=0.51, I^2=0%) (Figure 5).

Postoperative DASH

Two studies reported postoperative DASH scores. The DASH score is a patient-reported measure of upper extremity symptoms and daily activity performance. The minimal clinically important difference (MCID) for the DASH score has been established as 10.83.[22] In all included studies, the DASH scores were lower than the MCID threshold of 10.83, indicating that the observed differences were not clinically meaningful.

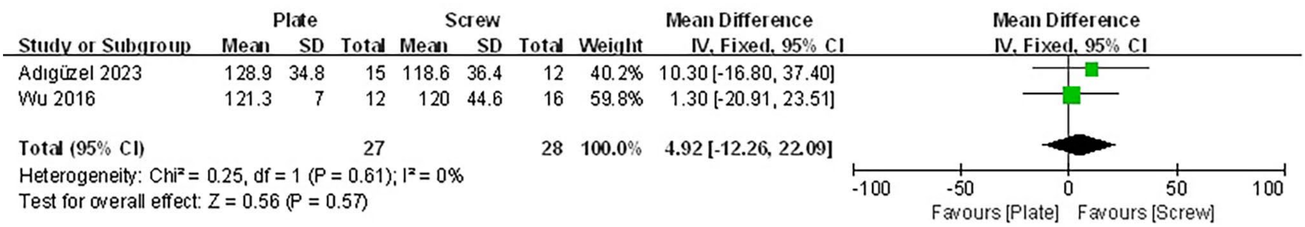

FIGURE 3. Forest plot diagram of included two studies for operation time.
SD: Standard deviation; CI: Confidence interval.

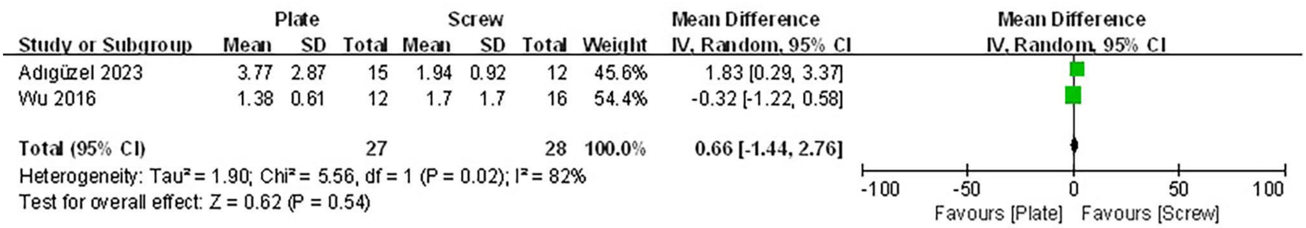

FIGURE 4. Forest plot diagram of included two studies for length of hospital stay.
SD: Standard deviation; CI: Confidence interval.

Pooled results showed that there was no significant difference on postoperative DASH scores comparing two methods (MD=2.13; 95% CI: –2.43-6.69; p=0.36) without significant heterogeneity (p=0.86, I^2=0%) (Figure 6). Moreover, the results were also below the MCID threshold, indicating a lack of clinical significance.

Postoperative MEPS

Three studies reported the postoperative MEPS.[23] The MEPS is an instrument used for testing the limitations, caused by pathology, of the elbow during activities of daily living, measured by doctors abjectly. It includes pain, range of motion, stability and daily function. Pooled results showed that plate decreased postoperative MEPS compared with HS (MD=–5.86; 95% CI: –9.11 to –2.61; p=0.0004) without significant heterogeneity (p=0.34, I^2=6%) (Figure 7). However, although the postoperative MEPS scores were higher the threshold of MCID of MEPS[24] (10 points), the pooled mean difference remained below this threshold, indicating that the difference in MEPS between the two groups, while statistically significant, was not clinically meaningful.

Range of motion

Postoperative range of motion was reported in four studies. Two studies recorded the range of flexion and extension respectively, while two studies used the range of flexion-extension for clinical outcomes. Pooled results indicated that postoperative flexion-extension (Figure 8), flexion (Figure 9), and extension (Figure 10) did not differ significantly between the HS group and the plate group. Nevertheless, the difference in flexion-extension demonstrated borderline statistical significance. However, plates significantly decreased

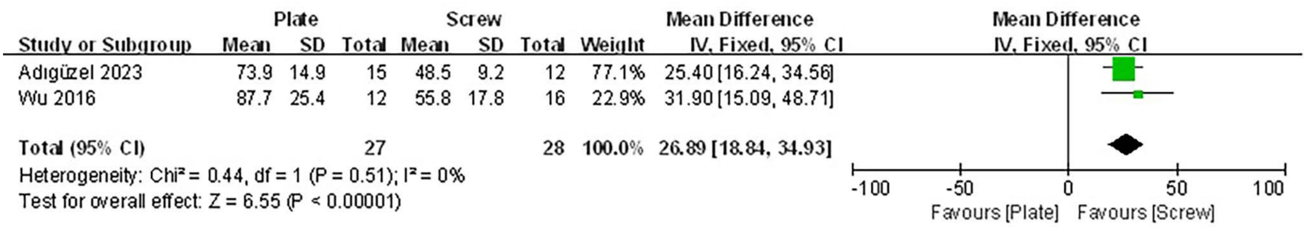

FIGURE 5. Forest plot diagram of included two studies for time to bone union.
SD: Standard deviation; CI: Confidence interval.

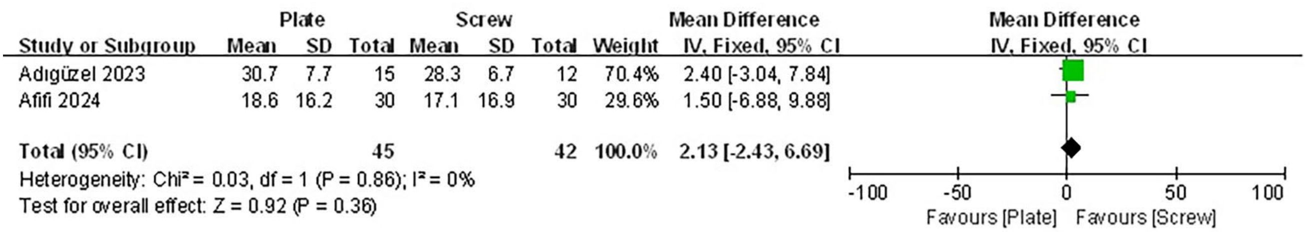

FIGURE 6. Forest plot diagram of included two studies for postoperative DASH.
SD: Standard deviation; CI: Confidence interval; DASH: Disabilities of the Shoulder, Arm, and Hand.

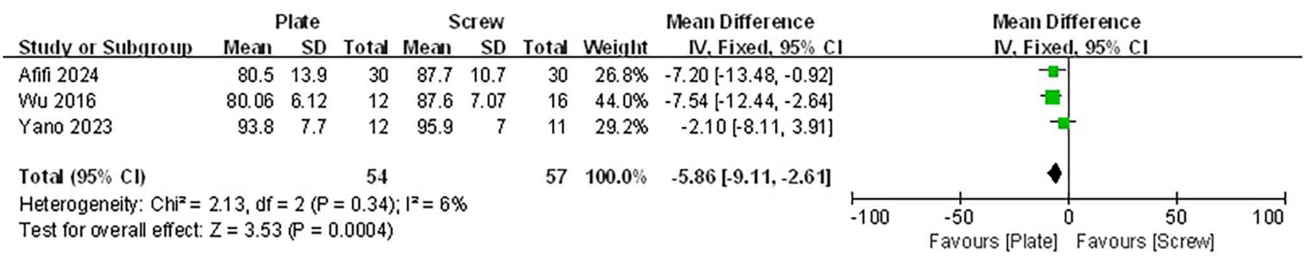

FIGURE 7. Forest plot diagram of included three studies for postoperative MEPS.
SD: Standard deviation; CI: Confidence interval; MEPS: Mayo Elbow Performance Score.

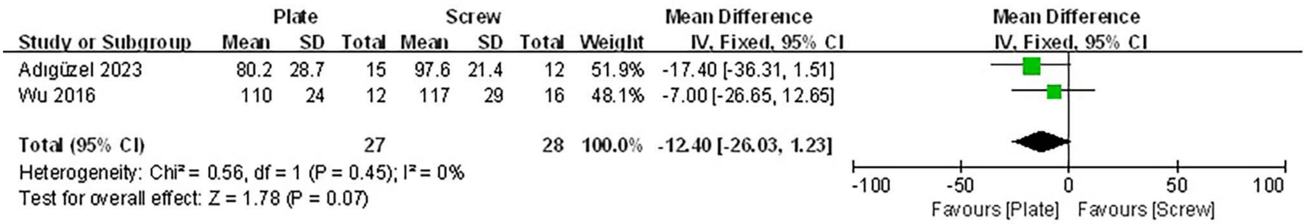

FIGURE 8. Forest plot diagram of included two studies for postoperative flexion-extension.
SD: Standard deviation; CI: Confidence interval.

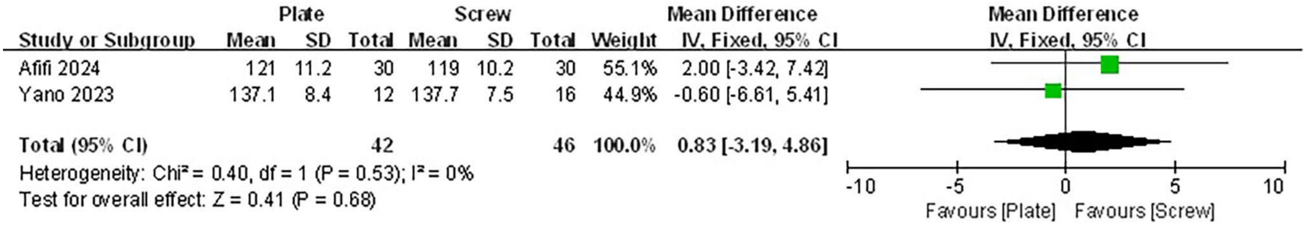

FIGURE 9. Forest plot diagram of included two studies for postoperative flexion.
SD: Standard deviation; CI: Confidence interval.

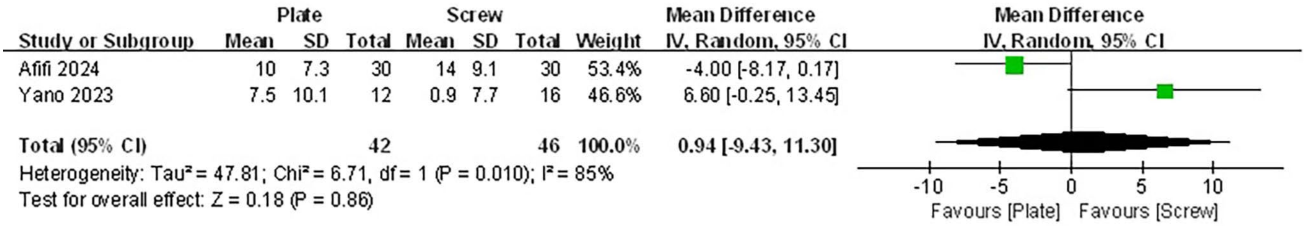

FIGURE 10. Forest plot diagram of included two studies for postoperative extension.
SD: Standard deviation; CI: Confidence interval.

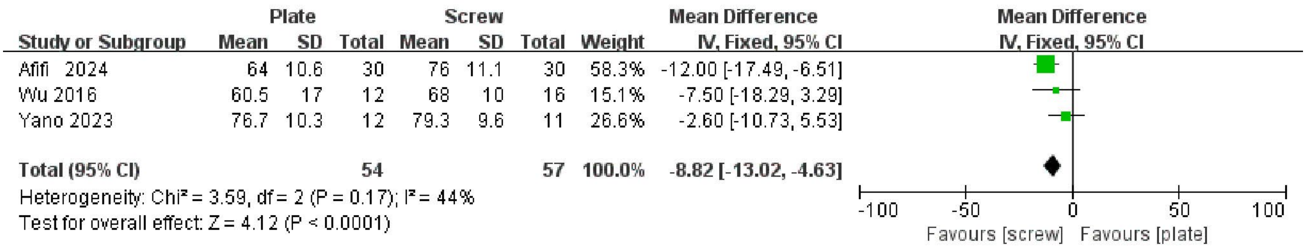

FIGURE 11. Forest plot diagram of included three studies for postoperative pronation.
SD: Standard deviation; CI: Confidence interval.

postoperative pronation (MD=–8.82; 95% CI: –13.02 to –4.63; p≤0.0001) and supination (MD=–8.79; 95% CI: –12.09 to –5.49; p<0.00001) without significant heterogeneity (Figure 11 and 12).

Postoperative complication

Three studies reported postoperative complication rates. Complications requiring surgical treatment were major complications, with all others being minor. We included data on minor complications from three studies in our analysis, including Müller's study,[1] in which heterogeneity in fracture characteristics might have introduced potential bias to the results.

Pooled results showed that plates did not significantly increase the incidence of minor

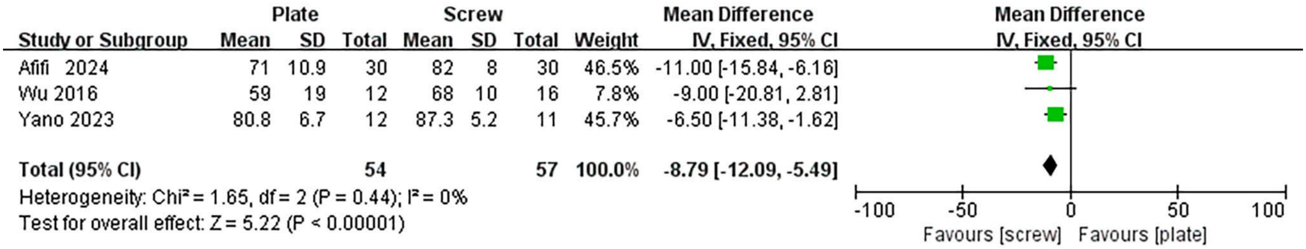

FIGURE 12. Forest plot diagram of included three studies for postoperative supination.
SD: Standard deviation; CI: Confidence interval.

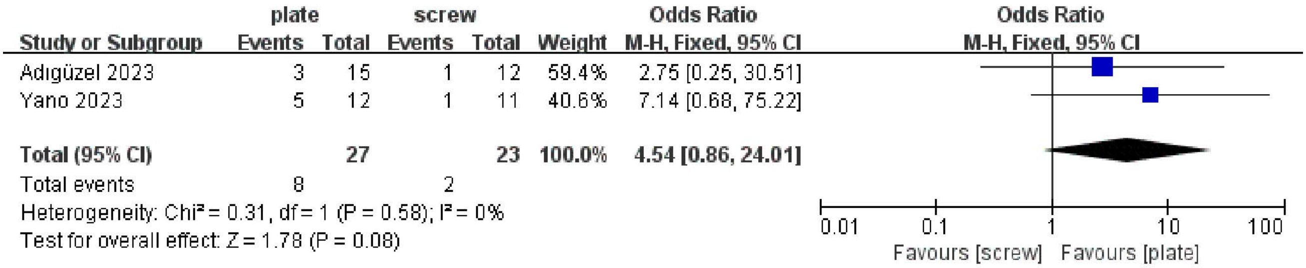

FIGURE 13. Forest plot diagram of included two studies for postoperative minor complications.
SD: Standard deviation; CI: Confidence interval.

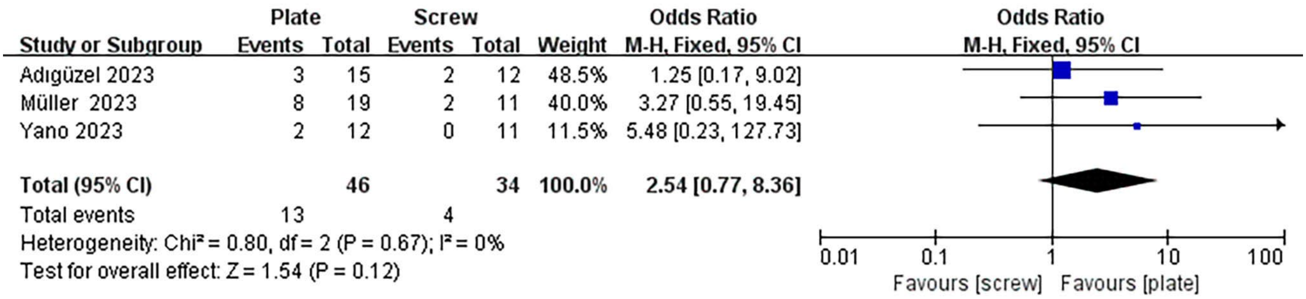

FIGURE 14. Forest plot diagram of included two studies for postoperative major complications.
SD: Standard deviation; CI: Confidence interval.

complications compared to HSs (OR=2.54; 95% CI: 0.77-8.36; p=0.12) without significant heterogeneity (p=0.67, I^2=0%) (Figure 13) and there was not a significant difference between the two groups regarding major complications (OR=4.54; 95% CI: 0.86-24.01; p=0.08) without significant heterogeneity (p=0.58, I^2=0%) (Figure 14), although a tendency toward a higher rate of major complications was observed in the plate group.

DISCUSSION

The biomechanics of the elbow joint, the role of the radial head in load transfer, and the importance of elbow joint stability have been well established. Currently, resection procedures for Mason Type 3 radial head fractures have been largely replaced by prostheses or internal fixation methods to maintain radial length and ensure elbow joint stability.[5,25] However, there remains significant controversy regarding the optimal choice of internal fixation for radial head fractures.

This systematic review reviewed five studies[1,5,20,26,27] comparing the outcomes of plates versus HSs for Type 3 radial head fractures. Due to the lack of a standardized protocol, outcome measures varied across studies, making it difficult to achieve consistency. Moreover, subgroup analyses were underpowered due to the small sample sizes. The findings, summarized in Table III, revealed that plates significantly

TABLE III
Meta-analysis results

			Overall effect			Heterogeneity	
Outcome	Studies	Groups (P/CS)	Effect estimate	95% CI	*p*	I^2 (%)	*p*
Operation time	2	27/28	4.92	–12.26 - 22.09	0.57	0	0.61
Length of hospital stay	2	27/28	0.66	–1.44 - 2.76	0.54	82	0.02
Time to bone union	2	27/28	26.89	18.84 - 34.93	0.00001	0	0.51
DASH	2	45/42	2.13	–2.43 - 6.69	0.36	0	0.86
MEPS	3	54/57	–5.86	–9.11 - –2.61	0.0004	6	0.34
Range of motion							
Flexion-extension	2	27/28	–12.4	–26.03 - 1.23	0.07	0	0.45
Flexion	2	42/46	0.83	–3.19 - 4.86	0.68	0	0.53
Extension	2	42/46	0.94	–9.43 - 11.3	0.86	85	0.01
Pronation	3	54/57	–8.82	–13.02 - –4.63	0.0001	44	0.17
Supination	3	54/57	–8.79	–12.09 - –5.49	0.00001	0	0.44
Minor complication	3	46/34	2.54	0.77 - 8.36	0.12	0	0.67
Major complication	2	27/23	4.54	0.86 - 24.01	0.08	0	0.58

P: Plate; CS: Controlled trial; CI: Confidence interval; DASH: Disabilities of the Shoulder, Arm, and Hand score; MEPS: Mayo Elbow Performance Score.

increased the time to bone union, without notable heterogeneity. Plate fixation was also associated with lower postoperative MEPS, with no significant heterogeneity observed across studies. However, the difference did not reach the threshold for clinical significance. Additionally, plates reduced postoperative supination and pronation, again without significant heterogeneity. No significant differences were observed between the two methods regarding operation time, length of hospital stay, postoperative flexion-extension, flexion, extension, minor complications, major complications or DASH scores. Nevertheless, the results for major complications and flexion-extension demonstrated borderline statistical significance. This trend suggests that the differences might have reached statistical significance with a larger sample size. Both plates and HSs have achieved good outcomes for Type 3 radial head fractures.[17,28,29] In our analysis, patients treated with either technique showed similar operation times and lengths of hospital stay. However, operation time and length of hospital stay are influenced by multiple factors, including fracture characteristics, surgeon variability, and surgical techniques. Therefore, these results should be interpreted with caution, and further high-quality studies are warranted to validate these findings. Recent studies indicate that plate-screw fixation and HS fixation provide similar strength and stiffness, with comparable failure forces, stresses, and strains.[30-32] However, due to the varying morphologies of the radial head and neck,[2] plates require precontouring and carry the risk of being ineffective.[33,34] This may result in major complications such as, poor reconstruction of the radial head, elbow stiffness, suboptimal reduction, and nonunion, leading to reoperation. Furthermore, proximal radioulnar joint and humeroradial joint are involved in forearm rotation, so reconstruction of the radial head and the function of proximal radioulnar joint play an important role in postoperative pronation and supination.[35] As a result, for full forearm rotation without impingement at the proximal radioulnar joint, plates must be accurately placed in the safe zone of the radial head,[2,36] achieving this requires significant periosteal stripping and tissue dissection, which disrupts the vascular supply to the radial head and hinders bone union,[37] contributing to longer bone union time. Even when plates are accurately placed in the safe zone, they are more likely to impair pronation and supination due to greater soft tissue dissection and their profile thickness,[5] thereby resulting in the development of modern precontoured low-profile locking plates for the radial head.[19,38] In our systematic review, conventional precontoured locking plates were used in two studies,[5,26] while others studies used precontoured low-profile locking plates, which maybe was a bias for systematic review.

Nevertheless, forearm flexion and extension are more related to humeroulnar joint, so the choice of internal fixation of radial head fracture probably does not make much difference on postoperative flexion and extension. As flexion-extension reflects the total arc of motion, the borderline significance observed in flexion-extension results might have been due to a cancellation or interaction effect. Further investigation is required to clarify this finding. In contrast, HSs are less invasive and can be placed within or outside the safe zone for optimal fixation without causing impingement or stiffness, thanks to their well-buried head.[39] Additionally, HSs can be directly applied to the fracture fragments, enhancing compression at the fracture line, stabilizing the fracture, and facilitating faster union.[29]

While MEPS is measured by physicians objectively, DASH is scored by patients themselves. When patients measure the outcomes of the operation, they compare the current measurements with preoperative situation, indicating that subjective factors may influence the scoring.

Furthermore, Mason Type 3 radial head fractures encompass a heterogeneous group of injuries, varying in both the number and size of fracture fragments. These differences can influence the choice of internal fixation as well as clinical outcomes. Although the systematic review results suggest that HSs for Type 3 radial head fractures result in shorter bone union times, improved postoperative pronation and supination, and fewer major complications, plate fixation may be preferable in cases of severely comminuted radial head fractures or when the largest fragment is not a suitable size for the screw diameter.

The type and size of plates used in radial head fracture fixation significantly influence clinical outcomes. T-shaped plates provide strong fixation but may cause soft tissue irritation and limited forearm rotation. Minimal-profile plates reduce impingement, but may compromise stability, as seen in studies where screw fixation yielded better functional results. Thick plates, while offering superior stability, are associated with higher rates of heterotopic ossification and revision surgeries. Studies have used different plate types, which findings suggest that plate selection should balance stability with soft tissue preservation to optimize functional outcomes.

Nonetheless, the findings of this study should be interpreted in light of its strengths and limitations. The primary limitation stems from the quantity and quality of the included studies. This study compared plates and HS fixation for Mason Type 3 radial head fractures based on clinical outcomes. However, due to limited data, the included studies featured diverse populations, regions, samples, fracture characteristics and clinical outcome measures, leading to high heterogeneity. Further high-quality research is needed to confirm and expand upon these findings. Variations in follow-up durations across studies may have influenced the comparability of long-term outcomes. The lack of standardized reporting on complications and functional recovery limits the ability to draw definitive conclusions. The main strengths of this study are: *(i)* This study provides a comprehensive comparison of plate fixation and headless screw fixation for type 3 radial head fractures, synthesizing available evidence to guide clinical decision-making. *(ii)*, the inclusion of multiple clinical outcome measures enhances the robustness of the analysis.

In conclusion, this systematic review indicates that HS fixation is associated with a faster time to bone union and better functional outcomes, particularly in terms of pronation and supination, compared to plate fixation. However, the differences observed in the MEPS and DASH score were statistically significant, although they did not exceed the MCID. Therefore, while HSs offer advantages in some clinical outcomes, the clinical significance of these improvements still remains marginal. Further studies with larger sample sizes are necessary to confirm these findings and identify the most appropriate fixation technique based on fracture characteristics and patient-specific factors.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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