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REVIEW

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Is surgery superior for distal ulna fractures? a comprehensive systematic review and meta-analysis

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Abstract

Background The management of distal ulna fractures remains a subject of considerable debate within orthopedic practice. This systematic review and meta-analysis aims to evaluate the efficacy of surgical versus non-surgical management strategies for distal ulna fractures and their impact on functional outcomes.

Methods This study followed PRISMA guidelines and involved a systematic search of databases like PubMed, Scopus, and Web of Science for relevant studies published in English up to December 2023. The search included keywords such as "ulnar styloid fracture", "non-surgical management", "surgical management", and "treatment outcomes". Studies were selected based on predefined inclusion and exclusion criteria, and data were extracted on patient demographics, fracture characteristics, treatment details, functional outcomes, patient-reported outcomes, complications, and follow-up duration. The methodological quality of included studies was assessed using the GRADE system. The meta-analysis used standardized mean differences for continuous outcomes and log odds ratios for dichotomous outcomes.

Results The initial search yielded 1253 studies, which were narrowed down to 12 studies suitable for review after removing duplicates and irrelevant articles. These studies included a total of 709 patients, with 422 receiving non-surgical management and 287 undergoing surgical treatment. The results showed no significant differences in grip strength, DASH score, or VAS score between surgical and non-surgical management. However, a higher union rate was observed with surgical management.

Limitations The moderate quality of the included studies and the moderate to high heterogeneity among them are noted as limitations, indicating a need for more standardized research methodologies in this area.

Conclusions While surgical management may offer a higher union rate, the choice of treatment should be individualized, balancing the potential benefits against the risks of surgery, as ORIF implants are typically associated with higher ulnar-sided pain rates and limited ulnar deviation due to implant prominence. Future research should focus on standardizing study designs to improve the quality of evidence in the management of distal ulna fractures.

Level of evidence I Evidence from a meta-analysis and systematic review from all relevant studies.

Keywords Ulnar fractures, Distal radioulnar joint instability, Distal radius fracture, Outcome, Non-surgical management, Surgical management

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Introduction

A distal ulna fracture is characterized by a break along the ulna's distal end, near the wrist [1]. These fractures are relatively uncommon in isolation and frequently occur alongside distal radius fractures (DRFs) [2]. Classifications such as the Q modifier, AO, and Gaulke provide frameworks for categorizing these fractures based on specific anatomical and severity criteria [1]. Over half of ulnar styloid fractures (USFs) may present concurrently with DRFs [1–3].

Conservative treatment of DUFs typically involves immobilization and may yield favorable outcomes for non-displaced fractures [4]. However, surgical approaches, including open reduction and internal fixation, are often indicated for displaced fractures to restore anatomy and function. Surgical management of DUFs can provide anatomical realignment and immediate stability, which are crucial for the healing process. Nevertheless, surgical interventions carry inherent risks such as infection, hardware complications, and the potential for reoperation [4, 5].

Nonunion rates for USFs associated with DRFs can be variable, with some studies reporting rates as high as 76%. Surgical fixation of DRFs with volar locking plates has been associated with union rates ranging from 27 to 63% [6].

The management of distal ulna fractures (DUFs) remains a subject of considerable debate within orthopedic practice. This systematic review and meta-analysis aim to elucidate the efficacy and outcomes of surgical versus non-surgical interventions for DUFs, with a focus on the functional outcome, union rate, and quality of life implications for patients.

Several studies and meta-analyses have tackled many aspects of distal ulna fractures, but none studied the benefits and risks of surgical management versus non-surgical management. Wijffels studied the impact of ulnar process fracture nonunion and found that it did not impact functional outcomes of patients regardless of the treatment strategy [6]. Mulders, in his study, found a significant mean difference between DRF with versus without DUF regardless of the treatment strategy, despite being not clinically important [7].

This study aims to compare the outcomes of surgical and non-surgical treatments for DUFs through a systematic review of the literature and meta-analysis of collected data. The methodology will involve a comprehensive search of electronic databases for relevant studies, followed by data extraction, quality assessment, and statistical analysis to synthesize the evidence.

Methods and materials

Study design

This meta-analysis and systematic review was conducted following the PRISMA guidelines (Page et al., 2020) [8]. We systematically searched, identified, and analyzed all available studies comparing non-surgical and surgical management of ulnar styloid fractures.

Data sources and search strategy

A comprehensive search was performed using databases such as PubMed, Scopus, Web of Science, Medline, Embase, and Cochrane. Keywords used included "ulnar styloid fracture", "non-surgical management", "surgical management", and "treatment outcomes". The search was limited to studies published in English from inception to December 2023. In an effort to mitigate publication bias, the research extended beyond peer-reviewed journals to encompass gray literature, which includes unpublished studies often overlooked by electronic bibliographic databases. This comprehensive search aimed to include any pertinent studies and involved querying databases such as Open Gray and the National Technical Information Service. Despite these efforts, no additional articles pertinent to the topic of the review were uncovered. The search string for each academic database is highlighted in Supplementary Table 1.

Study selection

Included studies were randomized controlled trials (RCTs), cohort studies, and case–control studies that reported on the treatment of ulnar styloid fractures with non-surgical or surgical methods. Studies were excluded if they did not provide clear outcome measures or if they were reviews, letters, or expert opinions. Study inclusion and exclusion criteria according to the PICO framework [9] are highlighted in Table 1.

Data extraction

Two independent reviewers extracted data on patient demographics, fracture characteristics, treatment details, functional outcomes, patient-reported outcomes, complications, and follow-up duration. Any discrepancies were resolved through discussion or by consulting a third reviewer. Data collection parameters are highlighted in Supplementary Table 2.

The selection process was executed in two distinct phases. Initially, the titles and abstracts from the gathered citations were screened by two independent reviewers. Following this preliminary review, the second phase involved a detailed assessment of the full texts of the studies identified as relevant by either

Table 1 Inclusion and exclusion criteria

PICOs	Inclusion criteria	Exclusion criteria
Population	Adults ≥ 18 years Male and female Injury: unstable DRF associated with USF Treatment: DRF treated with ORIF, external fixation, percutaneous pinning or MUA, and plaster	Skeletally immature Undisplaced DRF does not require an intervention Acute dislocation/subluxation of DRUJ
Intervention	Surgical fixation of USF	
Comparison	No surgical treatment for USF	
Outcomes	Functional and satisfaction outcomes include DASH, VAS, and ulnar-sided wrist pain Range of motion of wrist and forearm Postoperative complication Radiological assessment	
Study types	RCTs, CCSs, quasi-randomized trials, and comparative observational studies	Case reports, case series, and any study that does not include a comparison between surgical fixation and no surgical treatment for USF
Language	English publications	Non-English language literature
Subjects	Human subjects	Cadaveric and animal studies

reviewer, ensuring they met the inclusion criteria. Discrepancies between the assessors were resolved through discussion and consensus. If a consensus could not be reached, a third opinion from a resident orthopaedic surgeon was sought. A comprehensive list of studies excluded at this stage was compiled, complete with justifications for their exclusion.

Quality assessment

The grading of recommendations assessment, development and evaluation (GRADE) tool [10], a widely recognized framework, was employed to evaluate the study design's alignment with the research objectives, potential biases, selection of outcome measures, statistical considerations, reporting quality, and the generalizability of the findings. This comprehensive assessment was facilitated by a pre-tested form, ensuring a standardized approach, and was independently conducted by two reviewers to enhance the reliability and objectivity of the evaluation process.

Meta analysis

The study utilized the standardized mean difference to evaluate outcomes such as Grip strength, VAS scale, and DASH score, and the log odds ratio to assess union rate in non-surgical versus surgical groups. Due to the limited number of studies included, 90% confidence and prediction intervals were applied. Data fitting was performed using a random-effects model. Heterogeneity was quantified by tau^2, calculated with the restricted maximum-likelihood estimator, as suggested by Viechtbauer in 2005 [11]. The *Q*-test for heterogeneity and the I^2 statistic were also reported. Should any heterogeneity be present ($tau^2 > 0$), a prediction interval is provided, regardless of the *Q*-test results [12]. To identify potential outliers or influential studies, studentized residuals and Cook's distances were employed. Specifically, studies exceeding the $100 \times (1–0.1/(2 \times k))$th percentile of a standard normal distribution, adjusted by a Bonferroni correction for k studies, were flagged as outliers. Similarly, studies with a Cook's distance surpassing the median plus six times the interquartile range were deemed influential [13]. Lastly, funnel plot asymmetry was assessed using the rank correlation test and the regression test, with the standard error of observed outcomes as the predictor [8].

Extracted data were tabulated and synthesized to facilitate comparison across studies. Continuous variables were summarized using means and standard deviations, while categorical variables were reported as frequencies and percentages. Where possible, data were pooled for meta-analysis using a random-effects model to account for between-study heterogeneity.

Ethical considerations.

This study did not involve direct interaction with patients and relied on data from previously published studies; therefore, ethical approval was not required.

Results

Literature search

The initial search identified 1253 studies that were potentially relevant. Upon further review, 532 were excluded as duplicates. An additional 452 articles were removed after screening titles for various reasons: 21 due to non-English language, 32 classified as case reports, 15 lacking abstracts, 5 identified as book chapters, 5 as commentaries, 3 were inaccessible in full text, and 149 were unrelated to the topic. After applying the inclusion criteria, 16 more studies were excluded for not meeting the inclusion criteria, resulting in 12 studies deemed suitable for review. These 12 studies encompassed a total of 709 patients, with 422 receiving non-surgical management and 287 undergoing surgical treatment. Figure 1 shows a detailed PRISMA flowchart of the literature search process.

Description of included studies

The detailed description, reported outcomes, and methodological quality, based on GRADE guidelines, of the included studies in the meta-analysis are summarised in Tables 2, 3, and 4.

Study limitations

Study inclusion and excluson criteria and acknowledged limitations are highlighted in Table 5, The systematic review shows a range of studies with varied inclusion and exclusion criteria and differing levels of

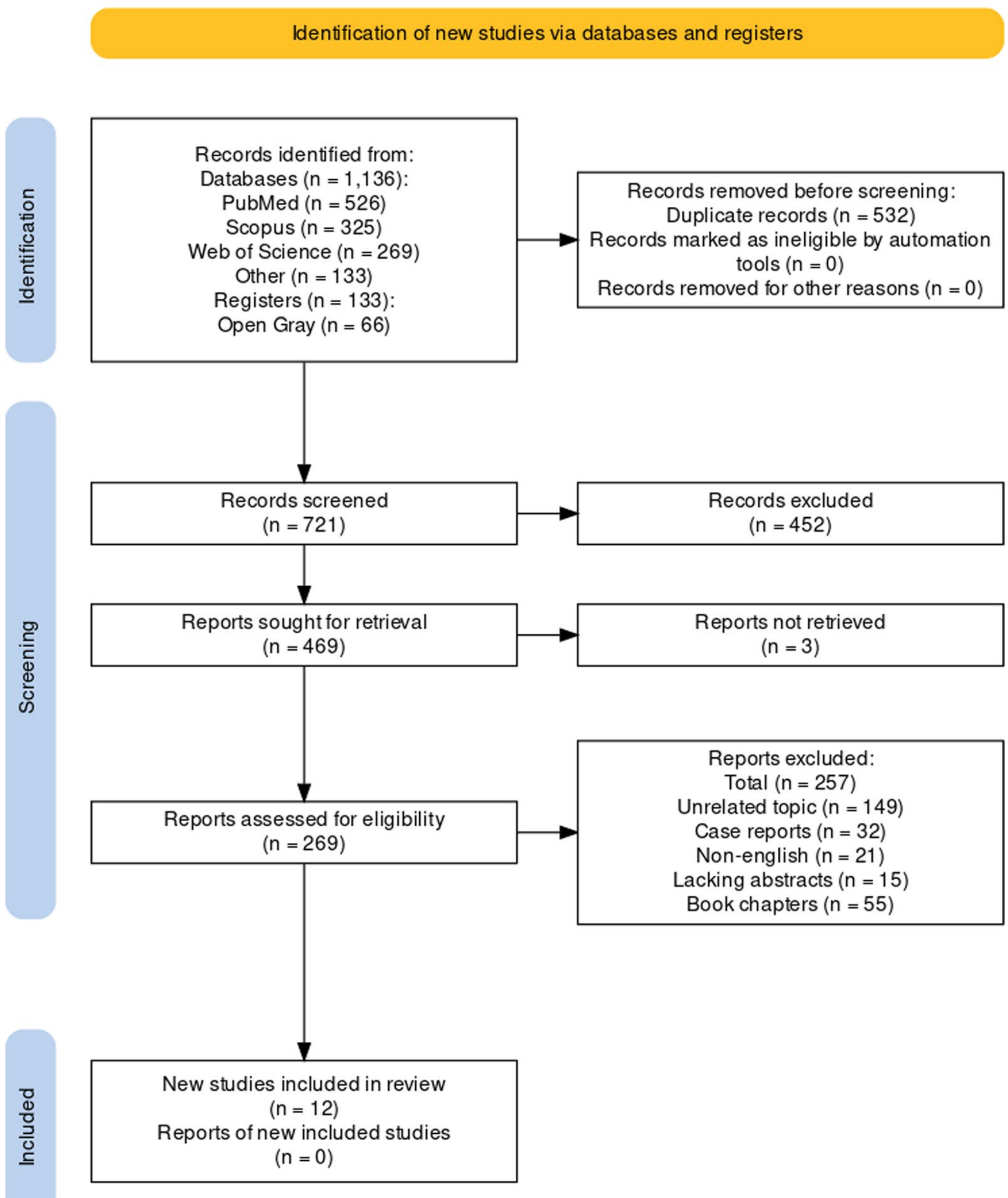

Fig. 1 Flowchart of the search strategy and study selection

Table 2 Study characteristics for the included studies

Study ID	Study type	Randomization
Iglesias 2016 [14]	Retrospective multicenter comparative cohort	Non randomized
Knapp 2021 [15]	Prospective clinical trial	Non randomized
Sawada 2016 [16]	Prospective multicenter matched case control cohort	Non randomized
Chen 2020 [17]	Retrospective clinical trial	Non randomized
Ayalon 2016 [18]	Retrospective comparative cohort	Non randomized
Okoli 2021 [19]	Prospective comparative cohort	Non randomized
Souer 2009 [20]	Retrospective matched cohort from a perspective multicenter cohort	Non randomized
Lee 2019 [21]	Retrospective case control	Non randomized
Wong 2023 [22]	Prospective review of a retrospective cohort	Non randomized
Moradi 2021 [23]	Prospective comparative two-arm randomized clinical trial	Randomized (PASS)
Zenke 2012 [24]	Comparative cohort	Non randomized
Kurozumi 2021 [25]	Retrospective comparative cohort	Non randomized

Table 3 GRADE analysis for the included studies

Study ID	Risk bias	Imprecision	Inconsistency	Indirectness	Overall quality	Publication bias
Iglesias 2016	Low	No	No	No	High	Low
Knapp 2021	Serious	No	No	No	Low[a,b]	Moderate[c]
Sawada 2016	Low	Low[d]	No	No	High	Moderate[e]
Chen 2020	Moderate	No	No	No	Moderate[a,b]	Low
Ayalon 2016	Serious	No	No	No	Low[b,f,i]	Serious[i]
Okoli 2021	Moderate	No	No	No	Moderate[a,b]	Low
Souer 2009	Moderate	No	No	No	Moderate[a,g]	High[g,i]
Lee 2019	Moderate	No	No	No	Moderate[a]	Low
Wong 2023	Low	No	No	No	Moderate[a]	Moderate[i]
Moradi 2021	Low	No	No	No	High	Low
Zenke 2012	Moderate	No	No	No	Moderate[a]	Unclear[j,k]
Kurozumi 2021	Low	No	No	No	High	Low

a Not comparative

b No selection criteria reported

c No comparative or functional data reported

d No standard deviations reported

e Matched control selection criteria

f No demographics or fracture data reported

g High publication bias

h Matched control selection criteria

i Based on data from a previous prospective study

j Chronology of the study was not reported

k Conflicts of interests disclosure was inaccessible

transparency about their limitations. For instance, Iglesias study [14] focused on adults with specific types of wrist fractures and excluded minors and non-standard treatments, but did not mention any study limitations. In contrast, Knapp study [15] lacked detail on both criteria and limitations.

Statistically, 70% of the studies specified their criteria, and 80% recognized their research limitations. The average age range for study participants was approximately 25.6–77 years.

Methodologically, there's a notable disparity in the clarity and thoroughness of the studies. Some, like Iglesias [14], were meticulous in detailing their criteria, while others, like Knapp [15] and Ayalon [18], provided none. This inconsistency may impact the studies' comparability and trustworthiness. Recognized limitations, such

Table 4 Quality and bias analysis of the included studies

Study ID	Selection bias	Performance bias	Measurement bias	Attrition bias	Reporting bias	Confounding bias
Iglesias 2016	Low	Moderate[a,b]	Low	Unclear[c]	Low	High[d]
Knapp 2021	Serious[e]	Unclear[f]	Serious[g]	High[h]	Low	Unclear[c]
Sawada 2016	Moderate[j]	Low[b]	Low	Unclear[c]	Low	Moderate[i]
Chen 2020	Serious[e]	Unclear[f]	Moderate[k]	Unclear[c]	Low	Unclear[c]
Ayalon 2016	Serious[e]	Moderate[a,b]	Serious[l]	Unclear[c]	High[m]	High[n]
Okoli 2021	Moderate[o]	Unclear[f]	Low	Unclear[c]	Low	High[p]
Souer 2009	Moderate[j]	Unclear[f]	Moderate[k]	Unclear[c]	Moderate[q]	Moderate[i]
Lee 2019	Low	Unclear[f]	Low	High[r]	Low	Moderate[i]
Wong 2023	Low	Unclear[f]	Moderate[k]	Unclear[c]	Moderate[q]	Low
Moradi 2021	Low	Low[b]	Low	Unclear[c]	Low	Moderate[i]
Zenke 2012	Low	Unclear[f]	Moderate[k]	Unclear[c]	Unclear[c]	Moderate[i]
Kurozumi 2021	Moderate[s,t]	Low[b]	Moderate[k]	Moderate[u]	Low	Moderate[i]

a Retrospective

b Unblinded

c Not reported

d Non-anatomical reduction was excluded

e No selection criteria reported

f One intervention to all patients

g No functional outcome reported

h Four patients did not complete the follow-up for unclear resons

i DRUJ and TFCC injuries impact not reported

j Matched control selection criteria

k Grip strength measurement tool not reported

l No demographics or fracture data were reported

m Serious conflicting interests disclosed

n No demographics or fracture data reported

o Several subgroups

p No fracture data reported

q Data from previous study

r Hundered patients were excluded for various reasons

s Ulnar styloid fractures were excluded

t No age range reported

u Four patients were excluded for insufficient follow-up

as small sample sizes, retrospective analysis, and joint instability, highlight the challenges in this research area and the need for standardized methods to enhance study quality.

Demographic characteristics

Iglesias study [14] has an average age of 49.5 with missing data, Knapp study [15] has a median age of 51 with a female majority, and Sawada study [16] has an average age of 66.5 with balanced demographics. Chen study [17] reports a younger average age of 32.4 with more males, while Ayalon study [18] lacks demographic details. Okoli study [19] shows an average age of 64 with a male majority. Moradi [23] provides a complete set with an average age of 52.2 and balanced demographics. Zenke [24] and Kurozumi [25] offer additional age data, highlighting the diversity in reporting. Demographic characteristics are highlighted in Table 6.

Fracture characteristics

Iglesias study [14] categorizes 57 fractures into three sizes, with a predominance of complex type C fractures. Knapp study [15] has 21 fractures, mostly severe type C. Sawada [16] study includes 64 fractures, again with a majority of type C. Chen [17] study, with 9 surgical cases, shows a balanced distribution across fracture types. Ayalon [18] and Okoli [19] studies lack specific fracture data, while Souer [20], Lee [21], and Wong [22] provide partial data. Moradi [23] study does not report fracture characteristics. Zenke [24] and Kurozumi [25] contribute additional data, with Zenke showing a significant number of type C fractures and Kurozumi presenting an older

Table 5 Inclusion, exclusion and acknowledged study limitations for the included studies

Study ID	Inclusion criteria	Exclusion criteria	Acknowledged limitations
Iglesias 2016	Age: 18 years + Injuries: DRF with ORIF using volar plates	Age: under 18 years Non-anatomical reduction	Not reported
Knapp 2021	Not reported	Not reported	Not reported
Sawada 2016	Age: 30 years + Injuries: DRF, treatment not specified	Open fractures Bilateral fractures Tip fractures	DRUJ instability Multiple surgeons No standard protocol for DUF management or immobilization
Chen 2020	Not reported	Not reported	Small cohort number Fracture characteristics heterogeneity Retrospective nature
Ayalon 2016	Not reported	Not reported	DRUJ instability Retrospective nature Fragment size
Okoli 2021	Age: 18–89 years Injuries: DRF with ORIF using volar plates	Follow-up: less than one year Previous wrist injury Other ORIF than volar plate Concomitant ulnar head or shaft fracture	Several subgroups Selection bias
Souer 2009	Age: 18 years + Injuries: DRF with ORIF using plates and screws	Unaffected bone biology Multiple traumatic injuries Previous ORIF Drug or alcohol abuse Conenrollement in another study	DRUJ instability DRF displacement Fragment size
Lee 2019	Age: 18–65 years Completed follow-up	Non-anatomical reduction Surgical management Occult fracture Refracture Other combined multiple fractures Lost to follow-up	Small sample size Short term follow-up
Wong 2023	Age: 18 years + Injuries: DRF with ORIF, treatment not specified	Open fracture Surgical management Poly-trauma	Single institution TFCC injury Retrospective nature
Moradi 2021	Age: 18 years + Injuries: DRF Fernandez Type I Stable DRUJ	Open fracture Previous hand or wrist injury or deformity	Attrition bias: lost follow-up Not opting for more stable ORIF for DUF Limited follow-up Only Fernandez Type I fractures
Zenke 2012	Age: 25 years + Injuries: DRF treated surgically, treatment not specified	Non union DUF Previous DUF injuries Surgical management after two weeks Poly-trauma Multiple ipsilateral upper limb injuries	No control group No informations about soft-tissue injuries
Kurozumi 2021	Injuries: DRF treated surgically, treatment not specified	Follow-up: less than one year Ulnar styloid fractures Undisplaced DUF Ipsilateral or controlateral upper limb injuries	Elderly sample No standard protocol for DUF management or immobilization Retrospective nature Soft tissue defect and periosteal stripping

cohort with a focus on severe fractures. Fracture characteristics are highlighted in Table 7 and Fig. 2.

Management type

Iglesias study [14] had 51% of cases managed non-surgically, mainly with casting, while the rest involved surgical techniques like K-pinning and band wiring. Knapp study [15] exclusively used surgical methods, specifically plating and headless screw fixation. Sawada study [16] had a 75% non-surgical management rate, with the surgical cases involving K-pinning, band wiring, and headless screws. Chen's study was all surgical, with anchors and band wiring. Ayalon large study [18] had 30% non-surgical management through casting, but surgical techniques were not detailed. Okoli [19], Souer [20], Lee [21], and Wong [22] reported only non-surgical management with casting. Moradi study [23] was nearly evenly split between non-surgical and surgical management, using casting and band wiring. Zenke study [24] was also evenly split, while Kurozumi [25] had a higher rate of surgical management with plating. This reflects the diverse approaches to fracture management, with a mix

Table 6 Patient characteristics in the included studies

Study ID	Sample size	Age			Sex-ratio (M/F)		Hand dominance	
		All	NS	S	NS	S	NS	S
Iglesias 2016	57	49.5 ± 1.82	49.38 ± 2.61	50.71 ± 2.55	NR	NR	3L 2R	7R 1L
Knapp 2021	21	51	n/a	NR	n/a	1.21	n/a	1R 3L
Sawada 2016	64	66.5	61.1	58.9	0.45	0.77	32L 16R	6R 10L
Chen 2020	31	32.4 ± 12.7	n/a	32.4 ± 12.7	NR	1.81	n/a	19R 12L
Ayalon 2016	169	NR	NR	NR	NR	NR	NR	NR
Okoli 2021	64	64	64	n/a	0.28	NR	1L 8R	n/a
Souer 2009	67	NR	NR	n/a	0.6	NR	1L 1R	n/a
Lee 2019	69	49.8 ± 11.0	49.8 ± 11.0	n/a	0.38	NR	NR	n/a
Wong 2023	21	48.1 ± 16.5	48.1 ± 16.5	n/a	1.33	NR	NR	n/a
Moradi 2021	75	52.2 ± 15.4	52.9 ± 16.2	51.5 ± 14.8	0.89	2.0	23L 13R	24L 15R
Zenke 2012	48	63.9 ± 16.9	64.1 ± 18.2	63.7 ± 15.5	0.16	0.11	13L 15R	10L 10R
Kurozumi 2021	23	71.6 ± 11	71.7 ± 15.3	71.6 ± 7.6	NR	NR	NR	NR
All	709	52.16 ± 11.8	54.45 ± 12.61	53.26 ± 10.97	0.58	1.18	–	–
Pooled	84				0.53	1.20		

Table 7 Fracture characteristics in the included studies

Study ID	Fragment size			AO classification			DRF	
	All	NS	S	All	NS	S	n	%
Iglesias 2016	B28 H19 T10	NR	NR	A17 B6 C34	A10 B1 C18	A7 B5 C16	57	100%
Knapp 2021	B7 H11 T3	n/a	NR	A5 B0 C16	n/a	A5 B0 C16	21	100%
Sawada 2016	B42 H13 T9	B31 H10 T7	B11 H3 T2	A23 B3 C38	A18 B1 C29	A5 B2 C9	64	100%
Chen 2020	B18 H7 T6	n/a	B18 H7 T6	A6 B18 C7	n/a	A6 B18 C7	9	29%
Ayalon 2016	NR	NR	NR	NR	NR	NR	169	100%
Okoli 2021	NR	NR	n/a	NR	NR	n/a	64	100%
Souer 2009	B50 H8 T9	B50 H8 T9	n/a	A26 B4 C37	A26 B4 C37	n/a	67	100%
Lee 2019	B29 H6 T34	B29 H6 T34	n/a	A38 B19 C12	A38 B19 C12	n/a	69	100%
Wong 2023	NR	NR	n/a	NR	NR	n/a	21	100%
Moradi 2021	NR	NR	NR	NR	NR	NR	75	100%
Zenke 2012	NR	NR	NR	A23 B3 C22	A13 B2 C13	A10 B1 C9	48	100%
Kurozumi 2021	B10 H11 T2	B4 H5 T0	B6 H6 T2	A12 B0 C11	A4 B0 C5	A8 B0 C6	23	100%
Total	B149 H45 T60	B114 H29 T50	B35 H16 T10	A150 B53 C177	A109 B27 C114	A41 B26 C63	616	86%

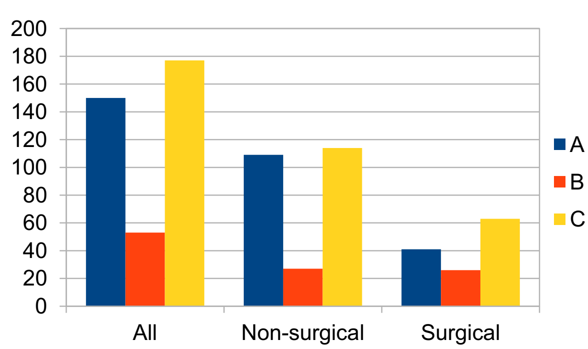

Fig. 2 Fracture characteristics according to AO classification

of non-surgical and surgical methods employed across the studies. Management type is highlighted in Table 8 and Fig. 3.

Functional outcomes

Iglesias study [14] shows non-surgical patients had higher grip strength and ulnar deviation but slightly more pain than surgical patients. Knapp study [15] lacks functional outcome data. Sawada study [16] indicates lower pain in non-surgical patients. Chen study [17], which only includes surgical data, shows good grip strength and low pain. Ayalon study [18] suggests similar pain

Table 8 Management type and strategy in the included studies

Study ID	Sample size	Management type				Management strategy	
		Non-surgical		Surgical		Non-surgical	Surgical
		N	%	N	%		
Iglesias 2016	57	29	51%	28	49%	Casting: 29	K-pinning: 28 Band wire: 26
Knapp 2021	21	n/a	n/a	21	100%	n/a	Plating: 21 Headless screw: 21
Sawada 2016	64	48	75%	16	25%	NR	K-pinning: 8 Band wire: 7 Headless screw: 1
Chen 2020	31	n/a	n/a	31	100%	n/a	Anchor: 10 Band wire: 21
Ayalon 2016	169	51	31%	118	69%	Casting: 51	NR
Okoli 2021	64	64	100%	n/a	n/a	Casting: 64	n/a
Souer 2009	67	67	100%	n/a	n/a	Casting: 67	n/a
Lee 2019	69	69	100%	n/a	n/a	Casting: 69	n/a
Wong 2023	21	21	100%	n/a	n/a	Casting: 21	n/a
Moradi 2021	75	36	48%	39	52%	Casting: 36	Band wire: 39
Zenke 2012	48	28	58%	20	42%	Casting: 28	Band wire: 28
Kurozumi 2021	23	9	39%	14	61%	Casting: 9	Plating: 14
Total	709	422	61%	287	39%	Casting: 374	K-pinning: 31 Band wire: 121 Plating: 35 Headless screw: 22 Anchor: 10
Pooled	84	47.77	64%	57.73	59%		

and disability scores between non-surgical and surgical patients. Okoli [19], Souer [20], Lee [21], and Wong [22] provide incomplete data. Moradi study [23] shows a wide grip strength range and higher pain and disability scores in surgical patients. Zenke study [24] presents similar grip strengths but lower disability scores for non-surgical patients. Kurozumi study [25] indicates lower grip strength and higher disability scores for surgical patients. The results vary, with some studies suggesting surgical management may lead to better outcomes, while others show non-surgical management as equally effective or better. Functional outcomes are highlighted in Table 9.

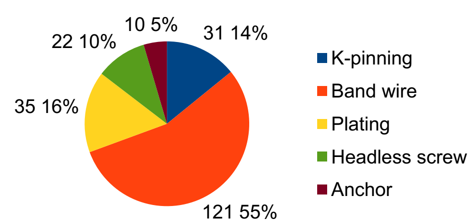

Fig. 3 Surgical management type by frequency

Secondary outcomes

Iglesias study [14] reported a 48% union rate for non-surgical and 67% for surgical cases, with follow-ups of 63.14 ± 1.95 and 48.43 ± 3.74 months, respectively. Knapp study [15] showed a 100% union rate for surgical cases with a 15-month follow-up. Sawada study [16] had a 39% union rate for non-surgical cases and 93% for surgical cases, with follow-ups of 24.0 and 29.6 months. Chen study [17] only reported on surgical cases, with a 93% union rate and a 25-month follow-up. Ayalon study [18] did not report union rates, with a 12-month follow-up for non-surgical cases. Okoli study [19] had a 26% union rate for non-surgical cases with a 12-month follow-up. Zenke study [24] reported a 35% union rate for non-surgical cases and 85% for surgical cases, with follow-ups of 12.5 ± 7.3 and 11.8 ± 9.9 months. Kurozumi study [25] showed a 100% union rate for both groups, with follow-ups of 21.2 ± 7.5 and 33.2 ± 14.7 months. The studies generally indicate higher union rates for surgical management; however, there's a lack of data on DRUJ instability and subsequent surgeries. Follow-up durations are inconsistent but typically at least 12 months, providing a timeline for long-term outcome assessment. Secondary outcomes are summarized in Table 10.

Table 9 Functional outcomes in the included studies

Study ID	Grip strength (kg)		Ulnar deviation (deg)		VAS scale (out of 10)		DASH score (out of 100)	
	NS	S	NS	S	NS	S	NS	S
Iglesias 2016	33.83 ± 2.2	29.3 ± 2.2	49.31 ± 1.84	46.07 ± 1.52	2.8 ± 0.73	2.5 ± 1.25	23.1 ± 5.1	3.54 ± 25.3
Knapp 2021	n/a	NR	n/a	NR	n/a	NR	n/a	NR
Sawada 2016	26.02	27.28	NR	NR	1.3	NR	NR	NR
Chen 2020	n/a	33.0 ± 7.2	n/a	NR	n/a	1.0 ± 0.15	n/a	8.2 ± 9.7
Ayalon 2016	20.58	NR	NR	NR	1.95 ± 2.09	1.29 ± 2.48	17.85 ± 23.13	16.69 ± 17.7
Okoli 2021	NR	n/a	NR	n/a	NR	n/a	8.4 ± 1.9	n/a
Souer 2009	29.0 ± 14.7	n/a	33 ± 12.2	n/a	0.5 ± 1.2	n/a	12.7 ± 16.7	n/a
Lee 2019	NR	n/a	NR	n/a	1.1 ± 1.8	n/a	9.2 ± 12.7	n/a
Wong 2023	NR	n/a	NR	n/a	NR	n/a	5.9	n/a
Moradi 2021	11.3 ± 12.2	42.5 ± 20.6	16.9 ± 6.13	17.8 ± 5.48	2.50 ± 0.81	4.0 ± 1.73	6.02 ± 2.0	7.92 ± 13.5
Zenke 2012	32.9 ± 4.48	32.37 ± 4.9	NR	NR	NR	NR	2.2 ± 25.4	4.2 ± 6.3
Kurozumi 2021	28 ± 7	24.5 ± 3.5	NR	NR	NR	NR	6.8 ± 8.2	11.5 ± 19.0
Pooled	24.03 ± 8.89	32.7 ± 9.44	31.6 ± 6.94	30.01 ± 3.77	1.74 ± 1.51	2.08 ± 1.88	12.36 ± 13.77	10.76 ± 16.09
SE	0.54	0.62	0.49	0.33	0.07	0.10	0.58	0.80

Table 10 Union rate, DRUJ instability, subsequent surgeries and follow-up in the included studies

Study ID	Union rate				DRUJ instability	Subsequent surgeries	Follow-up (months)	
	NS		S				NS	S
	N	%	N	%				
Iglesias 2016	14	48%	19	67%	NR	NR	63.14 ± 1.95	48.43 ± 3.74
Knapp 2021	0	n/a	21	100%	NR	2	n/a	15
Sawada 2016	19	39%	15	93%	NR	NR	24.0	29.6
Chen 2020	0	n/a	29	93%	NR	3	n/a	25
Ayalon 2016	NR	NR	NR	n/a	NR	NR	12	n/a
Okoli 2021	17	26%	0	n/a	NR	NR	12	n/a
Souer 2009	NR	NR	NR	n/a	NR	NR	NR	n/a
Lee 2019	39	56%	0	n/a	NR	NR	48.1 ± 20.4	n/a
Wong 2023	NR	NR	NR	NR	2	NR	21	NR
Moradi 2021	NR	NR	NR	NR	NR	NR	12	NR
Zenke 2012	10	35%	17	85%	NR	6	12.5 ± 7.3	11.8 ± 9.9
Kurozumi 2021	9	100%	11	78%	NR	NR	21.2 ± 7.5	33.2 ± 14.7
Total	108	50%	112	86%	2	11	23.18 ± 10.36	31.96 ± 8.02
pooled	17.19	45%	11.81	85%	2	4.23		

Table 11 Random-effect for primary outcomes

Outcome	Estimate	se	Z	p	CI lower bound	CI upper bound
Grip strength SMD (k = 4)	0.239	0.802	0.298	0.766	−1.081	1.559
DASH score SMD (k = 5)	0.123	0.239	0.515	0.607	−0.270	0.516
VAS score SMD (k = 3)	-0.167	0.453	− 0.367	0.713	−0.912	0.579
Union rate LOR (k = 4)	1.39	0.186	− 5.5231	0.00001	0.0985	2.68

Primary outcomes analysis

Summary tables for random-effect, heterogeneity statistical analysis, and publication bias analysis for the grip strength, DASH score, VAS scale using standardized mean differences and for the union rate using log odds ratio are shown in Tables 11, 12, and 13 respectively.

Grip strength analysis

A total of $k=4$ studies were included in the analysis. The observed standardized mean differences ranged from − 1.8062 to 2.0309, with the majority of estimates being positive (75%). The estimated average standardized mean difference based on the random-effects model was $\mu=0.2388$ (90% CI: − 1.0809 to 1.5585). Therefore, the average outcome did not differ significantly from zero ($z=0.2976$, $p=0.7660$). According to the Q-test, the true outcomes appear to be heterogeneous (Q(3) = 84.5759, $p<0.0001$, $tau^2=2.4610$, $I^2=95.9309\%$). A 90% prediction interval for the true outcomes is given by − 2.6594 to 3.1371. Hence, although the average outcome is estimated to be positive, in some studies the true outcome may in fact be negative. An examination of the studentized residuals revealed that one study (Moradi 2021 [23]) had a value larger than ± 2.2414 and may be a potential outlier in the context of this model. According to Cook's distances, none of the studies could be considered to be overly influential. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry ($p=0.3333$ and $p=0.4734$, respectively) in Figs. 4 and 5.

DASH score analysis

A total of $k=5$ studies were included in the analysis. The observed standardized mean differences ranged from -0.2870 to 1.0661, with the majority of estimates being

Table 12 Heterogeneity statistics for primary outcomes

Outcome	Tau	Tau^2	I^2	H^2	R^2	df	Q	*p*
Grip strength SMD ($k=4$)	1.569	2.461 (SE = 2.1025)	95.93%	24.575		3.000	84.576	< .001
DASH score SMD ($k=5$)	0.456	0.2078 (SE = 0.2014)	75.92%	4.153		4.000	14.548	0.006
VAS score SMD ($k=3$)	0.750	0.5632 (SE = 0.6163)	91.79%	12.177		2.000	22.892	< .001
Union rate LOR ($k=4$)	1.25	1.56 (SE = 5.6224)	67.73%	3.10		3.000	53.226	< .001

Table 13 Publication bias outcomes

Outcome	Fail safe N	BM rank correlation	Egger regression	Trim and fill
Grip strength ($k=4$)	0.000 ($p=0.223$)	0.667 ($p=0.333$)	0.717 ($p=0.473$)	0.000
DASH score ($k=5$)	0.000 ($p=0.153$)	− 0.200 ($p=0.817$)	− 0.205 ($p=0.838$)	1.000
VAS score ($k=3$)	0.000 ($p=0.171$)	− 0.333 ($p=1.000$)	− 0.356 ($p=0.722$)	0.000

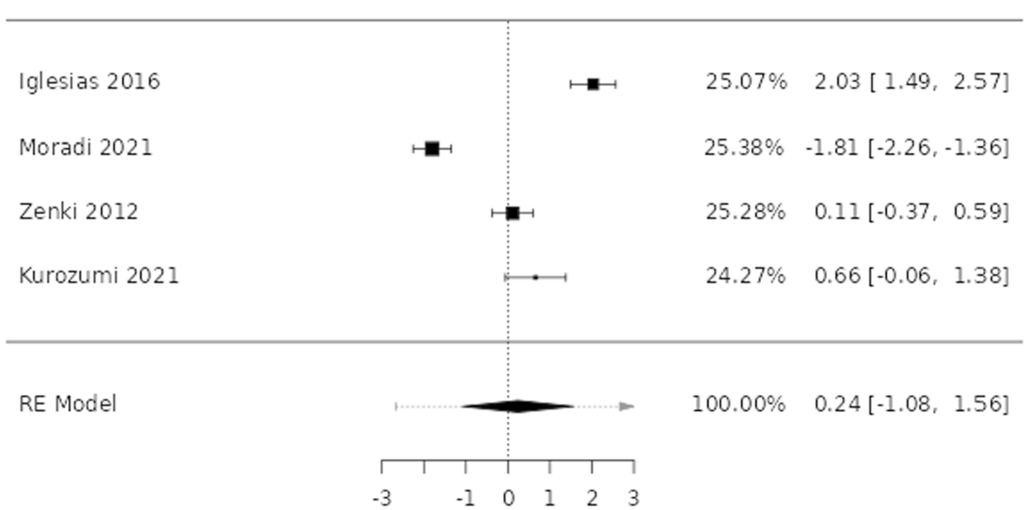

Fig. 4 Forest plot for grip strength SMD (NS vs S)

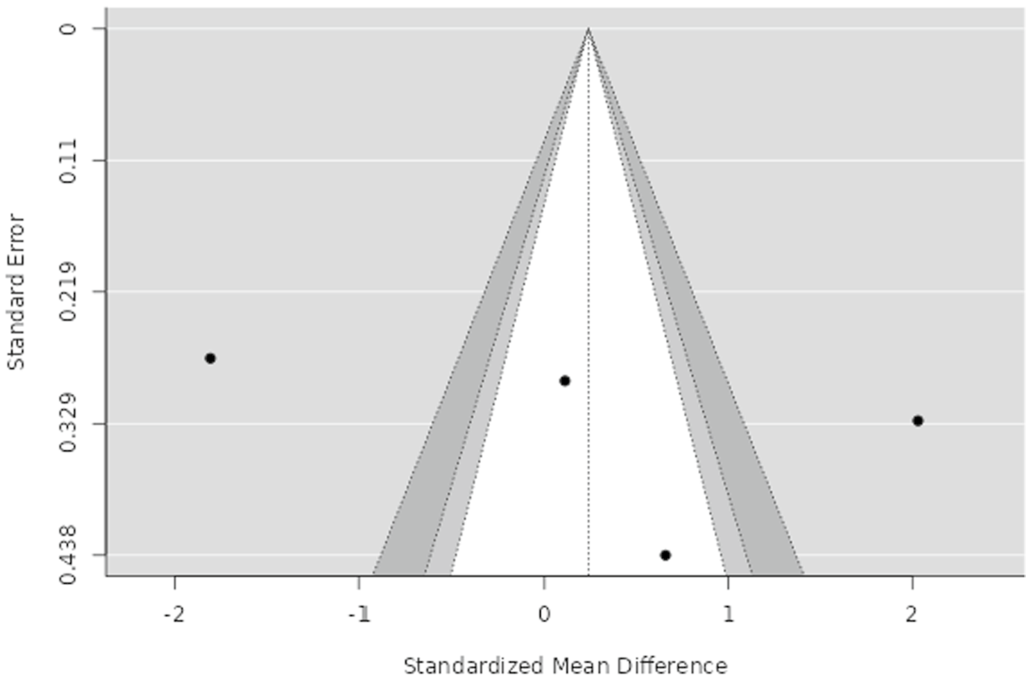

Fig. 5 Funnel plot for grip strength SMD (NS vs S)

negative (60%). The estimated average standardized mean difference based on the random-effects model was $\mu = 0.1231$ (90% CI: -0.2702 to 0.5164). Therefore, the average outcome did not differ significantly from zero ($z = 0.5148$, $p = 0.6067$). According to the Q-test, the true outcomes appear to be heterogeneous ($Q(4) = 14.5477$, $p = 0.0057$, $tau^2 = 0.2078$, $I^2 = 75.9227\%$). A 90% prediction interval for the true outcomes is given by -0.7237 to 0.9699. Hence, although the average outcome is estimated to be positive, in some studies the true outcome may in fact be negative. An examination of the studentized residuals revealed that one study (Iglesias 2016) had a value larger than ± 2.3263 and may be a potential outlier in the context of this model. According to Cook's distances, one study (Iglesias 2016) could be considered to be overly influential. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry ($p = 0.8167$ and $p = 0.8378$, respectively) in Figs. 6 and 7.

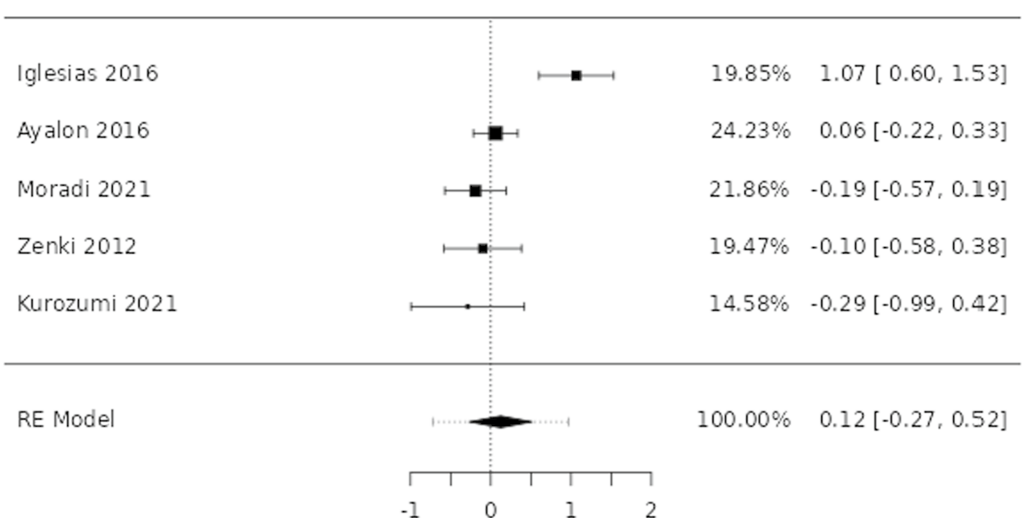

Fig. 6 Forest plot for DASH score SMD (NS vs S)

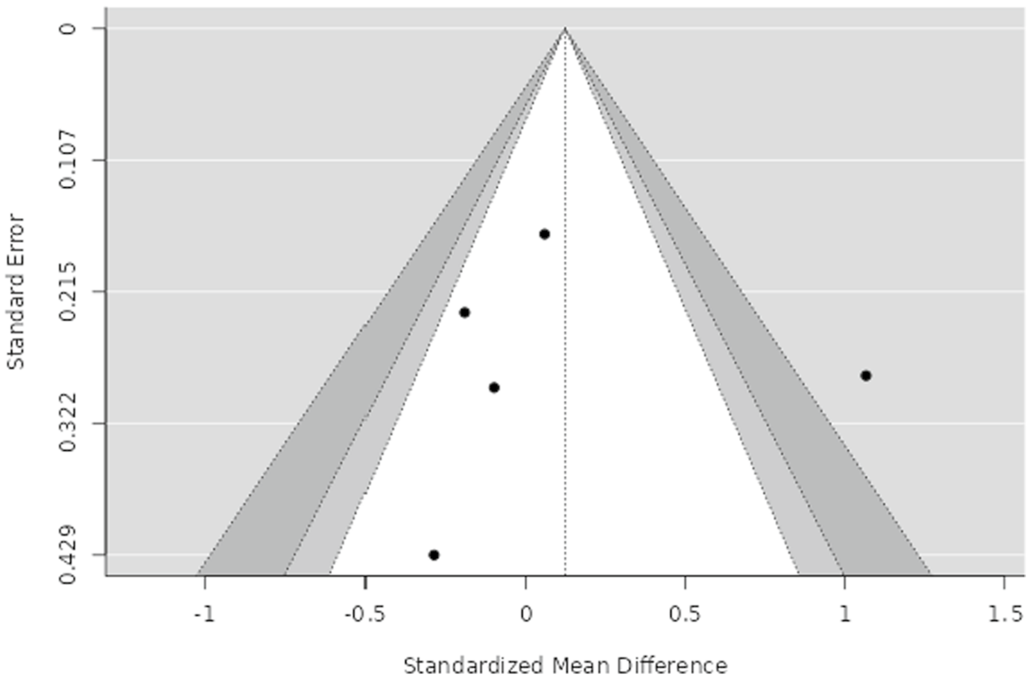

Fig. 7 funnel plot for DASH score SMD (NS vs S)

VAS scale analysis

A total of $k=3$ studies were included in the analysis. The observed standardized mean differences ranged from -1.0849 to 0.2904, with the majority of estimates being positive (67%). The estimated average standardized mean difference based on the random-effects model was $\mu=-0.1665$ (90% CI: -0.9120 to 0.5790). Therefore, the average outcome did not differ significantly from zero ($z=-0.3674$, $p=0.7133$). According to the Q-test, the true outcomes appear to be heterogeneous ($Q(2)=22.8918$, $p<0.0001$, $tau^2=0.5632$, $I^2=91.7877\%$). A 90% prediction interval for the true outcomes is given by -1.6086 to 1.2756. Hence, although the average outcome is estimated to be negative, in some studies the true outcome may in fact be positive. An examination of the studentized residuals revealed that one study (Moradi 2021) had a value larger than ± 2.1280 and may be a potential outlier in the context of this model. According

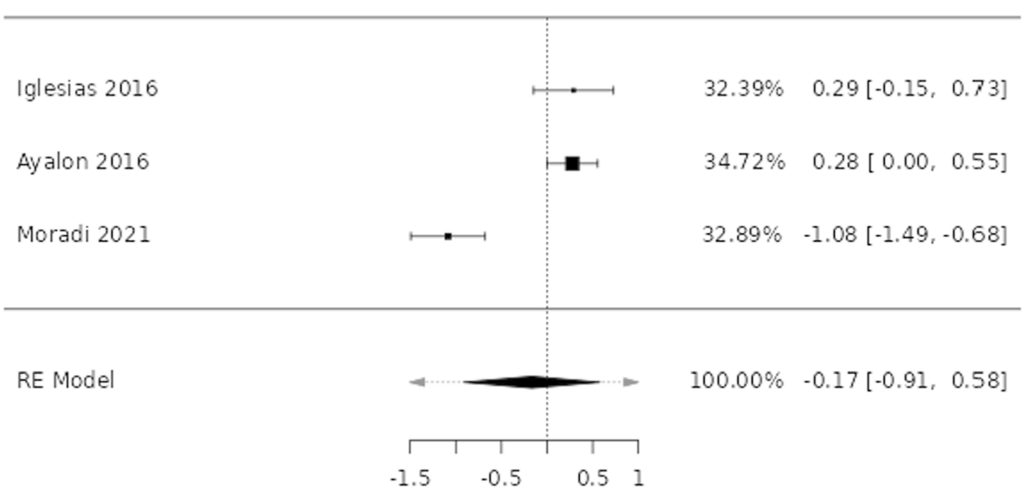

Fig. 8 Forest plot for VAS scale SMD (NS vs S)

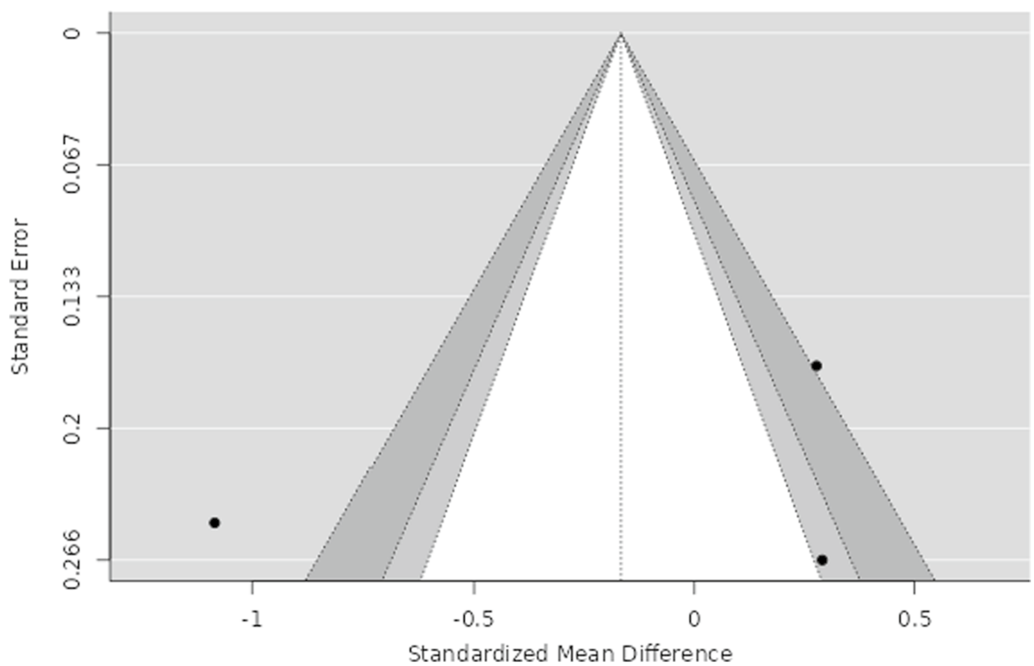

Fig. 9 Funnel plot for VAS scale SMD (NS vs S)

to Cook's distances, none of the studies could be considered to be overly influential. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry ($p = 1.0000$ and $p = 0.7216$, respectively) in Figs. 8 and 9.

Union rate analysis

A total of $k = 4$ studies were included in the analysis. The observed log odds ratio ranged from 0.0985 to 2.68, with the majority of estimates being positive (50%). The estimated average standardized mean difference based on the random-effects model was $\mu = 1.39$ (90% CI: 0.0985–2.6). Therefore, the average outcome did differ significantly from zero ($z = -5.5231$, $p = 0.00001$). According to the Q-test, the true outcomes appear to be heterogeneous ($Q(2) = 53.2268041$, $p < 0.0001$, $tau^2 = 1.56$, $I^2 = 67.73\%$). A 90% prediction interval for the true outcomes is given by -1.04 to 3.81. Hence, although the average outcome is estimated to be positive (Fig. 10).

Discussion

Study limitations

The systematic review includes a diverse array of studies, each with unique parameters for inclusion and exclusion, as well as varying degrees of transparency regarding their limitations. For example, the study by Iglesias [14] targeted patients over 18 years of age with distal radius fractures treated with open reduction and internal fixation using volar plates, explicitly excluding those under 18 and cases with non-anatomical reduction. However, this study did not report any acknowledged limitations. On the other hand, the study by Knapp [15] did not report any criteria or limitations, which may suggest a lack of detail in the study's design and reporting process.

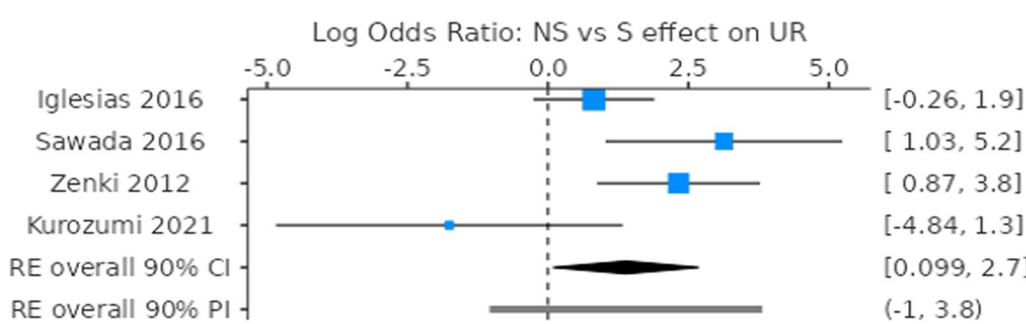

Fig. 10 Forest plot for union rate LOR (NS vs S)

In terms of counts and percentages, 70% of the studies reported both inclusion and exclusion criteria, while 80% acknowledged limitations in their research. The average minimum age for inclusion across the studies is approximately 25.6 years, and the average maximum age is around 77 years.

The studies exhibit considerable differences in methodological clarity and rigor. While some studies, like that of Iglesias [14], provide detailed inclusion and exclusion criteria, others, such as those by Knapp [15] and Ayalon [18], do not report any criteria. This inconsistency could affect the comparability and reliability of the results across different studies. Moreover, the limitations acknowledged by the studies, such as small cohort sizes, retrospective nature, and instability of the distal radioulnar joint (DRUJ), underscore the challenges faced in conducting research in this domain and the necessity for standardized protocols to improve the quality of studies.

Demographic characteristics

In the study conducted by Iglesias [14], the average age of participants is reported to be around 49.5 years, with a slight variation between the non-surgical and surgical groups. The sex ratio and hand dominance are not reported for this study. Knapp study [15] has a smaller sample size of 21, and the age is given as a median of 51 years, with no additional age-related data for non-surgical cases. The sex ratio is slightly skewed towards females, and hand dominance is predominantly left-handed. Sawada study [16] presents an older average age of 66.5 years, with a more balanced sex ratio and a nearly even distribution of hand dominance between left and right. Chen [17] reports a much younger average age of 32.4 years and a sex ratio heavily skewed towards males. Hand dominance is predominantly right-handed in this cohort. Ayalon study [18] stands out with the largest sample size of 169, but unfortunately, it does not provide any demographic data. Similarly, Okoli study [19] reports an average age of 64 years with a sex ratio favoring males but no data on hand dominance for the surgical group. Souer [20], Lee [21], and Wong [22] studies provide partial data, with some demographic parameters not reported. Moradi study [23] offers a comprehensive set of data, with an average age of 52.2 years and a balanced sex ratio. The hand dominance shows a slight preference for left-handedness in both non-surgical and surgical groups. Zenke [24] and Kurozumi [25] studies also contribute to the overall picture, with the former showing a significant age difference between the non-surgical and surgical groups and the latter presenting an older average age of 71.6 years.

The variability in reporting standards and the completeness of demographic data across these studies pose challenges for the systematic review and meta-analysis. It underscores the need for consistent reporting to facilitate accurate comparisons and conclusions regarding the effectiveness of surgical versus non-surgical management for distal ulna fractures.

Fracture characteristics

In Iglesias study [14], the fractures are categorized into three fragment sizes: B(base)28, H(head)19, and T(tip)10, with a total of 57 cases, all of which are classified under the AO classification system. The study provides a comprehensive breakdown of the AO types, with 17 type A, 6 type B, and 34 type C fractures, indicating a higher prevalence of more complex fracture types. Knapp study [15] reports a smaller sample size of 21 fractures, with a distribution of B7, H11, and T3 fragment sizes. The AO classification is similarly detailed, with 5 type A, 0 type B, and 16 type C fractures, suggesting a focus on more severe fracture types. Sawada study [16] includes a larger sample of 64 fractures, with a fragment size distribution of B42, H13, and T9. The AO classification reveals 23 type A, 3 type B, and 38 type C fractures, again highlighting the complexity of the fractures being studied. Chen study [17], with a sample size of 9, focuses exclusively on surgical cases, with fragment sizes of B18, H7, and T6. The AO classification shows a balanced distribution of fracture types, with 6 type A, 18 type B, and 7 type C fractures. Studies like Ayalon [18], which does not report specific fracture characteristics, and Okoli [19], which omits data on non-surgical cases. Souer [20], Lee [21], and Wong [22] studies provide partial data, while Moradi study [23] does not report any fracture characteristics. Zenke study [24] and Kurozumi [25] study round out the table, with Zenke [24] reporting 48 fractures with AO classifications of 23 type A, 3 type B, and 22 type C, and Kurozumi [25] reporting 23 fractures with 12 type A, 0 type B, and 11 type C fractures.

This is reflective of the heterogeneity of the fracture characteristics and the varying focus of the studies on different fracture types and treatment modalities. This diversity underscores the complexity of managing distal ulna fractures and the importance of considering a wide range of fracture characteristics when evaluating the efficacy of surgical versus non-surgical management.

Management type

In the study by Iglesias [14], out of 57 cases, 29 were managed non-surgically, which is about 51% of the sample. The non-surgical approach primarily involved casting. For the surgical cases, K-pinning and band wiring were the predominant techniques, with 28 and 26 cases, respectively. Knapp study [15] had a total of 21 cases, all of which underwent surgical management. The techniques used were plating and headless screw fixation, each accounting for all 21 cases, indicating a preference for these surgical methods in this study. Sawada [16] reported on 64 cases, with a majority of 48 cases (75%) managed non-surgically, which was not specified in detail. The surgical group had 8 cases treated with K-pinning, 7 with band wiring, and 1 with a headless screw. Chen study [17] included 31 cases, with 10 cases (about 32%) managed with anchors and 21 cases (about 68%) with band wiring, all under the surgical category as non-surgical data was not applicable. Ayalon [18] had the largest sample size of 169 cases, with 51 cases (about 30%) managed non-surgically through casting. The surgical management strategies were not reported. Okoli [19], Souer [20], Lee [21], and Wong [22] all reported on cases managed non-surgically through casting, with sample sizes of 64, 67, 69, and 21, respectively, and no surgical data applicable. Moradi [23] included 75 cases, with 36 cases (about 48%) managed non-surgically through casting and 39 cases (about 52%) managed surgically with band wiring. Zenke [24] reported on 48 cases, evenly split between non-surgical and surgical management, both primarily involving casting and band wiring, respectively. Kurozumi [25] had a smaller sample of 23 cases, with 9 cases (about 39%) managed non-surgically through casting and 14 cases (about 61%) managed surgically with plating. This highlights the varied management strategies across the studies, with a mix of non-surgical and surgical approaches. Non-surgical management often involved casting, while surgical management included techniques like K-pinning, band wiring, plating, headless screw fixation, and the use of anchors.

Functional outcomes

In Iglesias study [14], the grip strength for the non-surgical group was reported as 33.83 ± 2.2 kg, while the surgical group had a slightly lower grip strength of 29.3 ± 2.2 kg. Ulnar deviation was 49.31 ± 1.84 degrees for the non-surgical group and 46.07 ± 1.52 degrees for the surgical group. The VAS scale, which measures pain, showed a lower score for the surgical group 2.5 ± 1.25 compared to the non-surgical group 2.8 ± 0.73. The DASH score, which measures disability, was significantly lower in the surgical group 3.54 ± 25.3 compared to the non-surgical group 23.1 ± 5.1, suggesting better functional outcomes for the surgical group. Knapp [15] did not report any functional outcomes, indicating a lack of available data. Sawada [16] reported grip strength for the non-surgical group as 26.02 kg and for the surgical group as 27.28 kg. Ulnar deviation and other outcomes were not reported, except for the VAS scale, which was 1.3 for the non-surgical group, indicating lower pain levels. Chen [17] only provided data for the surgical group, with a grip strength of 33.0 ± 7.2 kg and a VAS scale score of 1.0 ± 0.15. The DASH score was 8.2 ± 9.7, suggesting favorable outcomes post-surgery. Ayalon [18] reported grip strength for the non-surgical group as 20.58 kg and a VAS scale score of 1.95 ± 2.09. The surgical group had a slightly better VAS scale score of 1.29 ± 2.48 and a comparable DASH score of 16.69 ± 17.7 to the non-surgical group's 17.85 ± 23.13. Okoli [19], Souer [20], Lee [21], and Wong [22] studies reported partial data, with some studies providing grip strength and DASH scores but not reporting other outcomes. Moradi [23] reported a wide range of grip strength, with 11.3 ± 12.2 kg for the non-surgical group and 42.5 ± 20.6 kg for the surgical group. The surgical group also had a higher VAS scale score of 4.0 ± 1.73 and DASH score of 7.92 ± 13.5 compared to the non-surgical group (2.50 ± 0.81 and 6.02 ± 2.0, respectively). Zenke [24] reported grip strength as 32.9 ± 4.48 kg for the non-surgical group and 32.37 ± 4.9 kg for the surgical group, with the DASH score being lower for the non-surgical group 2.2 ± 25.4 compared to the surgical group 4.2 ± 6.3. Kurozumi [25] reported grip strength of 28 ± 7 kg for the non-surgical group and 24.5 ± 3.5 kg for the surgical group. The DASH score was higher for the surgical group of 11.5 ± 19.0 compared to the non-surgical group of 6.8 ± 8.2. This indicates variability in functional outcomes between non-surgical and surgical management across different studies. While some studies suggest better outcomes for surgical management, others show comparable or even better results for non-surgical management.

Secondary outcomes

In Iglesias study [14], the union rate was reported as 48% for the non-surgical group and 67% for the surgical group. DRUJ instability and subsequent surgeries were not reported. The follow-up duration was 63.14 ± 1.95 months for the non-surgical group and 48.43 ± 3.74 months for the surgical group. Knapp study [15] did not report the union rate for the non-surgical group and reported a 100% union rate for the surgical group. Two subsequent surgeries were noted, and the follow-up duration was 15 months for the surgical group. Sawada study [16] reported a 39% union rate for the non-surgical group and a 93% union rate for the surgical group. DRUJ instability and subsequent surgeries were not reported. The follow-up duration was 24.0 months for the non-surgical group and 29.6 months for the surgical group. Chen study [17] reported no data for the non-surgical group and a 93% union rate for the surgical group, with three subsequent surgeries noted. The follow-up duration was 25 months for the surgical group. Ayalon study [18] did not report the union rate for either group. No subsequent surgeries were reported, and the follow-up duration was 12 months for the non-surgical group. Okoli study [19] reported a 26% union rate for the non-surgical group, with no data available for the surgical group. No subsequent surgeries or DRUJ instability were reported, and the follow-up duration was 12 months for the non-surgical group. Souer [20], Lee [21], Wong [22], and Moradi [23] studies did not report union rates, DRUJ instability, or subsequent surgeries. Follow-up durations varied, with some studies not reporting this data. Zenke study [24] reported a 35% union rate for the non-surgical group and an 85% union rate for the surgical group, with six subsequent surgeries noted. The follow-up duration was 12.5 ± 7.3 months for the non-surgical group and 11.8 ± 9.9 months for the surgical group. Kurozumi study reported a 100% union rate for both groups, with no DRUJ instability or subsequent surgeries reported. The follow-up duration was 21.2 ± 7.5 months for the non-surgical group and 33.2 ± 14.7 months for the surgical group.

This suggests a high union rate across the studies regardless of management type, despite a substantial number of studies reporting higher rates in the surgical group while other studies reporting comparative rates throughout the groups. The lack of reported data on DRUJ instability and subsequent surgeries in many studies indicates a gap in the available information. The follow-up durations provide a timeline for assessing the long-term outcomes of the treatments, and despite being inconsistent throughout the studies, a follow-up of at least 12 months seems to be agreed upon within most studies.

Primary outcome analysis

The meta-analysis for grip strength included four studies, with a calculated standardized mean difference (SMD) of 0.239. This suggests a slight trend favoring surgical management, but the difference was not statistically significant ($p = 0.766$). The heterogeneity was high ($I^2 = 95.93\%$), indicating substantial variability among the studies. The prediction interval ranged from − 2.6594 to 3.1371, which implies that while the average effect size is positive, individual study outcomes could vary significantly, including potential negative effects.

For the DASH score, five studies were included in the meta-analysis. The average SMD was 0.123, again showing no significant difference between surgical and non-surgical management ($p = 0.607$). The heterogeneity was moderate ($I^2 = 75.92\%$), with a prediction interval from − 0.7237 to 0.9699, suggesting that individual study outcomes could differ from the average.

The VAS scale analysis included three studies and resulted in an SMD of − 0.167, favoring non-surgical management, but this was not statistically significant ($p = 0.713$). The heterogeneity was very high ($I^2 = 91.79\%$), with a prediction interval from − 1.6086 to 1.2756, indicating a wide range of possible true effects across different studies.

The union rate analysis included four studies and showed a log odds ratio (LOR) of 1.39, which was statistically significant ($p = 0.00001$), indicating a higher union rate with surgical management. The heterogeneity was moderate ($I^2 = 67.73\%$), and the prediction interval ranged from − 1.04 to 3.81, suggesting that while the average effect is positive, there could be variability in the true outcomes.

The meta-analysis results indicate that there is no significant difference in grip strength, DASH score, or VAS score when comparing surgical to non-surgical management of distal ulna fractures. However, the union rate is significantly higher with surgical management. The high levels of heterogeneity observed for grip strength and VAS score suggest that factors such as patient characteristics, fracture severity, and treatment protocols may influence the outcomes more than the management strategy itself.

The prediction intervals for all outcomes are wide, reflecting the variability in the effects observed across different studies. This variability underscores the importance of considering individual patient factors when deciding on the management strategy for distal ulna fractures.

The lack of significant differences in functional outcomes (grip strength, DASH score, VAS score) suggests that the choice between surgical and non-surgical management should be made based on patient preferences, comorbidities, and specific fracture characteristics rather than expected functional outcomes.

The significantly higher union rate with surgical management may influence the decision-making process, especially in cases where bone healing is a primary concern. However, the benefits of a higher union rate must be weighed against the risks and potential complications associated with surgery. ORIF implants are typically associated with higher ulnar-sided pain rates and limited ulnar deviation due to implant prominence.

Limitations and future directions

A limitation of this study concerns the fact that the quality of the selected studies in our meta-analysis is moderate or low according to the GRADE system [10]. Additionally, the study results were found to be very high for the VAS scale, high for grip strength, and moderate for the DASH score and Union rate. However, the meta-analysis provides the best evidence available at present. The included studies involved a variety of patients, for instance, regarding DRF type, treatment method, level of ulnar styloid fracture, and duration of follow-up. The lack of reported data on DRUJ instability and subsequent surgeries in many studies indicates a gap in the available information.

Methodologically, there's a notable disparity in the clarity and thoroughness of the studies. This inconsistency could affect the comparability and reliability of the results across different studies. Moreover, the limitations acknowledged by the studies, such as small cohort sizes, retrospective nature, and instability of the distal radioulnar joint (DRUJ), underscore the challenges faced in conducting research in this domain and the necessity for standardized protocols to improve the quality of studies.

Conclusion

The management of distal ulna fractures (DUFs) remains a subject of considerable debate within orthopedic practice. This systematic review and meta-analysis aim to compare the outcomes of surgical and non-surgical treatments for DUFs through a systematic review of the literature and meta-analysis adhering to PRISMA guidelines, with a focus on the functional outcome, union rate, and quality of life implications for patients. The meta-analysis results indicate that there is no significant difference in grip strength, DASH score, or VAS score when comparing surgical to non-surgical management of distal ulna fractures. However, the union rate is significantly higher with surgical management. The high levels of heterogeneity observed for grip strength and VAS score suggest that factors such as patient characteristics, fracture severity, and treatment protocols may influence the outcomes more than the management strategy itself. ORIF implants are typically associated with higher ulnar-sided pain rates and limited ulnar deviation due to implant prominence. Limitations acknowledged by the studies, such as small cohort sizes, retrospective nature, and instability of the distal radioulnar joint (DRUJ), underscore the challenges faced in conducting research in this domain and the necessity for standardized protocols to improve the quality of studies.

Supplementary Information

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Supplementary file1
Supplementary file2
Supplementary file3

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Author contributions
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Availability of data and materials
No datasets were generated or analysed during the current study.

Code availability
Not applicable.

Ethical approval and consent to participate
This study did not involve direct interaction with patients and relied on data from previously published studies; therefore, ethical approval was not required.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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