

Surgical versus nonsurgical treatment for scaphoid waist fracture with slight or no displacement

A meta-analysis and systematic review

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Abstract

Background: Surgical or nonsurgical treatment for scaphoid waist fracture with slight or no displacement is still controversial. This study compared the efficacy of the 2 methods through meta-analysis to provide a reference for the choice of clinical treatment options.

Methods: Two individuals independently searched for relevant RCTs and cohort studies from PubMed (1946–February 2018), Embase (1946–February 2018), and Cochrane library (1997–February 2018). After quality assessment and data extraction, Stata 14 software was used for combining the effect size, testing heterogeneity, and studying bias. GRADEpro was used to rate the level of evidence.

Results: Ten RCTs and 4 cohort studies with 765 patients were included. No statistical difference in satisfaction, pain, and Disability of the Arm, Shoulder, and Hand score was found after surgical and nonsurgical treatments. Compared with nonsurgical treatment, surgical treatment shortened the time to union (SMD = -5.01 , 95% CI: -7.47 to -2.58 , $P = .000$), decreased the convalescence (SMD = -2.09 , 95% CI: -3.08 to -1.11 , $P = .000$), and reduced the incidence of nonunion (RR = 0.47 , 95% CI: 0.24 – 0.90), $P = .023$). Subgroup analyses showed that the percutaneous fixation treatment can shorten the time to union [SMD = -1.82 , 95% CI (-2.22 to -1.42), $P = .000$] and the convalescence (SMD = -4.26 , 95% CI: -6.16 to -2.35 , $P = .054$), and open reduction fixation treatment can reduce the incidence of nonunion (RR = 0.20 , 95% CI: 0.06 – 0.69 , $P = .01$).

Conclusion: For scaphoid waist fractures with slight or no displacement, there was no statistical difference in patient satisfaction, pain, and The Disability of the Arm, Shoulder, and Hand scores between surgical treatment and nonsurgical treatment. Closed surgical treatment can shorten the time to union and convalescence, and open reduction can reduce the incidence of nonunion. On the basis of this conclusion, chief physicians can consider which treatment to use according to the patient's clinical situation and their subjective intention.

Abbreviations: CI = confidence interval, DASH = The Disability of the Arm, Shoulder, and Hand, NOS = Newcastle–Ottawa scale, NSFC = National Natural Science Foundation of China, RCTs = randomized controlled trials, RR = relative risk, SD = standard deviation, SMD = standard mean difference, VAS = visual analog scale.

Keywords: meta-analysis, scaphoid waist fracture, surgical versus nonsurgical

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1. Introduction

Scaphoid waist fracture is a common type of wrist fracture,^[1] accounting for 51% to 90% of wrist fractures and 2% to 7% of total body fractures.^[2,3] Because of the particular distribution of scaphoid blood vessels, blood circulation is often blocked after fracture of the scaphoid.^[4,5] If blood circulation cannot be properly restored, severe wrist dysfunction can develop.^[6]

The best treatment for scaphoid waist fracture with slight or no displacement has been the focus of controversy.^[7,8] Some early scholars have suggested that nonsurgical treatment, such as long-arm or short-arm plaster support and brace fixation for 9 to 12 weeks^[9–11] until fracture union, which has a union rate of 90% to 95%.^[11–14] Above all, nonsurgical treatment is non-invasive and has a low economic burden. In recent years, some scholars have advocated the use of surgical treatment,^[15,16] for which the union rate is almost 100%.^[4,6,17,18] Surgical treatment is characterized by performing rehabilitation postoperatively, avoiding joint stiffness caused by long-term plaster fixation,^[6,19] and reducing the incidence of nonunion and malunion of the scaphoid bone.^[16,20]

There was no significant difference in the union rate between the 2 treatment methods. However, the differences in the trauma caused by treatment, degree of satisfaction caused by postoperative

joint stiffness, and pain were significant. This is an important factor affecting patients' quality of life and the main purpose of our treatment. Considerably insufficient attention to postoperative satisfaction and pain cannot provide reliable clinical evidence in studies regarding scaphoid waist fracture with slight or displacement.

At present, only 3 meta-analyses^[21–23] have reported on this topic, but because of the lack of basic literature and errors in document inclusion and data extraction,^[21] the validity of the evidence is insufficient. Thus, we searched for recent updates that included randomized, controlled trials (RCTs) and cohort studies to increase the number of primary documents.^[24–27] We performed a meta-analysis of outcome measures, such as patient satisfaction, pain, The Disability of the Arm, Shoulder, and Hand (DASH) scores, and fracture union in patients with scaphoid waist fracture with slight or no displacement between surgical and nonsurgical treatments. In addition, we performed a subgroup analysis on time to union, the convalescence, and incidence of nonunion between the surgical treatment groups (open reduction surgery versus percutaneous fixation surgery).

2. Methods

2.1. Search strategy

We performed this meta-analysis and systematic review following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analyses statement,^[28] and we retrieved articles from PubMed (1946–February 2018), Embase (1946–February 2018), and Cochrane library (1997–February 2018). The keywords used were “scaphoid bone;” “fractures, bone;” and “surgical procedures, operative” and synonyms for these terms. The references for relevant reviews and systematic reviews were manually retrieved. All analyses were based on previous published studies; thus, no ethical approval and patient consent are required.

2.2. Basic PubMed search

((“Surgical Procedures, Operative”[Mesh] OR ((((((((((Operative Surgical Procedure[Title/Abstract] OR Operative Surgical Procedures[Title/Abstract]) OR (“methods”[Subheading] OR “methods”[All Fields] OR “procedures”[All Fields] OR “methods”[MeSH Terms] OR “procedures”[All Fields]) AND Operative Surgical[Title/Abstract])) OR (“surgical procedures, operative”[MeSH Terms] OR (“surgical”[All Fields] AND “procedures”[All Fields] AND “operative”[All Fields]) OR “operative surgical procedures”[All Fields] OR (“surgical”[All Fields] AND “procedure”[All Fields]) OR “surgical procedure”[All Fields]) AND Operative[Title/Abstract])) OR Operative Procedures[Title/Abstract] OR Operative Procedure[Title/Abstract] OR (“methods”[MeSH Terms] OR “methods”[All Fields] OR “procedure”[All Fields]) AND Operative[Title/Abstract])) OR (“methods”[Subheading] OR “methods”[All Fields] OR “procedures”[All Fields] OR “methods”[MeSH Terms] OR “procedures”[All Fields]) AND Operative[Title/Abstract])) OR (“methods”[MeSH Terms] OR “methods”[All Fields] OR “procedure”[All Fields]) AND Operative Surgical [Title/Abstract])) OR (Surgery,[All Fields] AND Ghost[Title/Abstract]) OR Ghost Surgery[Title/Abstract]) AND (“Fractures, Bone”[Mesh] OR ((((((((((Broken Bones[Title/Abstract] OR (“bone and bones”[MeSH Terms] OR (“bone”[All Fields] AND “bones”[All Fields]) OR “bone and bones”[All Fields] OR

“bone”[All Fields]) AND Broken[Title/Abstract])) OR (“bone and bones”[MeSH Terms] OR (“bone”[All Fields] AND “bones”[All Fields]) OR “bone and bones”[All Fields] OR “bones”[All Fields]) AND Broken[Title/Abstract])) OR Broken Bone[Title/Abstract] OR Bone Fractures[Title/Abstract] OR Bone Fracture[Title/Abstract] OR Fracture, Bone[Title/Abstract] OR Spiral Fractures[Title/Abstract] OR (Fracture,[All Fields] AND Spiral[Title/Abstract])) OR (Fractures,[All Fields] AND Spiral[Title/Abstract])) OR Spiral Fracture[Title/Abstract] OR Torsion Fractures[Title/Abstract] OR (Fracture,[All Fields] AND Torsion[Title/Abstract])) OR (Fractures,[All Fields] AND Torsion[Title/Abstract])) OR Torsion Fracture[Title/Abstract])) AND (“Scaphoid Bone”[Mesh] OR ((((((((((“bone and bones”[MeSH Terms] OR (“bone”[All Fields] AND “bones”[All Fields]) OR “bone and bones”[All Fields] OR “bone”[All Fields]) AND Scaphoid[Title/Abstract] OR (“bone and bones”[MeSH Terms] OR (“bone”[All Fields] AND “bones”[All Fields]) OR “bone and bones”[All Fields] OR “bones”[All Fields]) AND Scaphoid[Title/Abstract]) OR Scaphoid Bones[Title/Abstract] OR Os Naviculare Manus[Title/Abstract] OR Os Scaphoideum [Title/Abstract] OR Navicular Bone of Hand[Title/Abstract] OR (“hand”[MeSH Terms] OR “hand”[All Fields]) AND Navicular Bone[Title/Abstract]) OR (“hand”[MeSH Terms] OR “hand”[All Fields]) AND Navicular Bones[Title/Abstract]))

2.3. Eligibility criteria

2.3.1. Inclusion criteria.

- (1) *Design type*: RCT and cohort studies concerning surgical or nonsurgical treatment for scaphoid fracture in English and Chinese were included.
- (2) *Participants*: Patients with no displacement or <1 mm of displacement, a scaphoid waist fracture, and follow-up for at least 2 months were included.
- (3) *Interventions*: Patients in the surgical treatment group underwent open reduction and percutaneous internal fixation; whereas, those in the nonsurgical treatment group received different types and lengths of plaster or braces to fix the fracture.

2.3.2. Exclusion criteria.

The exclusion criteria were as follows:

- (1) scaphoid tubercle fracture, proximal fracture, comminuted fracture, open scaphoid fracture, and scaphoid waist fracture with displacement >1 mm;
- (2) combination of ligament injuries and other wrist fractures;
- (3) fractures for >2 weeks;
- (4) previous wrist injury or surgical history, signs of osteoarthritis on the x-ray of the wrist, and previous disease that affects fracture union; and
- (5) case reports, cadaver research, and biomechanical research.

Two investigators (HL and WG) independently extracted data for cross-checking; if there was disagreement, the third investigator (SZ) would make a conclusion after discussion between the 2 parties.^[29]

2.4. Assessment of methodological quality

Two investigators (HL and WG) independently assessed the quality of the included literature: RCTs were assessed by the modified Jadad scale, with scores <4 indicating low quality.^[30] Cohort studies were assessed using the Newcastle–Ottawa scale (NOS), with scores <5 indicating low quality. After disagreement

was discussed by the 2 parties, the third investigator (RL) made the final decision.

2.5. Outcome measures

Indicators for assessing the efficacy included the following.

- (1) *Degree of patient satisfaction*: Patient's ultimate satisfaction with treatment outcomes was based on a self-assessment.
- (2) *Feeling of pain*: Using the visual analog scale (VAS) score, the degree of pain was represented by a number from 0 to 10, with 0 indicating no pain and 10 indicating the most pain.^[31]
- (3) *Functional evaluation*: The DASH score was used for the functional evaluation. It is a patient survey questionnaire containing 30 items on features and symptoms of upper limb disease, with scores ranging from 0 to 100; high scores represent poor function.^[32]
- (4) *Time to union*: Good trabecular bone structure at the transverse site revealed on images was considered fracture union.^[33]
- (5) *Convalescence*: The times until the patient returned to work and activity were assessed (e.g., athletes' return to previous training activities).
- (6) *Incidence of nonunion*: Nonunion was defined as signs of non-union at the fracture site more than one-half year postoperatively and during the 3-month follow-up (e.g., the fracture was still not healed).

2.6. Data collection

Two investigators (HL and WG) independently extracted data that contained the first author, year of publication, sample size, sex, intervention measures, follow-up time, patients' satisfaction, patients' pain, DASH scores, time to union, convalescence, incidence rate of nonunion.

We sent emails to the author of the relevant study in an attempt to obtain unpublished raw data, but no responses were received. When the standard deviation (SD) was not provided, range and median were used to estimate it,^[34] or the SD was estimated from the confidence interval (CI) using the method described in the Cochrane Handbook for Systematic Reviews of Interventions.^[29]

2.7. Statistical analysis

All data were analyzed using Stata 14 software (Stata Corp.). The heterogeneity among the included studies was analyzed using the chi-square test. The random effect model was used when $I^2 > 50\%$; otherwise, the fixed effect model was used for merging analysis.^[35] Dichotomous variables are represented by the relative risk (RR). Continuous therapeutic effect variables are expressed by standardized mean difference. The 95% CI estimates and hypothesis test results for each variable are listed in the forest map.

Heterogeneity was obvious when the P -value was $< .05$ (chi-square test) and I^2 was $> 50\%$.^[36] Sources of heterogeneity included diagnostic methods, reported results, and differences in surgical techniques. Because of the study design, these variables could not be controlled.^[37] When $I^2 > 50\%$, the included studies were removed one by one to the sensitivity analysis that was conducted to determine the sources of heterogeneity. For result indicators of no less than 8 primary documents, subgroup analysis was performed according to different methods of percutaneous fixation and open reduction and internal fixation. For outcome measures of > 10 primary documents, the

publication bias test was performed using a funnel plot and Egger's test. Finally, GRADEpro software (Grade Working Group) was used to verify the quality of evidence by classifying the results in order to provide reliable evidence for clinical selection.

3. Results

3.1. Search results and characteristics of the selected studies

Of the 2873 potentially suitable studies, 14 met our criteria (Fig. 1),^[24–27,38–47] including 10 RCTs^[25,27,39–42,44–47] and 4 cohort studies.^[24,26,38,43] Among 765 patients, 384 were treated with surgery, and 381 patients underwent nonsurgical treatment. Surgical treatment comprised open reduction and internal fixation ($n=195$) and percutaneous fixation ($n=189$). Nonsurgical treatment included short-arm plaster fixation ($n=174$), long-arm plaster fixation with the thumb ($n=14$) and short-arm plaster fixation with the thumb ($n=103$). The follow-up period for the basic studies ranged from 5 weeks to 13 years. The basic characteristics of the included studies are shown in Table 1.

The quality of each RCT was assessed according to the Jadad scale. Eight studies^[25,27,40,42,44–47] had high quality, all of which used allocation concealment with sealed envelopes. Two studies^[39,41] had low quality. There was no double-blind study. According to the NOS scale, the quality of each cohort study was scored, and 4 studies^[24,26,38,43] had high quality.

Two studies^[42,46] used the same participants but recorded different outcome indicators so all the patients from these studies were included in the present study. In 2008, Vinnars et al^[45] expanded the sample size based on their previous study,^[44] and increased and changed part of the outcome indicators; thus, those 2 studies were included. The same outcome measures were based on the later report.^[45] Two other studies^[25,27] had the same issue and were included at the same time.

3.2. Comparison of operative and nonoperative treatment on patients' satisfaction

Three studies^[24,27,40] reported patients' satisfaction, including 67 cases in the surgical treatment group and 72 cases in the nonsurgical treatment group, for a total of 139. $I^2=89.6\%$, so the random effect model was selected. There was no significant difference in the patients' satisfaction between the surgical treatment group and the nonsurgical treatment group [standard mean difference (SMD)=0.06, 95% CI (−0.29–0.41)] (Fig. 2). In the sensitivity analysis, Bond et al's study^[40] was excluded, and I^2 was reduced to 0% ($P=.433$). Using the fixed effect model, the conclusion was unchanged [SMD=0.22, 95% CI (−0.59–0.15), $P=.240$].

The GRADEpro system's quality classification of Patients' satisfaction was low (S1 Appendix, <http://links.lww.com/MD/C643>).

3.3. Comparison of operative and non-operative treatment on patients' pain

Three studies^[24,42,43] reported patients' pain, including 113 cases in the surgical treatment group and 102 cases in the nonsurgical treatment group, for a total of 215. $I^2=0\%$ ($P=.772$) of VAS score comparison in short-term follow-up, so the fixed effect model was selected. There was no significant difference in the patients' pain in short-term follow-up between the surgical

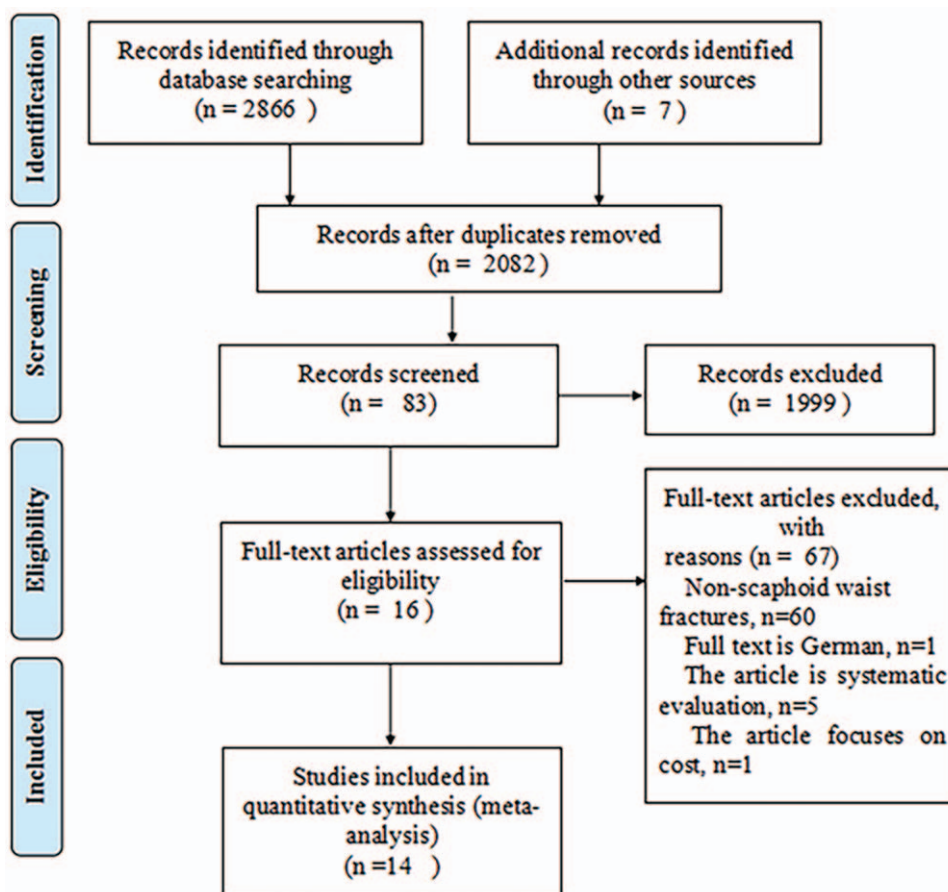


Figure 1. Flowchart of selection of studies.

treatment group and the nonsurgical treatment group [SMD = -0.22, 95%CI (-0.49-0.05), P = .107] (Fig. 3).

I² = 81.6% of VAS score comparison in long-term follow-up, so the random effect model was selected. There was no significant

difference in the patients' satisfaction in long-term follow-up between the surgical treatment group and the nonsurgical treatment group [SMD = 0.21, 95%CI (-0.07-0.49)] (Fig. 4). In the sensitivity analysis, Dias et al.'s study^[42] was excluded, and

Table 1

Main characteristics of all eligible studies included in the analysis.

Author	Year	Cases (T/C)	Intervention		Follow-up time	Quality score
			T	C		
Rettig	1994	18/12	Open reduction and internal fixation with screw	Playing cast	5-164 weeks	8 [‡]
Adolfsson	2001	25/28	Percutaneous screw fixation	Short arm cast	> 24 weeks	3 [§]
Bond	2001	11/14	Percutaneous internal fixation with screw	LATC → SATC	24-27 months	5 [§]
Saeden	2001	32/30	Openly fixated with screw	SATC	12 years	3 [§]
Dias	2005	44/44	Openly fixated with screw without a cast	Short arm cast	1 year	5 [§]
Arora	2007	21/23	Percutaneous scaphoid fixation under regional or general anaesthesia	Short arm cast	24 weeks	7 [‡]
Vinnars*	2007	26/26	Openly fixated with screw	SATC	6 months [†]	5 [§]
Vinnars*	2008	40/35	Openly fixated with screw	SATC	8-13 years	5 [§]
Dias	2008	35/36	Openly fixated with screw	Short arm cast	93 months	5 [§]
McQueen	2008	30/30	Percutaneous fixated with screw	Short arm cast	52 weeks	5 [§]
Schadel	2010	53/41	Percutaneous fixated with screw	Short arm cast	6 months	7 [‡]
Lin	2014	20/16	Percutaneous screw fixation	Short arm cast	24 months	8 [‡]
Clementon	2015	14/24	Wrist arthroscopy and percutaneous antegrade screw fixation	SATC	4-8 years	5 [§]
Clementon	2014	15/23	Arthroscopically assisted screw fixation	SATC	1 year	5 [§]

C = control group, LATC = long arm thumb spica cast, SATC = short arm thumb spica cast, T = treatment group.

24 weeks and 24 months indicated the follow-up time.

What 7[‡] and 8[‡] represent is that the article is a cohort study, which is graded using NOS.

* The annotated article included the scaphoid's waist, proximal and distal fractures.

† The follow-up until healing, removal of casts, and return to work.

‡ Cohort study NOS score.

§ RCT Jadad score.

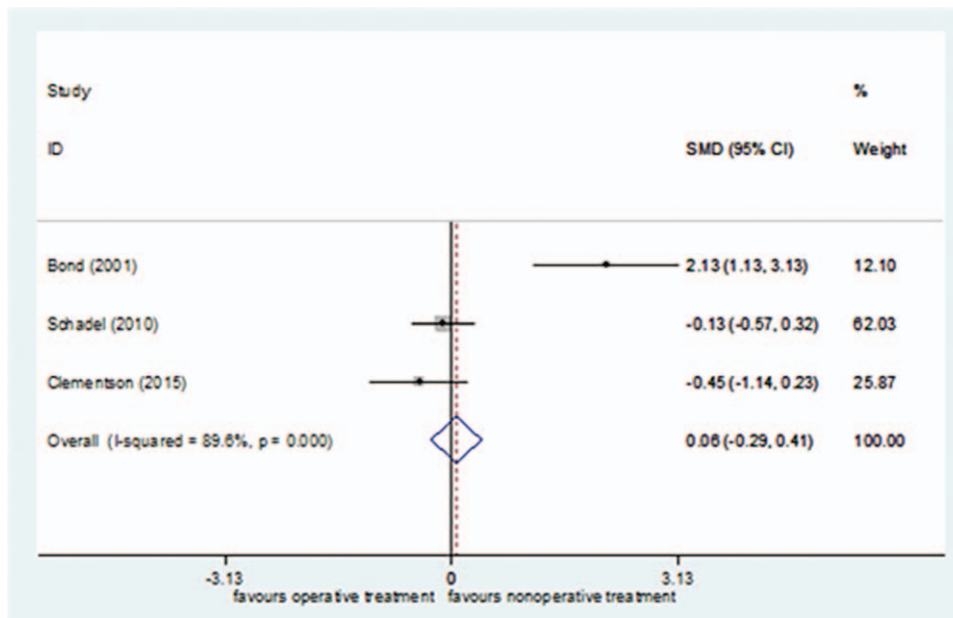


Figure 2. Forest plot for patients' satisfaction.

I^2 was reduced to 0% ($P = .963$). Using the fixed effect model, the conclusion was unchanged [SMD = -0.16, 95%CI (-0.51-0.20), $P = .390$].

The GRADEpro system's quality classification of Patients' Pain was low (S2 Appendix, <http://links.lww.com/MD/C643>).

3.4. Comparison of operative and nonoperative treatment on DASH scores

Four studies^[24,27,43,45] reported DASH scores, including 102 cases in the surgical treatment group and 94 cases in the

nonsurgical treatment group, for a total of 196. $I^2 = 59.6\%$, so the random effect model was selected. There was no significant difference in the DASH scores between the surgical treatment group and the nonsurgical treatment group [SMD = -0.19, 95%CI (-0.45-0.07)] (Fig. 5). In the sensitivity analysis, Arora et al's study^[43] was excluded, and I^2 was reduced to 3.5% ($P = .433$). Using the fixed effect model, the conclusion was unchanged [SMD = -0.04, 95%CI (-0.33-0.24), $P = .769$].

The GRADEpro system's quality classification of DASH Scores was low (S3 Appendix, <http://links.lww.com/MD/C643>).

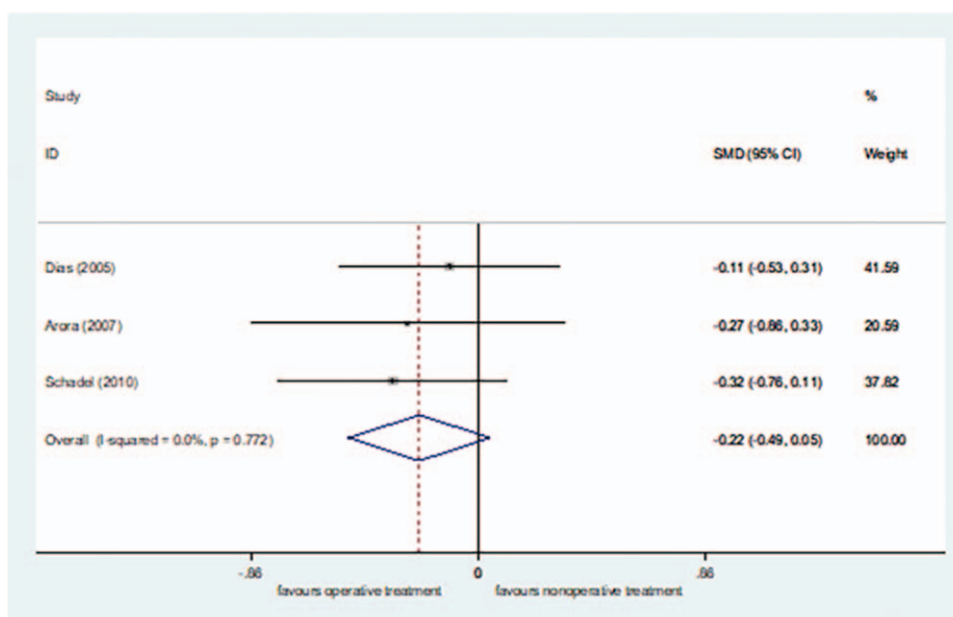


Figure 3. Forest plot for patients' pain at short-term follow-up.

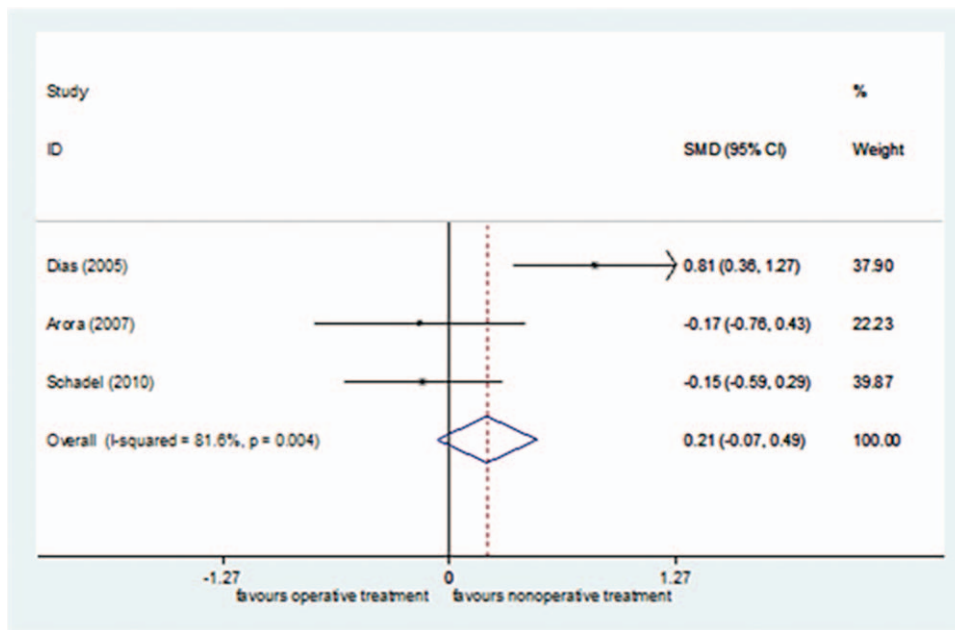


Figure 4. Forest plot for patients' pain at end-follow-up.

3.5. Comparison of operative and nonoperative treatment on time to union

Five studies^[25,26,40,43,47] reported time to union, including 95 cases in the surgical treatment group and 102 cases in the nonsurgical treatment group, for a total of 197. $I^2=96.3%$ ($P < 0.00001$), so the random effect model was selected. The time to union was shorter in the surgical treatment group than in the nonsurgical treatment group [SMD = -1.82, 95%CI (-2.22 to -1.42), $P = .000$] (Fig. 6). The sensitivity analysis did not find any sources of heterogeneity.

The GRADEpro system's quality classification of Time to Union was moderate (S4 Appendix, <http://links.lww.com/MD/C643>).

3.6. Comparison of operative and non-operative treatment on convalescence

Eight studies^[24,26,40-44,47] reported convalescence, including 208 cases in the surgical treatment group and 196 cases in the nonsurgical treatment group, for a total of 404. $I^2=93.8%$ ($P < 0.00001$), so the random effect model was selected. The convalescence was shorter in the surgical treatment group than in

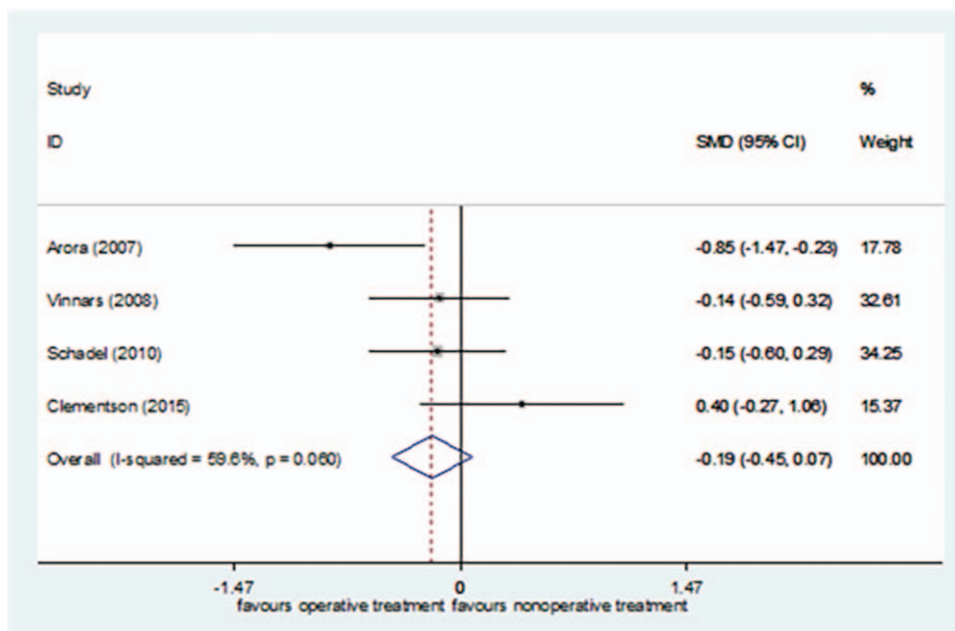


Figure 5. Forest plot for DASH scores. DASH=The Disability of the Arm, Shoulder, and Hand.

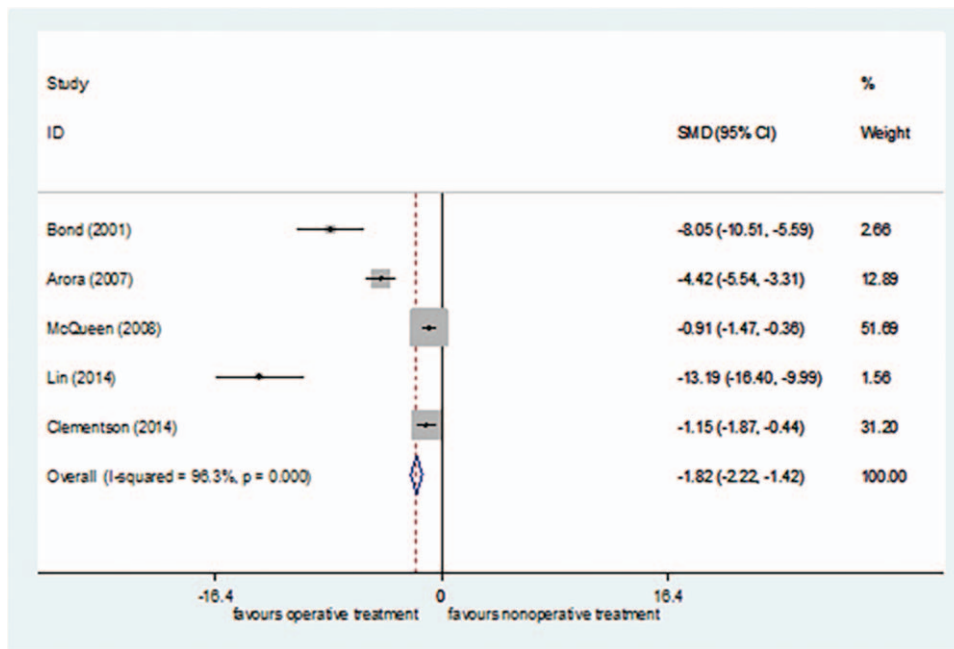


Figure 6. Forest plot for time to union of random.

the nonsurgical treatment group [SMD = -2.09, 95% CI (-3.08 to -1.11), $P = .000$] (Fig. 7). The sensitivity analysis did not find any sources of heterogeneity.

The subgroup analysis of surgical methods demonstrated that the convalescence was shorter in the percutaneous fixation group than in the nonsurgical treatment group [SMD = -4.26, 95% CI (-6.16 to -2.35), $P = .054$]. There was no significant difference in the convalescence between the open reduction fixation group and nonsurgical treatment group [SMD = -0.58, 95% CI (-1.18-0.01), $P = .000$] (Fig. 8).

The GRADEpro system’s quality classification of Convalescence was moderate (S5 Appendix, <http://links.lww.com/MD/C643>).

3.7. Comparison of operative and nonoperative treatment on the incidence rate of nonunion

Eleven studies^[24–26,38–43,45,47] reported the incidence rate of nonunion, including 282 cases in the surgical treatment group and 282 cases in the nonsurgical treatment group, for a total of

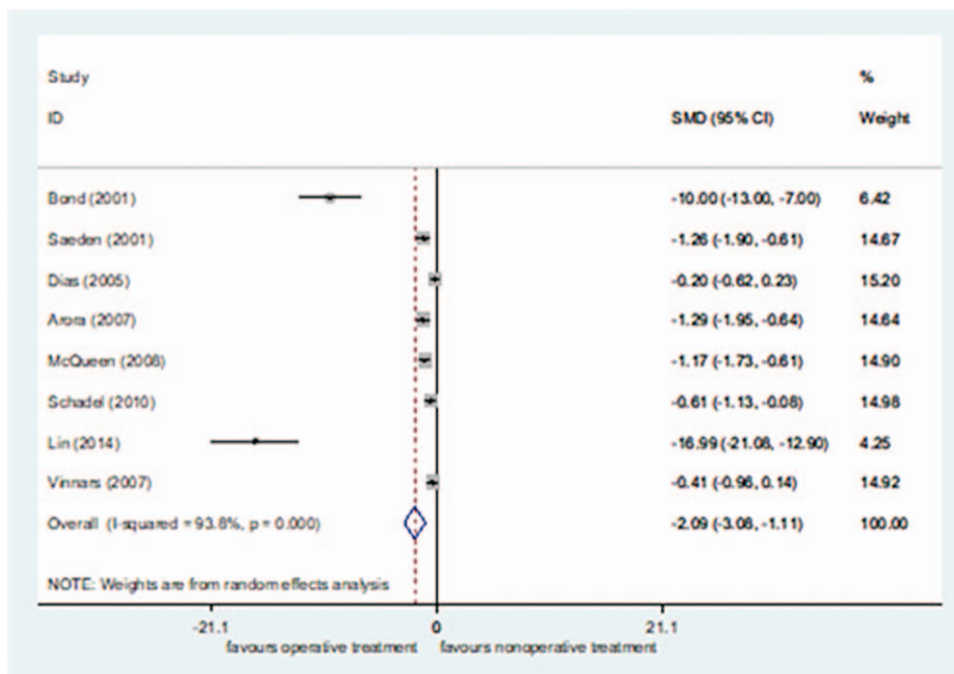


Figure 7. Forest plot for convalescence of random.

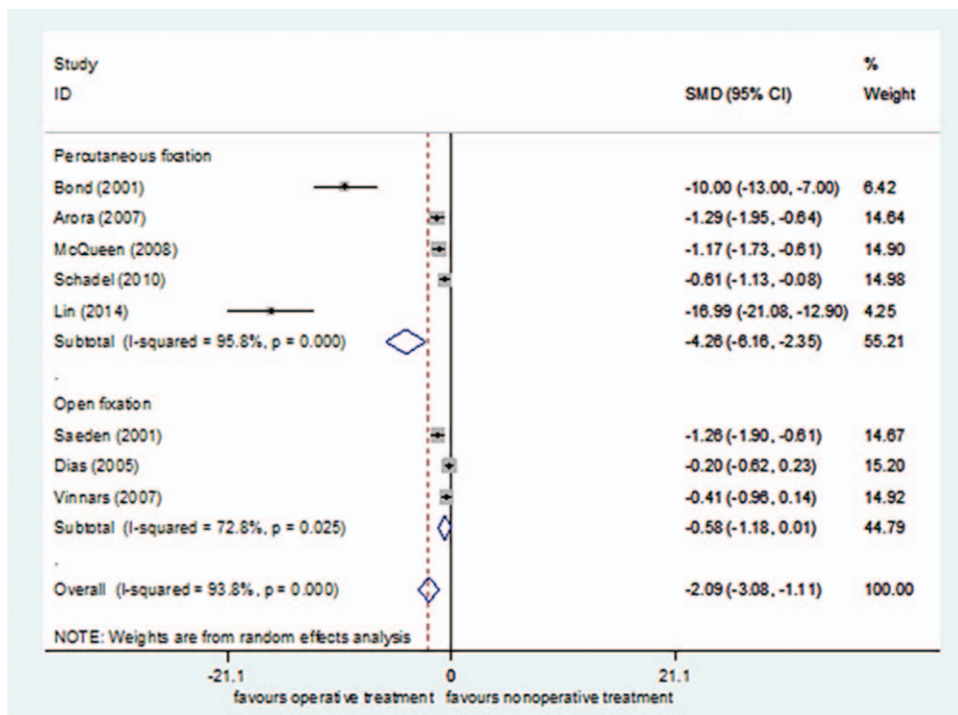


Figure 8. Subgroup analysis for convalescence.

564. $I^2=29.4%$ ($P=.175$), so the fixed effect model was selected. The incidence rate of nonunion was lower in the surgical treatment group than in the nonsurgical treatment group [RR = 0.47, 95%CI (0.24–0.93), $P=.03$] (Fig. 9).

The subgroup analysis of surgical methods demonstrated that the incidence of nonunion was lower in the open reduction

fixation group than in the nonsurgical treatment group [RR = 0.20, 95%CI (0.06–0.69), $P=.01$] (Fig. 10). There was no significant difference in the incidence of nonunion between the percutaneous fixation group and nonsurgical treatment group [RR = 0.86, 95%CI (0.36–2.05), $P=.74$] (Fig. 10). The funnel plot was symmetric, with an Egger’s test result of $P=.179$ (95%

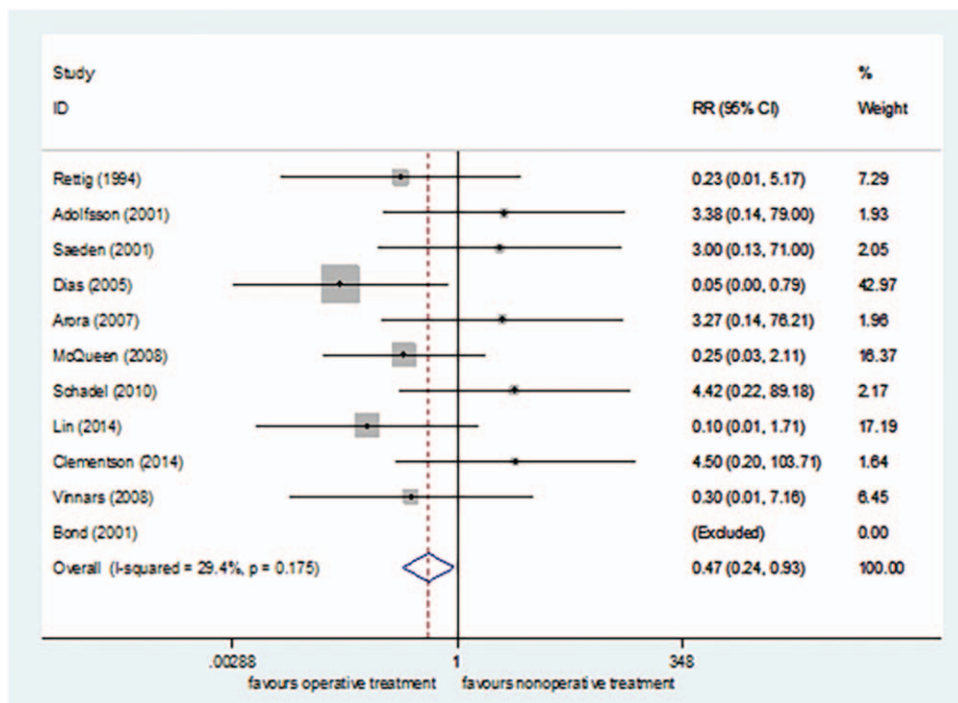


Figure 9. Forest plot for the incidence rate of nonunion.

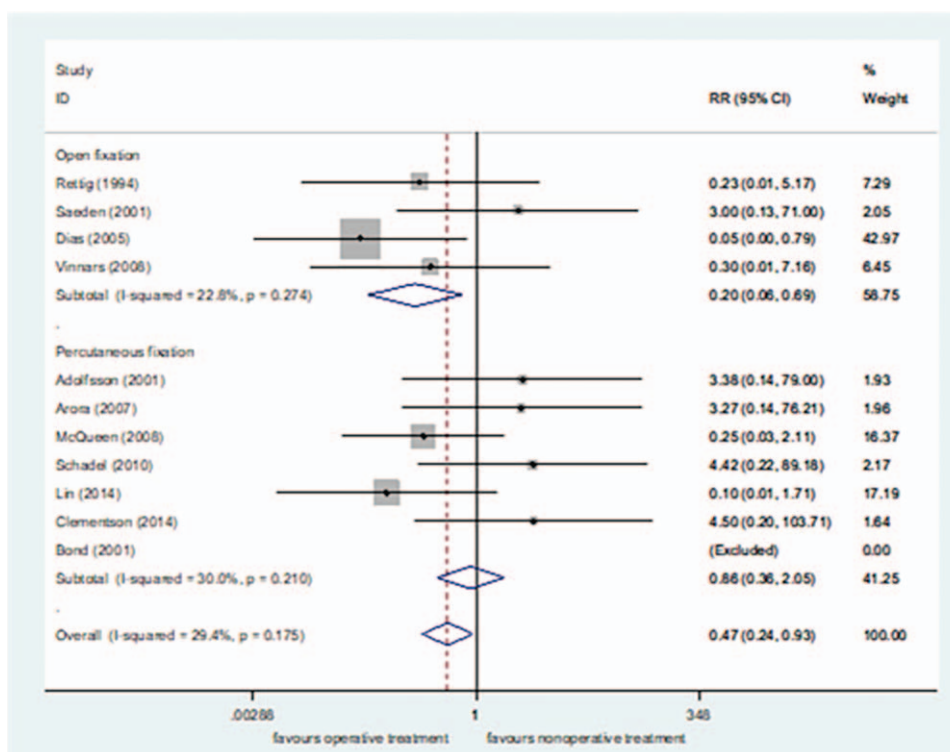


Figure 10. Subgroup analysis for the incidence rate of nonunion.

CI [-2.24–10.15]), with no apparent publication bias (Figs. 11 and 12).

The GRADEpro system’s quality classification of the Incidence Rate of Nonunion was moderate (S6 Appendix, <http://links.lww.com/MD/C643>).

4. Discussion

4.1. Key findings

Our results showed that the degree of patient satisfaction, pain, and DASH scores were not significantly different between surgical and nonsurgical treatments for scaphoid waist fracture with slight or no displacement. The time to union was faster, recovery time was shorter, and incidence of nonunion was lower in the surgical treatment group than in the nonsurgical treatment group. That is, surgical treatment was more advantageous in the treatment of scaphoid waist fracture with slight or no displacement. The GRADEpro system^[48,49] rated the quality of the DASH score, time to union, convalescence, and incidence of nonunion as moderate evidence, and patient satisfaction and pain as low.

4.2. Sensitivity analysis

Previous meta-analysis and systematic reviews have lacked effective research on patient satisfaction. Suh et al^[22] and Symes et al^[23] only conducted a qualitative systematic evaluation and lacked a quantitative meta-analysis. Although Buijze et al^[21] tried to perform quantitative analysis, they only included Bond et al’s study.^[40] Moreover, the five-point satisfaction rating (score, 0–4) was incorrectly described as a six-point system (score, 0–5). This study found that the overall satisfaction of surgical treatment and

nonsurgical treatment was high, and there was no statistical difference. The participants in Bond et al’s study^[40] had different job functions. They were young military personnel aged 18–34 years. Their postoperative recovery was quick so their satisfaction was generally high. This may be the main source of heterogeneity.

Surgical treatment and nonsurgical treatment showed no significant difference in pain at the short-term and final follow-ups. Dias et al^[42] used an alternative approach called “aggressive conservative treatment” to achieve effective therapeutic effects, and this may be also a source of heterogeneity. A treatment protocol^[50] also proposed “non-invasive surgery,” in which all non-displaced scaphoid fractures were first treated with nonsurgical treatment, and if there was no sign of union at the fracture site at week 12, further surgery was considered.

The time to union and convalescence was shorter after surgical treatment than after nonsurgical treatment. The main reason for this finding may be as follows: long-term plaster fixation leads to joint stiffness, muscle weakness, and failure to effectively pressurize the fracture site.^[51–53] In the study of time to union, the surgical treatment group was treated with percutaneous fixation without open reduction and internal fixation. Thus, the time to union of percutaneous fixation was shorter than that of nonsurgical treatment. The clinical heterogeneity of this outcome measure was large, mainly because the time to union, as an important indicator reflecting the therapeutic effect, was difficult to measure, and imaging instruments with different precisions resulted in inaccurate results.^[37,54] For example, Bond et al^[40] used x-rays to evaluate union once every 2 weeks. Lin et al^[26] used computed tomography scans and Mimics software to assess union. With regard to the convalescence, subgroup analysis according to the surgical method found that the convalescence

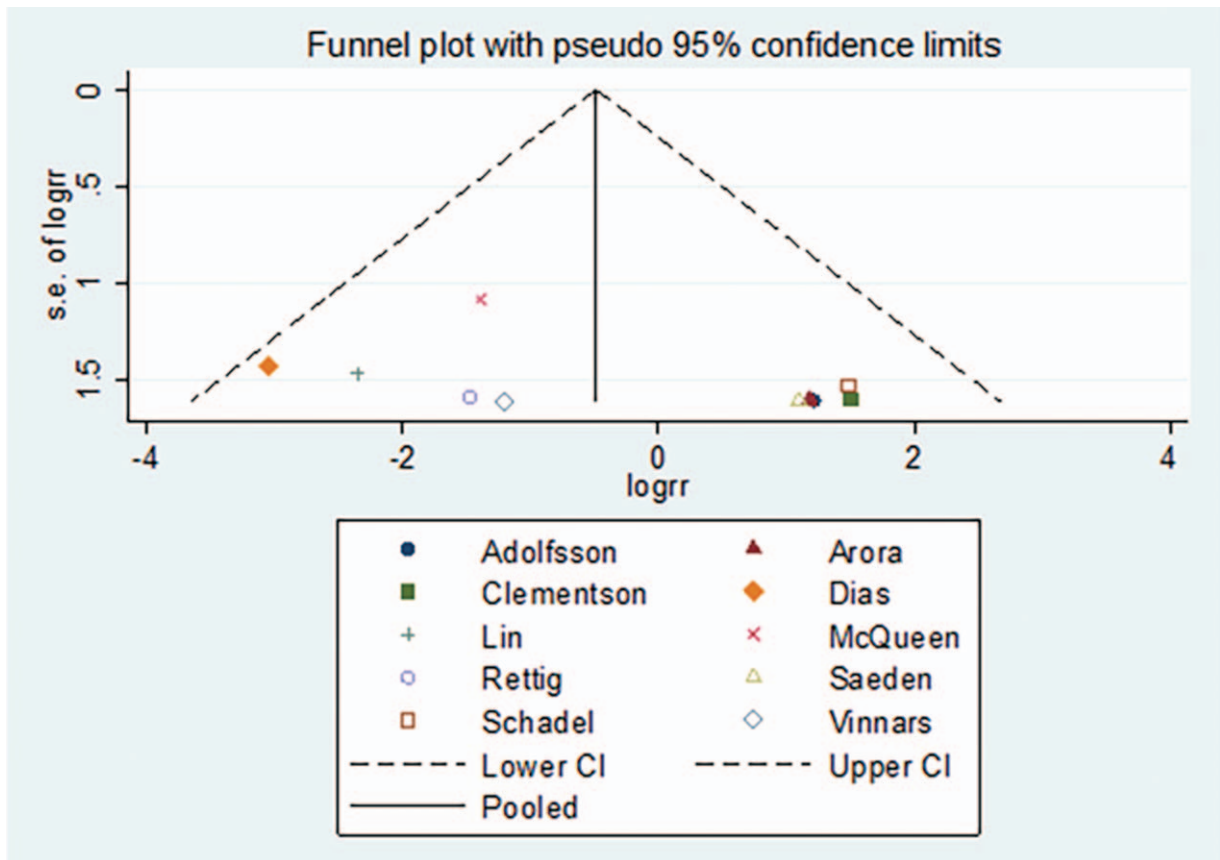


Figure 11. Funnel plot for the incidence rate of nonunion.

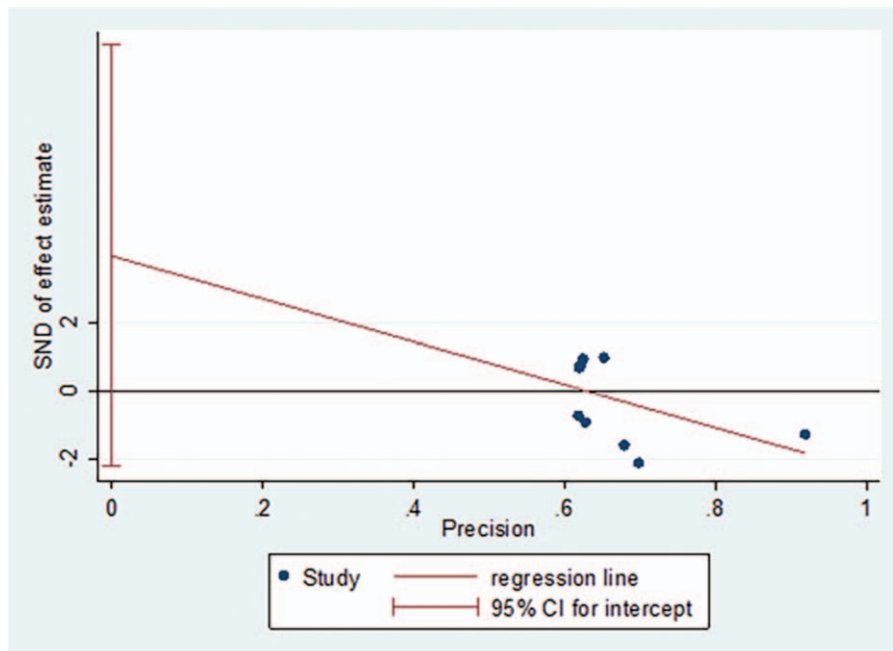


Figure 12. Egger's regression plot for the incidence rate of nonunion.

was shorter in the percutaneous fixation group than in the nonsurgical treatment group, and there was no statistical difference in the convalescence between the open reduction fixation group and nonsurgical treatment group. The possible explanations for this finding are that percutaneous fixation of scaphoid fractures provides effective pressure on the fracture ends, does not require the articular capsule to be cut, causes less damage to regional soft tissue, and does not damage the peripheral ligaments and nerves, thereby avoiding further aggravation of the wrist injury and obviously shortening the convalescence.^[23,55,56] Open reduction and internal fixation may increase injury to the associated ligaments and nerves, which is not conducive to the healing of soft tissue. Postoperatively, it is often necessary to supplement with external fixation, which results in joint stiffness and makes surgery less effective in shortening the convalescence.^[57–59]

The incidence of nonunion was lower after surgical treatment (2.36% [7/296]) than after nonsurgical treatment (6.55% [19/290]). Vinnars et al's study^[45] included the scaphoid waist and distal and proximal ends. It was not possible to extract only part of the scaphoid wrist data. Therefore, after retaining the data analysis, the data were carefully eliminated for sensitivity analysis, and it was found that the conclusion was unchanged. The subgroup analysis found that the incidence of nonunion was lower in the open reduction fixation group than in the nonsurgical treatment group; there was no significant difference in the incidence of nonunion between the percutaneous fixation group and nonsurgical treatment group. Previously, we empirically and mistakenly considered percutaneous fixation as a minimally invasive surgery that can achieve the goal of pressurizing the fracture end without destroying blood flow of the soft tissue around the fracture site, and promote fracture union. Alshryda et al^[50] also unexpectedly discovered that contrary to their expectations, open reduction and internal fixation is superior to percutaneous treatment in fracture union. A possible explanation for this result is that open reduction and internal fixation can remove foreign matter, such as a blood clot, crushed bone, and broken bone fragments in the tissue; therefore, more accurate reduction and sufficient pressure can better stimulate the increase of blood supply, thereby reducing the incidence of nonunion.^[10,20,21,50,59–62] Conversely, percutaneous fixation is performed blindly so a blood clot left in the tissue may result in inflammatory irritation to the blood supply of the scaphoid bone, resulting in less effective fracture union.^[50]

4.3. Strengths and limitations

In addition to conventional outcome measures, this meta-analysis added the degree of patient satisfaction and pain that were ignored or insufficiently investigated in previous meta-analyses. Additionally, we included Chinese and English studies, RCTs, and cohort studies; expanded the number of primary documents; and increased data sources for outcomes. The GRADEpro system was also used to assess the quality of the evidence.

However, this meta-analysis still has the following limitations. First, different data structure standards reported by various literatures make it impossible to extract the data from some studies, resulting in an insufficient number of basic literatures. Second, because of the lack of age-related data in the included studies, we could not assess the effect of age on outcome measures for surgical and nonsurgical treatments among patients of different ages.^[63]

5. Conclusions

For scaphoid waist fractures with slight or no displacement, there was no statistical difference in patient satisfaction, pain, and DASH scores between surgical treatment and nonsurgical treatment. Closed surgical treatment can shorten the time to union and convalescence, and open reduction can reduce the incidence of nonunion. On the basis of this conclusion, chief physicians can consider which treatment to use according to the patient's clinical situation and their subjective intention.

5.1. Implications for Future Research

Future research teams should focus on patient satisfaction and pain indicators, and further explore the effects of percutaneous and open surgery on the time to union, recovery, and incidence of nonunion to provide recommendations for treating scaphoid fractures. Furthermore, in future clinical studies, investigators should carefully design high-quality study protocols, pay attention to the different nature of the patients' job type, and use standardized observation standards, measurement standards, and record forms in measurement analysis to develop a unified display method. Thus, the meta-analysis can lead to a precise conclusion.

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