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Original Research

## Clinical and Radiological Outcomes of Scaphocapitate Fusion in Kienböck Disease: A Systematic Review and Meta-Analysis



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**Purpose:** To report the functional and radiological outcomes of scaphocapitate (SC) arthrodesis in the treatment of Kienböck disease.

**Methods:** This meta-analysis was conducted with adherence to PRISMA guidelines. Google Scholar, PubMed, Cochrane and Virtual Health Library were searched from inception until November 2022. All original studies that investigated the outcomes of scaphocapitate fusion in Kienböck disease were included. Exclusion criteria were arthroscopically performed fusions, concomitant radial shortening, traumatic or other etiologies of lunate avascular necrosis, and studies published in languages other than English. Outcomes of interest were pre- and post-operative wrist range of motion, VAS score, functional scores, radiological outcomes, surgical technique, complication rate and reoperation rate.

**Results:** The total number of included participants was 203 from 11 articles. The results showed no significant differences pre- and post-operatively in terms of wrist flexion, extension and ulnar deviation. However, there was a significant reduction in radial deviation after the surgery (WMD  $-2.30$ ; 95% CI,  $-4.26$  to  $-0.33$ ). Moreover, a significant increase was noticed in grip strength in Kg (WMD  $13.29$ ; 95% CI,  $3.21$ – $23.37$ ) and mmHg post-operatively (WMD  $23.75$ ; 95% CI,  $17.56$ – $29.94$ ). In addition, the models demonstrated significant decrease in carpal height (WMD  $-0.01$ ; 95% CI,  $-0.02$  to  $0.00$ ), scapholunate angle (WMD  $-12.11$ ; 95% CI,  $-20.46$  to  $-3.77$ ) and radioscapoid angle after the surgery (WMD  $-12.09$ ; 95% CI,  $-15.51$  to  $-8.67$ ). The pooled overall rate of complication and reoperation rates were 24% (95% CI, 6%–47%) and 14% (95% CI, 3%–31%), respectively.

**Conclusions:** Scaphocapitate arthrodesis is an effective procedure for treatment of Kienböck disease. This procedure is associated with satisfactory functional outcomes and significant improvement in pain scores and grip strength. Further studies with larger sample sizes and reduced heterogeneity are needed for a better evaluation of the results.

**Clinical relevance:** Scaphocapitate arthrodesis is a recommended surgery for Kienböck disease with satisfactory functional and radiological outcomes. However, patients should be counseled on the possible complications and reoperation rate.

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Kienböck disease is avascular necrosis of the lunate. The pathophysiology of this disease is poorly understood and has been linked to an interplay of different lunate and wrist risk factors.<sup>1,2</sup> Repetitive stress and pathological loads applied to “at-risk” lunate and wrist can lead to disruption of the lunate blood supply,

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**Table 1**  
Quality Assessment of the Included Studies Using the Joanna Briggs Institute Critical Appraisal Tool

Study Question	Eid and Alsoufi <sup>19</sup>	Luegmair et al <sup>14</sup>	Zakzouk et al <sup>23</sup>	Rhee et al <sup>13</sup>	Charre et al <sup>20</sup>	Özdemir et al <sup>21</sup>	Abodonia et al <sup>24</sup>	Hasan et al <sup>25</sup>	Goyal et al <sup>11</sup>	Meena et al <sup>22</sup>	Park et al <sup>15</sup>
Were there clear criteria for inclusion in the case series?	No	Yes	Yes	Yes	Yes	Yes	Not clear	Yes	Yes	Yes	Yes
Was the condition measured in a standard, reliable way for all participants included in the case series?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were valid methods used for the identification of the condition for all participants included in the case series?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Did the case series have consecutive inclusion of participants?	Not clear	Not clear	Not clear	Not clear	Not clear	Not clear	Not clear	Not clear	Not clear	Yes	Not clear
Did the case series have complete inclusion of participants?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was there a clear reporting of the demographics of the participants in the study?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was there a clear reporting of clinical information of the participants?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were the outcomes or follow-up results of cases clearly reported?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the statistical analysis appropriate?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

subsequent lunate osteonecrosis, collapse, and eventually alteration of the wrist joint biomechanics.<sup>3–7</sup>

Despite the fact that the treatment of Kienböck disease is still controversial, its management depends on the clinical presentation and radiological stages of the disease. The surgical options to treat this disease can be categorized into lunate unloading, vascularized bone grafts, and salvage procedures.<sup>8,9</sup>

In case of lunate collapse and altered carpal mechanics, a motion-sparing salvage procedure in the form of a limited wrist fusion is a viable option. Scaphocapitate arthrodesis is a type of limited intercarpal fusion described by Pisano et al<sup>10</sup> and aims to reduce the axial load across both the radiolunate and lunocapitate joints.<sup>11</sup> Many studies have shown promising outcomes of this procedure because it is considered a predictable fusion with satisfactory results in preventing further collapse of the carpus, decreasing pain, and improving functional outcomes.<sup>12–15</sup>

Therefore, the aim of this meta-analysis was to report the outcomes of scaphocapitate arthrodesis in the treatment of Kienböck disease in terms of radiological and functional parameters. We hypothesized that this procedure provides improved postoperative pain, grip strength, and functional outcome scores, in addition to preventing further carpal collapse.

## Materials and Methods

This systematic review and meta-analysis was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.<sup>16</sup> The protocol was registered in advance on the International Prospective Register of Systematic Reviews with the registration number: CRD42023390810.

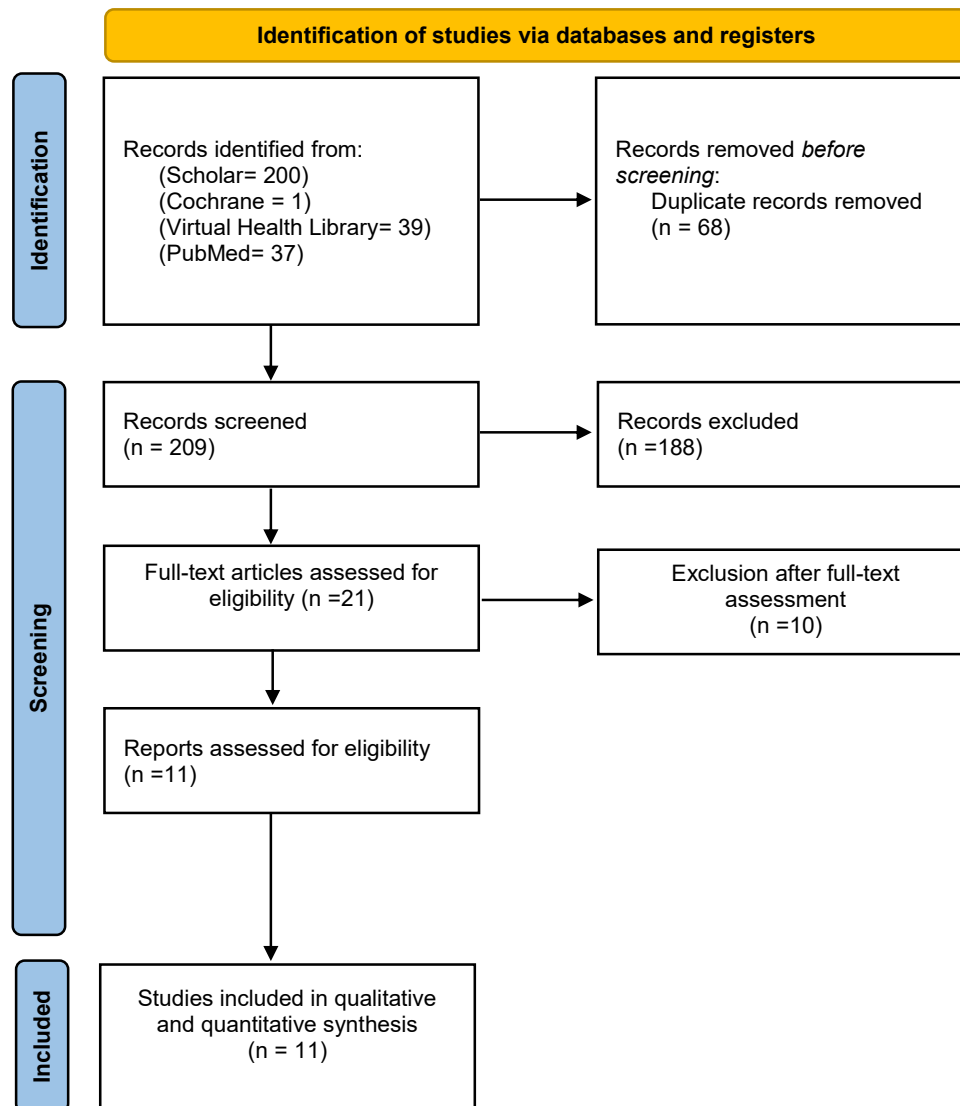
## Information sources and search strategy

PubMed, Google Scholar Virtual Health Library and the Cochrane Library databases were searched from the study's inception until November 2022 for literature investigating the outcomes of scaphocapitate fusion in Kienböck disease. The following keywords were used: Scaphocapitate AND (Fusion or Arthrodesis) AND Kienbock\*. Two authors (A.H. and F.B.) performed an independent and blinded study selection process based on titles and abstracts. A full-text review was performed for the eligible studies as per the eligibility criteria mentioned below. Any conflict regarding any study was resolved by a discussion with a senior author (E.H.).

The visual analog scale (VAS) score was the primary outcome. The secondary outcomes were wrist range of motion (ROM), functional scores (*Quick* Disabilities of the Arm, Shoulder, and Hand [*QuickDASH*] score, modified Mayo score, and Patient-Rated Wrist Evaluation [PRWE] score), radiological outcomes (radioscaphoid angle, carpal height ratio, scapholunate angle, and ulnar variance), complications, and reoperation rate.

## Eligibility criteria

The inclusion criteria included all original studies that investigated the outcomes of scaphocapitate fusion in Kienböck disease. We excluded arthroscopically performed fusions, concomitant radial shortening procedures, and traumatic or other etiologies of lunate avascular necrosis for the exclusion criteria. In addition, biomechanical studies, cadaveric studies, review articles, reports, studies with incomplete or nonextractable data, and studies published in languages other than English were excluded.



**Figure 1.** Search strategy flowchart.

#### Data collection process and data items

The following data were collected: studies' characteristics (authors' names and study year), patients' demographics (age and sex), follow-up duration, preoperative and postoperative wrist ROM, stage of the disease, VAS and functional scores (*QuickDASH* and modified Mayo scores), radiological outcomes (radioscaphoid angle, carpal height ratio, scapholunate angle, and ulnar variance), surgical technique, complications, and reoperation rate.

#### Qualitative assessment (risk of bias)

Two authors (A.H. and O.A.) performed an independent and blinded evaluation of the methodological quality of the included studies using the Joanna Briggs Institute critical appraisal tool.<sup>17</sup> [Table 1](#) demonstrates the quality assessment of the included studies.

#### Data analysis

Mean and standard deviation were analyzed for continuous outcomes, and whenever median and interquartile were

encountered, they were converted to mean and standard deviation using the method by Wan et al.<sup>18</sup> The effect size was reported using the weighted mean difference (WMD) and its related 95% confidence intervals (95% CIs) for continuous outcomes. The effect size of the rates of the events was the prevalence with its related 95% CI. The studies were pooled using a random effect model if  $I^2$  was  $>50\%$ , whereas they were pooled using a fixed effect model when  $I^2$  was  $<50\%$ . The heterogeneity of the included studies was assessed using the Cochrane Q statistic and  $I^2$ . The analysis was performed using Meta XL, version 5.3 (EpiGear International).

## Results

#### Search results

The search yielded 277 articles, of which 68 were duplicates. Two hundred nine studies were screened using the titles/abstracts, and 188 articles were excluded. The remaining 21 articles were screened using the full text, and 10 studies were excluded. Finally, 11 articles were included in the analysis ([Fig. 1](#)).

**Table 2**  
Characteristics of the Included Studies

Study	Design	Level of Evidence	Number of Patients (Male)	Follow-up (Range)	Lunate Excision	Classification	Complications	Reoperation
Eid and Alsoufi <sup>19</sup>	Case series	IV	19 (13)	20 mos (12–27)	No	III	1 Transient paresthesia of the sensory radial nerve	-
Luegmair et al <sup>14</sup>	Case series	IV	10 (7)	8.75 y (1.3–18.6)	5 Yes 5 No	IIIB and IV	1 Nonunion 5 Radioscaphoid arthritis	1 Proximal row carpectomy 1 Radial styloidectomy 1 Extensor pollicis longus tenolysis
Zakzouk et al <sup>23</sup>	Case series	IV	18 (13)	28 mo (18–61)	No	III	12 Persistent pain 2 Radioscaphoid arthritis	-
Rhee et al <sup>13</sup>	Case series	IV	27 (17)	60 mos (12 months–16 y)	11 No Yes Subtotal 12: moderate-to-severe lunate fragmentation Partial: 4 minimal fragmentation	III and IV	5 Persistent pain 2 Complex regional pain syndrome 11 Progression of radioscaphoid and/or mid-carpal arthritis	1 Radial styloidectomy, screw removal, ulnar styloidectomy, and partial wrist denervation 1 Partial wrist denervation and ulnar styloidectomy 1 Staple removal 2 Conversion to the total wrist
Charre et al <sup>20</sup>	Case series	IV	17 (7)	10.7 y (2.3–22)	Yes	IIIA, IIIB, and IV	2 Complex regional pain syndrome 2 Superficial infections 1 Psuedoarthrodesis 2 Styloscaphoid Arthritis	-
Özdemir et al <sup>21</sup>	Case series	IV	9 (3)	17.33 ± 4.69 mos (12–24)	Yes	IIIB	Not mentioned	-
Abodonia et al <sup>24</sup>	Case series	IV	10 (4)	14.2 ± 6.8 mos (6–24)	Yes	III	Not mentioned	-
Hasan et al <sup>25</sup>	Case series	IV	20 (14)	6 mos (6–12)	No	II and IIIA	1 Superficial wound infection	-
Goyal et al <sup>11</sup>	Case series	IV	11 (3)	18 mos (18–26)	Both performed (not specified)	IIIA and IIIB	Not mentioned	-
Meena et al <sup>22</sup>	Case series	IV	23 (9)	8.1 y (7–10)	No	IIIA and IIIB	2 Nonunions	-
Park et al <sup>15</sup>	Case series	IV	39 (18)	40 mos (12 months–12 y)	Yes Partial: if fragmentation is minimal Subtotal: if lunate fragmentation is moderate to severe	IIIA, IIIB, and IV	12 Radioscaphoid arthritis	2 Removal of K-wires

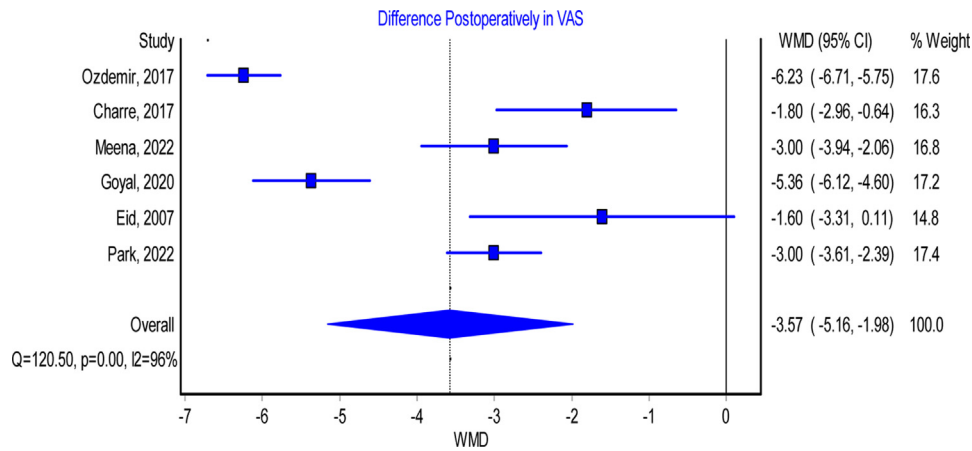


Figure 2. The difference in preoperative and postoperative pain VAS scores.

Table 3  
Preoperative and Postoperative ROM, Grip Strength, Pain Scores, Radiological Outcomes, and Functional Outcomes

Outcome	Preoperative Mean	Postoperative Mean	WMD	P value
<b>ROM</b>				
Flexion	33.7	33.5	1.3	NS
Extension	39.1	38.1	0.4	NS
Ulnar deviation	20.3	22.4	0.4	NS
Radial deviation	17.5	15.4	-2.3	.03*
<b>Grip strength</b>				
Kg	25.1	33.4	13.3	.00*
mm Hg	155.6	180.5	23.8	.00*
<b>Pain</b>				
VAS	6.3	1.7	-3.8	.00*
<b>Radiological outcomes</b>				
CHR	0.46	0.46	-0.01	.04*
mCHR	1.4	1.4	-0.1	NS
SLA	48.8	37.1	-12.1	.00*
RSA	60.8	51.4	-12.1	.00*
<b>Functional outcomes</b>				
QuickDash score	-	28.1	-	-
Modified Mayo score	-	59.9	-	-
PRWE score	-	31.7	-	-

CHR, carpal height ratio; mCHR, modified carpal height ratio; RSA, radioscaphoid angle; SLA, scapholunate angle.

\* Significant.

Characteristics of the included studies

The total number of included patients was 203 from 11 articles, of whom 53.2% were men. The mean patient follow-up of the included studies was 50.5 ± 14.3 months. The characteristics of the included studies are summarized in Table 2.

VAS score

Six studies evaluated the postoperative VAS score.<sup>11,15,19–22</sup> Overall, there was a significant decrease in the postoperative VAS score (Fig. 2; WMD, -3.6; 95% CI, -5.2 to -2.0; P =.00), with significant heterogeneity (I<sup>2</sup> = 96%; P =.00). Table 3 summarizes the details of the preoperative and postoperative pain score means.

ROM

Nine studies evaluated the postoperative wrist flexion ROM<sup>11,13,14,20–25</sup>; there was no significant difference before and after surgery (Fig. 3; WMD, 1.3; 95% CI, -3.0 to 5.5, P = NS), but the heterogeneity was significant (I<sup>2</sup> = 82%; P value =.00). Nine studies investigated wrist extension.<sup>11,13,14,20–25</sup> Overall, there was no

significant difference in wrist extension after surgery (Fig. 3; WMD, -0.4; 95% CI, -3.5 to 4.2), but the heterogeneity was significant (I<sup>2</sup> = 75%; P =.00). Eight studies compared the preoperative and postoperative ulnar deviation.<sup>11,13,14,20,22–25</sup> Overall, there was no significant difference in ulnar deviation after the surgery (Fig. 3; WMD, -1.6; 95% CI, -4.93 to 1.66; P value = NS), but heterogeneity was significant (I<sup>2</sup> = 77%; P =.00). Eight studies evaluated postoperative radial deviation.<sup>11,13,14,20,22–25</sup> Overall, there was a significant reduction in radial deviation after surgery (Fig. 3; WMD, -2.3; 95% CI, -4.3 to 0.3; P v =.03) with significant heterogeneity (I<sup>2</sup> = 73%; P =.00). Table 3 summarizes the details of the preoperative and postoperative ROM means.

Grip strength

Three studies evaluated the grip strength in mm Hg after surgery.<sup>20,24,25</sup> Overall, there was a significant increase in postoperative grip strength (preoperative: mean, 155.6; 95% CI, 49.1–262.0; postoperative: mean, 180.5; 95% CI, 93.6–267.5) (Fig. 4; WMD, 13.3; 95% CI, 3.2–23.4; P value =.00) and heterogeneity was significant (I<sup>2</sup> = 95%; P =.00). Moreover, seven studies evaluated the postoperative grip strength in kg.<sup>11,13,15,20–22</sup> Pooling

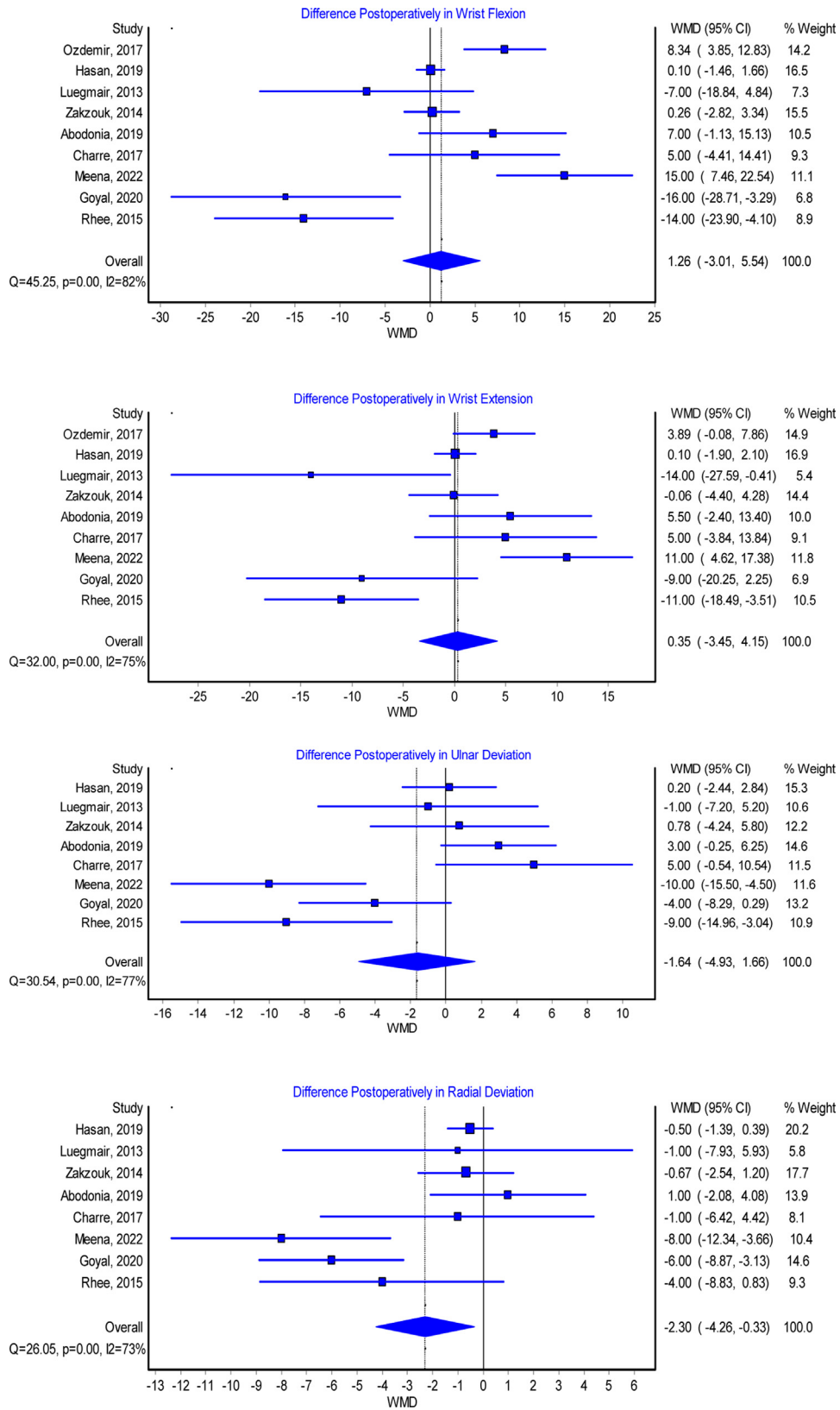


Figure 3. The difference in preoperative and postoperative wrist ROM.

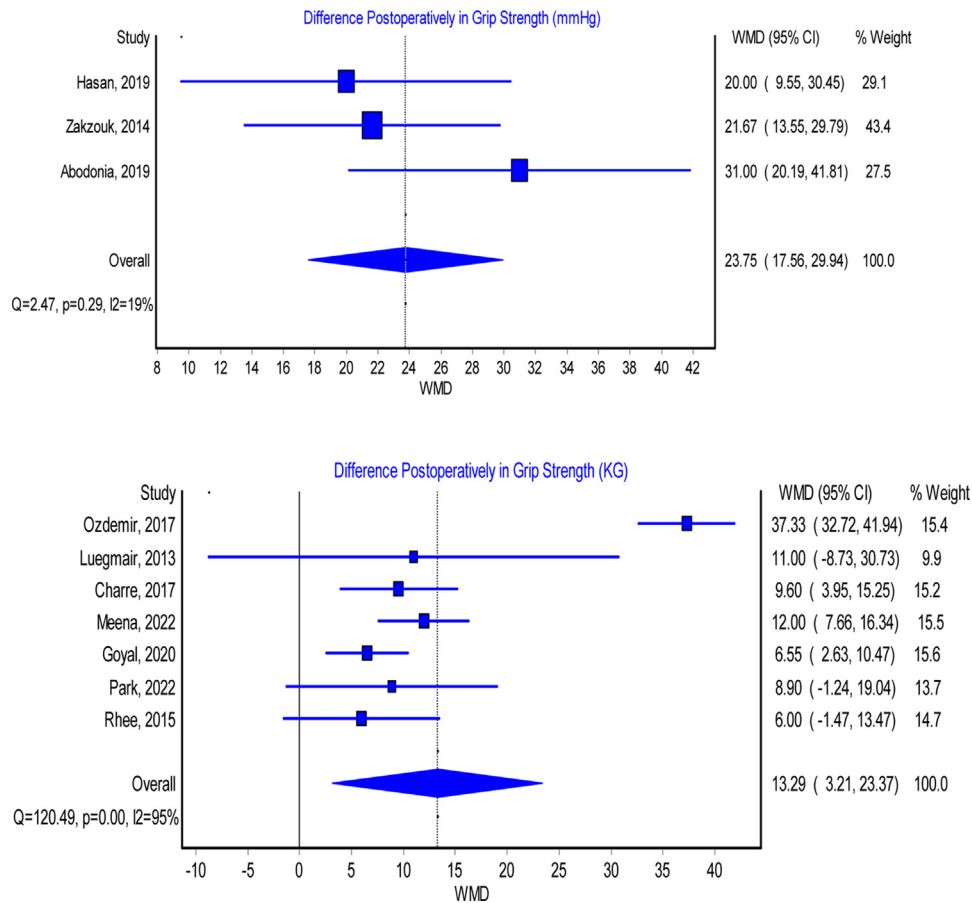


Figure 4. The difference in preoperative and postoperative grip strength.

these studies showed a significant increase in postoperative grip strength (preoperative: mean, 25.1; 95% CI, 16.8–33.4; postoperative: mean, 40.4; 95% CI, 23.4–57.3) (Fig. 4; WMD, 23.8; 95% CI, 17.6–29.9;  $P = .00$ ), and heterogeneity was insignificant ( $I^2 = 19\%$ ;  $P = .29$ ). Table 3 summarizes the details of the preoperative and postoperative grip strength.

#### Functional Outcomes

Six studies evaluated the postoperative QuickDASH score.<sup>11,14,15,19,20,22</sup> Overall, the mean postoperative QuickDASH score was 28.1 (Fig. 5; 95% CI, 21.3–34.9) with an insignificant heterogeneity ( $I^2 = 0\%$ ;  $P$  value = NS). Moreover, two studies evaluated the modified Mayo score.<sup>15,24</sup> Overall, the mean postoperative modified Mayo score was 59.9 (Fig. 5; 95% CI, 18.7–101.0), and heterogeneity was significant ( $I^2 = 87\%$ ;  $P = .01$ ). In addition, three studies assessed postoperative PRWE scores.<sup>11,20,22</sup> Overall, the mean postoperative PRWE score was 31.7 (Fig. 5; 95% CI, 18.7–44.8), and heterogeneity was insignificant ( $I^2 = 0\%$ ;  $P$  value = .98).

#### Radiological outcomes

Four studies evaluated the postoperative carpal height ratio.<sup>11,14,20,23</sup> Pooling these studies revealed a significant decrease in the carpal height ratio (Fig. 6; WMD  $-0.01$ ; 95% CI,  $-0.02$  to  $0.00$ ;  $P = .04$ ) with an insignificant heterogeneity ( $I^2 = 0\%$ ;  $P = .69$ ). Three studies investigated the modified carpal height ratio.<sup>13,21,22</sup> Overall, there was an insignificant difference in the modified carpal height

ratio between before and after the surgery (Fig. 6; WMD,  $-0.1$ ; 95% CI,  $-0.3$  to  $0.1$ ;  $P$  value = NS), and heterogeneity was insignificant ( $I^2 = 84\%$ ;  $P = .00$ ). Furthermore, three studies evaluated the scapholunate angle.<sup>11,21,22</sup> Pooling these studies showed a significant decrease in the scapholunate angle after surgery (Fig. 6; WMD,  $-12.1$ ; 95% CI,  $-20.5$  to  $-3.8$ ;  $P = .00$ ) with a significant heterogeneity ( $I^2 = 85\%$ ;  $P = .00$ ). Five studies evaluated the radioscapoid angle.<sup>11,13,14,20,22</sup> Overall, there was a significant decrease in the radioscapoid angle after surgery (Fig. 6; WMD,  $-12.1$ ; 95% CI,  $-15.5$  to  $-8.7$ ;  $P = .00$ ) with an insignificant heterogeneity ( $I^2 = 45\%$ ;  $P = .12$ ). Table 3 summarizes the details of the preoperative and postoperative radiological findings.

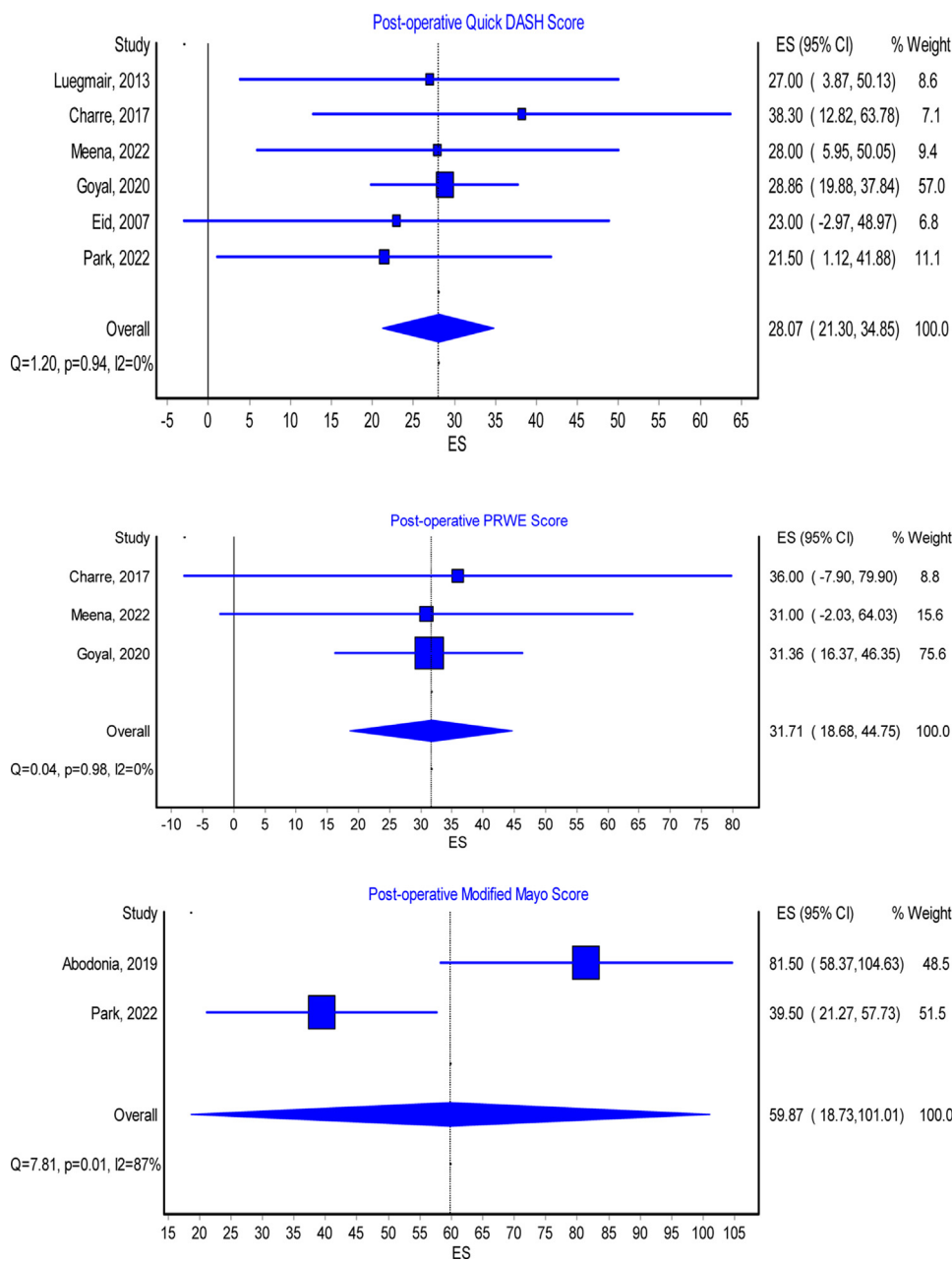
#### Complications and reoperation rate

Seven studies reported postoperative complications.<sup>13–15,19,20,22,23,25</sup> The overall complication pooled rate was 24% (95% CI, 0.1–0.5) with a significant heterogeneity ( $I^2 = 87\%$ ;  $P = .00$ ). In addition, three studies evaluated the reoperation rate.<sup>13–15</sup> The pooled reoperation rate was 14% (95% CI, 3%–31%), and heterogeneity was insignificant ( $I^2 = 62\%$ ;  $P = .07$ ).

#### Discussion

This meta-analysis demonstrated that patients with Kienböck disease who underwent scaphocapitate fusion had a significant improvement in grip strength, substantial pain relief, and a significant reduction in radioscapoid angles. On the other hand, these patients had a significant reduction in postoperative radial





**Figure 5.** Postoperative functional outcome scores (QuickDASH, PRWE, and modified Mayo scores).

deviation. Furthermore, the reduction in the scapholunate angle was found to be insignificant. The overall reported complication and reoperation rates were 24% and 14%, respectively.

Limited carpal arthrodesis is one of the procedures used to treat Kienböck disease, and it is well-known as a motion-limiting procedure. Özdemir et al<sup>21</sup> and Meena et al,<sup>22</sup> who did not include stage four cases, were the only studies that showed significant improvement in flexion and extension after surgery. The improvement in ROM can be explained by including patients with earlier disease stages and the imprecise estimation of preoperative ROM that is usually restricted because of pain. On the contrary, most included studies showed no significant difference in flexion and extension before and after the surgery.<sup>13,14,20,23,24</sup> Nevertheless, the study by Rhee et al,<sup>13</sup> in which >40% of the patients were in the osteoarthritis stage of the disease, reported a reduction in postoperative flexion and extension. This analysis showed that the main

change in the postoperative ROM was the reduction in radial deviation with no significant difference across the other motions. However, all studies concluded that the final ROM was functional and satisfactory.<sup>11,13–15,19–25</sup>

Patients with Kienböck disease present a notable loss of grip strength. Moreover, pain is a major limiting factor that restricts the functionality of the wrist in such cases. This meta-analysis proved that scaphocapitate arthrodesis significantly improved both pain scores (WMD,  $-3.8$ ;  $P = .00$ ) and grip strength (in kg: WMD,  $13.3$ ;  $P = .00$ ; in mm Hg: WMD,  $23.8$ ;  $P = .00$ ), which is in agreement with what has been reported in the literature.<sup>10,12</sup> However, the debate on whether to excise the lunate or not is still unresolved. Rhee et al<sup>13</sup> and Park et al<sup>15</sup> did not support lunate excision. This is consistent with the study by Budoff and Gable,<sup>26</sup> which proved that lunate excision creates more stress on the radioscaphiocapitate ligament, leading to carpal-ulnar translation. On the other hand,



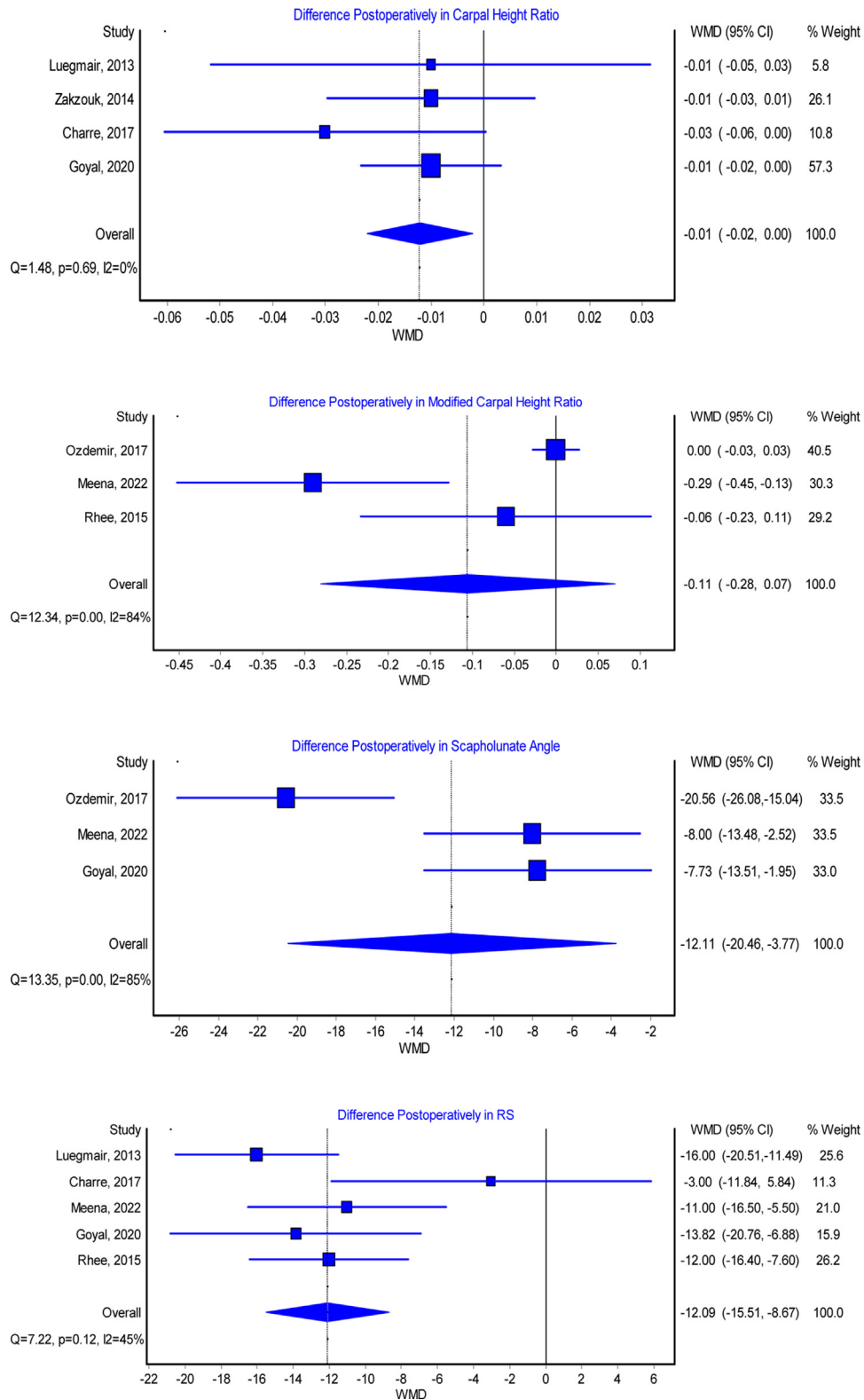


Figure 6. The difference in pre-and postoperative radiological outcomes.

Charre et al<sup>20</sup> showed no benefit or harm from excising the lunate. The inconsistency of the results in the literature can be attributed to the variations in the disease stages in addition to the non-standardized surgical techniques. However, this is still debatable, and the question of whether to excise the lunate could not be

investigated in this meta-analysis because of low number of included studies.

Scaphoid alignment is substantial in restoring wrist biomechanics and preventing progressive degenerative changes. Five of the included studies evaluated the radioscaphoid angle, and their

analysis showed significant correction after surgery with a postoperative mean of 51.4° (WMD, -12.1; 95% CI, -15.5 to -8.7;  $P = .00$ ).<sup>11,13,14,20,22</sup> This is consistent with cadaveric study conducted by Minamikawa et al,<sup>27</sup> in which he determined the ideal radioscapoid angle (30°–57°). In addition, Sennwald and Ufenast<sup>12</sup> reported an improvement in this angle to a mean of 52° after surgery. Moreover, radioscapoid osteoarthritis evident on x-rays has been reported to reach up to 50%.<sup>7</sup> In this meta-analysis, this was the most commonly reported complication after scaphocapitate fusion.<sup>13–15,20,23</sup> This can be attributed to the increased loading over the radioscapoid articulation after the fusion. Furthermore, a reoperation rate was reported in 3 studies<sup>13–15</sup> with an overall rate of 14% and conversion to total wrist arthrodesis in 2 cases<sup>13</sup> and one case of proximal row carpectomy.<sup>14</sup>

### Limitations

To our knowledge, this is the first meta-analysis to investigate the outcomes of scaphocapitate arthrodesis. Although significant conclusions can be derived from this study, some limitations should be acknowledged. First, there was high heterogeneity in some of the included studies, which can be explained by the different characteristics of the included patients and variable follow-up durations. Second, like all meta-analyses, the risk of bias in the primary studies could not be eliminated. Furthermore, the lack of preoperative functional scores limited the ability to conduct preoperative and postoperative comparisons. In addition, because of small number of included studies and the lack of details in reporting the surgical technique used, this meta-analysis could not investigate the outcomes of excising/sparing the lunate or the effect of other variables that might have influenced the outcomes, such as the fixation method. Furthermore, a sub-analysis according to the disease stage could not be performed because of small number of studies, and the included studies did not specify the outcomes according to the stage of the disease. Moreover, because the studies included in this meta-analysis are only a small case series, the available literature upon which this meta-analysis was conducted is considered to be of low-level evidence (level IV). Therefore, well-conducted studies with large sample sizes are required to comprehensively assess scaphocapitate arthrodesis.

In summary, scaphocapitate arthrodesis is an effective procedure for treating Kienböck disease. This procedure is associated with satisfactory functional outcomes and significant improvement in pain scores and grip strength. Further studies with larger sample sizes and reduced heterogeneity are needed to evaluate the results better.

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