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1 **Title:** Proximal humeral fracture. A commentary on systematic reviews of surgical versus non-surgical  
2 management in older adults.

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9 **Keywords:** Proximal Humeral Fracture, management, surgical, non-surgical, older adults

10 **Abstract:**

11 *Background*

12 Proximal humeral fractures (PHFs) are common fractures in older adults and their prevalence is on the  
13 rise. Recovery following this fracture can be complex and disabling. Treatment varies from non-surgical  
14 management such as immobilisation to surgical procedures, with choice dependent on type and severity  
15 of fracture and patient health.

16 *Objective*

17 Several systematic reviews have considered the evidence for non-surgical versus surgical management of  
18 PHF in older adults. This commentary considers these findings for clinical practice and further research.

19 *Methods*

20 Three systematic reviews exploring non-surgical versus surgical management were selected based on the  
21 quality of their included evidence, and individually critically appraised. Findings from the reviews were  
22 reported for each outcome, and the implications considered for clinical practice and future research.

### 23 *Results*

24 Findings from the three reviews suggest that surgical management of PHF in older adults does not result  
25 in better functional outcomes or quality of life and non-surgical management should achieve acceptable  
26 upper limb function while decreasing the risks of surgery. More complex three-part fractures may also  
27 be managed non-surgically with fair to good functional results relative to fracture severity.

### 28 **Conclusion**

29 The findings align with current guidance to offer non-surgical management to uncomplicated cases of PHF  
30 in adults and older adults. More complex three-part PHFs may also be managed well non-surgically. There  
31 is however a lack of evidence and guidance on the specifics of rehabilitation for this type of management  
32 and further research is needed to evaluate the factors that contribute to the effectiveness of non-surgical  
33 interventions.

### 34 **Introduction**

35 Proximal humeral fractures (PHF, or shoulder fractures) are painful and debilitating injuries and account  
36 for approximately 6% of all adult fractures [1]. PHF symptoms include pain, swelling, and loss of movement  
37 [2], with functional capacity impaired for an average of two to three months [3]. Recovery from a shoulder  
38 fracture can be a long and often incomplete process that can be hindered by complications [4], including  
39 long-term consequences of mal union, non-union, avascular necrosis, and traumatic arthritis [5]. PHFs are  
40 also associated with a higher risk of hospitalisation or further fracture within the first year, and an  
41 increased utilisation of healthcare services and hospital costs [6,7].

42 The incidence of PHF varies with estimations ranging from 45.7 per 100,000 person years in Australia to  
43 60.1 per 100,000 in Southern Europe and 74.2 per 100,000 in Northern Europe, during the period 2016-  
44 2018 [8-10]. The incidence of PHF is also increasing over time [9,10,11], with significant increases in  
45 females and older adults [8,9,11]. Shoulder fractures are most common in people over 65 who fall from  
46 a standing height, accounting for the third most common fracture in this population [12-15]. The  
47 escalating incidence of PHF in the older population is driven by an aging population, a suspected decline  
48 in the bone health of older adults and an increase in more severe falls [16,17].

49 The management of PHF varies from non-surgical management to surgical procedures, with choice of  
50 treatment depending on factors such as fracture type, severity and patient health status [18,19]. Non-  
51 surgical management of PHF usually involves a period of immobilisation (typically of three-four weeks)  
52 providing support and pain relief, followed by physiotherapy to restore function and mobility [20].  
53 Variation exists in the recommended period of immobilisation [21], however evidence suggests that early  
54 mobilisation (within one week) may have beneficial effects on function [22]. Current guidelines in England  
55 advise that surgical management should be considered for complex PHF in adults, whereas non-surgical  
56 management is recommended for uncomplicated injuries (National Institute for Health and Care  
57 Excellence [23]. The most common definition for PHF is the Neer classification system with fractures  
58 defined by the number of parts involved (one to four part) [24].

59 The increasing incidence of PHF, together with the uncertainty of treatment options, variations in practice  
60 and emerging research, all endorse the need for updated evidence. This commentary aims to critically  
61 appraise the methods used in three systematic reviews exploring surgical versus non-surgical  
62 management for PHF in older adults; Beks et al. 2018 [25], Handoll et al. 2022 [26], and non-surgical  
63 management in more complex three- and four-part fractures (Soler-Peiro et al. 2020) [27]. The findings  
64 are subsequently discussed in the context of clinical practice and further research.

65 **Methods**

66 The selection of reviews for this commentary was based on surgical versus non-surgical management of  
67 PHF in older adults, where evidence from the included studies' outcomes of interest was deemed to be of  
68 moderate to good quality. The reviews that matched these criteria explored randomised controlled trials  
69 (RCTs) or quasi RCTs pertinent to the treatment and rehabilitation of PHF in adults [26] or focused on  
70 surgical versus non-surgical management through RCTs and observational studies [25]. One review also  
71 reported outcomes for comparisons such as early mobilization versus delayed [26]. As our focus was on  
72 the comparison of surgical versus non-surgical treatment, only the outcomes related to this comparison  
73 were reported here. Despite the inclusion of similar trials across the two systematic reviews, we  
74 incorporated the less recent review [25], as the authors argued that the addition of observational studies  
75 provided a broader study population. Furthermore, they included an analysis of function by Constant-  
76 Murley score which was reported in the more recent review [26], but with limited data. This commentary  
77 also reports on a review of non-surgical management for more complex fractures (three and four-part  
78 fractures) that explored RCTs and observational studies for three- or four-part PHFs [27].

79 Using the PICO (Population, Intervention, Control, Outcome) variables, methodological components of  
80 clinical evidence were compared for each review (Table 1). Inclusion criteria were not specific to older  
81 adults, however all three reviews subsequently included older populations (mostly over 60). Exclusion  
82 criteria from the studies within the reviews consisted of fracture dislocations, open fractures, multiple  
83 trauma, clear indication for surgery and comorbidities precluding surgery. Outcomes for the three reviews  
84 included upper-limb function, quality of life, additional surgery, and adverse events. In one review,  
85 secondary outcomes for constant score, pain and power were reported for a limited number of studies  
86 and downgraded to mostly low or very low certainty evidence [26], and are therefore not reported here.  
87 Two reviews reported outcome follow-up periods of at least one year [25, 27], and one review reported  
88 at six months, one and two years [26].

89 (Insert Table 1 here)

90 Using the Joanna Briggs Institute critical appraisal checklist for systematic reviews and research syntheses  
91 [28], all three systematic reviews were judged to be methodologically robust (Table 2) with some areas of  
92 concern. These were: 1) lack of publication bias assessment in [26, 27], explained as being due to an  
93 insufficient number of trials, and 2) an unclear description of the number of reviewers for critical appraisal  
94 [27]. The use of an arbitrary score for study quality [25] was also questioned due to the difficulties this  
95 poses for valuing the importance of individual items. However, the subsequent analysis included studies  
96 of all quality and good quality which allowed for comparison. Thus, despite some concerns, the three  
97 systematic reviews were overall deemed to provide an accurate and comprehensive summary of the  
98 evidence available.

99 (Insert Table 2 here)

### 100 *Unions of effect*

101 Effect sizes are reported as mean difference (MD), standardised mean difference (SMD) or Risk Ratio (RR).  
102 SMD effect sizes are interpreted as small (0.2), moderate (0.5) or large (0.80 with a significance level of  
103  $p=0.05$  [29]. Heterogeneity is reported using the  $I^2$  statistic and interpreted as 0-40% (might not be  
104 important), 30-60% (may represent moderate), 50-90% (may represent substantial), 75-100% (may  
105 represent considerable) [30].

### 106 **Results**

107 Study characteristics (including reported primary outcome measures) are described for the three  
108 systematic reviews in Table 3.

109 (Insert Table 3 here)

110 Estimates of effectiveness from the meta-analyses reported in Beks et al. 2018 [25] and Handoll et al.  
111 2022 [26] can be found in Table 4. These include the reported outcomes of function, quality of life,

112 mortality, major reinterventions, adverse events, and include as assessment of quality. The conservative  
113 treatment of more complex fractures including the review by Solar-Peiro 2020 [27] is reported as a  
114 narrative only.

115 (Insert Table 4 here)

#### 116 *Function*

117 The most recent review [26] reported no important clinical difference in patient reported functional  
118 outcomes (physical function or shoulder and upper limb function) at six months, one- and two-years  
119 follow-up comparing surgical and non-surgical treatments of PHF, based on high certainty evidence [the  
120 authors have confidence that the true effect is similar to the estimated effect]. The earlier review [25]  
121 found similar findings in that there was no functional difference between the two groups at least one year  
122 post follow-up, based on mostly good quality evidence but with substantial heterogeneity. A sub-analysis  
123 of studies interpreted as good quality, showed no difference in surgical versus non-surgical treatment  
124 [25](MD=0.55, 95% CI: -2.93 to 4.03,  $p=0.76$ ).

#### 125 *Quality of life*

126 One review [26] reported no clinically important difference in quality of life (EQ-5D score  $>0.12$ ) between  
127 surgical and non-surgical treatment at one and two years follow up, based on high-and moderate certainty  
128 evidence respectively.

#### 129 *Mortality*

130 One review [26] reported no or little difference in mortality up to two years follow-up between surgical  
131 and non-surgical treatment, based on low certainty evidence [the true effect might be markedly different  
132 from the estimated effect] and no reported heterogeneity.

#### 133 *Major reinterventions*

134 Major re-interventions (additional and unplanned surgery for implant removal) occurred statistically more  
135 often with surgical treatment compared to non-surgical based on mostly good quality evidence and no  
136 reported heterogeneity [25]. A sub-analysis of studies interpreted as good quality showed a similar result  
137 (RR=2.52, 95% CI: 1.55 to 4.11). One review [26] reported a statistically higher risk of additional or  
138 secondary surgery in the surgery treatment group at two-year follow-up based on low certainty evidence.

#### 139 *Adverse events*

140 One review [26] reported a non-significant, higher risk of complications with surgery at two-year follow-  
141 up based on low certainty evidence (RR=1.46, 0.92 to 2.31, p=0.11). Looking at complications individually,  
142 one review [26] reported that nonunion and avascular necrosis were more common in the non-surgical  
143 group but stated that the clinical implications of these radiological findings were unclear as many cases  
144 were asymptomatic. One review [25] also reported that nonunion was statistically more common in the  
145 non-surgical group and there was no difference in the rate of avascular necrosis based on mostly good  
146 quality evidence and low reported heterogeneity. A sensitivity analysis of good quality studies maintained  
147 these findings.

#### 148 *Conservative treatment of more complex fractures*

149 Treatment of three-part fractures with conservative management resulted in fair to good functional  
150 outcomes (mean constant score, 64.5) at a minimum of 12 month follow up, based on evidence  
151 considered by the study authors to be mostly good quality [27]. For four-part fractures, lower functional  
152 outcomes were achieved (mean constant score 54.9). There were some complications reported for three  
153 and four-part fractures treated conservatively (21% malunion, 9% avascular necrosis) with less avascular  
154 necrosis reported in three-part, compared to four-part fractures (7 and 10% respectively). Malunion  
155 however was higher in the three-part fractures (27%) compared to four-part fractures (17%).  
156 Consolidation was achieved in 96% of three-part fractures and 90% of four-part fractures.

157



158 A sub-group analysis in Beks et al. 2018 [25] reported that in studies where patients with a three- or four-  
159 part fracture underwent treatment, there was no difference in functional outcome between operative  
160 and non-operative treatment (SMD 0.02, 95% CI: -0.20 to 0.24,  $p=0.86$ ).

161

## 162 **Commentary**

163 Using the JBI checklist [28], the three reviews overall can be considered to provide an adequate  
164 and comprehensive summary of evidence that address the question of interest. The findings  
165 suggest that for older adults, surgical management of PHF does not typically lead to better  
166 functional outcomes or quality of life compared to non-surgical approaches. Non-surgical  
167 management is likely to provide acceptable upper limb function while also reducing the risks  
168 associated with surgery. It is worth noting that in one review the functional outcome reported  
169 is based on studies of substantial heterogeneity [25]. However, the other review [26] reported  
170 high certainty GRADE evidence for functional outcomes.

171 These results align with NICE recommendations to offer non-surgical management as a definitive  
172 treatment for uncomplicated PHF in adults [23], and the review findings show that this is also  
173 relevant for older adults. Based on the review of more complex fractures [27], most three-part  
174 PHFs can also be managed non-surgically with fair to good functional results (in accordance with  
175 the severity of the fracture), a high rate of consolidation and few complications. Four-part PHFs  
176 also achieved a high rate of consolidation from non-surgical management and few complications  
177 but with poorer functional results than three-part PHFs. It is worth noting that in Handoll et al.  
178 2022 [26], 66% of the fractures in the study population were also three- or four-part fractures  
179 and in Beks et al. 2018 [25], a sub-group analysis of three- and four-part fractures showed no

180 difference in functional outcome between surgical and non-surgical treatment. Current NICE  
181 guidance however recommends that surgical management is considered for those with  
182 complicated fractures such as fractural dislocation or a split of the humeral head [23].

183 Despite the data supporting the use of non-surgical management for PHF, there is a lack of  
184 current evidence and guidance on the specifics of rehabilitation for this type of management.

185 The effectiveness of early versus delayed mobilisation after injury was explored, but the available  
186 data for this comparison were limited and uncertain [26]. Similarly, another systematic review  
187 found that early mobilisation may have a beneficial effect on function, but quality of evidence  
188 was low [31]. A more recent systematic review comparing early mobilisation (one week) to three-  
189 week immobilisation suggested early mobilisation may be beneficial for improving function at 6  
190 month follow-up with long-term results less certain [22]. Exercise programmes for PHF,  
191 supervised or non-supervised have not been shown to reduce impairment or improve activity  
192 [32]. The consequences of immobilising older people however, should be considered due to the  
193 potential impact of physical inactivity on both physical and mental health [33]. Where  
194 prescription of exercise is appropriate, evidence has suggested that starting exercise early  
195 combined with a shorter immobilisation period may be more effective than a longer  
196 immobilisation period [31,32,34]. When considering intensity of supervised exercise, one trial  
197 reported no advantages to a more intensive rehabilitation regime over a conventional  
198 programme [35]. Exercise programmes can also be managed at home [34] with high satisfaction  
199 levels reported by patients due to good functional outcome, the availability and ease of being at  
200 home and maintaining independence [36].

201 Given the findings supporting a non-surgical approach to PHF management, it may be useful to  
202 provide further guidance on what this means to older patients, notably that non-surgical  
203 treatment should achieve acceptable upper limb function without the risks of surgery. Providing  
204 information to patients following a fracture is recommended within NICE guidelines [23] and  
205 should include expected outcomes of treatment, activities to work on independently, homecare  
206 options if needed and information on rehabilitation, mobilisation and weight bearing. For older  
207 patients, a booklet may be preferable to other formats [36]. In addition to information provision,  
208 positive relationships with healthcare professionals following PHF in the older population  
209 contributes to increased levels of patient trust, perceptions of recovery and improvement in  
210 emotional state [37]. Communication of treatment options and consideration of other risk  
211 factors for poor function could therefore be explored by healthcare professionals when treating  
212 patients post PHF. For example, social deprivation is associated with an increased incidence of  
213 adult fractures [38], and in those over 60, longer hospital stays, hospital readmission and higher  
214 mortality [39]. Another factor to consider for patients with PHF is psychological health and its  
215 impact on recovery. The reviews did not specifically address psychological outcomes for non-  
216 surgical vs surgical treatment, yet in recovery from a fracture, high fear avoidance beliefs and  
217 levels of catastrophising have been shown to substantially increase the risk of future pain and  
218 less than full recovery of strength respectively [40]. Self-efficacy interventions such as goal  
219 focused rehabilitation may help to improve coping abilities, reduce anxiety and depression and  
220 improve quality of life in people with post-traumatic fractures [41]. At present, there is no clear  
221 guidance to provide direction for these psychological factors when considering PHF management  
222 and NICE guidelines would benefit from an update.

223 Questions remain around the most effective rehabilitation protocol following non-surgical  
224 management of PHF. Further research is needed to evaluate the factors that contribute to the  
225 effectiveness of non-surgical interventions for PHF which may include sling use, exercise  
226 programmes, psychological support, and provision of patient information.

227

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345 **Table 1: PICO variables for the three included systematic reviews**

<b>PICO</b>	Beks et al. (2018) [25]	Handoll et al. (2022) [26]	Soler-Peiro et al. (2020) [27]
<b>Population</b>	Adults, proximal humeral fracture.	Adults, proximal humeral fracture.	Adults, three and four-part proximal humeral fracture.
<b>Intervention</b>	Surgical management. External osteosynthesis as an operative treatment was excluded.	Non-surgical and surgical management. Pharmacological, biological and acupuncture trials were excluded.	Conservative management. Surgical treatment was excluded.
<b>Comparison</b>	Non-surgical management.	Two or more treatments for management of PHF (our focus on surgical versus non-surgical).	None.



<b>Outcome</b>	Functional outcomes and complications including major reinterventions (additional and unplanned surgery), and adverse events.	For comparison of surgical versus non-surgical: functional outcomes, health related quality of life, mortality, additional surgery and adverse events.	Functional outcomes, complications and consolidation.
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354 **Table 2: JBI critical appraisal checklist for systematic reviews [28]**

<b>Criteria</b>	<b>Beks et al. (2018) [25]</b>	<b>Handoll et al. (2022) [26]</b>	<b>Soler-Peiro et al. (2020) [27]</b>
Is the review question clearly and explicitly stated?	Yes: 'To compare operative versus nonoperative treatment of displaced PHF'	Yes: 'To assess the effects (benefits and harms) of treatment and rehabilitation interventions for proximal humeral fractures in adults'.	Yes: 'To assess criteria for indications, treatment protocols, and outcomes obtained with conservative treatment of three--part and four-part PHFs'.
Were the inclusion criteria appropriate for	Yes: PICO structure was followed according to question.	Yes: PICO structure was followed according to question.	Yes: PICO structure was followed according to question.

the review question?			
Was the search strategy appropriate?	Yes: A clear search strategy addressing each of the identifiable PICO components of the review question was conducted up to September 5 <sup>th</sup> , 2017. Studies in a language other than English, Dutch or German were excluded.	Yes: A clear search strategy addressing each of the identifiable PICO components of the review question was conducted up to September 2020. No language or publication restrictions.	Yes: A clear search strategy addressing each of the identifiable PICO components of the review question was conducted from 2000-January 20 <sup>th</sup> , 2020. Restricted to English publications.
Were the sources and resources used to search for studies appropriate?	Yes: MEDLINE, Embase, CENTRAL and CINAHL. Reference and citation tracking was performed.	Yes: CENTRAL, MEDLINE, Embase, CINAHL, AMED and PEDro. Trial databases, reference lists and conference proceedings were also searched.	Yes: PubMed and the Cochrane Library.
Were the criteria for appraising studies appropriate?	Yes: Methodological quality was assessed using the Methodological Index for Non-Randomised Studies (MINORS). Scores ranged from 0-24 with an author interpreted score of 16+ representing good methodological quality.	Yes: Risk of bias was assessed using the Cochrane handbook, plus four other aspects of trial quality. The GRADE approach was used to rate the certainty of evidence: very low, low, moderate or high.	Yes: Risk of bias was evaluated [33] and considered to be low risk (good quality) when 6/12 criteria were met.
Was critical appraisal conducted by two or more reviewers?	Yes: Critical appraisal was carried out by two reviewers independently and disagreements resolved by a third reviewer.	Yes: Critical appraisal was carried out by two reviewers independently and differences resolved through discussion.	Unclear: No indication as to how many reviewers evaluated risk of bias.

reviewers independently?			
Were there methods to minimise errors in data extraction?	Yes: Data extraction was completed independently by two reviewers with a data extraction file.	Yes: two reviewers independently completed a data extraction tool. Differences were discussed.	Yes: A piloted data extraction form was completed independently by two reviewers.
Were the methods used to combine studies appropriate?	Yes: Outcomes reported by two or more studies were pooled in a meta-analysis. When heterogeneity was present, a random-effects model was used.	Yes: Where possible, data were pooled using both fixed-effect and random-effects models (depending on clinical heterogeneity).	Yes: A descriptive synthesis of outcomes was reported.
Was the likelihood of publication bias assessed?	Yes: Inspection of a funnel plot of the primary outcome measure. Publication bias not detected.	No: not assessed due to - insufficient number of trials to merit production of funnel plots.	No: not assessed.
Were recommendations for policy and/or practice supported by the reported data?	Yes: Appropriate recommendations were made based on the findings of the review.	Yes: Appropriate implications for practice were made based on the findings of the review.	Yes: Appropriate implications for practice were made based on the findings of the review.
Were the specific directives for new research appropriate?	N/A: no recommendations for new research were made	Yes: a need for similar trials to address key treatment uncertainties and optimisation of non-surgical treatments, plus decisions	Yes: Future research of conservative treatments of PHFs, including subgroups of fractures

		on priority topics identified from the ongoing trial data.	and comparing diverse treatment protocols
Total criteria	11/11	10/11	9/11

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357 **Table 3. Study characteristics of Beks et al. 2018 [25], Handoll et al. 2022 [26] and Soler-Peiro et al.**  
358 **2020 [27]**

Systematic Review	Number of included studies	Participants	Primary outcome	Follow-up period
Beks et al. (2018) [25]	22 studies (7 RCTs, 15 observational studies)	Total of 1743 patients of which the average age was 68 years, and 75% were women. Included patients with two-, three- or four--part fractures (Neer classification).	The primary outcome measure for function was the Constant-Murley Score.	Follow-up ranged from 12 to 86 months. Reported as at least one year.
Handoll et al. (2022) [26]	For the treatment comparison of surgical versus non-surgical, there were 10 RCTs included.	For the treatment comparison of surgical versus non-surgical, there were 717 participants of which 66% were three or four-part fractures (Neer classification). Most participants were over 60 and over two-thirds were women.	The primary outcome for function was measured using four different scores: The American Shoulder and Elbow Surgeons (ASES), the Disability of the Arm, Shoulder, and Hand questionnaire (DASH), Oxford Shoulder Score (OSS) and Simple Shoulder Test (SST). Quality of life was evaluated using the EQ-5D.	For the pooled results, the follow-up period was up to two years. Reported as 6 months, 1 and 2 years.

Soler-Peiro et al. (2020) [27]	6 studies (3 RCTs, 3 observational)	133 patients, of which the average age was 74, and 79% were women. Using the Neer classification, there were 41% three-part fractures and 59% four-part fractures.	The primary outcome for function was the Constant-Murley Score.	Follow-up was between 12 to 68 months. Reported as a minimum follow-up of one year
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<b>Table 4. Estimates of effectiveness for surgical versus non-surgical treatment on outcomes of function, quality of life, adverse events, and mortality outcomes (Beks et al. 2018 [25]; Handoll et al.2022[26])</b>					
<b>Systematic Review</b>	<b>Number and type of trial</b>	<b>Follow-up period</b>	<b>Estimate of effect</b> MD, SMD, RR (95% CI), <i>p</i> value, <i>I</i> <sup>2</sup>	<b>Interpretation of effect and heterogeneity</b>	<b>Quality Assessment of included studies</b> (summary)
<b>Functional outcome</b>					
Beks et al. (2018) [25]	14 studies (5 RCTs, 9 observational)	At least 1 year	MD= -0.87 (-5.13 to 3.38), <i>p</i> =0.69, <i>I</i> <sup>2</sup> =69%	No difference in functional outcome between groups, substantial heterogeneity.	Mostly good quality studies (11/14)
Handoll et al. (2022) [26]	3 RCTs	6 months	SMD = 0.17, (-0.04 to 0.38)	No clinically important difference in patient reported functional scores between groups, no reported heterogeneity	GRADE: Moderate Certainty

Handoll et al. (2022) [26]	7 RCTs	1 year	SMD= 0.10 (-0.07 to 0.27), $p=0.24$ , $I^2=0\%$	No clinically important difference in patient reported functional scores between groups, no reported heterogeneity.	GRADE: High certainty
Handoll et al. (2022) [26]	5 RCTS	2 years	SMD= 0.06, (-0.13 to 0.25), $p=0.54$ , $I^2=0\%$	No clinically important difference in patient reported functional scores between groups, no reported heterogeneity.	GRADE: High certainty
<b>Major Reintervention</b>					
Beks et al. (2018) [25]	15 studies (6 RCTs, 9 observational)	At least 1 year	RR= 2.72 (1.71 to 4.34), $p<.0001$ , $I^2=0\%$	Major reinterventions occurred more often in the surgical treatment than in non-surgical, no heterogeneity reported.	Mostly good quality studies (13/15)
Handoll et al. (2022) [26]	9 RCTs	Up to 2 years	RR 2.06 (1.21 to 3.51), $p=0.007$ , $I^2=23\%$	A higher risk of additional surgery in the surgery group, low heterogeneity.	GRADE: low certainty
<b>Nonunion</b>					
Beks et al. (2018) [25]	13 studies (6 RCTs, 7 observational)	At least 1 year	RR =0.45 (0.23 to 0.89), $p=.02$ , $I^2=0\%$	Surgical treatment resulted in fewer nonunions than non-surgical treatment, no heterogeneity reported.	Mostly good (11/13)
Handoll et al. (2022) [26]	8 RCTs	Up to 2 years	RR =0.42 (0.19 to 0.94), $p=0.04$ , $I^2=0\%$	Nonunion was more common in the non-surgical treatment group, no heterogeneity reported.	Unclear
<b>Avascular Necrosis</b>					

Beks et al. (2018) [25]	13 studies (6 RCTs, 7 observational)	At least 1 year	RR 1.24 (0.87 to 1.77), $p=0.24$ , $I^2=24%$	No difference in the rate of avascular necrosis between groups, low heterogeneity.	Mostly good quality studies (10/13)
Handoll et al. (2022) [26]	8 RCTs	Up to 2 years	RR 0.52 (0.33 to 0.81), $p=0.004$ , $I^2=50%$	Avascular Necrosis was more common in the non-surgical treatment group, moderate heterogeneity.	Unclear
<b>Quality of Life</b>					
Handoll et al. (2022) [26]	6 RCTs	1 year	MD =0.01 (-0.02 to 0.04), $p=0.51$ , $I^2=0%$	No clinically important difference in quality of life between groups, no reported heterogeneity.	GRADE: high certainty evidence
Handoll et al. (2022) [26]	5 RCTs	2 years	MD=0.01 (-0.02 to 0.05), $p=0.42$ , $I^2=56%$	No clinically important difference in quality of life between groups, moderate heterogeneity.	GRADE: moderate certainty evidence
<b>Mortality</b>					
Handoll et al. (2022) [26]	8 RCTs	2 years	RR 1.35 (0.70 to 2.62), $p=0.37$ , $I^2=0%$	Little difference between groups, no reported heterogeneity.	GRADE: low certainty evidence