

Comparison of surgical outcomes between fixation with hook plate and loop suspensory fixation for acute unstable acromioclavicular joint dislocation: a systematic review and meta-analysis

Alisara Arirachakaran¹ · Manusak Boonard² · Peerapong Piyapittayanun¹ · Vajarin Phiphobmongkol¹ · Kornkit Chaijenkij³ · Jatupon Kongtharvonskul⁴

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Abstract Treatment of acute (≤ 4 weeks) high-grade acromioclavicular (AC) joint separation (types III–VI) is still controversial. Currently, the two modern techniques that are widely used include hook plate fixation and coracoclavicular (CC) ligament fixation using a suspensory loop device (tightrope, synthetic ligament or absorbable polydioxansulfate sling). These techniques are both reported to have superior clinical outcomes. This systematic review and meta-analysis aimed to assess and compare clinical outcomes of hook plate fixation versus fixation of the CC ligament using a loop suspensory fixation (LSF) device for the treatment of AC joint injury. These clinical outcomes consist of the Constant–Murley score (CMS),

pain visual analog score (VAS) and postoperative complications. Relevant comparative studies were identified from MEDLINE and Scopus from inception to October 5, 2015. Five of 571 studies were eligible; 5, 3, 3, and 5 studies were included in the pooling of CMS, pain VAS, surgical time and postoperative complications, respectively. The unstandardized mean difference (UMD) of the CMS for LSF was 4.43 [95 % confidence interval (CI) 0.73, 8.14], which was statistically significantly higher than the CMS in hook plate fixation. For VAS, the UMD was 0.02 points (95 % CI -3.54 , 3.73) higher than LSF but without statistical significance. The surgical time of LSF was 16.21 min (95 % CI 6.27, 26.15) statistically significantly higher than hook plate fixation. LSF had a lower chance of postoperative complications by 0.62 units (95 % CI 0.30, 1.32) when compared to hook plate fixation, but this also was not statistically significant. In acute high-grade AC joint injuries, loop suspensory fixation had higher postoperative functional CMS and mean surgical time when compared to hook plate fixation. However, for postoperative VAS and complication rates, there were no statistically significant differences between groups.
Level of evidence IV

✉ Jatupon Kongtharvonskul
Jatupon_kong@hotmail.com

Alisara Arirachakaran
amy.alisara@gmail.com

Manusak Boonard
mboonard@gmail.com

Peerapong Piyapittayanun
Ppiyapittayanun@yahoo.com

Vajarin Phiphobmongkol
vajarin@hotmail.com

Kornkit Chaijenkij
kornortho@gmail.com

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Introduction

Acromioclavicular joint dislocation is a common injury in active young adults [3]. The prevalence is approximately 9 % of all shoulder girdle injuries [2, 20]. AC dislocation is associated with AC and CC ligament injuries [29]. These injuries are classified into type I–VI injuries on the

¹ Orthopedics Department, Police General Hospital, Bangkok, Thailand
² Orthopedics Department, Srinakarin Hospital, Khonkaen, Thailand
³ Orthopedics Department, College of Sports Science and Technology, Mahidol University, Bangkok, Thailand
⁴ Section for Clinical Epidemiology and Biostatistics, Faculty of Medicine Ramathibodi Hospital, Bangkok, Thailand

basis of the radiographic findings using the Rockwood criteria [18, 29]. Non-operative treatment has generally been accepted as the gold standard of treatment in Rockwood I and II lesions [34], whereas the optimal method of treatment for grade III–VI lesions remains a matter of controversy [13, 22, 36]. Although type IV–VI injuries are treated operatively because of their severe instability, [31] treatment for type III injury is still controversial [17, 34]. The aim of any surgical approach to address the instability of the ACJ should be an anatomic reduction and restoration of normal arthrokinetics [14]. The surgical methods have been employed for the treatment of AC dislocations including extraarticular fixation by CC restoration with metallic cables, autologous ligament or LARS artificial ligament, or transarticular fixation by hook plate (HP) and Kirschner wires. Kirschner wires and threaded pins are frequently used for temporary fixation of the AC joint. However, serious concerns still exist regarding pin migration or breakage, pin-site infection, fixation failure, and recurrent instability after pin removal [12, 16, 23]. AC or CC augmentations [5, 6, 9, 11, 15, 23, 24, 26, 28, 30, 33] and hook plates [1, 5, 9, 21, 26, 36] have been successfully used to treat these injuries. However, transarticular fixation with HP may induce bony erosion, shoulder impingement and rotator cuff damage, resulting in poor functional results [9, 19]. Extra-articular fixation is also not as efficient as expected [4, 10]. Some studies show improvement in pain and CMS after AC or CC augmentations [21, 36], whereas other studies do not [1, 9, 14]. Thus, there has been no consensus as to which method is most preferred for treatment of acute unstable ACJ injuries. Therefore, we have conducted a systematic review and meta-analysis that aims to assess and compare clinical outcomes of hook plate fixation versus fixation of the CC ligament using a loop suspensory fixation (LSF) device for the treatment of AC joint injury. These clinical outcomes consist of the CMS, pain VAS and postoperative complications.

Materials and methods

MEDLINE and Scopus databases were used for identifying relevant studies published in English since the date of inception to October 5, 2015. The PubMed and Scopus search engines were used to locate studies with the following search terms: {[acromioclavicular joint] OR AC joint] AND [(separation) OR dislocation OR trauma OR injury] AND [(hook plate) OR locking plate OR fixation OR tightrope OR dogbone] AND [(constant score) OR constant murley scale OR CMS OR pain OR UCLA]}. Search strategies for MEDLINE and Scopus are described in detail in “Appendix 1”. References from the reference

lists of included trials and previous systematic reviews were also explored.

Selection of studies

Identified studies were first selected based on titles and abstracts by two independent authors (J.K. and A.A.). Full papers were retrieved if a decision could not be made from the abstracts. Disagreements were resolved by consensus and discussion with a third party (M.B.). Reasons for ineligibility or exclusion of studies were recorded and described.

Inclusion criteria

Randomized controlled trials and comparative studies that compared clinical outcomes between hook plate and fixation of the CC ligament using a loop suspensory fixation (LSF) device for treatment of AC joint injury were eligible if they met following criteria:

- Compared clinical outcomes between hook plate and CC ligament using a loop suspensory fixation (LSF) device for treatment of AC joint injury
- Compared at least one of the following outcomes: CMS, pain VAS and postoperative complications.
- Had sufficient data to extract and pool, i.e., the reported mean, standard deviation (SD), the number of subjects according to treatments for continuous outcomes, and the number of patients according to treatment for dichotomous outcomes.

Data extraction

Two reviewers (J.K. and A.A.) independently performed data extraction using standardized data extraction forms. General characteristics of the study (i.e., mean age, gender, body mass index (BMI), mean follow-up time, mean duration after injury, pain VAS and CMS scores at baseline) were extracted. The number of subjects, means and SD of continuous outcomes (i.e., pain VAS and CMS) between groups were extracted. Cross-tabulated frequencies between treatment and all dichotomous outcomes (postoperative complications) were also extracted. Any disagreements were resolved by discussion and consensus with a third party (M.B.).

Quality assessment

Assessment of risk of bias was performed using the modified Newcastle–Ottawa scale [35]. Five domains were assessed, i.e., representativeness of cohorts, ascertainment of exposure and outcome, adjustment for confounders and

duration of follow-up. The risk of bias in each domain was classified as low risk, high risk or unclear (Appendix 2). Disagreements between two authors were resolved by consensus and discussion with a third party (M.B.). Level of agreement for each domain and the overall domains were assessed using kappa statistics.

Outcomes of interest

The outcomes of interests included CMS, pain VAS and postoperative complications. These outcomes were measured as reported in the original studies, which were VAS pain scale from 0 to 10 cm (lower values of these scores refer to better outcomes) and CMS from 0 to 100 cm (higher values are equivalent to better outcomes). Postoperative complications (wound problems, loss of reduction, implant migration and osteolysis) were also considered.

Statistical analysis

For continuous outcomes (i.e., VAS pain and CMS), the mean difference for hook plate and CC ligament using a loop suspensory fixation (LSF) device for treatment of AC joint injury was estimated for each study. Unstandardized mean difference was applied for pooling outcomes across studies. Before pooling, intervention effects were assessed on whether they varied or were heterogeneous across included studies. Heterogeneity of mean differences was checked using the Q statistic, and the degree of heterogeneity was also quantified using the I^2 statistic. If heterogeneity was significant or $I^2 > 25\%$, the unstandardized mean difference was estimated using a random effects model, otherwise a fixed effects model was applied.

For dichotomous outcomes, the odds ratio (OR) for complications (wound problems, loss of reduction, implant migration and osteolysis) was estimated for each study. Heterogeneity of ORs across studies was assessed using the same method as mentioned previously. If heterogeneity was present, the random effects by Dersimonian and Laird method were applied for pooling ORs, otherwise the fixed effects by inverse variance method were applied.

Meta-regression was applied for exploring the cause of heterogeneity by fitting a co-variable (e.g., mean age, duration of injury, follow-up time, preoperative scores (VAS and CMS) and percentage of females) in the meta-regression model. Subgroup or sensitivity analysis was then performed according to the results of meta-regression. Publication bias was assessed using contour funnel plots [25, 27] and Egger tests [8]. Asymmetry of the funnel plot may have been due to some missing studies in which the negative results might not have been published and thus could not be identified. The metatrim and fill method

was used to estimate the number of studies that might have been missing and to adjust the pooled estimate [7]. All analyses were performed using STATA version 13.0 [32]. A p value <0.05 was considered statistically significant, except for the test of heterogeneity where <0.10 was used.

Results

Two hundred thirty-one and 378 studies were identified from MEDLINE and Scopus, respectively (Fig. 1); 38 studies were duplicates, leaving 571 studies for review of titles and abstracts. Of these, five studies were reviewed and data extracted. Characteristics of the 5 studies are described in Table 1. All five studies were retrospective cohorts that reported postoperative CMS and postoperative complications. Postoperative pain was reported using VAS in three studies, and surgical time was reported in three studies. Mean age and mean follow-up time of participants varied from 37.6 to 42.3 years and 3 to 48 months, respectively. Percentages of male patients ranged from 88.5 to 100. Fixation was done in AC joint injury types III–VI in the 5 studies. Two studies had type V injuries, two studies had type III and V injuries, and one study had type IV–VI injuries. Three studies used arthroscopic-assisted techniques, and two studies used open techniques. Three studies were used single-loop fixation, whereas two studies used double-loop fixation.

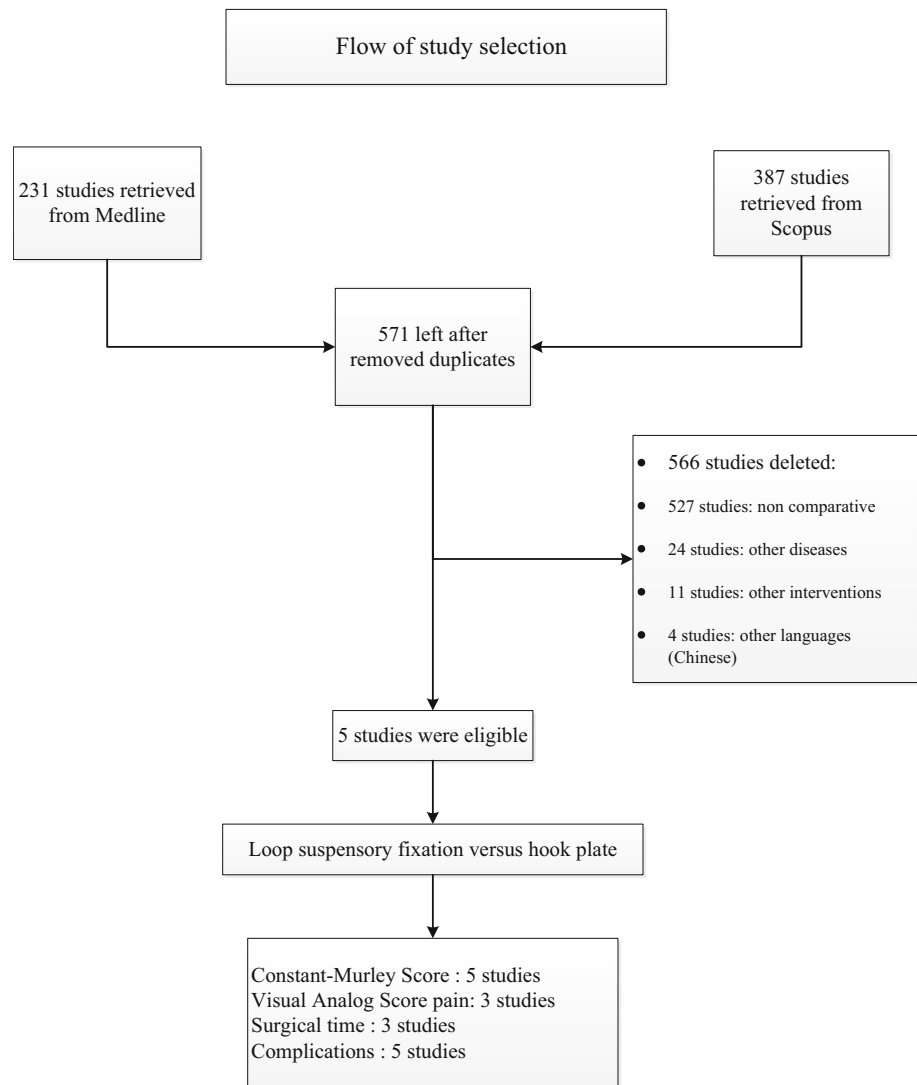
Quality assessment

Descriptions of the quality of the studies are presented in Table 2 (according to the classifications described in Appendix 2). All studies had a low risk of bias in the domain of representativeness of cohort, ascertainment of exposure and ascertainment of outcome. However, all studies had a high risk of bias in the domain of adjustment for confounder. For the duration of follow-up, three studies reported an overall low risk of bias, one study reported high risk of bias, and one study reported unclear risk of bias.

Outcome

Constant–Murley score

Five studies compared the mean values of CMS between LSF and hook plate fixation (Table 3). The pooled UMD varied highly across studies ($I^2 = 86.9\%$) and was 4.44 (95% CI 0.73, 8.14), i.e., the mean CMS had a statistically significant difference of 4.44 points between the two implants (Fig. 2). Separately fitting co-variables in a meta-

Fig. 1 Flow of study selection**Table 1** Characteristics of included studies

Authors	Type of study	Follow-up (months)	Arthroscopic assisted	Suspensory loop (single or double)	Age	Type of AC injury	Male (%)	Time interval from injury to surgery (days)	Outcome
Eschler [9]	Cohort	31.2	N	Single	42.3	V	88.5	8.5	VAS, CMS, surgical time, complications
Andreani [1]	Cohort	3	N	Single	–	IV/VI	100	7.2	CMS, complications
Jensen [14]	Cohort	48	Y	Double	39	III/V	91.1	–	VAS, CMS, surgical time, complications
Metzlaff [21]	Cohort	32	Y	Single	37.6	III/V	79.5	14	CMS, surgical time, complications
Yoon [36]	Cohort	–	Y	Double	40	V	78.6	9.2	VAS, CMS, complications

regression analysis and none of the co-variables could explain the heterogeneity. Egger's test and a contour funnel plot (Fig. 3) did not suggest any evidence of publication bias.

Visual analog score for pain

Three studies reported mean pain VAS between LSF and hook plate fixation (Table 3). Mean difference was similar

Table 2 Risk of bias assessment

Author	Representativeness of cohort	Ascertainment of exposure	Ascertainment of outcome	Adjustment for confounder	Duration of follow-up
Escher	Low	Low	Low	High	Low
Andreani	Low	Low	Low	High	High
Jensen	Low	Low	Low	High	Low
Metzlaff	Low	Low	Low	High	Low
Yoon	Low	Low	Low	High	Unclear

Table 3 Mean differences between LSF and hook plate

Author	LSF			Hook plate		
	N	Mean	SD	N	Mean	SD
(A) CMS						
Eschler	25	94.6	1	27	91.2	2.2
Andreani	19	90	7.5	9	75	5.8
Jensen	26	82.5	14.36	30	73.8	24.24
Metzlaff	24	93.6	3.4	20	92.8	3.8
Yoon	18	89.2	3.5	24	90.2	9.9
UMD (95 % CI)	4.44 (95 % CI 0.73, 8.14)*					
(B) VAS						
Eschler	25	0.8	0.2	27	0.77	0.2
Jensen	26	1.3	1.8	30	1.7	2.3
Yoon	18	1.3	1.3	24	1.6	1.5
UMD (95 % CI)	0.02 (95 % CI -0.08, 0.13)					
(C) Surgical time						
Eschler	25	65.3	4.8	27	42.9	2.2
Jensen	26	76.75	25.46	30	62.5	33.71
Metzlaff	24	45.6	12.7	20	36.2	15.3
UMD (95 % CI)	16.21 (95 % CI 6.27, 26.15)*					

*Statistically significant difference ($P < 0.05$)

across studies ($I^2 = 0\%$) with an UMD of 0.02 (95 % CI -0.08, 0.13), indicating that the LSF group had similar pain VAS to the hook plate group (Fig. 2). There was no evidence of publication bias by Egger's test or contour funnel plot (Fig. 3).

Surgical time

Three studies compared the mean surgical time between LSF and hook plate fixation (Table 3). The pooled UMD varied highly across studies ($I^2 = 79\%$) and was 16.21 (95 % CI 6.27, 26.15), i.e., the mean surgical time had a statistically significant difference of 16.21 min between the two types of fixation (Fig. 2). Separately fitting co-variables in a meta-regression analysis and none of the co-variables could explain the heterogeneity. Egger's test and a contour funnel plot (Fig. 3) did not suggest any evidence of publication bias.

Complications

Five studies reported occurrences of wound problems, loss of reduction, implant migration and osteolysis within the LSF and hook plate groups (Table 4). Risk of having complications between two groups was similar ($I^2 = 0\%$, Fig. 2), with a pooled RR of 0.62 (95 % CI 0.30, 1.32), indicating that the chance of having a wound problems, loss of reduction, implant migration and osteolysis between the two groups were not significantly different (Table 4; Fig. 2). Neither contour funnel nor Egger's test suggested evidence of publication bias (Fig. 3).

Sources of heterogeneity

Meta-regression was applied for exploring the cause of heterogeneity by fitting a co-variable (i.e., age, percentage of sex, type of AC injury, approach, number of bundle and

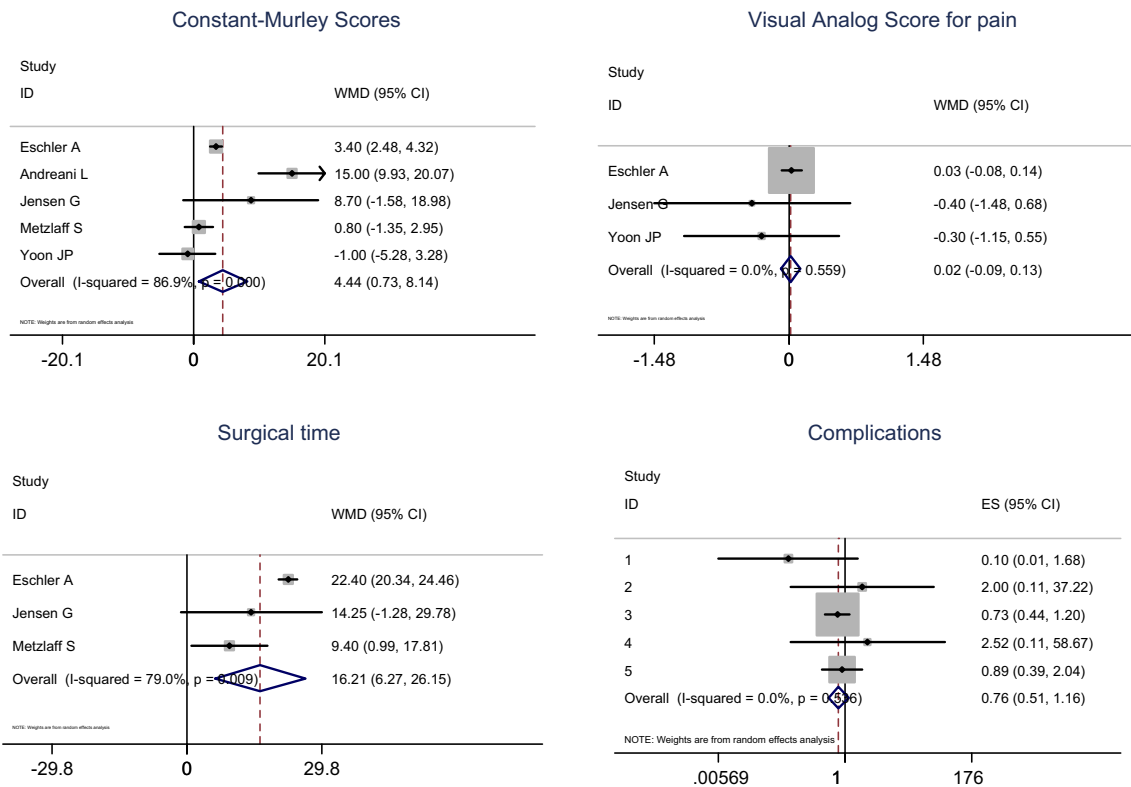


Fig. 2 Comparison of all outcome between loop suspensory fixation and hook plate

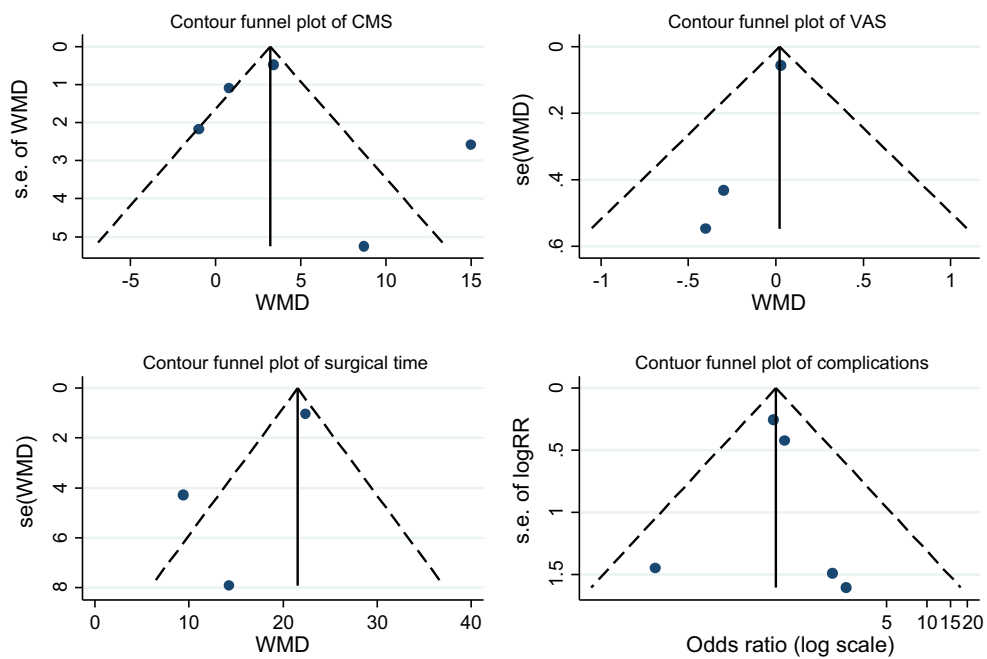


Fig. 3 Contour funnel plot of CMS, VAS, surgical time and complications between LSF and hook plate

Table 4 Comparisons of dichotomous outcomes between LSF and hook plate

Authors	(A) Complication				RR	95 % CI
	LSF		Hook plate			
	Yes	No	Yes	No		
Eschler	0	25	5	22	0.08	(0.004, 1.53)
Andreani	2	17	0	7	0.50	(0.09, 50.23)
Jensen	12	14	19	11	0.50	(0.17, 1.45)
Metzlaff	1	23	0	20	2.62	(0.10, 67.83)
Yoon	6	12	9	15	0.83	(0.23, 3.00)
Pooled					0.62	(0.30, 1.32)

duration before surgery), and meta-regression was applied to assess this. None of the co-variables could explain the heterogeneity. However, the type of approaches and number of bundle of fixation might be the source of heterogeneity then subgroup analyses were, therefore, performed as described in Table 4.

Discussion

This review suggests that loop suspensory fixation implants have about 4.4 points of significant difference in outcomes of CMS when compared to hook plate implants. However, the LSF devices can be used by two different approaches (arthroscopic or open) and two different implant designs (single or double loop). After subgroup analysis, the results show that patients who received single LSF implants had approximately 5.5 points significantly higher postoperative CMS than those who had hook plate implant fixation. On the other hand, the double LSF implants showed no statistically significant difference in postoperative CMS when compared to patients with hook plate implants. In terms of surgical time, the hook plate fixation is approximately 17 min significantly faster when compared to loop suspensory fixation. VAS and postoperative complications showed no statistically significant differences. After all outcomes were pooled and the sources of heterogeneity were explored by meta-regression analysis, the differences in type of LSF, arthroscopic-assisted/open techniques and types of AC injuries were shown to have no effect on all outcomes.

This meta-analysis of comparative studies including 110 and 112 patients reached a type I error of 1 % for detecting the 4.4 point and 16 min difference in CMS and surgical times on LSF fixation versus hook plate fixation an acute AC joint dislocation. The results show that LSF has better postoperative shoulder function but longer operative time when compared to hook plate fixation. However, VAS and postoperative complications were no different. Although

postoperative complications had no significant differences between the two groups, this result does not reflect any particular specific complication. Moreover, there was an unequal chance for the two groups in risk of postoperative complications because in the hook plate group all implants were removed 3 months after surgery, whereas in the LSF group, only patients that had an implant-specific problem had the implant removed.

This study has several strengths. First of all, five cohort studies were included for pooling relevant clinical outcomes (i.e., postoperative CMS, VAS, surgical time and complications) after AC joint fixation by two different implants. The power to detect differences or equivalences between the two implants is 90 % or higher with false-positive results of only 1 %. Secondly, possible causes of heterogeneity were explored if covariate data at baseline (e.g., mean age, percent male, follow-up times, type of LSF, arthroscopic-assisted and types of AC injuries) were available. Third, publication bias for each outcome was also assessed.

There are some limitations in this study that deserve discussion. The quality of studies for the meta-analysis was not very high. Ideal evidence for systematic review is a randomized controlled trial (RCT), which is most commonly used in testing the efficacy of surgery. The methodology of RCTs should include randomization procedures, allocation concealment, blinding and intention to treat. However, it is difficult to perform surgery with blinding and also difficult to obtain a long-term follow-up, so there were no RCTs available comparing LSF versus hook plate fixation in the treatment of acute AC joint injury. All five trials included were comparative studies (retrospective cohort studies) and this might result in bias between groups because of opportunity for selection, even though they were matched for baseline characteristics. Another limitation is that outcomes that can be used to compare LSF and hook plate fixation also include cost of operation, postoperative satisfaction and quality of life. However, these factors could not be analyzed because of insufficient data. The last limitation is that most studies had a mean follow-up time of about 1–2 years; therefore, mid-term to long-term effects of the different types of fixation are still unknown.

In conclusion, acute high-grade AC joint injuries, the short-term outcomes of loop suspensory fixation displayed higher postoperative functional scores (CMS) when compared to hook plate fixation. However, for postoperative pain and complication rates, there were no statistically significant differences between groups. Further research with an increased sample size, mid-term or long-term follow-up periods and a prospective randomized controlled trial study design are required to determine as to whether the LSF implant is superior to hook plate fixation or not.

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Compliance with ethical standards

Conflict of interest None.

Appendix 1

Search term and strategy

#1 acromioclavicular joint

#2 AC joint

#3 #1 OR #2

#4 separation

#5 dislocation

#6 trauma

#7 injury

#8 #4 OR #5 OR #6 OR #7

#9 hook plate

#10 locking plate

#11 fixation

#12 tightrope

#13 dogbone

#14 #9 OR #10 OR #11 OR #12 OR #13

#15 constant score

#16 constant murley scale

#17 CMS

#18 pain

#19 UCLA

#20 #15 OR #16 OR #17 OR #18 OR #19

#21 #3 AND #8 AND #14 AND #20

Appendix 2

See Table 5.

Table 5 Criteria for risk of bias assessment

Domain	Risk of bias	Description
Representativeness of cohort	Low	Study's participants were recruited from population-based or hospital-based settings
	High	Study's participants were selected from specific groups such as nurses
	Unclear	No description of derivation of cohort
Ascertainment of exposure	Low	From objective measurements, work registry or specific diagnosis
	High	From questionnaire or self-report
	Unclear	No description
Ascertainment of outcome	Low	From blood test or medical chart review
	High	From self-report
	Unclear	No description
Adjustment for confounder	Low	Control of confounder on the basis of study design or analysis
	High	No control of confounder
	Unclear	No description
Duration of follow-up	Low	≥2 years for population with impaired glucose tolerance test ≥3 years for normal population
	High	<2 years for population with impaired glucose tolerance test <3 years for normal population
	Unclear	No description

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