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Abstract

Purpose:
To synthesise the evidence on the prevalence of associated intraarticular lesions in subjects with acute acromioclavicular joint (ACJ) dislocations.

Methods:
A search in two electronic databases (PUMBMED and EMBASE) was performed from 1985 to 2019. Two independent reviewers selected studies that complied with the following inclusion criteria: (1) the study included data on surgically treated ACJ dislocation grade III–V in the Rockwood classification, (2) the ACJ injuries were acute (the surgery was performed less than 6 weeks after injury), (3) an arthroscopic evaluation of the glenohumeral joint was performed during surgery. The quality of the studies included was assessed using the tool of the Joanna Briggs Institute.

Results:
A total of 47 studies with acute ACJ injuries met the initial inclusion criteria. Of these, 21 studies (9 retrospective case series, 9 prospective case series and 3 retrospective cohort studies) presented data on associated intraarticular lesions amenable for use in the meta-analysis. The meta-analysed studies included a total of 860 subjects with acute ACJ dislocations with a male/female ratio of 6.5 and a mean age of 32 years. The meta-analysis showed a prevalence of associated intraarticular lesions in subjects with acute ACJ of 19.9% (95% confidence interval [CI] 14.0–26.4%; 21 studies, 860 analysed participants; $P = 0.000$; I^2: 74.5% random-effects model; low risk of bias).

Conclusion:
One in five subjects with surgically treated acute ACJ dislocations will have an associated intraarticular lesion that requires further intervention. The case for a customary arthroscopic evaluation of the joint, even when an open procedure is performed to deal with the ACJ dislocation, is strong.

Level of evidence IV

Trial registry Systematic review registration number: PROSPERO CRD42018090609.

Keywords (separated by '-') Shoulder arthroscopy - Acute acromioclavicular joint injury - Associated lesions - Acromioclavicular joint injury

Footnote Information **Electronic supplementary material** The online version of this article (https://doi.org/10.1007/s00167-020-05917-6) contains supplementary material, which is available to authorized users.

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SHOULDER

The prevalence of intraarticular associated lesions after acute acromioclavicular joint injuries is 20%: a systematic review and meta-analysis

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Abstract

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Methods A search in two electronic databases (PUMBMED and EMBASE) was performed from 1985 to 2019. Two independent reviewers selected studies that complied with the following inclusion criteria: (1) the study included data on surgically treated ACJ dislocation grade III–V in the Rockwood classification, (2) the ACJ injuries were acute (the surgery was performed less than 6 weeks after injury), (3) an arthroscopic evaluation of the glenohumeral joint was performed during surgery. The quality of the studies included was assessed using the tool of the Joanna Briggs Institute.

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Introduction

Acute acromioclavicular joint (ACJ) injuries are relatively common. Their management depends on the severity of the injury, that is usually assessed according to the Rockwood

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classification [3]. Grade I and II lesions are usually managed conservatively [51] but more severe injuries might require surgical treatment [3]. The indication for surgical repair and the specific technique is a clearly controversial topic [51].

As the forces involved in the development of these injuries are significant [22], sometimes, other injuries develop in the shoulder. The emergence of arthroscopically assisted techniques to deal with these injuries [42] allowed to perform a more complete assessment of the glenohumeral joint during surgery and to identify associated intraarticular lesions. The prevalence of these associated lesions has been reported in the literature in the last 10 years, with prevalences ranging from 6.5 to 48% [2, 28, 39, 40, 43, 55]. To obtain a more precise knowledge of the prevalence of these associated lesions is necessary as it might impact the management of ACJ dislocations: if the prevalence is high, other diagnostic procedures might be necessary or the surgeon might err on the side of a more aggressive approach to these injuries that includes a thorough arthroscopic assessment; if the prevalence is low, they should not affect the decision to surgically treat these injuries or affect the surgical technique used.

The objective of this systematic review was to synthesise the evidence available regarding the prevalence of associated intraarticular lesions in subjects with severe acute acromioclavicular joint dislocations (grade III, IV or V Rockwood's classification).

Materials and methods

This systematic review adheres to the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [33, 35].

Protocol and registration

The review was registered in the PROSPERO prospective register of systematic databases with registration number CRD42018090609. The registry access is accessible at: https://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42018090609.

Eligibility criteria

Types of studies

Prevalence studies, case series, case–control studies, cohort studies and randomized controlled trials with usable data for this review were considered for inclusion.

Types of participants

Subjects with acromioclavicular joint (ACJ) dislocation. To be eligible, the ACJ dislocation should fulfil the following characteristics: (1) caused by a trauma; (2) severe, that is, grades III to V from Rockwood´s classification; (3) required surgical treatment; (4) acute, that is, surgery was performed less than 6 weeks after injury; and (5) an arthroscopic evaluation of the glenohumeral joint was performed during surgery.

Types of outcome measures

Primary outcome Prevalence of any associated intraarticular lesions in the ipsilateral shoulder of the subjects with acute severe ACJ dislocation (dichotomous data). The associated intraarticular lesions must have been detected with the arthroscopic evaluation of the glenohumeral joint performed during in the surgery.

An associated intraarticular lesion was defined as a lesion identified during arthroscopy in the ipsilateral shoulder of a subject being surgically treated for an acute acromioclavicular joint disruption that required further surgical attention (that is, the surgeon had to perform another procedure to deal with the associated lesion).

Information sources and search

The search strategy included electronic databases and searches in other resources to find additional eligible studies that had not been disseminated via usual channels. The following restrictions based on language or date of publication were applied: studies published in languages different from English or Spanish were excluded; studies were included if publication date was after 1/1/1985. This date set limit was used as operative shoulder arthroscopy was initiated in 1987 [14] and only developed during the nineties [26].

The following electronic databases were consulted up to 28/06/2019: MEDLINE (via Pubmed, Accessed 28/06/2019) with search strategy: (acromioclavicular OR acromioclavicular joint [MeSH Terms]) AND ("1985/01/01"[Date—Publication]: "2017/10/30"[Date—Publication]); and Scopus (Accessed 28/06/2019) with search strategy: TITLE-ABS-Key (acromioclavicular) AND PUBYEAR > 1984. The bibliographies of the included studies, review articles, and clinical guidelines were reviewed looking for additional eligible studies. Web of Science citation mapping was used to track articles that had cited the studies included for full-text review. Handsearching of journals was not performed, because, to our knowledge, all relevant journals in this field

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are indexed in PubMed. Experts in the field were also contacted to identify additional unpublished studies.

Study selection

Two researchers (MARI and MSMR) independently screened titles and abstracts for eligibility. Full-text articles of potentially relevant or unclear studies were obtained and two reviewers (MARI and MSMR) independently applied the eligibility criteria. Disagreements were resolved through discussion. The included studies were identified and the reasons for exclusion of full-texts were recorded and detailed in the PRISMA flowchart (Fig. 1) [35] and in the table of characteristics of excluded studies (see Appendix 1).

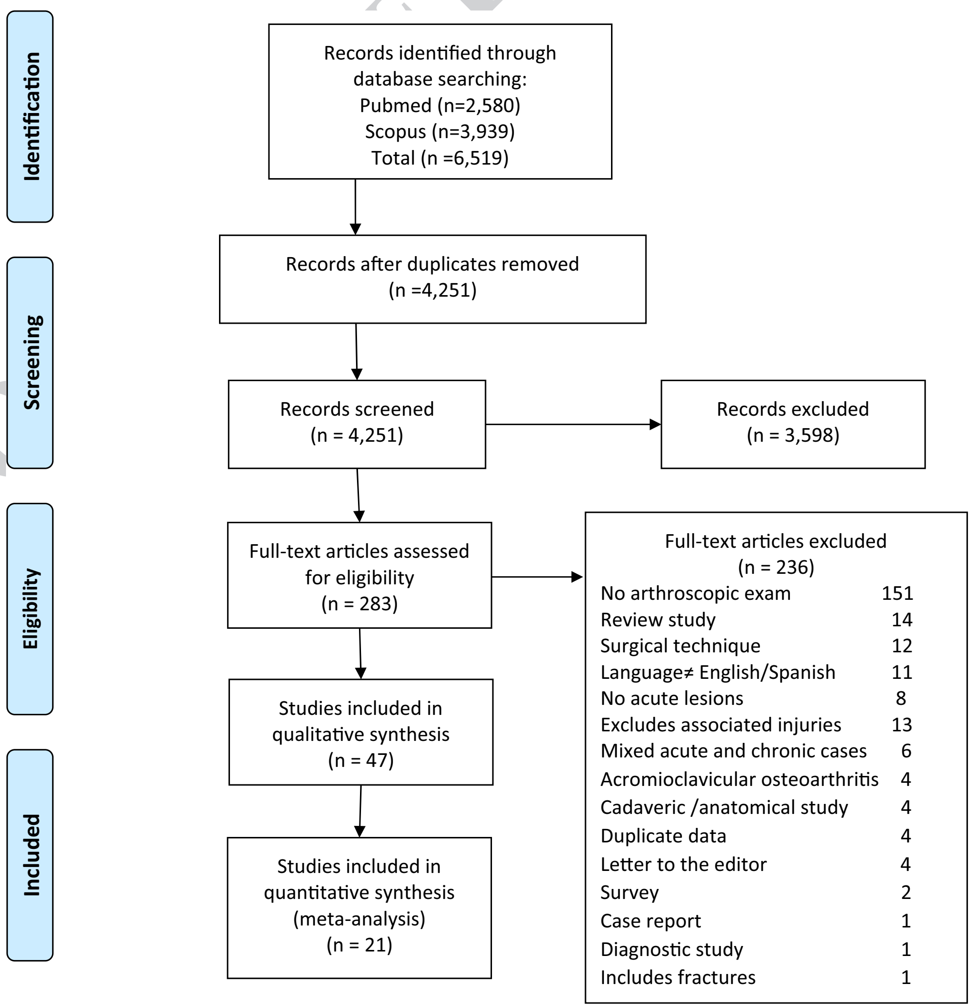
Data collection process

The data of each included study was independently extracted by two of the authors (MARI and MSMR). A consensus method was used to agree on the final extraction. A third author (RRD or JDH) intervened in case of disagreement. We did not try to obtain crucial missing information or clarification from study authors.

The following data were extracted for each study included: authors´ names, journal name, year of publication, country where the study was done, type of study (case series, case–control, cohort, randomized controlled trial, prevalence study), temporal sequence of the study (prospective or retrospective study), unicentric or multicentric, whether the primary aim of the study was to identify prevalence of associated intraarticular lesions, dates of subject recruitment, sample size, sex (male:female) ratio, age (mean, standard deviation, range), definition of an acute injury, dominance of the involved arm, type of ACJ lesion (II, IV or V in the Rockwood classification) and whether or not associated intraarticular lesions were reported.

The number of associated intraarticular lesions were recorded along with the type of injury, type of treatment performed (whether debridement or any other surgical treatment was performed) and whether the lesion was considered acute (related to the traumatic event that caused

Fig. 1 PRISM flow diagram for the systematic review



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the ACJ injury) or pre-existing. The number of other lesions that did not require additional surgical treatment was also recorded.

For each subject with an associated intraarticular lesion, detailed information was recorded, if available, including age, sex, type of ACJ injury, side, Rockwood type, characteristics of the associated intraarticular lesion and specific treatment.

Risk of bias in individual studies

The risk of bias of each individual study was assessed according to the recommendations of the Joanna Briggs Institute 2014 Manual for Systematic Review of Prevalence and Incidence Data [25]. Based on this nine-item Critical Appraisal Checklist, we created a data extraction form with specific instructions for assessment of risk of bias (See Appendix 2). The form was piloted with five studies. Two authors (MARI and MSMR) independently assessed the risk of bias of each included study. Discrepancies were resolved through discussion. A third author (JLA or AM) intervened in case of disagreement.

Statistical analysis

Meta-analysis

For each review outcome, it was attempted to combine the results from individual studies in a meta-analysis to provide a pooled prevalence estimate only if the following criteria were met: (1) there were at least two studies; and (2) the studies were sufficiently similar in terms of participants. All the studies were combined independently of their study design. The results were combined in a meta-analysis independent of their risk of bias but we assessed the impact of this decision by sensitivity analysis (see Sensitivity analysis).

It was anticipated that the prevalence estimates would vary among studies due to the presence of different study populations and study designs. Thus, the pooled estimate of the meta-analysis was obtained with Freeman–Tukey Double Arcsine Transformation to stabilize the variances; the exact method was used to compute the confidence intervals, and also the DerSimonian and Laird (DL) method [12] which is based on a random-effects model. The influence of the statistical model used to pool data was assessed with a sensitivity analysis (see Sensitivity analysis). Results were presented as a central estimation of the prevalence accompanied with the 95% confidence interval (CI). Statistical analyses were done using Stata 14 (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX).

Assessment of heterogeneity

First the presence of clinical and methodological heterogeneity was assessed. Secondly, the statistical heterogeneity of the results was assessed considering the following factors: (1) visual inspection of the prevalence estimates: the results of the studies were displayed graphically with forest plots, and the heterogeneity was assessed visually; (2) the chi-squared test was used to identify heterogeneity (Chi^2 P value < 0.10 was defined as statistically significant) [10]; (3) the I^2 statistic was used to describe the percentage of the total variation across studies that was due to heterogeneity rather than sampling error (chance) [24]. Substantial statistical heterogeneity was defined as an I^2 estimate greater than or equal to 50% with a statistically significant Chi^2 P value.

To explain the heterogeneity found, subgroup analyses were conducted (if the number of studies found was sufficient). See 'Subgroup analysis and investigation of heterogeneity'.

Assessment of publication bias

Publication bias was assessed with visual inspection of the funnel plot.

Investigation of heterogeneity

Meta-regression was used to determine if heterogeneity in the prevalence of associated intraarticular lesions varied by the patients' age. In addition, subgroup analyses was preformed to determine if heterogeneity in the results could be explained by the following factors: (1) Type of ACJ injury (III, IV or V in the Rockwood´s classification); (2) Sex (male or female).

Sensitivity analysis

First, to assess the impact of the risk of bias of the included studies, the meta-analysis was repeated excluding studies with high risk of bias Second, another sensitivity analysis was performed adding the 22 studies that did not report data on AI: assuming that these studies did not find associated lesions. Third, an additional sensitivity analysis was performed including only the five studies that focused specifically in determining the prevalence of IAL (assuming that those might be more focused in answering the question).

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The study did not require Institutional Review Board approval as it did not include any interaction with patients or medical records.

Results

Search results

The search of the electronic databases to 28 June 2019 identified a total of 6519 records. The searches of other sources identified no additional records. Following removal of duplicates, 4251 records were assessed by title and abstract, and 3598 records that did not match our inclusion criteria were excluded. A total of 283 full-text reports were retrieved for further assessment and excluded 236 full-text articles that did not meet the eligibility criteria (see Appendix 2; Fig. 1); the most frequent reason for exclusion [$n = 151$] was that no arthroscopic evaluation of the glenohumeral joint was performed during the surgical procedure. No ongoing studies eligible for this review were identified.

Characteristics of the included studies

This review included a total of 47 studies [1, 2, 4–9, 11, 13, 15–21, 23, 27–32, 34, 37–40, 43–46, 48–50, 52–62] (Table 1). Of these, 21 [2, 5, 6, 11, 18, 19, 27, 29, 38–40, 43–46, 48–50, 53, 55, 62] had information on associated intraarticular lesions and were included in the meta-analysis.

Of the 47 studies, 24 (51%) were retrospective case series, 14 (30%) were prospective case series, 6 (13%) were retrospective cohort studies and 3 (6%) were prospective cohort studies. Of the 21 studies that reported data on associated intraarticular lesions, there were 9 (43%) retrospective case series, 9 (43%) prospective case series and 3 (14%) retrospective cohort studies. Five of the studies [2, 39, 40, 43, 55] were specifically designed to identify the prevalence of associated intraarticular lesions in subject with ACJ injuries. The specific details and main characteristic of each of the included studies can be found in Table 1.

The reports were published between 2004 and 2018, all of them in English, except for one in Spanish. The studies were conducted in different countries, including developing countries, being the most frequent Germany (with 14 of 47 studies, 30%). The sample sizes of the included studies ranged from 3 to 229 participants. All the studies included adults (mean ages ranging from 26 to 40 years). The proportion of males in the included studies ranged from 60 to 100%.

Regarding the characteristics of the ACJ injuries, in 18 studies (38%), subjects with all severe (III–V) injuries were included, in 17 studies (36%), only subjects with type III or V injuries were included, in 6 studies (13%), only type IV and V lesions were included; to finish, 4 (8%) studies focused only in type V lesions and 2 (4%) in type III lesions. Only one study [43] included a single type VI lesion that was excluded from the analysis.

Risk of bias in individual studies

The results of the Critical appraisal Checklist for all 47 included studies can be seen on Table 2. Twenty five of the 47 studies (53%) had good methodological quality (answered positively in more than 4 questions). Regarding the 21 studies included in the meta-analysis, all but 1 [11] (95%) had good methodological quality (Table 3).

Results of individual studies

The meta-analysis included 21 studies and a total of 860 participants. The proportion of patients with associated intraarticular lesions ranged from 0% (two studies [11, 18] informed no associated intraarticular lesions in a combined total of 12 subjects with acute ACJ) to 43% [48]. For the 179 subjects that had associated intraarticular lesions a total of 185 associated intraarticular lesions were reported, because six subjects presented two associated intraarticular lesions. The details of the associated intraarticular lesions found are presented in Table 4.

Synthesis of results

The prevalence of associated intraarticular lesions in subjects with acute ACJ was 19.9% (95% confidence interval (CI) 14.0–26.4%; 21 studies, 860 analysed participants; $Tau^2 = 0.07$; $Chi^2 = 78.51$, $P = 0.000$; I^2: 74.5% random-effects model; low risk of bias; Fig. 2).

Assessment of publication bias

Visual inspection of the funnel plot did not show a high risk of publication bias (see Fig. 3).

Sensitivity analyses

The meta-analysis was repeated to determine if the methodological quality had an impact in the prevalence estimate. After excluding the only study with low quality [11], the prevalence estimate did not present relevant changes (prevalence 20.8%, 95% CI from 14.8 to 27.4%; 20 studies, 852 analysed participants; random-effects model).

Adding the 22 studies that did not report data on associated intraarticular lesions, and assuming that the prevalence of associated intraarticular lesions in those studies was 0%, the prevalence thus estimated was 7.2% (95% CI from 3.5 to 11.8%%; 1672 analysed participants; random-effects model).

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Table 1 The general characteristics of the 47 included studies: first author name, year of publication, language, country of origin of the sample, study type, its prospective or retrospective nature, whether it was focused in finding the prevalence of AIL, the number of subjects with acute ACJ injuries included, mean age, male-to-female ratio, severity of the lesions included according to the Rockwood classification and whether the study was finally included in the meta-analysis (shadowed studies)

N	First author	Publication date	Language	Country	Study characteristics	Retrospective/Prospective	Focus on prevalence	Number of subjects	Mean age	Male/Female Ratio	Severity of lesions included	Included in meta-analysis
1	Abat, F	2012	Spanish	Spain	Case series	Retrospective	No	12	31	NR	III, IV and V	No
2	Arrigoni, P	2014	English	USA, Italy, France, and Argentina	Case series	Retrospective	Yes	64	37	7	III	Yes
3	Bin Abd Razak, HR	2018	English	Singapore	Case control	Prospective	No	16	41	15	III, IV and V	No
4	Cavinatto, LM	2011	English	Brasil	Case series	Retrospective	No	20	33	All males	III and V	Yes
5	Chaudhary, D	2015	English	India	Case series	Retrospective	No	17	35	7.5	III, IV and V	Yes
6	Chernchujit, B	2006	English	Germany	Case series	Prospective	No	13	40	5.5	IV and V	No
7	Cohen, G	2011	English	France	Case series	Retrospective	No	16	38	15	III and IV	No
8	De Beer, J	2017	English	South Africa	Case series	Prospective	No	6	27	All males	IV and V	No
9	Defoort, S	2010	English	Belgium	Case series	Prospective	No	9	NR	NR	III and IV	Yes
10	El Sallakh, SA	2012	English	Egypt	Case series	Retrospective	No	10	26	9	III and V	No
11	Faggiani, M	2016	English	Italy	Cohorts	Retrospective	No	8	NR	NR	III and IV	No
12	Flinkkila, TE	2014	English	Finland	Case series	Retrospective	No	57	40	8.5	III and V	No
13	Gangary, SK	2016	English	India	Case series	Prospective	No	11	34	2.67	III, IV and V	No
14	Gille, J	2013	English	Germany	Case series	Prospective	No	3	NR	NR	III, IV and V	Yes
15	Glanzmann, MC	2013	English	Switzerland	Case series	Retrospective	No	19	37	8.5	III and IV	Yes
16	Gupta, P	2016	English	India	Case series	Prospective	No	10	32	4	III and V	No
17	Hann, C	2018	English	Germany	Cohorts	Prospective	No	34	43	5.8	V	No
18	Hashiguchi, H	2018	English	Japan	Case series	Retrospective	No	12	41	All males	III and V	No
19	Jensen, G	2017	English	Germany	Case series	Retrospective	Yes	229	39	7.67	III and V	No
20	Jensen, G	2014	English	Germany, USA	Cohorts	Retrospective	No	26	40.3	NR	III, IV and V	Yes
21	Jobmann, S	2017	English	Germany	Case series	Prospective	No	55	35.2	8.25	III, IV and V	Yes
22	Kany J	2012	English	France	Case series	Retrospective	No	28	33.9	27	IV and V	No
23	Kraus, N	2013	English	Germany	Cohorts	Prospective	No	28	39.3	13	V	No
24	LA, G. O. V	2009	English	Brazil	Case series	Retrospective	No	10	34	All males	III, IV and V	No
25	Liu, X.,	2015	English	China	Case series	Retrospective	No	12	48	2	III and V	No
26	Müller,D	2018	English	Germany	Case series	Prospective	No	73	36	12	III, IV and V	No
27	Murena, L., E	2009	English	Italy	Case series	Retrospective	No	16	33	15	III, IV and V	Yes
28	Pauly, S	2013	English	Germany	Case series	Prospective	Yes	125	38	19	III, IV and V	Yes
29	Pauly, S.,	2009	English	Germany	Case series	Prospective	Yes	40	39	8.61	III and V	Yes
30	Ruiz Iban, MA	2018	English	Spain, Portugal	Case series	Retrospective	Yes	200	37	3	III, IV and V	Yes
31	Rush, L. N	2016	English	USA	Cohorts	Retrospective	No	21	30	All males	III, IV and V	Yes
32	Salzmann, G	2010	English	Germany	Case series	Prospective	No	23	38	10.5	III, IV and V	Yes
33	Scheibel, M.,	2011	English	Germany	Case series	Prospective	No	37	39	8.25	V	Yes
34	Shin, S. J	2015	English	Korea	Case series	Prospective	No	18	45	17	III, IV and V	Yes
35	Shin, S. J.,	2017	English	Korea	Case series	Prospective	No	21	41	20	III and V	Yes
36	Spoliti, M.,	2014	English	Italy	Case series	Retrospective	No	19	33	5.33	III, IV and V	Yes

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Table 1 (continued)

N	First author	Publication date	Language	Country	Study characteristics	Retrospective/Prospective	Focus on prevalence	Number of subjects	Mean age	Male/Female Ratio	Severity of lesions included	Included in meta-analysis
37	Takase, K	2016	English	Japan	Case series	Retrospective	No	22	38	6.33	V	No
38	Theopold, J	2015	English	Germany	Cohorts	Retrospective	No	26	38	25	III, IV and V	Yes
39	Thiel, E	2011	English	USA	Case series	Retrospective	No	11	42	10	IV and V	No
40	Tischer, T	2009	English	Germany	Case series	Retrospective	Yes	77	36	7.56	III, IV and V	Yes
41	Tomlinson, DP	2008	English	USA	Case series	Retrospective	No	5	NR	NR	IV and V	No
42	Trikha, SP	2004	English	UK	Case series	Retrospective	No	4	NR	NR	III and V	No
43	Vrgoc, G	2015	English	Kroatia	Cohorts	Retrospective	No	6	38	5	III and V	No
44	Vulliet, P	2017	English	France	Cohorts	Retrospective	No	40	38	5.67	III and V	No
45	Xu, J	2018	English	China	Case series	Retrospective	No	78	30	2.9	IV and V	No
46	Zhang, LF	2017	English	China	Case series	Retrospective	No	24	29	7	III and V	Yes
47	Zhang, L	2018	English	China	Case series	Retrospective	No	61	30	1.65	III	No

The meta-analysis that included only the five studies [2, 39, 40, 43, 55] that focused specifically in determining the prevalence of IAL estimated a prevalence of 20.4% (95% CI from 9.6 to 33.9%%; 5 studies, 507 analysed participants; random-effects model), and thus did not present relevant changes.

Investigation of heterogeneity

The meta-regression analysis for age did not demonstrate statistically significant differences in the mean age of the participants with higher associated intraarticular lesions prevalence than those with lower associated intraarticular lesions prevalence.

The subgroup analysis according to the severity of the ACJ (grade III, IV or V) considered a total of seven studies that contained complete information on the severity of all subjects ($n=522$) [2, 6, 7, 43, 44, 52, 55]. The analysis did not demonstrate statistically significant differences in the prevalence of associated intraarticular lesions in these subgroups with a prevalence of 10.4% (5.7–15.9%) for grade 3, 17.2% (6.2–30.8%) for grade 4 and 18.8% (13.8–24.4%) for grade 5 (n.s.).

To perform the subgroup analysis according to the sex of the subjects with ACJ, a total of six studies that contained complete information on the sex of the subjects were included [6, 7, 40, 43–45]. The analysis did not demonstrate statistically significant differences in the prevalence of associated intraarticular lesions between sexes: males had a prevalence of associated intraarticular lesions of 17.2% (4.3–26.4%) and females had a prevalence of 3.7% (0.0–29.9%) (n.s.).

Discussion

Summary of main results

The most important finding of this study is that one in five subjects (19.9%, 95% confidence intervals: 14.0–26.4%) with an acute severe (Rockwood grade III–IV–V) ACJ dislocation has an associated intraarticular injury that required surgical management. This meta-analysis was based on 21 studies (all of them but one of good quality). However, we found substantial heterogeneity between them that could not be easily explained.

Quality of the evidence

The risk of bias of the included studies was low. However, there was substantial statistical heterogeneity in the results, which could not be explained by predefined factors. This reduces our confidence in the estimate obtained by our meta-analysis. In addition, publication bias was not assessed by

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Table 2 Quality assessment for the 47 included studies

N	First author	Publication date	Included in meta-analysis	Question 1				Question 2				Question 3			
				Yes	No	Unclear	N. A	Yes	No	Unclear	N. A	Yes	No	Unclear	N. A
1	Abat, F	2012	No	X				X					X		
2	Arrigoni, P	2014	Yes	X				X					X		
3	Bin Abd Razak, HR	2018	No	X				X					X		
4	Cavinatto, LM	2011	Yes			X				X			X		
5	Chaudhary, D	2015	Yes	X						X			X		
6	Chernchujit, B	2006	No	X				X					X		
7	Cohen, G	2011	No	X				X					X		
8	De Beer, J	2017	No			X				X			X		
9	Defoort, S	2010	Yes	X				X					X		
10	El Sallakh, SA	2012	No	X				X					X		
11	Faggiani, M	2016	No	X				X					X		
12	Flinkkila, TE	2014	No	X				X					X		
13	Gangary, SK	2016	No	X				X					X		
14	Gille, J	2013	Yes		X				X				X		
15	Glanzmann, MC	2013	Yes	X				X					X		
16	Gupta, P	2016	No	X				X					X		
17	Hann, C	2018	No	X				X					X		
18	Hashiguchi, H	2018	No	X				X					X		
19	Jensen, G	2017	No	X				X					X		
20	Jensen, G	2014	Yes	X				X				X			
21	Jobmann, S	2017	Yes	X				X					X		
22	Kany J	2012	No	X				X					X		
23	Kraus, N	2013	No	X				X					X		
24	LA, G. O. V	2009	No			X				X			X		
25	Liu, X.,	2015	No	X				X					X		
26	Müller,D	2018	No	X				X					X		
27	Murena, L., E	2009	Yes	X				X					X		
28	Pauly, S	2013	Yes	X				X					X		
29	Pauly, S.,	2009	Yes	X				X					X		
30	Ruiz Iban, MA	2018	Yes	X				X				X			
31	Rush, L. N	2016	Yes	X				X					X		
32	Salzmann, G	2010	Yes	X				X					X		
33	Scheibel, M.,	2011	Yes	X				X					X		
34	Shin, S. J	2015	Yes	X				X					X		
35	Shin, S. J.,	2017	Yes	X				X					X		
36	Spoliti, M.,	2014	Yes	X				X					X		
37	Takase, K	2016	No	X				X					X		
38	Theopold, J	2015	Yes	X				X					X		
39	Thiel, E	2011	No			X				X			X		
40	Tischer, T	2009	Yes	X				X					X		
41	Tomlinson, DP	2008	No			X				X			X		
42	Trikha, SP	2004	No			X				X			X		
43	Vrgoc, G	2015	No	X				X					X		
44	Vulliet, P	2017	No	X				X					X		
45	Xu, J	2018	No	X				X					X		
46	Zhang, LF	2017	Yes	X				X					X		
47	Zhang, L	2018	No	X				X					X		

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Table 2 (continued)

N	First author	Publication date	Included in meta-analysis	Question 4				Question 5				Question 6			
				Yes	No	Unclear	N. A	Yes	No	Unclear	N. A	Yes	No	Unclear	N. A
1	Abat, F	2012	No			X		X				X			
2	Arrigoni, P	2014	Yes	X				X				X			
3	Bin Abd Razak, HR	2018	No	X				X				X			
4	Cavinatto, LM	2011	Yes	X				X				X			
5	Chaudhary, D	2015	Yes			X		X				X			
6	Chernchujit, B	2006	No	X				X				X			
7	Cohen, G	2011	No			X		X				X			
8	De Beer, J	2017	No			X		X				X			
9	Defoort, S	2010	Yes			X		X				X			
10	El Sallakh, SA	2012	No			X		X				X			
11	Faggiani, M	2016	No			X		X				X			
12	Flinkkila, TE	2014	No			X		X				X			
13	Gangary, SK	2016	No			X		X				X			
14	Gille, J	2013	Yes		X			X				X			
15	Glanzmann, MC	2013	Yes	X				X				X			
16	Gupta, P	2016	No			X		X				X			
17	Hann, C	2018	No			X		X				X			
18	Hashiguchi, H	2018	No			X		X				X			
19	Jensen, G	2017	No			X		X				X			
20	Jensen, G	2014	Yes			X		X				X			
21	Jobmann, S	2017	Yes	X				X				X			
22	Kany J	2012	No	X				X				X			
23	Kraus, N	2013	No			X		X				X			
24	LA, G. O. V	2009	No			X		X				X			
25	Liu, X.,	2015	No			X		X				X			
26	Müller,D	2018	No	X				X				X			
27	Murena, L., E	2009	Yes	X				X				X			
28	Pauly, S	2013	Yes	X				X				X			
29	Pauly, S.,	2009	Yes	X				X				X			
30	Ruiz Iban, MA	2018	Yes	X				X				X			
21	Rush, L. N	2016	Yes			X		X				X			
32	Salzmann, G	2010	Yes			X		X				X			
33	Scheibel, M.,	2011	Yes			X		X				X			
34	Shin, S. J	2015	Yes	X				X				X			
35	Shin, S. J.,	2017	Yes	X				X				X			
36	Spoliti, M.,	2014	Yes	X				X				X			
37	Takase, K	2016	No	X				X				X			
38	Theopold, J	2015	Yes			X		X				X			
39	Thiel, E	2011	No			X		X				X			
40	Tischer, T	2009	Yes	X				X				X			
41	Tomlinson, DP	2008	No		X			X				X			
42	Trikha, SP	2004	No		X			X				X			
43	Vrgoc, G	2015	No	X				X				X			
44	Vulliet, P	2017	No	X				X				X			
45	Xu, J	2018	No			X		X				X			
46	Zhang, LF	2017	Yes			X		X				X			
47	Zhang, L	2018	No			X		X				X			

Table 2 (continued)

N	First author	Publication date	Included in meta-analysis	Question 7				Question 8				Question 9				
				Yes	No	Unclear	N. A	Yes	No	Unclear	N. A	Yes	No	Unclear	N. A	Quality score
1	Abat, F	2012	No		X				X				X			4
2	Arrigoni, P	2014	Yes	X					X			X				7
3	Bin Abd Razak, HR	2018	No		X				X				X			5
4	Cavinatto, LM	2011	Yes		X				X			X				4
5	Chaudhary, D	2015	Yes		X				X					X		3
6	Chernchujit, B	2006	No		X				X				X			5
7	Cohen, G	2011	No		X				X				X			4
8	De Beer, J	2017	No		X				X					X		2
9	Defoort, S	2010	Yes		X				X				X			4
11	El Sallakh, SA	2012	No		X				X				X			4
12	Faggiani, M	2016	No		X				X				X			4
13	Flinkkila, TE	2014	No		X				X				X			4
14	Gangary, SK	2016	No		X				X				X			4
15	Gille, J	2013	Yes		X				X			X				3
16	Glanzmann, MC	2013	Yes		X				X			X				6
17	Gupta, P	2016	No		X				X				X			4
18	Hann, C	2018	No		X				X				X			4
19	Hashiguchi, H	2018	No		X				X				X			4
20	Jensen, G	2017	No		X				X			X				5
21	Jensen, G	2014	Yes			X		X				X				7
22	Jobmann, S	2017	Yes		X				X			X				6
23	Kany J	2012	No		X				X				X			5
24	Kraus, N	2013	No		X				X				X			4
25	LA, G. O. V	2009	No		X				X				X			2
26	Liu, X.,	2015	No		X				X				X			4
27	Müller,D	2018	No		X				X				X			5
28	Murena, L., E	2009	Yes		X				X			X				6
29	Pauly, S	2013	Yes	X					X			X				7
30	Pauly, S.,	2009	Yes	X					X			X				7
31	Ruiz Iban, MA	2018	Yes			X		X				X				8
32	Rush, L. N	2016	Yes		X				X					X		4
33	Salzmann, G	2010	Yes		X				X			X				5
34	Scheibel, M.,	2011	Yes		X				X			X				5
35	Shin, S. J	2015	Yes		X				X			X				6
36	Shin, S. J.,	2017	Yes		X				X			X				6
37	Spoliti, M.,	2014	Yes		X				X					X		5
38	Takase, K	2016	No		X				X				X			5
39	Theopold, J	2015	Yes		X				X			X				5
40	Thiel, E	2011	No		X				X				X			2
41	Tischer, T	2009	Yes	X					X			X				7
42	Tomlinson, DP	2008	No		X				X				X			2
43	Trikha, SP	2004	No		X				X				X			2
44	Vrgoc, G	2015	No		X				X				X			5
45	Vulliet, P	2017	No		X				X				X			5
46	Xu, J	2018	No		X				X				X			4
47	Zhang, LF	2017	Yes		X				X					X		4
48	Zhang, L	2018	No		X				X				X			4

The answer to each predefined question (for full question text see appendix 1) and the number of positively evaluated questions is included

Table 3 The information on number of associated intraarticular lesions (AIL) in subjects with acute acromioclavicular joint injuries (ACJ) for the 21 studies included in the meta-analysis

Study *n*	Author	Year	Acute acromioclavicular joint injuries (ACJ)							Associated intraarticular lesions (AIL)						
			N ACJ	N ACJ according to Rockwood type			Mean age ACJ	Sex ACJ		N AIL	N of AIL according to Rockwood type			Mean age AIL	Sex AIL	
				III	IV	V		♀	♂		III	IV	V		♀	♂
2	Arrigoni, P	2014	**64**	64	0	0	37,1	8	56	**19**	19	0	0	–	–	–
4	Cavinatto, LM	2011	**20**	5	0	15	33		20	**1**	0	0	1	29.0	0	1
5	Chaudhary, D	2015	**17**	6	1	10	35	2	15	**1**	0	0	1	21.0	0	1
9	Defoort, S	2010	**9**	2	7	0	–	–	–	**0**	0	0	0	–	–	–
14	Gille, J	2013	**3**	–	–	–	–	–	–	**0**	0	0	0	–	–	–
15	Glanzmann, MC	2013	**19**	16	3	0	37,2	2	17	**5**	–	–	–	–	–	–
20	Jensen, G	2014	**26**	10	16	16	39	3	23	**3**	–	–	–	–	–	–
21	Jobmann, S	2017	**55**	–	–	–	35,2	6	49	**15**	–	–	–	–	–	–
27	Murena, L., E	2009	**16**	10	4	2	33,3	1	15	**4**	–	–	–	–	–	–
28	Pauly, S	2009	**40**	3	3	34	38,2	2	38	**9**	–	–	–	41.1	0	9
29	Pauly, S	2013	**125**	6	0	119	38,5	13	112	**37**	0	0	37	44.8	4	33
30	Ruiz Iban, MA	2018	**200**	110	34	56	36,7	52	148	**20**	9	7	4	36.6	1	19
31	Rush, LN	2016	**21**	5	1	15	30,3	0	21	**5**	–	–	–	30.2	0	5
32	Salzmann, G	2010	**23**	3	3	17	37,5	2	21	**4**	–	–	–	–	–	–
33	Scheibel, M.,	2011	**37**	–	–	37	38,6	4	33	**5**	–	–	–	–	–	–
34	Shin, SJ.,	2017	**21**	7	–	14	41,1	1	20	**9**	–	–	–	–	–	–
35	Shin, SJ	2015	**18**	3	1	14	45,4	1	17	**7**	–	–	–	–	–	–
36	Spoliti, M.,	2014	**19**	10	3	6	33	3	16	**7**	3	3	1	30.9	–	–
38	Theopold, J	2015	**26**	3	4	19	38	1	25	**11**	–	–	–	–	–	–
40	Tischer, T	2009	**77**	5	30	42	35,5	9	68	**14**	0	6	8	–	–	–
46	Zhang, LF	2017	**24**	8	0	16	28,7	3	21	**3**	–	–	–	–	–	–

The mean age, the sex and Rockwood's grade information when available is provided for both ACJ and AIL. (–: information not available)

381 statistical methods as there is not an accepted approach for prevalence data.

To our knowledge, there is no system available to determine the quality of a body of evidence for meta-analyses of prevalence data [47]. A system-like GRADE (Grading of Recommendations Assessment, Development and Evaluation) [47] is needed for evidence obtained in a meta-analysis of prevalence data.

In summary, considering all these factors, it cannot be concluded that the quality of the evidence obtained in this meta-analysis is high. It should be downgraded, at least, due to the presence of unexplained heterogeneity.

Potential biases in the review process

The searches were extensive to reduce the risk of publication bias and to identify as much relevant evidence as possible: an exhaustive search across relevant databases was conducted. Moreover, experts in the field were contacted looking for non-published trials. However, we cannot conclude that the results of our meta-analysis were not distorted by publication bias. The consideration of all relevant information available for the review outcome was hindered, because not all studies included in the systematic review were included in the meta-analysis.

There is not a validated tool to assess the risk of bias of prevalence studies. The tool developed by the JBI [25] was used even as it considers domains not related to the risk of bias such as external validity assessment. Anyhow, this tool was useful to identify relevant methodological flaws in the included studies.

One significant bias in this study is that all the subjects included for analysis had surgery. Surgery for a severe ACJ dislocation is not warranted as the treatment these lesions is controversial and not all are operated. In none of the included studies, the authors operated all the severe ACJ dislocation that they encountered; leaving an undisclosed percentage of subjects managed conservatively. The prevalence

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Table 4 Summarized characteristics of the 185 associated intraarticular lesions (AIL) found in 179 subjects with acute acromioclavicular joint injuries (ACJ)

Lesion type	*N*	Treatment
Biceps lesions	**84**	
SLAP lesion	77	
Undefined SLAP	8	Repair (6), not reported (2)
Type I SLAP	30	Debridement (30)
Type II SLAP	30	Repair (10), tenodesis (5), debridement (6), not reported (9)
Type III SLAP	4	Repair (2), tenodesis (1), debridement (1)
Type IV SLAP	5	Repair (3), tenodesis (1), debridement (1),
Biceps tendon partial tear	4	Biceps Tenodesis (4)
Degenerative biceps	3	Biceps Tenodesis (3)
Posterosuperior cuff lesions	**42**	
PASTA	26	Debridement (23), repair (3)
Bursal tears	2	Repair (2)
Full thickness supraspinatus tear	5	Debridement (2), repair (3)
Two or three tendon tears	5	Not reported (5)
Unspecified cuff lesion	4	Debridement (2), repair (1), not reported (1)
Subscapularis lesions	**28**	
Partial SSC	28	Debridement (18), repair (10)
Labral lesions	**22**	
Anteroinferior	18	Repair (15), not reported (3)
Posterior	2	Repair (1), not reported (1)
SLAP 5	2	Repair (2)
Chondral lesions	**5**	
Glenoid	3	Debridement (3)
Humerus	2	Debridement (2)
Rotator interval lesions	**4**	
Rotator interval tears	1	Debridement (1)
Biceps pulley type 1 lesions	3	Debridement (3)

The treatment is also stated with the number between parentheses stating the number of lesions that were treated with that option

of IAL lesions in this conservatively managed group might be different. The results reported here should then only be applied to subjects in which surgery is being considered.

Agreements and disagreements with other studies or reviews

The general prevalence of associated intraarticular lesions found in this meta-analysis is 20%. This is broadly in line with that found in the only two previous prospective studies focused in defining the prevalence of these lesions after acute ACJ dislocation: Pauli et al. [39] found a prevalence of 22.5% and later on, examining a different cohort [40] found a prevalence of 30%. The prevalence in retrospective series seems to be lower, this might be probably due to the fact that milder lesions were overlooked when reporting clinical results. This probably explains also the lower prevalence (10%) found in our large retrospective study [43]. The analysis excluded the large prospective study by Jensen et al. [28] in which a prevalence of 53% was found. The exclusion was unfortunate but was due to the inability to effectively distinguish data from lesions found in acute and chronic cases.

The subgroup analysis according to the severity of the ACJ injuries did not yield significant prevalence differences. This contradicts with Pauli et al. [40] who did find an increased prevalence grade V injuries (23%) compared to grade III injuries (0%). Ruiz Ibán et al. [43] also found an increased prevalence of IAL in subjects with grade IV lesions (17%) compared to those with grade III lesions (7.6%). That this difference was not appreciated in the meta-analysis might be explained by the heterogeneity of the studies.

The subgroup analysis according to the sex of the subjects with ACJ injuries did not yield significant prevalence differences. This is in line with other studies [28, 40, 55] but Ruiz Ibán et al. [43] found an increased prevalence of IAL in males (13%) compared to females (2%). That this difference

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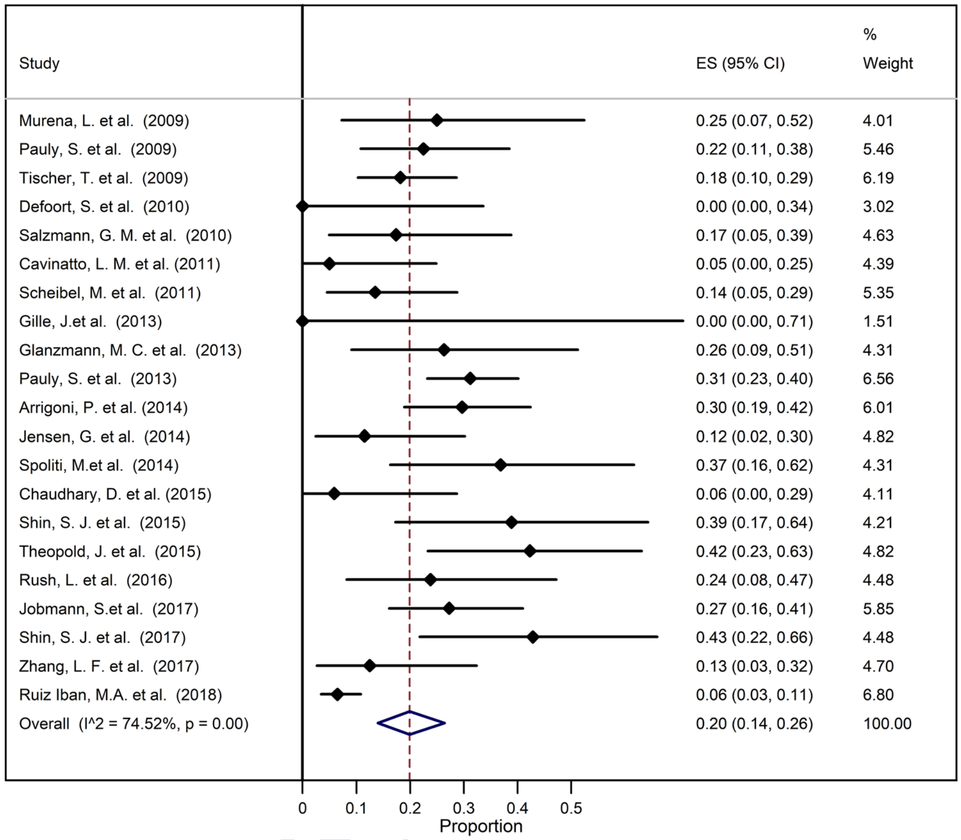
Fig. 2 PRISM flow diagram for the systematic review



was not appreciated might be explained by relative scarcity of ACJ lesions in females (the sex ratio was 8:1).

The meta-regression analysis on the effect of age did not clarify whether more IAL should be expected in younger or older subjects. This is in line with the findings of most authors [2, 39, 40, 55] but differs with the findings of Jensen et al. [28]; but as stated by these authors, the difference was mainly in chronic AJC injury cases, not in acute injuries. Probably, if IAL that were present before the traumatic insult are excluded, there would not be any relevant effect of age on prevalence.

Implications for clinical practice

In severe ACJ, in particular grade III injuries, whether to operate or not and whether the surgical procedure should be delayed initially to assess for early outcomes are controversial issues. Knowing the prevalence of relevant associated injuries in the glenohumeral joint is important. If the prevalence is high, magnetic resonance imaging (MRI) might be needed in these subjects, or surgical treatment might be considered right away to deal with the associated lesions. Furthermore, arthroscopic assessment of the glenohumeral joint should be considered for all surgical cases even if definitive management is performed though open surgery. If the prevalence is low, then the possible presence of these associated injuries should not affect clinical decision-making.

The results of this meta-analysis show that between 14 and 26% of subjects with ACJ injuries have associated intraarticular lesions that require further surgical treatment. This relatively high prevalence might warrant further imaging studies such as MRI. MRI has shown a high concordance with arthroscopic findings [36], but it is unclear if it would be able to detect associated lesions [28, 41].

Whether these figures tilt anybody to decide for treating an ACJ injury surgically instead of conservatively should be left to each specific surgeon, but we agree with Jensen [41], Tischer [55] and Pauly [40] that, if a patient has been already scheduled for surgery, an arthroscopic examination of the glenohumeral joint should be performed customarily.

Implications for future research

The data synthesised in this meta-analysis, although it has a substantial statistical heterogenicity, come from relatively high-quality studies, two of them being prospective studies focused specifically in finding prevalence of associated

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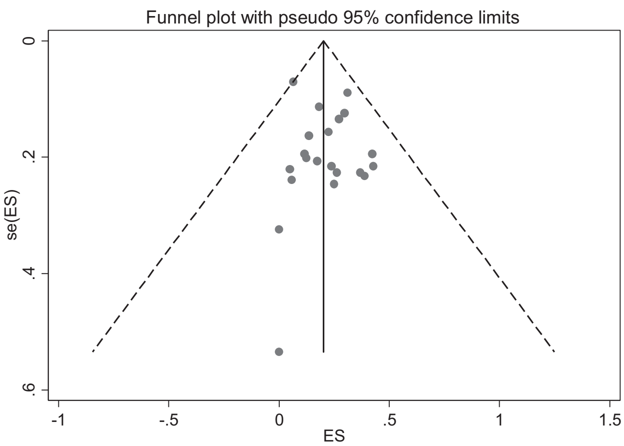

Fig. 3 PRISM flow diagram for the systematic review

intraarticular lesions in subjects operated for severe ACJ injuries.

But there is an unmet need: we do not know the prevalence of these lesions in subjects who were not eventually operated, thus, a prospective MRI evaluation of a full cohort of subjects with severe acute ACJ injuries might be helpful in defining the true prevalence of these associated lesions.

Conclusions

One in five subjects with surgically treated acute ACJ dislocations will have an associated intraarticular lesion that requires further intervention. The case for a customary arthroscopic evaluation of the joint, even when an open procedure is performed to deal with the ACJ dislocation, is strong.

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