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SHOULDER

Prognostic factors influencing the outcome of rotator cuff repair: a systematic review

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Abstract
Purpose To identify prognostic factors significantly associated with rotator cuff repair outcome and define the strength of these associations.
Methods Search was performed using electronic databases. Studies reporting prognostic factors affecting rotator cuff repair outcome were included. Primary outcomes were: structural integrity, Disabilities of the Arm, Shoulder and Hand score, American Shoulder and Elbow Surgeons score, and Constant score. Each other outcome was considered as secondary outcome. Descriptive statistics was used. When possible, meta-analyses were performed. Methodological quality was assessed using the Quality In Prognosis Studies Tool. A best evidence synthesis was performed using the Grading of Recommendations Assessment, Development and Evaluation framework adapted to prognostic studies.
Results Sixty-four studies were included. Methodological quality was high only for twelve studies. The overall quality of evidence was low to very low. Meta-analyses were possible only for seven studies. Older age and larger tears size were found to affect retear risk. Results were controversial for fatty infiltration, acromioclavicular joint or biceps procedures, acromiohumeral distance, delamination of tendon edges, musculotendinous junction position, number of tendons involved, and tendon length, quality and retraction. Baseline scores and workers compensation claim predicted functional outcomes. Subjective outcome was also affected by patient's expectations.
Conclusions Despite the large number of outcomes and prognostic factors evaluated by a relative small number of studies, almost not prognostic in design, it was not possible to reach any definitive conclusion regarding the most relevant predictors of outcome of rotator cuff repair. Moreover, the low methodological quality of the included studies and, subsequently, the low quality of evidence, seriously affected the strength of recommendation of the present review. Based on data available, retear risk is mainly affected by older age and larger tears size. Baseline scores and work compensation claim are the most significant predictors for functional outcomes.
Level of evidence Systematic review of level I–IV prognostic studies, Level IV.

Keywords Rotator cuff · Prognostic factors · Structural integrity · Functional outcomes · Systematic review

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Introduction

Rotator cuff repair is one of the most commonly performed orthopaedic procedures, and approximately 250,000 rotator cuff repairs are performed in the USA each year [46]. As societal and economic value of such a widespread treatment has to be carefully estimated, a growing interest is emerging around factors that can be predictive of a successful rotator cuff repair in order to provide a substantial evidence to the decision-making process. However, no valid conclusions can be drawn from the current literature on the overall efficacy of the procedure, and this depends on several factors. First, correlation between anatomical integrity of repaired tendons and functional outcomes is relatively unpredictable, and albeit subjective results are satisfactory in most of the patients, tendon retear or non-healing rate remains high [67]. Second, several important factors related to the patient, to the tear pattern or to the surgical technique have been identified as potential predictors of outcome of rotator cuff repair [12, 17, 20, 38, 44, 47, 63, 68], albeit repeated prognostic studies and systematic literature reviews did not confirm clear independent associations between these variables and anatomical and/or functional outcome [8, 9, 17, 19, 25, 38, 47, 54, 56].

The purpose of the present study was to systematically review the literature on rotator cuff repair in order to identify all the prognostic factors significantly associated with the outcomes of the procedure and further to define the strength of these associations. The hypothesis of the study was that some predictors of outcome are significantly and independently associated with structural integrity and functional recover after rotator cuff repair.

Materials and methods

This systematic review was conducted following the PRISMA guideline (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [42].

Literature search

Studies were identified by searching major electronic databases from their inception up to 13 April, 2014. The search strategy was applied to MEDLINE through OVID platform, and adapted for EMBASE and Web of Knowledge. To minimize the number of missed studies, no filters were applied to the search strategies (Appendix 1). From title and abstracts, two authors independently selected studies for inclusion. All studies with levels of evidence from I to IV reporting prognostic factors affecting the results following rotator cuff repair were included. Studies that were not prognostic in design, but provided prognostic factors associated with rotator cuff repair outcome were also included. Only papers published in English were considered for inclusion. Exclusion criteria were: studies on partial-thickness rotator cuff tears and isolated subscapularis tendon tears, revision surgery, and studies focused on histological features or performed on animal models. Studies that included both full-thickness and partial-thickness rotator cuff tears or both isolated and combined subscapularis tendon tears, which clearly separated the results by group, were allowed, with only the data from full-thickness cuff tears included in the analysis. Literature reviews, editorial pieces and expert opinions were also excluded. References within included studies and review articles were manually cross-referenced for potential inclusion if omitted from the initial search. In cases of disagreement of paper inclusion/exclusion at any stage of the selection process, a consensus was reached through discussion or, if not possible, by arbitration from the senior author. Titles of journals, names of authors or supporting institutions were not masked at any stage.

Data extraction and outcomes

Two authors independently extracted available data from the full text of all eligible studies using a piloted form. Information gathered included the following study characteristics: authors and year of publication, number of shoulders included, age of participants, surgical approach (open, mini-open or arthroscopic), duration of follow-up, post-operative imaging (if available), outcome measures and associated prognostic factors, statistical methods and results of prognostic analysis. A third author checked the extracted data.

The following outcomes were considered as primary outcomes: structural integrity, American Shoulder and Elbow Surgeons Standardized Shoulder assessment form (ASES score), Constant-Murley (Constant) score and Disabilities of the Arm, Shoulder and Hand (DASH) score. Each other outcome reported by every single study was considered as secondary outcome.

Data analysis

Descriptive statistics was used to summarize findings across all included studies. When possible, extraction of results focused on obtaining odds ratios (ORs) and 95 % confidence intervals (95 % CIs), so that a meta-analysis could be performed using ORs as pooled effect estimates. Heterogeneity was assessed using the Chi-square test, and consequently, a random- or fixed-effects model was used to combine data according to the presence or the absence of heterogeneity, respectively. Data were analysed using the statistical software STATA 13.0 for Windows (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP).

No attempt was made to contact authors for obtaining individual patient data.

Methodological quality

Methodological quality of all included studies was assessed by using the recently updated version of the Quality In Prognosis Studies (QUIPS) Tool [27]. It explores six important domains to consider when evaluating validity and bias in studies of prognostic factors: participation, attrition, prognostic factor measurement, outcome measurement, confounding factors and statistical analysis. According to the authors' instructions to grade the tool, each of the six bias domains is rated as having high, moderate or low risk of bias; assessment of the overall risk of bias is based on the rating given to the most important bias domains (as determined a priori) [27]. Consensus was reached among the authors of the present review to select the following most important domains: study participation, study attrition, prognostic factor measurements and statistical analysis.

Methodological evaluation was initially conducted independently by two reviewers, and results were subsequently discussed until a completely unanimous grade was allocated to each item. If a consensus was not reached, the grade was assigned by arbitration of the senior author.

Grading quality of evidence

A best evidence synthesis was performed using a recently published adaptation of the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework [26], to judge the quality of prognostic evidence [30]. It considers six factors that can decrease the confidence in estimates of effects (phase of investigation, study limitations, inconsistency, indirectness, imprecision and publication bias) and two factors that may increase the quality (moderate or large effect size and exposure–response gradient). The starting point for judging quality of evidence in prognostic studies is based on phase of investigation. Phase 1 studies are usually conducted in the earlier phase of research and therefore provide weaker evidence. Phase 2 and 3 studies constitute high-quality evidence on prognosis because they, respectively, confirm and explain the independent association between specific prognostic factors and the outcome [30]. The overall quality of evidence is described according to the original GRADE in four quality categories: high, moderate, low and very low [2]. A summary assessment was carried out to draw conclusions about the overall quality of evidence for the primary outcomes.

Results

Literature search

The electronic search resulted in 451 hits. Following the PRISMA flow chart, 64 studies were finally included in the review [1, 3–11, 13–16, 18, 19, 21–25, 28, 29, 31–37, 39–41, 43, 45, 48–62, 64–66, 69–79] (Fig. 1).

Characteristics of included studies

Studies' characteristics, outcomes and associated prognostic factors are reported in Appendix 2. The included studies analysed 59,313 shoulders. Age of participants at the time of surgery ranged from 18 to 90 years, and the length of follow-up ranged from 6 to 150 months across the studies. Different surgical approaches were performed: 968 shoulders underwent an open repair, 498 a mini-open repair and 4529 underwent an all-arthroscopic repair. Five studies did not clearly report patients' distribution according to the surgical technique [6, 23, 58, 69, 74]. Forty-one studies also included post-operative imaging at the follow-up evaluation: ultrasonography (US) was chosen by 16 studies [9–11, 15, 18, 22, 25, 34, 40, 54, 55, 61, 62, 65, 72, 79]; computed tomography arthrography (CTA) was used by 11 studies [5, 7, 9–11, 19, 22, 23, 36, 56, 57]; 20 studies [4, 5, 8, 13, 21–23, 32–35, 40, 43, 48–50, 52, 73, 74, 76] preferred the magnetic resonance (MR) imaging, whereas six studies [15, 19, 36, 41, 51, 78] used the MR arthrography (MRA).

Several prognostic factors have been taken into consideration across the studies, which were classified into three main categories: patient-related factors, disease-related factors and procedure-related factors.

Patient-related factors were variables used to define demographics, lifestyle and general health status; disease-related factors were variables used to assess the disease by history, clinical exam, imaging studies, patient-reported outcome measures and intraoperative evaluation; procedure-related factors were variables related to the surgical procedure. Moreover, surgeon's experience and hospital volume have been also considered as potential predictive factors.

Primary outcomes were evaluated as follows: tendon retear or healing was evaluated by 34 studies [4, 5, 8–10, 13, 15, 18, 19, 21–23, 25, 33–35, 40, 41, 43, 48, 49, 51, 52, 54–57, 61, 62, 65, 72, 73, 76, 79]; ASES score was reported in 16 studies [1, 3, 4, 9, 18, 21, 25, 35, 39, 40, 54–57, 62, 77]; Constant score was reported in 24 studies [4, 7, 18, 19, 21–24, 31, 33–37, 39, 40, 43, 52, 56, 57, 64–66, 76]; and DASH score was reported in eight studies [1, 6, 24, 28, 29, 52, 53, 71].

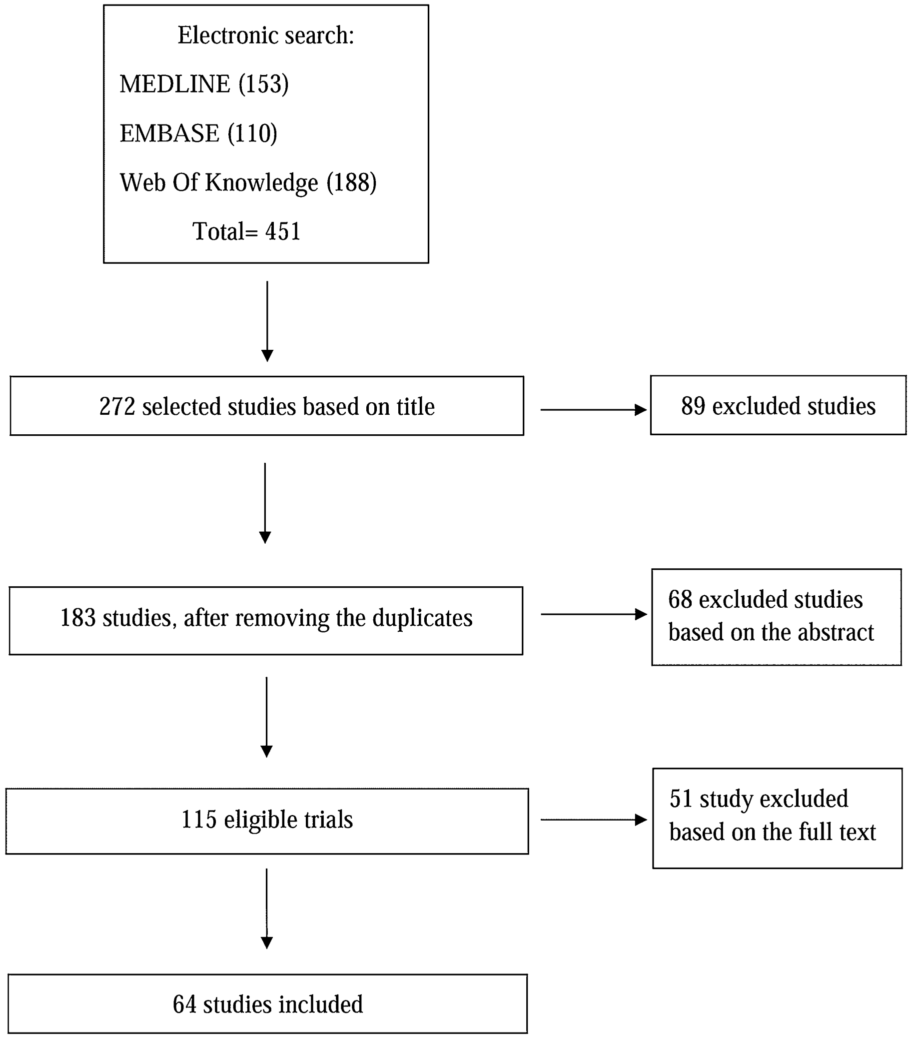

Fig. 1 Studies selection based on PRISMA flow chart

Secondary outcomes included clinical findings, imaging findings, subjective and objective functional evaluation scores, and revision surgery.

Data analysis

Seventeen studies [3, 6, 9, 10, 14, 25, 32, 40, 51, 52, 55, 57, 61, 65, 69, 72, 79] provided statistical measures of the effect of prognostic factors of interest on rotator cuff repair outcome. However, a data pooling of all the extracted data was not possible due to different statistical methods used across the studies and sometimes presence of incomplete data. The remaining studies extracted variables that influenced the outcome of the study and then mentioned them as prognostic factors.

Only seven studies [9, 25, 40, 52, 54, 57, 72], which evaluated prognostic factors affecting tendon retear/healing and ASES score, could be included into the meta-analysis.

Factors affecting structural integrity outcome

Forty-nine factors have been investigated as possible prognostic factors influencing rotator cuff retear or healing. No associations have been found for 35 of those. Heterogeneous results have been reported for the remaining 14 variables (Table 1). Although debated, some studies showed that older age [4, 5, 8, 13, 18, 19, 25, 41, 43, 48, 54, 55, 65, 72, 76, 79], lower bone mineral density (BMD) [10], smaller acromiohumeral distance (AHD) [19], severe fatty infiltration [8–10, 19, 23, 49, 51, 52, 56, 57, 61, 62, 73], more medialized musculotendinous (MTJ) (respect to the glenoid face) [73], preoperative tendon length of less than 15 mm [51], larger tear size [4, 5, 8, 19, 21, 25, 34, 40, 41, 49, 52, 54, 55, 79], multiple tendons involvement [25, 49, 51, 54, 55, 72], delamination of tendon edges [5, 19], poor tendon quality (based on tissue thickness and reducibility) [54, 55], tendon retraction [10, 51, 57], long head of the biceps (LHB) [25, 54, 55] and acromioclavicular joint

Table 1 Description of factors investigated as possible predictors of structural integrity outcome

Prognostic factors	Association with outcome (no. of studies)	
	Significant	Nonsignificant
Patient-related factors		
Age	16 [4, 5, 8, 13, 18, 19, 25, 41, 43, 48, 54, 55, 65, 72, 76, 79]	14 [9, 10, 15, 22, 34, 40, 49, 51, 52, 56, 57, 61, 62, 73]
Gender		15 [5, 9, 10, 13, 15, 41, 51, 52, 55–57, 61, 62, 65, 72]
Dominance		8 [9, 10, 13, 15, 52, 56, 57, 62]
Type of work		5 [9, 10, 34, 52, 57]
Sports activity level		3 [9, 10, 57]
ADL		1 [34]
Smoking		8 [9, 10, 15, 25, 34, 54, 57, 72]
BMD	1 [10]	1 [9]
BMI		2 [13, 34]
Comorbidities		4 [9, 10, 34, 72]
Diabetes		3 [9, 10, 34]
ASA grade		1 [65]
Work comp		2 [5, 19]
Disease-related factors		
Traumatic onset		5 [8, 10, 57, 65, 72]
Timing		13 [5, 8–10, 19, 49, 52, 56, 57, 61, 65, 72, 76]
Aggravation of symptoms		2 [10, 57]
Pain		5 [9, 15, 25, 34, 54]
Narcotics		1 [54]
NSAIDs		2 [25, 54]
Subacromial injections		4 [5, 10, 15, 19]
PROM		2 [9, 10]
AROM		4 [9, 15, 34, 57]
Pseudoparalysis		2 [9, 57]
Strength		3 [15, 34, 40]
Baseline ASES score		4 [25, 34, 40, 54]
Baseline Constant score		5 [15, 34, 40, 43, 65]
Baseline SSV score		1 [15]
Baseline WORC score		1 [40]
AHD	1 [19]	4 [9, 10, 22, 61]
Acromial index		1 [48]
Fatty infiltration	13 [8–10, 19, 23, 49, 51, 52, 56, 57, 61, 62, 73]	5 [13, 18, 21, 22, 41]
Muscle atrophy		2 [21, 41]
MTJ position	1 [73]	1 [51]
Tendon length	1 [51]	3 [33, 61, 73]
Tear size	14 [4, 5, 8, 19, 21, 25, 34, 40, 41, 49, 52, 54, 55, 79]	10 [9, 10, 13, 43, 48, 56, 57, 62, 65, 73]
Tear shape		2 [41, 52]
No. of tendons involved	6 [25, 49, 51, 54, 55, 72]	3 [22, 41, 61]
Tendon delamination	2 [5, 19]	3 [15, 56, 61]
Tendon quality	2 [54, 55]	2 [25, 79]
Tendon retraction	3 [10, 51, 57]	10 [9, 13, 15, 18, 41, 43, 52, 56, 62, 73]
Tendon reducibility		1 [79]
Procedure-related factors		
Surgical approach (O/M/A)		1 [49]
Surgical technique (SR/DR)	2 [33, 40]	7 [9, 10, 25, 48, 54, 55, 57]
Other techniques[a]		4 [8, 13, 52, 65]

Table 1 continued

Prognostic factors	Association with outcome (no. of studies)	
	Significant	Nonsignificant
No. of anchors		4 [40, 52, 54, 73]
Type of anchors		1 [57]
Footprint coverage		2 [35, 61]
Acromioplasty		4 [5, 41, 65, 76]
ACJ procedures	3 [25, 54, 55]	5 [9, 10, 43, 56, 57]
LHB procedures	3 [25, 54, 55]	7 [9, 10, 43, 52, 56, 57, 62]
SLAP tears		3 [25, 54, 56]

ADL activities of daily living, *BMD* bone mineral density, *BMI* body mass index, *ASA* American Society of Anesthesiologists, *Work comp* workers compensation claim, *NSAIDs* nonsteroidal anti-inflammatory drugs, *PROM* passive range of motion, *AROM* active range of movement, *SSV* subjective shoulder value, *WORC* Western Ontario Rotator Cuff, *AHD* acromiohumeral distance, *MTJ* musculotendinous junction, *ACJ* acromioclavicular joint, *LHB* long head of biceps, *O* open, *M* mini-open, *A* arthroscopic, *SR* single row, *DR* double row

[a] Include: microfractures, transosseous, combination of side to side sutures and anchor repair, watertight repair

Table 2 Factors affecting retear risk and tendon healing: results of meta-analyses

Outcome	Prognostic factors		No. of studies	OR	95 % CIs	
					Lower limit	Upper limit
Retear	Patient-related factors	Age*	2 [25, 54]	1.10	1.05	1.15
		Smoking	2 [25, 54]	0.97	0.75	1.25
	Disease-related factors	Pain	2 [25, 54]	1.69	0.58	4.92
		NSAIDs	2 [25, 54]	0.72	0.19	2.69
		ASES baseline	2 [25, 54]	1.01	0.97	1.05
		Tear size*	2 [25, 54]	1.88	1.32	2.67
		No. of tendons involved*	2 [25, 54]	7.79	3.48	17.47
		Tissue quality*	2 [25, 54]	2.63	1.06	6.51
	Procedure-related factors	Surgical technique	2 [25, 54]	0.62	0.31	1.27
		ACJ procedures*	2 [25, 54]	4.51	1.99	10.22
		LHB procedure*	2 [25, 54]	13.09	4.5	37.8
		SLAP tears	2 [25, 54]	0.93	0.49	1.78
Tendon healing	Patient-related factors	Age	2 [40, 72]	0.71	0.313	1.583
	Disease-related factors	Fatty infiltration	3 [9, 52, 57]	6.93	0.26	187.28

NSAIDs nonsteroidal anti-inflammatory drugs, *ACJ* acromioclavicular joints, *LHB* long head of biceps, *OR* odds ratio, *CIs* confidence intervals

* Statistically significant

(ACJ) procedures [25, 54, 55] significantly affect the retear. Moreover, it must be highlighted that two studies [33, 40] found a significant association between row configuration and healing rate. Kim et al. [33] showed that single-row repair positively affects healing rate when remnant tendons are less than 10 mm in length; Lapner et al. [40] showed that double-row repair leads to significantly greater healing rate in small rotator cuff tears.

Only seven studies [9, 25, 40, 52, 54, 57, 72] could be included into the meta-analysis. Although retear and tendon healing are inverses of each other and they have been considered as one outcome for the qualitative analysis, a data pooling for the meta-analysis was not possible. Therefore, separate meta-analyses have been conducted for factors affecting tendon retear and tendon healing. Particularly, retear risk was found to be significantly increased by older age, larger tear size, multiple tendons involvement, poor tissue quality, and associated ACJ and/or LHB procedures [25, 54] On the other hand, with the data available, none of the factors included into the meta-analysis showed a significant correlation with tendon healing (Table 2).

Factors affecting ASES score

Thirty-eight factors were investigated as possible predictors of post-operative ASES score. No associations were found for 28 of them, and heterogeneous results have been shown for the remaining 10 variables (Appendix 3). Few studies showed that female gender [55], smoking [3], BMI [77], workers compensation claim [3], higher degree of fatty infiltration [21], muscle atrophy [21], larger tear size [4, 56], multiple tendons involvement [54, 55] and ACJ procedures [54, 55] negatively affect the outcome. Moreover, only one study [3] showed a significant association between baseline scores and post-operative results.

Only data from two studies [25, 54] could be pooled and therefore included into a meta-analysis. The following factors were analysed: pain, use of narcotics or NSAIDs, tendon quality, surgical technique, ACJ and LHB procedures, and SLAP repair. None of them significantly affected the post-operative ASES score.

Factors affecting constant score

Forty factors have been claimed as possible predictors of functional outcome evaluated through the Constant score. No significant associations were documented for 23 variables, and heterogeneous results were found for the remaining 17 variables (Appendix 4). Meta-analysis was not possible. Several studies showed that older age [19, 24, 64, 66], female gender [7, 19, 37, 65], manual work [7, 19], higher ASA grade [37], workers compensation claim [19], longer duration of symptoms [37, 52], presence of pseudoparalysis [57], lower AHD [19], severe fatty infiltration [19, 23, 52], muscle atrophy [21], larger tears [4, 31, 34, 66], delamination of tendon edges [19], poor tendon quality [19, 31], tendon retraction [19, 52], LHB rupture [31] and poor bone quality [7] negatively affect the post-operative Constant score.

The influence of the preoperative score was evaluated by six studies [7, 22, 24, 39, 52, 65] Three studies [7, 39, 52] showed no correlation between pre- and post-operative score at multivariate analysis. However, two studies [22, 65], which only conducted a univariate analysis, showed a positive correlation between baseline and follow-up evaluation.

Finally, among procedure-related factors, one study [65] showed a positive correlation between acromioplasty and the outcome.

Factors affecting DASH score

The influence of 30 factors on the post-operative DASH score was assessed. No association was found with 17 of those, and heterogeneous results have been shown for the remaining 13 variables (Appendix 5). Meta-analysis was not possible. According to several studies, the following factors negatively influence the post-operative DASH score: older age [52], higher number of comorbidities [53], workers compensation claim [28, 29, 53], longer duration of symptoms [52], greater acromial index [1], higher degrees of fatty infiltration [52], tendon retraction [52] and open surgery [6]. Larger tear size [24] and LHB procedures [24] showed a negative influence on the post-operative DASH score only at univariate analysis.

On the contrary, male gender [24] and higher patient's expectations [28] positively affect the outcome. Baseline DASH score was found to be significantly associated to the outcome only by two studies [6, 24].

Secondary outcomes

Factors affecting secondary outcomes are summarized in Appendix 6.

Several subjective and objective evaluation forms have been used for the evaluation of functional outcomes. Overall, the most important predictive factors were: age [6, 11, 25, 28, 56, 59, 66, 69, 70], comorbidities [6, 28, 69, 71], patients' expectations (only for subjective outcome) [28, 58, 70], tear size [14, 39, 49, 50, 59, 60, 66, 75] and workers compensation claim [3, 28, 29].

Methodological quality

The methodological quality of all included studies was assessed according to the QUIPS tool [27]. Thirty-six out of 64 included studies were judged to be at high risk of bias. Most of these studies did not clearly describe the study sample, did not report the number of patients lost at follow-up and the reasons for their loss, or did not use an appropriate statistical model. Sixteen studies were considered to be of moderate risk of bias because, although a better description of the most important domains has been provided, reported data were incomplete. Only 12 studies were judged to be at low risk of bias (Appendix 7).

Grading quality of evidence

The overall grade of evidence ranged from low to very low for all the outcomes considered (Appendix 8–11).

During the selection process, in order to minimize the number of missed studies, no restrictions were applied to the phase of investigation. As a consequence, the present review majorly included phase 1 studies and a small number of phase 2 exploratory studies. No phase 3 exploratory studies could be found. Therefore, the quality of evidence of the selected studies was initially rated as moderate. It was further downgraded due to very serious limitations concerning description of sample frame and recruitment, sample size, multiple uncontrolled confounding factors, inadequate description of dropouts, improper statistical analysis and selective reporting of results. As previously described, heterogeneity was found for most of the significant findings across the studies. No indirectness in prognostic factors or outcomes has been found, since the review was not intentionally limited to a specific prognostic factor or outcome. However, studies assessing the outcome in a specific patients' population (such as a specific patient's range of age) were considered to be indirect in population. Almost all included studies were also downgraded for lack of precision due to inadequate sample size and completeness in reporting of results. Taking into account that the quality of evidence was already downgraded for early phase of investigation, we avoided to downgrade it for publication bias, unless a very small number of studies assessed the prognostic factor of interest. The grading could not be uprated for effect size and dose effect due to the inadequate number of studies reporting moderate or large effect size, as well as the investigation of a dose effect.

Discussion

The principal finding of the present review is that, up to now, the most relevant predictors of retear risk after rotator cuff repair are older age and larger tear size, as stated by the majority of included studies. Conflicting results have been shown for fatty infiltration. Although it has been claimed as one of the most important factors, there is insufficient evidence to confirm its importance. Associated AC joint or LHB procedures, AHD, delamination of tendon edges, MTJ position, number of tendons involved, tendon length, quality and retraction, were significant predictors of outcome in some studies, albeit they need to be verified in a larger number of confirmatory prognostic studies before drawing definitive conclusions. The role of row configuration also needs to be further clarified. Despite the huge number of studies comparing single-row and double-row repair [12, 63, 68], only a few studies included in the present review assessed the predictive role of row configuration, and therefore, a definitive conclusion could not be reached.

Regarding the functional status assessed through ASES, Constant and DASH scores, different factors have been shown to affect those outcome measures, but only baseline scores and workers compensation claim were overall accepted as important predictors. Patient's expectations have been shown to affect the subjective outcome [28, 58, 70]. Once again, the predictive role of fatty infiltration and muscle atrophy could not be clearly stated due to inadequate number of studies and conflicting results.

The remaining outcomes assessed by each included study were considered as a secondary outcome, but taking into account the large number of outcomes and prognostic factors evaluated by a relative small number of studies, almost not prognostic in design, it was not possible to reach any definitive conclusion. Moreover, the low methodological quality of the included studies and, subsequently, the low quality of evidence, seriously affected the strength of recommendation of the present review.

According to the current literature, a growing interest is emerging around factors affecting rotator cuff repair outcome, and, consequently, three review papers [17, 38, 47] have been recently published on this topic. All of them considered the structural and the functional outcomes separately, but a different number of studies were included in each review and a different number of prognostic factors and functional outcomes were considered. This was probably due to different inclusion/exclusion criteria applied to the selection process.

In the present review, we considered all the papers reported in the literature without any restriction on date of publication or surgical approach and tried to clarify the different impact of each predictor on each outcome. An attempt was made to perform a data pooling and consequently a meta-analysis, but only few studies could be pooled. Moreover, we not only assessed the methodological quality of each included study, but also tried to grade the quality of evidence according to the available data.

Comparing the results of the present review with those reported by the previous papers, we noticed that several prognostic factors such as dominance, use of NSAIDs as well as narcotics, or subacromial injections, tendon length, MTJ position, acromial index, tendon reducibility, footprint coverage and anchor type, were not considered by the previous papers. Although these factors have been considered by a very few studies and their impact on the structural as well as functional outcome could be less important than other variables such as age or tear size, in absence of high-quality prognostic studies, we thought that at least defining which variables have been found to affect the outcome, could be important for future research studies.

Older age and larger tear size were recognized as significant factors increasing the retear risk in the present and previous papers. BMD was considered only by the present review and by McElvany et al. [47], with the same results. McElvany et al. [47], after conducting a data pooling, showed that higher degree of fatty infiltration as well as LHB procedures surely increased the retear risk. Other significant prognostic factors were identified in the previous reviews, such as: tendon retraction, double-row repair, delamination of tendon edges, number of tendon involved and AC joint procedures. Results of the present study did not confirm a strong association between these factors and the structural integrity outcome. Nonetheless, we agree that there is a possible influence of these variables on the retear risk, albeit further studies are needed to clarify their impact on the outcome.

A comparison between the present review and the previous ones for factors affecting the functional outcomes was almost impossible because several functional outcomes were analysed in the previous reviews but they were finally reported as a whole without considering the different impact of one factor over another on the different functional outcomes.

Nevertheless, differently from general opinion, it must be highlighted that no effect of smoking on any structural outcome could be found in the present review as well as in the previous ones. Among functional outcomes, smoking showed a possible negative effect on VAS for pain [45], ASES [3] and UCLA scores [45]. Interestingly, McElvany et al. [47], after a data pooling, showed that smokers have better functional results than non-smokers. Further studies are needed to clarify this issue.

The present review has several limitations, mainly due to the low methodological quality of included studies. The high variability in prognostic factors and outcomes evaluated as well as in statistical measures and data reported decreased the quality of the studies and made a data pooling impossible. Specific limitations of included studies have been already discussed in the results. Certainly, a better agreement on functional outcome evaluation must be reached and phase 2 and 3 confirmatory prognostic studies are needed to clearly state factors affecting rotator cuff repair outcome. Limitations strictly related to the review methodology should be also taken into account. First, only English papers were included, and this could have led to miss eligible studies. Second, no attempt was made to contact trialists for obtaining individual patient data and then to carry out a comprehensive meta-analysis. Finally, the overall quality of evidence was assessed only for primary outcomes. Secondary outcomes were not considered due to the paucity of studies.

Conclusions

Despite the large number of outcomes and prognostic factors evaluated by a relative small number of studies, almost not prognostic in design, it was not possible to reach any definitive conclusion regarding the most relevant predictors of outcome of rotator cuff repair. Moreover, the low methodological quality of the included studies and, subsequently, the low quality of evidence, seriously affected the strength of recommendation of the present review. Based on the data available, retear risk was mainly affected by older age and larger tears size. Baseline scores and work compensation claim were found to be the most significant predictors for functional outcomes.

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