Specific patient-related prognostic factors for rotator cuff repair: a systematic review

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Background: Many studies that describe factors affecting outcome in primary rotator cuff repair (RCR) have been published, but so far there is no review that summarizes them. This systematic review was conducted to identify prognostic factors influencing functional (clinical) outcome and radiologically proven cuff integrity after RCR.

Methods: A literature search was conducted up to July 2013 for prospective studies that describe prognostic factors affecting outcome in primary RCR. Inclusion criteria were open or arthroscopic repair of a full-thickness supraspinatus or infraspinatus tear. Included outcome measures were shoulder function and cuff integrity. Studies describing revision surgery, muscle transpositions, and subscapular or partial-thickness tears and those with retrospectively collected data were excluded, as were studies without linear or multivariate regression. The literature search resulted in 662 hits, and 12 of those studies were included in this review.

Results: Moderate evidence was found for increasing age, larger tear size, and additional biceps or acromioclavicular procedures to have a negative influence on cuff integrity at follow-up as well as for Workers’ Compensation Board status to have a negative influence on functional outcome after RCR. There is limited evidence that performance of an additional acromioclavicular procedure has a negative influence on functional outcome. There was insufficient evidence for other described prognostic factors.

Conclusion: Several patient-specific factors influencing functional and radiologic outcome after RCR have been identified. These factors can guide orthopedic surgeons in their decision-making process as to whether to operate on their patients.

Level of evidence: Level IV, Systematic Review.

Keywords: Prognostic factors; rotator cuff repair; systematic review; functional outcome; cuff integrity

Full-thickness tears of the rotator cuff are common, but the indications for repair of a nontraumatic rotator cuff tear (RCT) as part of a degenerative entity are not always evident. Rotator cuff repair (RCR) is a frequently performed procedure. Reported satisfactory outcome of surgical treatment of RCT is 38% to 95%, but the indications for repair of a nontraumatic rotator cuff tear (RCT) as part of a degenerative entity are not always evident. Rotator cuff repair (RCR) is a frequently performed procedure. Reported satisfactory outcome of surgical treatment of RCT is 38% to 95%, but the indications for repair of a nontraumatic rotator cuff tear (RCT) as part of a degenerative entity are not always evident. Rotator cuff repair (RCR) is a frequently performed procedure. Reported satisfactory outcome of surgical treatment of RCT is 38% to 95%, but the indications for repair of a nontraumatic rotator cuff tear (RCT) as part of a degenerative entity are not always evident. Rotator cuff repair (RCR) is a frequently performed procedure. Reported satisfactory outcome of surgical treatment of RCT is 38% to 95%, but the indications for repair of a nontraumatic rotator cuff tear (RCT) as part of a degenerative entity are not always evident. Rotator cuff repair (RCR) is a frequently performed procedure. Reported satisfactory outcome of surgical treatment of RCT is 38% to 95%, but the indications for repair of a nontraumatic rotator cuff tear (RCT) as part of a degenerative entity are not always evident. Rotator cuff repair (RCR) is a frequently performed procedure. Reported satisfactory outcome of surgical treatment of RCT is 38% to 95%, but the indications for repair of a nontraumatic rotator cuff tear (RCT) as part of a degenerative entity are not always evident. Rotator cuff repair (RCR) is a frequently performed procedure. Reported satisfactory outcome of surgical treatment of RCT is 38% to 95%, but the indications for repair of a nontraumatic rotator cuff tear (RCT) as part of a degenerative entity are not always evident. Rotator cuff repair (RCR) is a frequently performed procedure. Reported satisfactory outcome of surgical treatment of RCT is 38% to 95%, but the indications for repair of a nontraumatic rotator cuff tear (RCT) as part of a degenerative entity are not always evident. Rotator cuff repair (RCR) is a frequently performed procedure. Reported satisfactory outcome of surgical treatment of RCT is 38% to 95%, but the indications for repair of a nontraumatic rotator cuff tear (RCT) as part of a degenerative entity are not always evident.
process. Many studies have described different prognostic factors for functional outcome and radiologic outcome (e.g., cuff integrity) after RCR. No regression analysis was performed in the majority of the studies, though, making the results less interpretable.

So far, no systematic reviews have been published that summarize the available patient-specific prognostic factors for RCR. The purpose of this systematic review of the literature was to determine patient-specific prognostic factors for functional outcome and cuff integrity in RCR. It was not our intention to develop a guideline.

Materials and methods

Literature search

A search of the literature in PubMed (from 1948 onward), EMBASE (from 1947 onward), PEDro (from 1929 onward), and the Cochrane Central Register of Controlled Trials was conducted to identify relevant publications until July 2013, without language restrictions. The literature search strategy for PubMed is presented in Table I.

Study selection and quality assessment

The publications had to meet the following selection criteria:

- Study design: prospective studies that describe prognostic factors affecting outcome in primary RCR. Studies describing revision surgery and muscle transpositions were excluded, as were studies without linear or multivariate regression analyses, studies with retrospectively collected data, and those that compared different surgical techniques.

  Explanation: The purpose of linear or multivariate regression analysis is to predict outcome on the true basis of different independent variables or to describe how outcome depends on different independent variables. By weighing the influence of different relevant variables on outcome, true significant prognostic factors can be identified.

- Participants: adult patients with full-thickness tears of the supraspinatus or infraspinatus; subcapsular tears were excluded.

  Explanation: The subscapular tendon is an anterior stabilizer of the shoulder joint5,6 as opposed to supraspinatus and infraspinatus tendon tears, which are more commonly degenerative tears.23,37 For these reasons, indications to repair subscapular tears differ from those for supraspinatus and infraspinatus tears. Therefore, subcapsular tears were excluded.

- Interventions: open, mini-open, and arthroscopic techniques.

  Explanation: All these techniques were included because previous studies did not show differences in long-term follow-up.2

- Outcome measures: functional outcome and cuff integrity.

  The search resulted in 662 citations. According to the study selection criteria, 2 of the authors independently selected the relevant articles for this review by reading all titles and abstracts retrieved by the search strategy. A total of 602 articles were excluded. Sixty articles were retrieved for a more detailed evaluation. Of these, 16 articles were excluded as they were not prognostic or had no randomized controlled design; in 18 articles, no linear or multivariate regression analysis was used; concomitant subscapular tears resulted in exclusion of 11 studies; other reasons for exclusion were tendon transfer (n = 1) and partial RCT (n = 2). Twelve articles met our inclusion criteria (Fig. 1).1,8-10,12-15,18,19,28,29

All publications were assessed by 2 reviewers (L.H. and O.D.) according to a methodologic quality list for the assessment of prognostic cohort studies (Table II). Each criterion was graded as positive/yes (+), negative/no (−), or unclear (?). A quality score was calculated for the selected studies by summing the positive answers. The maximum attainable score was 9. Studies were considered to be of a high methodologic quality when at least 7 items scored positively; the labels “medium quality” and “low quality” were assigned when, respectively, 4 to 6 or 0 to 3 items scored positively. One trial was classified as high quality,14 9 trials as medium quality,1,8-10,12,15,18,19,28,29 and 2 trials as low quality13,18 (Table III). In 1 trial, the 2 observers disagreed on item A. A binding verdict was given by one of the coauthors.

Extraction of results focused on obtaining risk ratios and their respective confidence intervals for dichotomous data or means (or median scores), with standard deviations and differences in means (or median scores) and their confidence intervals for continuous outcomes or P values when confidence intervals were not given. Meta-analysis was not possible because of diversity in outcome measures among the included studies and the different and sometimes incomplete presentation. A best evidence synthesis was performed. Guidelines for systematic reviews from the Cochrane Collaboration Back Review Group were used.53 The best evidence synthesis was modified for purposes of this review on the basis of the method presented by Steultjens et al56 (Table IV).

Data extraction

Using standardized forms, 2 reviewers independently extracted data from the selected studies on characteristics of the study population, study descriptions concerning reliability and standardization of interventions, prognostic factors, and results. The outcome parameters tested were functional outcome and cuff integrity. Different functional outcome questionnaires in the studies (Disabilities of the Arm, Shoulder and Hand; Constant-Murley score; American Shoulder and Elbow Surgeons shoulder

<table>
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<tr>
<th>Table I</th>
<th>Literature search strategy for MEDLINE</th>
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<tr>
<td>1</td>
<td>Shoulder joint [MeSH]</td>
</tr>
<tr>
<td>2</td>
<td>Rotator cuff [MeSH]</td>
</tr>
<tr>
<td>3</td>
<td>NOT (capsulitis [TW] OR frozen shoulder [TW] OR osteoarthritis [Mesh] OR instability [TW])</td>
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<tr>
<td>5</td>
<td>Prognostic OR predictive OR [influence AND outcome]</td>
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MeSH, medical subject headings; TW, text word; PT, publication type; SH, sub heading.
score; global range of motion) were combined into the term “functional outcome.” In all applicable studies, cuff integrity was assessed with ultrasonography at follow-up. The prognostic factors tested in the different studies were age, Workers’ Compensation Board (WCB) status, smoking, trauma, duration of symptoms, preoperative expectations, comorbidity, obesity, tear size, tissue quality, multiple tendon involvement, additional biceps procedure, and additional acromioclavicular (AC) procedures.

**Results**

**Age**

Mean age of the patients ranged from 52 to 59.5 years (overall range, 32-80 years). The prognostic importance of age on functional outcome was assessed in 1 high-quality study and 6 medium-quality studies.1,9,10,14,15,19,28 None of the studies showed that age had a significant influence on functional outcome. We conclude that there is insufficient evidence that age has an influence on functional outcome.

Age was assessed in 3 medium-quality studies to determine its influence on cuff integrity.10,19,29 Gulotta et al.19 showed in their study that the odds ratio (OR) was 1.15 (95% confidence interval [CI], 1.04-1.28) for each year of increasing age. In the study of Nho et al.,19 the OR was 1.08 (95% CI, 1.02-1.14). In a study by Tashjian et al.,29 younger patients were more likely to have an intact cuff integrity.
rotator cuff at follow-up (OR, 0.42; 95% CI, 0.19-0.92). We conclude that there is moderate evidence that increasing age has a negative influence on cuff integrity at follow-up.

**WCB status**

WCB status was assessed in 4 medium-quality studies and 1 low-quality study.\(^1\)\(^{12}\)\(^{13}\)\(^{18}\)\(^{28}\) WCB status had a significantly negative influence on functional outcome in 2 medium-quality studies\(^1\)\(^{13}\) and in 1 low-quality study\(^18\) and no significant influence in 2 medium-quality studies.\(^15\)\(^{28}\) We conclude that there is moderate evidence that WCB status has a negative influence on functional outcome after RCR.

**Smoking**

In 2 medium-quality studies, smoking showed no significant effect on functional outcome.\(^1\)\(^{28}\) In 2 medium-quality studies, smoking showed no significant influence on cuff integrity at follow-up.\(^10\)\(^{19}\) We conclude that there is insufficient evidence that smoking has an influence on functional or radiologic outcome.

**Traumatic onset**

Traumatic onset of complaints was assessed in 2 medium-quality studies; no significant influence on functional outcome was identified.\(^1\)\(^{15}\) We conclude that there is
insufficient evidence that traumatic onset has an influence on functional outcome.

Duration of symptoms

Three medium-quality studies assessed duration of symptoms until surgery.1,15,29 In 1 study, patients with a duration of symptoms of more than 6 months did not have a significantly worse functional outcome than that of patients whose symptoms lasted less than 6 months.1 In the other 2 studies, duration of symptoms did not have a significant influence on functional outcome, although the duration was not specified.15,29 We conclude that there is insufficient evidence that duration of symptoms has an influence on functional outcome.

No study was found that assessed the relation between cuff integrity and duration of symptoms.

Obesity, comorbidity, and preoperative expectations

Obesity was assessed in only 1 medium-quality study.18 No significant influence on functional outcome was found. Comorbidity was assessed in 2 medium-quality studies.18,28 In 1 study, patients with more medical comorbidities showed greater improvement in overall shoulder pain, function, and quality of life scores compared with preoperative scores than did patients without comorbidities.28 A second study found no significant influence on functional outcome.18 Regarding positive preoperative expectations, 1 medium-quality study found a significant influence on functional outcome13; another found none. We conclude that there is conflicting evidence about obesity, comorbidity, and preoperative expectations having an influence on functional outcome.

No studies were found that assessed the relation between obesity, comorbidity, or preoperative expectations and cuff integrity.

Tear size

In 1 high-quality14 and 4 medium-quality8,10,19,28 studies, tear size was assessed to determine its influence on functional outcome. Tear size was measured in all studies preoperatively. In 1 study, the tear size was measured in 2 directions, in square millimeters.14 In 2 studies, tear size was measured in sagittal direction.10,19 Two studies failed to specify the direction of the tear measurements.8,29 In 4 medium-quality studies, tear size was not related to functional outcome. We conclude that there is no evidence that tear size has an influence on functional outcome.

In 3 medium-quality studies,8,10,19 a larger tear size was significantly associated with greater risk of re-tear. Gulotta et al10 had an OR of 1.72 (95% CI, 1.04-2.85), and Nho et al19 had an OR of 2.29 (95% CI, 1.55-3.38). We conclude that there is moderate evidence that a larger tear size has a negative influence on cuff integrity at follow-up.

Tissue quality

Tissue quality was assessed in 4 medium-quality studies.8,10,15,19 In 1 study, the quality of the tissue was assessed preoperatively with magnetic resonance imaging (MRI), determining fatty infiltration and supraspinatus and infraspinatus atrophy.8 In another study, only fatty infiltration was determined with MRI or computed tomography arthrography (CTA).15 In 2 studies, tissue quality was determined intraoperatively and scored as good or degenerative.10,19 In the study of Gladstone et al,8 infraspinatus atrophy assessed on MRI (>grade 2) and moderate to severe fatty infiltration of the infraspinatus were significantly associated with a worse functional outcome. Lafosse et al15 showed no influence on functional outcome of fatty infiltration of the rotator cuff assessed by CTA or MRI. When tissue quality was judged intraoperatively, there was no significant influence on functional outcome.19 We conclude that there is insufficient evidence about tissue quality having an influence on functional outcome.

The effect of tissue quality on cuff integrity was assessed in 3 medium-quality studies8,10,19. In 2 of the studies, tissue quality had no such influence.8,10 In their study, Nho et al19 showed a significantly negative influence of tissue quality, preoperatively scored, on cuff integrity at follow-up. We conclude that there is insufficient evidence for tissue quality having an influence on cuff integrity at follow-up.

Multiple tendon involvement

Multiple tendon involvement was assessed in 3 medium-quality studies.10,19,29 Gulotta et al10 found no significant influence on functional outcome of the number of tendons involved (OR, 1.04; 95% CI, 0.31-3.49). Nho et al19 found a significantly negative influence on functional outcome (OR, 0.42; 95% CI, 0.19-0.97). We conclude that there is no evidence that multiple tendon involvement has an influence on functional outcome.

Multiple tendon involvement had a significantly negative influence on cuff integrity in the studies of both Gulotta et al10 (OR, 5.56; 95% CI, 1.23-25.22) and Nho et al19 (OR, 8.92; 95% CI, 3.43-23.18). However, in the study of Tashjian et al,29 the number of tendons involved showed no influence on cuff integrity at follow-up. We conclude that there is moderate evidence that multiple tendon involvement has a negative influence on cuff integrity at follow-up.

Additional biceps procedure

The influence of an additional biceps procedure (tenodesis or tenotomy) on functional outcome was assessed in 3 medium-quality studies.1,15,19 There was no significant
influence on functional outcome. We conclude that there is no evidence that additional biceps procedures have an influence on functional outcome.

Cuff integrity was assessed after performance of a biceps procedure in 2 medium-quality studies. An additional biceps procedure showed a significantly negative influence on cuff integrity in the studies of Gulotta et al (OR, 16.16; 95% CI, 3.01-86.65) and Nho et al (OR, 11.39; 95% CI, 2.90-44.69). We conclude that there is moderate evidence that an additional biceps procedure has a negative influence on cuff integrity.

Additional AC procedure

In 1 medium-quality study, the effect of an additional AC procedure on functional outcome was assessed. There was a significantly negative influence on functional outcome (OR, 0.29; 95% CI, 0.13-0.64). We conclude that there is limited evidence that performance of an additional AC procedure has a negative influence on functional outcome.

Two medium-quality studies assessed cuff integrity after performance of an AC procedure. The studies of both Gulotta et al (OR, 6.70; 95% CI, 1.46-30.73) and Nho et al (OR, 3.85; 95% CI, 1.46-10.12) showed a significantly negative influence on cuff integrity at follow-up. We conclude that there is moderate evidence for additional AC procedures to have a negative influence on cuff integrity at follow-up.

Discussion

Many articles have described prognostic factors for RCR; yet there are conflicting results, and adequate statistical analysis (e.g., multivariate regression analysis) is not always performed. This systematic review was designed to identify patient-specific prognostic factors influencing functional and radiologic outcome after RCR and summarizes the evidence available up to now.

Possible side effects of RCR are increased pain, re-tear, and stiff shoulder; less common are infection, implant migration, and deltoid atrophy. Only patients who benefit most from RCR should be exposed to the risk of these side effects. Furthermore, increasing health care costs demand a selection of patients who are most likely to have good postoperative results.

Of all the factors researched, only WCB status and additional AC or biceps procedures appeared to have a significantly negative influence on functional outcome. There was insufficient evidence that age, smoking, trauma, duration of symptoms, preoperative expectations, comorbidity, obesity, tear size, tissue quality, and multiple tendon involvement were significant prognostic factors for functional outcome.

Age, multiple tendon involvement, tear size, and additional AC or biceps procedures had a significantly negative influence on cuff integrity at follow-up. There was insufficient evidence that WCB status, smoking, trauma, duration of symptoms, preoperative expectations, comorbidity, obesity, and tissue quality were significant prognostic factors for cuff integrity.

Factors like age, tissue quality, tear size, and traumatic onset of complaints would logically influence functional and radiologic outcome. Increasing age is proportionately associated with RCT size. Although tear size and age negatively influence cuff integrity, we did not find evidence for these prognostic factors having a negative influence on functional outcome. As also found in other studies, this indicates that cuff integrity is not correlated with functional outcome. In several studies, however, re-tear of the cuff is correlated with weakness of elevation. In a study by Paxton et al, patients with a re-tear did not experience a decrease in function 10 years after RCR compared with 3 years postoperatively. This might be explained by a decreasing level of disability, as stated by Galatz et al, presumably because of a concurrent decrease in activity level and the demands on the shoulder as patients age.

Four studies assessed tissue quality in functional outcome. In 1 study, quality was assessed by MRI; in another, MRI and CTA were used. In 2 studies, tissue quality was assessed intraoperatively. Because of the different methods for assessing tissue quality, we believe that firm conclusions cannot be drawn. A decrease in tissue quality would obviously increase the chances of re-tear.

Regarding tear size, different measurements were used in the selected studies (measurement in square millimeters and length in the coronal and sagittal planes). The morphology of tears was not addressed, and therefore comparisons cannot be made. Only when tear geometry is appreciated can the surgeon perform an effective repair. Proper documentation in articles describing cuff repair is therefore important.

Patients diagnosed with RCT after a traumatic event may have had an asymptomatic tear before the accident. Ten percent of the population has an atraumatic RCT in their fourth decade of life; this increases to 50% in the sixth decade and 80% in the eighth decade. Fifty percent of patients older than 50 years with asymptomatic RCT become symptomatic within 5 years. Although a short duration of symptoms or a traumatic onset may suggest good quality of the rotator cuff tissue, this should not be assumed.

Our best evidence synthesis resulted in moderate evidence that both additional biceps procedures and AC procedures have a negative influence on cuff integrity. We also found limited evidence that performance of an additional AC procedure negatively influences functional outcome. Nontraumatic RCTs can be seen as degenerative changes in the shoulder joint. Biceps degeneration and AC joint osteophytes are part of this continuum. An additional intervention, such as a biceps or AC joint procedure, is not only patient but also surgeon dependent. The decision for
the orthopedic surgeon to perform a biceps procedure during RCR can depend on the patient’s age, comorbidities, activity level, extent of disability, presence of rotator cuff arthropathy, and quality of the rotator cuff tissue. AC joint osteophytes are highly associated with rotator cuff tendon failure. Presuming that in the selected articles a biceps or AC joint procedure was performed more often in cases of a degenerative and more retracted RCT, it would make sense if these patients scored worse on cuff integrity.

**Limitations**

This review summarizes the best available evidence for patient-specific prognostic factors for functional and radiologic outcome after RCR up to now. This evidence is mainly based on a limited number of moderate-quality studies, all using different prognostic factors and outcome measures. Because of the diversity in outcome measures among the included studies and the different and sometimes incomplete presentation (median scores, mean scores, relative risk ratios), meta-analysis was not possible. We therefore chose to summarize the results by means of a qualitative analysis (best evidence synthesis).

Another limitation is that none of the included trials described the outcomes of patients lost to follow-up. In 9 of 11 studies, it was not clear if the outcome assessment was blinded.

In 9 of the 11 selected studies included in this review, superior labral anterior-posterior (débridement/repair), biceps (débridement, tenotomy or tenodesis), and AC procedures were performed during the RCR. The remaining studies provided no or insufficient information about this. When more pathologic change is found in one shoulder, what causes most symptoms is not always evident. Hence, when more pathologic processes are treated simultaneously, it is also more difficult to know which postoperative result is being tested. We know many elderly people have asymptomatic RCT. An arthritic AC joint can, for instance, be treated concomitantly to repair an asymptomatic RCT. Good postoperative results could then be attributed to the RCR. This is why we believe that simultaneous interventions influenced the outcome in the prognostic studies.

**Recommendations**

On the basis of the selected articles, it would not be feasible to make an algorithm selecting patients who will benefit most from RCR or for whom surgery might lead to unsatisfactory results, although it was not our primary intention in this review. Apart from being high quality, future research should include all relevant prognostic factors presented in this and other previous studies. On the basis of those results, a decision tree can be made that can guide orthopedic surgeons in their decision process as to whether to operate.

**Conclusions**

Indications for repair of nontraumatic RCT as part of a degenerative entity are not always evident. So far, no systematic review has described patient-specific prognostic factors for RCR. Selection of appropriate patients for surgery should prevent unsatisfactory postoperative results, reducing adverse events and health care costs.

Considering the available evidence as summarized in this review, performance of RCR should be carefully considered in patients from older age groups as well as in those with a WCB status, multiple tendon involvement or greater tear size, or additional AC or biceps disease; these patient groups show moderate to reasonable evidence suggesting a disappointing result in cuff integrity and functional outcome after RCR.

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