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ORIGINAL STUDY

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Does early repair of traumatic rotator cuff tears provide better outcomes? A systematic review

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Our aim was to systematically review literature of trauma related rotator cuff tears in order to evaluate the outcome and healing integrity in relation to time of surgery. Our research question was whether earlier surgical repair leads to superior functional results. This review was conducted according to PRISMA statement. A literature search of Pubmed, Embase, Cohrane was conducted, with two researchers assessing studies for eligibility and quality. A total of 20 studies, published between 1980 and 2019, met the inclusion criteria and were divided into two groups based on duration of symptoms before surgery. Group A comprised of studies in which duration was < 3 months and Group B > 3 months. Within each group there was a statistically significant improvement in the CS from pre-operative to post-operative outcome, but the improvement for Group A was statistically higher in comparison to Group B (P=0.01). Nevertheless, there was no significant difference in the final outcome for the two groups (P=0.29). The re-tear rate per 100 patients was calculated 28.5(±7.2) for Group A, and 17.2 (±12.56) for Group B (P=0.056). Our results suggest that functional outcome and tendon healing may not be valid arguments for early surgical repair. Therefore, repair of traumatic RCTs could be recommended whenever technically possible.

Keywords: Rotator cuff; acute; traumatic; injury; repair; surgery; systematic review.

INTRODUCTION

Most of rotator cuff tears (RCTs) are usually considered as degenerative and evolve with aging *(1)*. However, RCTs can also occur acutely in previously asymptomatic patients who identify a traumatic event leading to a sudden onset of symptoms which include severe pain, immediate loss of strength, and functional impairment of the involved shoulder *(2)*. The estimated incidence of symptomatic RCT after shoulder trauma without fracture or dislocation is 9% *(3)*. Few studies have tried to investigate a correlation between time from

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Table I. — Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
1) Randomized controlled trials, cohort studies, case series 2) Prospective and retrospective studies 3) Male or female patients of any age 4) Traumatic tear which has resulted from an identifiable injury 5) Primary repair with no augmentation: graft or biologic (open, mini-open, or arthroscopic repair) 6) Reporting data on time to surgery from onset of symptoms 7) Reporting data on functional results 8) All tear sizes, all rotator cuff tendons	1) Literature reviews, case studies, commentaries, grey literature 2) Non-English language 3) Cadavers or animal studies 4) Conservative treatment 5) Chronic RCTs, or studies with heterogeneous patient populations (both traumatic and degenerative tears) 6) Mean Follow-up less than 12 months

injury and functional outcome. Despite limited evidence and conflicting literature, the preferred treatment until now is early surgical intervention. Swedish National Guidelines state that patients with acute full-thickness traumatic RCTs should undergo surgery within three or six weeks depending on their clinical findings *(4)*.

The objective of this Systematic Review was to identify, analyze and appraise all existing studies of traumatic RCT (TRCT) with reporting data on time, from injury to operation, in order to report and compare outcomes across early and delayed repaired patients. The research question was whether earlier surgical repair of traumatic RCTs leads to superior functional results. We hypothesized that shorter time to surgery will prove more beneficial in terms of achieving higher Constant score (CS) score, American Shoulder and Elbow Surgeons (ASES) score, University of California Los Angeles (UCLA) score and Oxford Shoulder Score(OSS) *(5-8)*.

MATERIALS AND METHODS

This study was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines *(9)*. The search was performed using the databases of Pubmed, Embase and Cohrane Libraries. By utilizing the PICO search strategy, we used the following terms: rotator cuff OR supraspinatus OR infraspinatus OR teres minor OR subscapularis AND traumatic OR acute OR injury AND repair OR surgery. The only limit applied at this stage was the year of publication, which had to be from January 1980 to August 2019.

Two reviewers (I.P and N.P) independently screened all resulting titles and abstracts. At the following stage, the full text of selected articles was assessed for eligibility criteria. The references of all included studies and review articles were also manually cross-referenced to verify that no relevant articles were missing. Any disagreement in eligibility was discussed and if appropriate the senior author was consulted (P.G).Possible studies for inclusion were those with acute or traumatic RCT with reporting data on duration of symptoms before surgery, clinical outcome and a minimum mean follow-up of one year (Table I).

Each study was assessed for its methodological quality with the Methodological Index for Non-Randomized Studies (MINORS) scale *(10)*. MINORS is a valid instrument designed to assess the methodological quality of non-randomized surgical studies, whether comparative or non-comparative. Finally, the presence of risk of bias in individual studies was analyzed.

The data from each study that met the inclusion criteria were abstracted by two independent reviewers (I.P and N.P). Details of study design, sample size and patient demographics were recorded. In addition, tendons involved, surgery type, duration of symptoms, functional outcome scores, length of follow up and re-tear rates were also extracted.

We conducted the statistical analysis using Stata 15.1. We divided studies into two groups based on duration of symptoms from injury to surgery. Group A represented early repair (< 3 months), whilst Group B delayed repair (> 3 months). For a comparison between the two groups, Student's

t-tests were used, and P values of less than 0.05 were considered significant. Weighted means of patient demographics and functional outcome scores were compared.

To test whether time to surgery affects the effectiveness of surgery in improving treatment outcomes formally, we used a multivariate regression model that extends the previous t-tests by adding regressors/control variables that may also influence outcomes. The dependent variable of the multivariate regression model was equal to the difference of the cross-group preoperative CS difference to the cross-group postoperative CS difference. We regressed this difference to an indicator that takes the value of one when the mean time to surgery was greater than three months and zero, which takes into account the percentage of male patients, age and its square root and a constant.

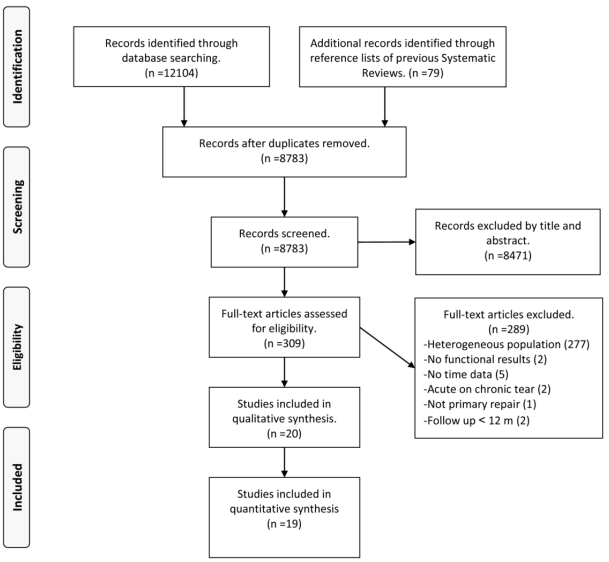

Fig 1. — PRISMA flow diagram depicting the flow of information through different phases of research.

RESULTS

A total of 20 studies met the inclusion criteria of this systematic review and the process of selection is summarized in a flow diagram (Fig 1).The initial literature search yielded 12104 records, 6814 from Pubmed, 4865 from Embase and 425 from Cohrane. After removing duplicates, 8783 studies were screened by two of the authors (I.P and N.P).Finally, 309 full text articles were evaluated for eligibility. By implementation of inclusion and exclusion criteria 20 studies underwent further analysis. One study[11] was excluded from quantitative analysis due to insufficient time data, which resulted in inability to categorize it in one of two groups.

Among studies included in qualitative analysis, one was Level of evidence II, nine were Level of evidence III and ten were Level of evidence IV. Only three out of twenty studies were prospective, with the rest being retrospective. The mean MINORS score for all studies was 14 (±3.85). In Group A the mean MINORS was 13.4 (±3.77), whereas in Group B 14.5 (±4.04). There was no significant difference in the quality of included studies across the two groups (P=0.52).

A total of 675 patients were allocated in one of two groups. Eleven studies contributed data to Group A, ten studies to Group B. Two of these studies provided data to both groups. Group A consisted of 317 patients with a mean age of 58 (±3.2) years, whereas Group B comprised of 358 patients with a mean age of 57.5 (±4.9) years. The percentage of male patients was 75.3% and 68.7%, respectively. Dominant extremity was involved in 68.6% in Group A and in 70.8% in Group B. There was no statistical difference between the two groups regarding age (P=0.78), sex (P=0.16), dominant side injury (P=0.68) and number of patients (P=0.19). The mean time from injury to surgery for Group A was 1.4 (±0.7) months, while the corresponding figure for Group B was 8.3 (±3.7) months. Mean follow-up time was 41 months for the early repair, and 27.1 months for the delayed repair group (P=0.14).

The CS was the most frequently used score for functional outcome (10 studies), followed by UCLA (5 studies), ASES (5 studies) and OSS (3 studies). In Group A, the mean pre-operative CS was 25.74 (±7.27) and increased to 71.65 (±6.38) post-operatively. Similarly, in Group B the mean pre-operative CS was 46.80 (±6.79) and rose to 76.78 (±8.92) after surgery. Within each group there was a statistically significant improvement in the CS from pre-operative to post-operative outcome, but the improvement for Group A was statistically higher

in comparison to Group B (P=0.01). Nevertheless, there was no significant difference in the final outcome for the two groups (P=0.29).

Regarding the UCLA scale, the mean pre-operative score was 9.47(±3.34) for Group A and 13.43(±1.57) for Group B, reaching post-operatively 30.93 (±1.91) and 30.91 (±5.41), respectively. Due to limited number of studies participating for this score we couldn't demonstrate any significant difference between the two groups. There was insufficient data for ASES and OSS, and thus a comparison of means could not be performed with statistical accuracy.

The results of the multivariate regression model using the discrete measure of time to surgery are shown at Table II and Figure 2. The estimated coefficient in the weighted model indicates that the outcome benefit from having surgery at least three months after the injury is lowered by 18.4 CS units. We cannot discern any differences in outcome benefits from having surgery three months or later in UCLA or ASES units. However, those tests are relatively underpowered as the sample size decreases from CS to UCLA and ASES. In addition, for the CS weighted multivariate regression model, we did find that older patients experienced fewer gains from surgery (regardless of time of surgery). Specifically, an additional year in the mean age leads to reduced outcome benefit from surgery by 11.95 CS units, but this was weakly statistically significant at the 10% level.

Rotator cuff integrity was evaluated in eleven studies, eight of them used MRI *(12-19)*, two of them used Ultrasound *(2,20)* and one of them MRI or Ultrasound *(21)*. Five studies contributed data to Group A, four studies to Group B and two studies to both groups. The re-tear rate per 100 patients was calculated 28.5(±7.2) for Group A, and 17.2 (±12.56) for Group B (P=0.056). Hantes et al. *(15)* reported similar re-tear rates for early (33.5%) and delayed repair (35%). However, the presence of re-tear was associated with worse functional results in the delayed repair group. Zhaeentan et al. *(19)* observed a re-tear incidence of 24% in both early and late repair groups. Duncan et al. *(21)* described lower rate of healing in delayed repair group. All patients in the early repair group were treated with non-operative measures, in contrast to 80% of patients in the delayed group who remained symptomatic and underwent revision repair.

Table II. — Discrete measure of time to surgery

VARIABLES	CS	UCLA	ASES
Surgery after 3 Months	-18.40**	-4.562	6.322
	(5.454)	(2.746)	(0)
% Male	0.00948	0.747	
	(0.324)	(0.387)	
Patient Age	-11.95*	-12.17	0.437
	(3.770)	(10.38)	(0)
Patient Age squared	0.1000**	0.102	
	(0.0309)	(0.0853)	
R-squared	0.913	0.870	1.000

Notes: Multivariate Regression Output; weighted by the number of patients in the sample used by each study. Outcomes: Difference in post-, pre-operative CS, UCLA, ASES score. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

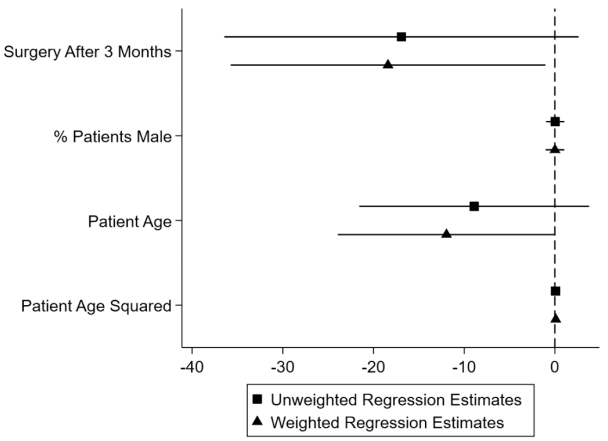

Fig. 2. — Coefficient plot. Discrete treatment effect.

Given the low level of evidence of the available literature regarding TRCTs, the potential for selection bias is present. Inclusion of consecutive patients and prospective collection of data reduced that bias in some studies *(2,12,14-16,19-25)*. Moreover, the individual experience of one surgeon and the treatment of TRCTs with concomitant pathology leads to performance bias *(14,16-18,23,24)*. The lack of an independent examiner at the follow-up can influence the results and introduces additional detection bias *(2,13,16-18,22-28)*. For instance, the

Constant Score is made up of 65% objective and 35% subjective results, thus it could be manipulated by the examiner. It is also worth mentioning that it is not uncommon for patients with TRCTs to be involved in accident compensation claims, a fact that could bias the outcome *(23,29)*. Finally, our review was exclusively based on English-language studies, which inevitably introduces language bias.

DISCUSSION

The main findings of this systematic review were (1) that according to existing literature there is no significant difference in the final functional outcome scores when delayed repair of TRCTs is compared with acute repair, and (2) patients who have their operation at the first 3 months after injury show a greater improvement in CS. Although the CS increases with time in both groups, the rate of increase is at its highest level in the first 3 months – therefore operating within this period of time leaves more room for post-operative improvement. Lastly, (3) early repair is correlated with lower rate of healing.

Among included studies, there were four clearly advocating early repair of TRCTs. Basset and Cofield[26] reported that repair within three weeks leads to superior surgical results. Hantes et al. *(15)* found significantly better CS and UCLA scores for patients operated early (<3 weeks) in comparison to those operated late (>3 weeks). Furthermore, Kreuz et al. *(27)* noted that the delay between trauma and surgical intervention was inversely proportional to the improvement in the CS. An improvement of at least 40 points in the CS was seen only in patients with a maximum delay of three months (for isolated tears) or four months (for combined tears). Moreover, Petersen and Murphy *(24)* found a significant difference in the post-operative UCLA score between patients undertaking surgery before and after four months from injury. However, they could not identify any difference if the operation was done either within four or within two months.

On the other hand, Bjornsson et al[2] demonstrated no difference in the functional outcome with respect to time from injury. It should be noted though that all patients were operated within three months. Namdari et al. *(23)* described no significant correlation between outcome scores and duration of symptoms (range 1 to 12 months). Zhaeentan et al. *(19)* reported no difference for any of the assessed outcome scores between early (<3 months) and delayed repair (>3 months). Kukkonen et al. *(22)* found that waiting time to surgery did not affect the final results in patients with traumatic RCTs. Finally, Duncan et al. *(21)* suggested that early repair (<6 months) of acute rotator cuff tears results in a statistically and clinically greater improvement in outcome compared with delayed repair. They also performed subgroup analysis of early repair group to see if repair before four months or between four and six months after injury affected the outcome scores. No difference in post-operative OSS was found in these two subgroups.

To our knowledge, there have been two other systematic reviews regarding traumatic rotator cuff tears. Mall et al. *(30)* examined the epidemiology, mechanism of injury, tear characteristics, outcomes, and healing of TRCTs. They concluded that TRCTs are more likely to occur in relatively young (mean age 54.7), largely male patients who suffer a fall or trauma to an abducted, externally rotated arm. However, they did not compare functional outcomes in relation to time. Mukovozov et al. *(31)* suggested, with cautious interpretation, that earlier repair may be linked with better clinical scores and range of movement. It should be noted though, that they included one study in which RCTs were treated with tendon transfers and at least three studies with heterogeneous population.

Our review has a number of limitations, inherent to the included studies. Despite the fact that this systematic review was designed to include only traumatic RCTs, it is certain that some patients had degenerative tears prior to injury. In addition, the assignment of patients already diagnosed with RCTs in a traumatic group mainly depends on their memory, as there is no sensitivity among clinical scores to measure a difference. Given the variation in the number and size of tendons involved, surgical approach, surgical technique, post-operative rehabilitation and concomitant pathology in included studies, these could all affect the final results. Noteworthy, the threshold of progression

from an acute tear to chronic cuff degeneration is not well-defined *(28)*. We chose a three-month threshold motivated by Basset and Cofield *(26)* who suggested that an acute tear approaches a chronic state by three months. Moreover, Mukovozov et al. *(31)* also applied the same distinction to their systematic review. In spite of those limitations our study has also several strengths. We took into account only studies with a minimum mean follow-up time of one year. Although it could be argued that this is relatively short time, it has been previously reported that after RCT repair the CS improves until the first year; after which it is stabilized *(32)*. Similarly, it has been shown that all patients with an intact tendon after one year remain intact at the two year follow-up, indicating that longer follow-up would not make any difference *(33)*.

There is still a debate about the timing of TRCT repair. Our results suggest that functional outcome and tendon healing may not be valid arguments for early surgical repair. These results may be due to insufficient evidence to recommend for or against acute repair. With the number of available studies we could not demonstrate any significant difference in the final CS if this difference actually exists. Therefore, based on existing literature, repair of TRCTs could be recommended whenever technically possible.

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