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Title page

The influence of age, delay of repair and tendon involvement in acute rotator cuff tears - Structural and clinical outcomes after repair

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Abstract

Background and purpose

Few studies have considered the result after acute traumatic rotator cuff tears in previously asymptomatic patients. The purpose of the current study was to investigate if delay of surgery, age at repair and the number of cuff tendons involved affected the structural and clinical outcome.

Material and Methods

42 patients with pseudoparalysis after trauma and no previous history of shoulder symptoms were included. A full-thickness tear in at least 1 of the rotator cuff tendons was diagnosed in all patients. Mean time to surgery was 38 (SD 21) days. At follow-up, 39 (SD 23) months after surgery evaluation was performed with ultrasound, plain radiographs, Constant-Murley-, DASH- and WORC scores.

Results

At follow-up 4 patients had a full-thickness tear and 9 had a partial-thickness tear in the repaired shoulder. No correlation between the structural or clinical outcome and the time to repair, within 12 weeks, were found. The patients with a tendon defect at follow-up had a statistically significantly lower Constant-Murley score and Western Ontario Rotator cuff index in the injured shoulder and were statistically significantly older than those with intact tendons. No differences in any of the outcomes were found in relation to the number of tendons repaired.

Interpretation

A delay of 12 weeks to repair did not affect the outcomes. The patients with cuff defects at follow-up were older and had a worse clinical outcome. Multi-tendon injury did not generate worse outcomes than single tendon tears at follow-up.

Introduction

“Codman’s trauma theory” postulated that trauma may rupture healthy rotator cuff tendons but that the rupture most often occur in cases where aged tendons are weakened by overuse, degeneration or toxic conditions (Fukuda 2000, Sorensen et al. 2007). Still, cuff ruptures with sudden pseudoparalysis occurring after trauma is usually considered acute and immediate repair has been recommended (Bassett and Cofield 1983, Lahteenmaki and Lawrence 2007, Petersen and Murphy 2010). Almost all previous studies concerning rotator cuff repair include patients with both acute and chronic degenerative tears. In the clinical setting it is difficult to distinguish an acute tear from a degenerative one with acute symptoms after trauma (Bassett and Cofield 1983, Lahteenmaki and Lawrence 2007, Petersen and Murphy 2010, Sorensen et al. 2007). Since there are few studies, with rather few participants including only acute traumatic tears little is known regarding this group of patients and the result after repair (Bassett and Cofield 1983, Lahteenmaki and Lawrence 2007, Petersen and Murphy 2010). The Swedish national guidelines state that acute full-thickness tears with pseudoparalysis after trauma, in previously asymptomatic patients should be repaired within 3 weeks (Swedish National Musculoskeletal Competence Centre 2006). The support for this guideline in the literature is sparse. To our knowledge there are only a few earlier studies that have studied the influence of time to surgery after acute traumatic tear (Bassett and Cofield 1983, Lahteenmaki and Lawrence 2007, Petersen and Murphy 2010). Bassett and Cofield indicate that early repair within 3 weeks result in better shoulder function but Petersen and Murphy state that the clinical outcome is not affected by a 4 month surgical delay (Petersen and Murphy 2010). The majority of traumatic cuff tears occur in aged tendons, as stated

by Codman and others (Duquin et al. 2010, Fukuda 2000, Perry et al. 2009, Sorensen et al. 2007). However the influence of age on the results after acute cuff repair has not been studied in detail before. The numbers of cuff tendons injured are reported to affect the structural and clinical outcomes in chronic tears but as far as we know the same correlations have not been reported in patients with acute tears (Jost et al. 2006, Nho et al. 2009a, Oh et al. 2009, Oh et al. 2010, Zingg et al. 2007). Structural defects following repair of chronic tears has been reported to range between 13 and 94 % (Fuchs et al. 2006, Jost et al. 2006, Oh et al. 2009, Zingg et al. 2007). To our knowledge there are no studies reporting the results regarding maintenance of tendon integrity following repair of acute tears.

The aims of the present study were to investigate if the structural and clinical outcomes after surgical repair of an acute rotator cuff tear in a previously asymptomatic patient was influenced by delay to repair, age at repair and the extent of initial cuff injury.

Materials and methods

A retrospective review of our computerized database identified 53 patients repaired with rotator cuff suture at the Department of Orthopaedics, Linköping University Hospital from May 2004 until May 2009 due to an acute traumatic cuff tear. 42 patients, 32 men and 10 women, who fulfilled the inclusion criteria, were willing to participate in a follow-up evaluation after written and oral informed consent. For detailed description of patients, see table 1. The local ethics committee approved the study the 9th of September 2009, (Dnr. M128-09). The inclusion criteria were; trauma to the shoulder, sudden onset of symptoms, asymptomatic in the shoulder before trauma, pseudoparalysis and full thickness rotator cuff tear of at least one tendon

with an acute appearance when sutured and no signs of previous cuff tearing or other cuff pathology. Patients with previous or gradual onset of symptoms in the traumatised shoulder, partial cuff tear or displaced fracture were excluded. The acute cuff tears were diagnosed with unilateral magnetic resonance imaging (MRI) or ultrasound preoperatively and ultimately verified at surgery. Pseudoparalysis was defined as less than 45 degrees of motion in both active forward flexion and abduction. Due to the trauma the rotator cuff tear was combined with other injuries in some patients: 17 of the 42 patients had a glenohumeral dislocation and of these, 4 had a transient minor axillary nerve injury after the dislocation, 1 had a minor glenoid fracture and 3 had a non-displaced fracture of the greater tuberosity. None of the associated injuries required additional surgery. In 41 patients the full-thickness tear involved the supraspinatus tendon alone or in combination with other tendons and 1 patient had an isolated subscapularis tear (Table 2).

Repair and post-operative rehabilitation

Randomly, due to timetabled service, 1 of 3 experienced shoulder surgeons performed the surgical procedures. Repair was performed with open technique using osteosutures and suture anchors in all patients except one arthroscopic procedure. The surgical approach was deltoid-split in 29 cases and deltopectoral in 12 cases. All preoperatively diagnosed full-thickness tears were repairable. Open or arthroscopic subacromial decompression and bursectomy were performed in 35 patients. Postoperatively the patients used a shoulder immobiliser for 4 to 5 weeks. Rehabilitation was tutored by a physical therapist beginning with pendulum and passive ranges of motion exercises. After the first 5 weeks active range of motion was allowed and from 7 to 8 weeks strengthening exercises began and was

progressed individually. In cases with multi-tendon tears including subscapularis, the shoulder was immobilised for 5 weeks and then similar exercises started but the strengthening exercises were delayed until week 9 to 10. Time from trauma to repair was in average 38 (SD 22) days (Table 1), 11 patients were repaired within 3 weeks, another 13 within 3 to 6 weeks and the remaining 18 within 6 to 12 weeks. Time from trauma to repair was due to delay in patients' referral.

Anatomical and clinical evaluation at follow-up

The mean length of follow-up was 39 (SD 23) months and mean age at injury was 59 (SD 12) years (Table 1). All patients were examined with bilateral ultrasound at the Department of Radiology, the University Hospital of Linköping. Both an experienced radiologist and an orthopaedic specialist interpreted the ultrasound independently from each other according to a standard protocol. The equipment used was a Siemens Acuson Sequoia 512 ultrasound machine with a variable 8 to 10 MHz linear array-transducer. The rotator cuff was evaluated in 2 planes with standardized positions and motions. The tendons were assessed as intact, partial thickness tear (PTT) or having a full-thickness tears (FTT). The PTT was defined as a localized absence of the tendon, seen in 2 orthogonal imaging planes in less than the full-thickness of the tendon. The FTT was defined as a non-visualization of the tendon throughout the whole thickness. Thinner tendons but with full continuity were defined intact. Additionally, a radiologic examination of the glenohumeral and the acromioclavicular joint bilaterally was performed. All but 1 patient, who declined x-ray, underwent the radiological examination. An experienced radiologist and 2 shoulder specialists (H. B., L. A.) assessed the radiological findings independently from each other according to a protocol including signs of; osteoarthritis in the glenohumeral

and acromio-clavicular joint, proximal humeral migration and signs of subacromial degeneration (sclerosis, cysts and spur-formations). In case of non-agreement on ultrasound or radiological examination a consensus discussion was used.

The follow-up clinical assessments was performed by 1 orthopaedic specialist (H. B.), not involved in any of the formerly surgical procedures, using a standardised interview and a per protocol physical examination. Outcome measures used were the Constant-Murley score, the Disabilities of Arm Shoulder and Hand questionnaire (DASH) and Western Ontario Rotator Cuff index (WORC) (Atroshi et al. 2000, Constant and Murley 1987, Kirkley et al. 2003). 2 patients did not complete the DASH questionnaire or WORC index. To asses the possible influence of age, the total study sample was divided into older and younger than 65 years at follow-up. This age cut off was chosen for comparison with previous published data using 65 years as limit (Charousset et al. 2010, Fehringer et al. 2008). In addition the clinical results were analyzed in relation to age as a continuous variable using ANCOVA.

Eller

In addition the clinical results were age-adjusted using ANCOVA.

Statistics

The patients were divided into two groups at follow-up, those with a cuff defect (defect group) and those with intact tendons (intact group). Student's t-test and ANCOVA, with age as a covariate, was used for comparisons of means between independent groups. Proportional differences between groups were analyzed using Pearson's Chi-square test or Fisher's Exact Probability Test. P-values < .05 were considered statistically significant and the wording significant or significantly always refer to statistical significance. SPSS Statistics 17.0 was used for all analysis.

Results

Post-operative complications and additional surgery

3 patients had post-operative complications. 1 patient was diagnosed with wound infection and 2 patients developed complex regional pain syndrome (CRPS). During the time from cuff repair until the follow-up assessment 5 patients had developed impingement symptoms and were re-operated with arthroscopic subacromial decompression. In 4 of these 5 patients subacromial decompression was not performed at the initial repair procedure of the cuff. 1 patient developed impingement symptoms in the contralateral shoulder and was operated with arthroscopic decompression during the time to follow-up. None of the included patients had sustained an additional trauma in any of their shoulders during the time from repair to follow-up.

Ultrasound and radiological results

The ultrasound examination of the operated shoulder identified 4 patients with FTT and 9 with PTT. In the non-traumatised contralateral shoulder 11 patients with FTT and 2 with PTT were found (Table 3). The 4 patients with FTT in the repaired shoulder also had FTT in the contralateral shoulder. Osteoarthritis was identified in 2 patients, bilateral in 1 of these patients (Table 3). Both these patients also had FTT bilaterally at follow-up. Radiological findings of subacromial degenerative changes were noted in the repaired shoulder in 2 patients and in the contralateral shoulder in 19 patients (Table 3). No consensus discussion was required due to the total agreement of findings in the ultrasound- and radiologic examination.

Clinical results

At follow-up patients with a cuff defect (defect group) were significantly older, mean age 68 (SD 11) years, than the patients with no identifiable defect (intact group) with a mean age of 60 (SD 12) (Table 1). However when the total study sample was divided into older or younger than 65 years at follow-up no significant differences in the clinical scores or the structural outcome could be found.

Mean time to repair was 38 (SD 23) days in the defect group and 39 (SD 21) days in the intact group (Table 1). No significant differences in the Constant-Murley-, DASH-score or WORC index were found between the groups, regardless if the repair was performed within 3 weeks, 6 weeks or 12 weeks. There was no statistically significant relationship between the number of involved tendons at the primary injury and the clinical or structural outcomes. At follow-up the patients with a cuff defect in the previously repaired shoulder had a significantly lower Constant-Murley-score and WORC index in the repaired shoulder as compared to the patients with intact tendons. The difference between the two groups in DASH score was non-significant (Table 4). There were a significant difference in Constant-Murley score within the defect group between the repaired and the contralateral shoulder but no significant difference was found within the intact group between the repaired and the contralateral shoulder.

Discussion

Patients with sudden onset of pseudoparalysis due to an acute rotator cuff tear shall, according to the Swedish guideline, be repaired within 3 weeks (Swedish National Musculoskeletal Competence Centre 2006). This guideline originates from a few studies based on clinical evaluation that suggested that early repair was beneficial (Bassett and Cofield 1983, Lahteenmaki and Lawrence 2007, Petersen and Murphy

2010). One of our aims was to assess if patients repaired later presented worse clinical and structural outcomes. In contrast to the results shown by Bassett and Cofield (Bassett and Cofield 1983) no statistically significant differences in any of the outcomes could be related to whether the repair was performed within 3, 6 or 12 weeks from the trauma in the present study. Our results suggest that patients with a delayed repair, within a 3-month limit, may receive the same satisfactory shoulder function as those with early repair. This is supported by the recently published study by Petersen and Murphy (Petersen and Murphy 2010) and a study on rabbits that reported equal surgical success whether supraspinatus repair was performed immediately or up to 12 weeks after the tearing (Koike et al. 2006). Based on the findings in the present study age appears to affect the integrity of the cuff repair but the age cut-off was not found to be at 65 years. Similar findings have been presented in mid- to long-term follow-up studies including both acute and chronic tears (Adolfsson and Lysholm 1993, Harryman et al. 1991, Nho et al. 2009b, Oh et al. 2009, Oh et al. 2010, Zingg et al. 2007). When the total study sample was divided into older and younger than 65 years as a cut-off no differences were found in any of the clinical outcomes. Age has not been proven to be an independent factor and should not be the only variable to consider in the clinical decision about surgery or not (Oh et al. 2010).

The presented results do not seem to support the concept that more than 1 full-thickness cuff tear results in worse mechanical properties and worse shoulder function after repair (Perry et al. 2009). Neither do the current findings support the view that patients with multiple tendon tears initially are predisposed to an increased risk of future structural defects as compared to patients with single tendon tears (Nho

et al. 2009b, Oh et al. 2010). We could not find any difference in clinical or structural outcomes regardless of the number of initially injured tendons.

Only 4 out of 42 patients were at follow-up identified with a full-thickness cuff defect and 9 with a partial-thickness defect in the operated shoulder. All of these defects were located in the formerly repaired tendons, which might be a consequence of a re-tearing, or a never fully healed tear. Interestingly, in addition to the 4 patients with bilateral full-thickness cuff defects 7 other patients were identified having a full-thickness cuff defect in the contralateral non-traumatized shoulder. This might suggest that the group of patients with a rotator cuff defect at follow-up has an ongoing degenerative process in both shoulders. The same phenomenon with a high prevalence of bilateral lesions has been reported in patients with chronic tears when evaluated 2 years after repair (Harryman et al. 1991). An increasing prevalence of asymptomatic tears with advancing age is well described and despite the effort to include only acute tears in this study, some of the patients might have had cuff degeneration or even an asymptomatic rotator cuff tear in any of their shoulders before the trauma (Milgrom et al. 1995, Sorensen et al. 2007, Yamaguchi et al. 2001). Even though this study only includes patients that were asymptomatic before the trauma and all sutured tears had an acute appearance at surgery there is no way to ascertain that degenerative changes were not already present. Given the fact that the incidence of cuff tears increase with age, and hardly ever appear before middle age, it is even likely that there are no such thing as an acute cuff tear without some previous tendon degeneration.

Subacromial decompression was performed in the majority (35 of 42) of the included patients. The fact that the cuff-repaired shoulder

s had fewer full-thickness tears at follow-up than the contralateral side (Table 3), might be explained by the subacromial decompression. This procedure's protective effect for the rotator cuff has been suggested in previous studies (Adolfsson and Lysholm 1993, Björnsson et al. 2010, Chin et al. 2007). A number of patients were operated with arthroscopic subacromial decompression during the follow-up period and this might have affected the clinical outcome. Of particular interest is that in 4 of the 7 patients that did not have this procedure done at the same time as the cuff repair, the decompression had to be performed at a later stage. In contrast, only 1 of the 35 patients that underwent simultaneous cuff suture and decompression developed impingement symptoms during the follow-up period. This suggests that subacromial decompression should be an integrated part of the cuff repair procedure. When considering only chronic tears, diverging results of correlations between recurrent structural defects and the clinical outcomes as shoulder function and pain have been reported (Harryman et al. 1991, Nho et al. 2009b, Oh et al. 2009, Zingg et al. 2007). The trend is toward a better functional outcome with an intact repair at follow-up (Perry et al. 2009). This trend is supported by the present study of acute lesions with a statistically significantly better Constant-Murley-score and WORC index in the intact group (Table 4).

The choice of ultrasound examination to investigate the structural condition of the rotator cuff has many advantages. It is highly accurate in evaluating the integrity of the rotator cuff after cuff repair, with a sensitivity of 100 %, a specificity of 85 %, the images are not distorted by the suture anchors like MRI and the evaluation is harmless regarding ionising radiation (Harryman et al. 1991, Nho et al. 2009a, Oh et al. 2009, Sorensen et al. 2007, Teefey et al. 2004). The relatively small number of participants in this study limited the possibility of a complete multivariate analysis

since it rendered to few subjects in the relevant subgroups. On the other hand the current study, with 42 patients included, is as far as we know the first study to report imaging results from a relatively large number of acute traumatic rotator cuff tears. The statistically significant differences described with p-values have rather wide confidence intervals, which may affect the generalisation of the results. It could be argued that the time to follow-up was relatively short for some patients (range 12 – 108 months). However, Nho et al. reported that all patients with an intact tendon after 1 year remained intact at a 2-year follow-up indicating that longer follow-up would not make a difference (Nho et al. 2009a). A strength of this study is the structural follow-up of the rotator cuff tendons with both radiologic and ultrasound examination bilaterally which made it possible to correlate the structural findings of both shoulders to the surgical procedures performed. Further, both the ultrasound and radiologic assessments at follow-up was validated since they were performed by 2 to 3 independent investigators who were in agreement about the findings.

In conclusion, acute traumatic tears of the rotator cuff in previously healthy shoulders can be repaired with an open technique at least up to 12-weeks after the injury. Independent of the delay to surgery within 12 weeks it seems to yield the osame structural and clinical results at follow-up. Patients with a rotator cuff defect at follow-up were statistically significantly older and the defect resulted in statistically significantly worse Constant-Murley score and WORC index in the repaired shoulder compared to patients with an intact cuff. Patients with acute multiple tendon tears did not have a worse clinical or structural outcome at follow-up than patients with only 1 tendon tear.

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Table 1 Description of the study population

	All patients [n=42]	Intact group [n=29]	Defect group [n=13]	Mean difference (95% CI) [Intact–Defect]	P-value*
	Mean (SD)	Mean (SD)	Mean (SD)		
Days from trauma to surgical repair	38.4 (21.7)	38.6 (21.5)	38.0 (23.1)	0.6 (-14.2 – 15.4)	0.937
Months to follow-up from surgical repair	38.6 (23.1)	40.8 (22.7)	33.6 (24.0)	7.2 (-8.4 – 22.8)	0.356
Age at follow-up	62.1 (11.8)	59.7 (11.5)	67.5 (10.8)	-7.8 (-15.4 – -0.2)	0.045
Women %	24	24	23		1.000

* An independent Student's *t*-test comparing patients having no cuff defect (intact group) with patients having cuff defect (defect group including partial- and full-thickness tears). Level of statistical significance $p < .05$

Table 2 Distribution of the peroperative acute full-thickness rotator cuff tear(s) among all patients in the study (n=42)

Tendon tears	Patients [n]
Isolated Supraspinatus	14
Isolated Subscapularis	1
Subtotal single tendon tears	15
Supraspinatus, Subscapularis	8
Supraspinatus, Infraspinatus	7
Supraspinatus, Subscapularis, Infraspinatus	8
Supraspinatus, Infraspinatus, Teres minor	3
Supraspinatus, Subscapularis, Infraspinatus, Teres minor	1
Subtotal multiple tendon tears	27
Total	42

Table 3 Structural evaluation at follow-up with ultrasound and radiologic examination

	Repaired shoulder [n]	Contra lateral shoulder [n]
Ultrasound		
Intact rotatorcuff	29	29
PTT	9	2
FTT	4	11
Radiology		
Osteoarthritis	2	1
Proximal humeral migration	4	5
Signs of subacromial degeneration	2	19

PTT = Partial Thickness Tear, FTT = Full Thickness Tear

1 **Table 4** Clinical evaluation at follow-up

	All patients [n=42]	Intact group [n=29]	Defect group [n=13]	Mean difference (95% CI) [Intact–Defect]	Age adjusted mean difference (95% CI) [Intact–Defect]	P-value*
	Mean (SD)	Mean (SD)	Mean (SD)			
Constant-Murley score, repaired shoulder	67.3 (22.0)	72.7 (21.0)	55.4 (20.0)	17.3 (3.3 – 31.3)	15.9 (1.1 – 30.7)	0.036
Constant-Murley score, contra lateral shoulder	83.1 (17.5)	87.4 (13.6)	73.4 (21.7)	14.0 (0.2 – 27.8)	10.2 (-0.9 – 21.3)	0.071
WORC (%) ^a	74.6 (22.0)	79.2 (20.4)	65.2 (22.9)	14.0 (-1.5 – 29.5)	16.2 (0.9 – 31.5)	0.039
DASH ^a	21.5 (21.2)	17.3 (20.9)	31.2 (19.3)	-13.9 (-28.1 – 0.4)	-15.1 (-30.3 – 0.1)	0.051

2 * ANCOVA with age as a covariate, comparing patients having no cuff defect (intact group) with patients having cuff defect (defect group including partial- and full-thickness
3 tears). Level of significance $p < .05$

4 ^a Missing values $n=2$

5

6 **Competing interests**

7 None

8 **Contributions of authors**

9 Study design: H. B. and L.A.

10 Data collection: H. B.

11 Statistical analysis: H. B. and K. J.

12 Data analysis: H. B., R. N., K. J and L. A.

13 Writing the manuscript: H. B., R. N., K. J. and L. A.

14