

Articular-sided rotator cuff tears: which is the best repair? A three-year prospective randomised controlled trial

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Abstract

Purpose To compare two groups of patients who underwent two different arthroscopic procedures for repair of articular-sided partial-thickness rotator cuff tears (PTRCTs).

Materials this is a comparative prospective study of two methods for repair of partial cuff tears Thirty-two patients underwent arthroscopic rotator cuff repair with a transtendon technique (group 1); 28 underwent arthroscopic full-thickness conversion and repair of the lesion (group 2). ROM measures, clinical findings, MRI features (tendon healing and re-tear),

Constant–Murley and ASES scores were assessed pre- and postoperatively and compared. Patients were also asked about return to sport and level of activity.

Results At the last appointment, patients of both the groups were significantly improved for clinical findings, ROM measures, imaging features, Constant–Murley and ASES scores than at baseline, without any significant inter-group difference. In group 1, 15 of 20 patients (75 %) who practiced recreational sport activities had returned to sport at the same level as before the onset of symptoms, without any discomfort. In group 2, 12 of 18 patients (67 %) had returned to the same level of sport activity they practiced before symptoms. At the last follow up, MRI showed rotator cuff healing in 31 patients of Group 1 and 27 patients of Group 2 ($p=0.83$).

Conclusions The two procedures are safe, effective, and comparable.

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Introduction

The current evidence does not provide guidance as to the best management plan for symptomatic partial thickness rotator cuff tears (PTRCTs) [1]. Debridement, with or without acromioplasty, was advocated [2, 3], but the current trend is to repair lesions involving more than 50 % of the tendon thickness, or exceeding 6 mm (Grade 3) of depth [4]. The present evidence favours conversion from partial into full thickness, and repair of the tear in a traditional fashion [5, 6], or a trans-tendon repair [7, 8]. Both techniques are effective in functional recovery and relief of symptoms, but controversy persists because of the lower morbidity rate and earlier recovery when completing and repairing tear, whereas tendon integrity, native footprint, and biomechanical properties (gapping and mean ultimate failure strength) are better restored when performing a transtendon repair, leaving the bursal side intact [9, 10].

This is a randomised controlled study comparing clinical, functional and imaging outcomes for patients with symptomatic PTRCTs tears who had undergone transtendon repair (group 1) and conversion to full-thickness tear followed by traditional repair (group 2). We postulated that both procedures would significantly improve clinical, functional and MRI findings without any significant inter-group differences in range of motion, functional scores, return to sport activity, and imaging features (tendon integrity and re-tear).

Materials and methods

This is a randomised controlled trial of 60 patients who underwent arthroscopic repair of articular-sided PTRCTs from 2007 to 2009. All procedures were performed after the local ethics committee had approved the study.

We included symptomatic patients with articular sided PTRCTs exceeding 50 % of the tendon thickness, unresponsive to a minimum of three months of conservative management. Bursal-sided rotator cuff lesions, subscapularis intra-articular tears extending to more than 50 % of the tendon thickness, Bankart lesions, grade III-IV Outerbridge chondral damage [11] moderate to severe degenerative arthropathy according to Hamada classification, and prior surgery to ipsilateral shoulder were exclusion criteria.

Sample size and sample features

We based our sample size calculation on the mean and standard deviation of Constant–Murley scores observed in a pilot study on 16 patients, in which we found a mean difference of 4 points and a standard deviation (SD) of 4.3 points. Power analysis showed that a total sample size of 46 patients (23 patients in each group) would provide a statistical power of 90 % with a 2-sided level of .05 to detect significant differences. The patient selection process is reported in Fig. 1. Thirty-two patients underwent arthroscopic rotator cuff repair with a trans-tendon technique (group 1), 32 underwent arthroscopic full-thickness conversion and repair of the lesion (group 2). Sixty patients were assessed at the last follow-up; four were lost during the study.

Group 1 included 32 patients (18 men and 14 women) who underwent surgery at an average age of 57.3 years (range 38–71), after an average of 15.5 months from the onset of symptoms (range seven to 23 months). In group 2, 28 patients (13 men and 15 women) were operated upon at an average age of 55.6 years (range 34–69), after an average duration of symptoms of 14 (from six to 19) months (Table 1). The first author (FF) made the diagnosis in all patients by history, clinical examination, MRI findings, and confirmed at arthroscopy in all instances. At final

assessment, at an average follow up of 38 months in Group 1 and 39 months in Group 2, an orthopaedic surgeon, who had not been involved in the original management, examined all the patients, administered all the tests, and scheduled and assessed all the images.

Preoperative assessment

At preoperative clinical examination, all patients referred pain, discomfort and disability to the shoulder. Preoperatively and at the last follow-up, a trainee, blinded to the nature of the procedure, recorded range of motion measures in passive maximum forward flexion, abduction, external rotation, and internal rotation of the shoulder. Forward flexion under 110°, external rotation under 25°, and internal rotation below the second sacral vertebral level were all criteria of shoulder stiffness [12, 13]. Preoperatively, all patients underwent MRI and radiographic assessment (antero-posterior, axillary and outlet views) of the affected shoulder. The American Shoulder and Elbow Surgeons (ASES) and the Constant Murley scores were also administered to each patient.

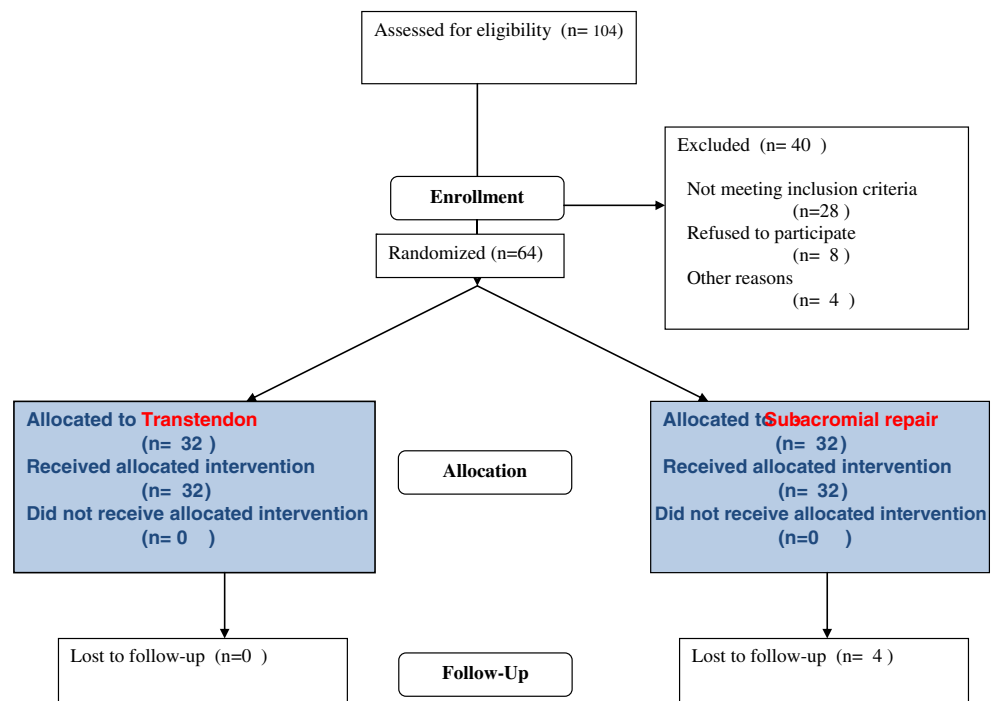
Surgical techniques

Under general anesthesia and interscalene block, with the patient in the lateral position, the shoulder was positioned in 30° of abduction and 15° of forward flexion, with the arm subjected to five kilograms of distal traction. The glenohumeral joint was entered and explored through a primary standard posterior portal, and an anterior working portal was placed into the rotator interval. Frayed partial thickness articular-sided rotator cuff tears were debrided with a shaver blade to visualise the articular side partial-thickness tear (Fig. 2). After debridement of the articular-sided tendon, the depth of the tear was measured using a full radius shaver (Arthrex, Naples, FL), considering the lesion to involve more than 50 % of tendon thickness when the tip of the shaver sank entirely into the defect. With a spinal needle into the centre of the defect, we inspected the corresponding bursal-side rotator cuff, and took care to leave the needle in situ. With the arthroscope into the Ellman portal, bursectomy was performed and fibrotic adhesions were removed. The indications to acromioplasty were the presence of osteophytes over the inferior acromial surface and a hook shaped acromion. The number of suture anchors was determined based on the anterior-to-posterior length of the torn tendon.

Transtendon repair (Fig. 3)

On the footprint, to define the best site for placement of suture anchors, we inserted percutaneously a spinal needle, adjacent to the lateral aspect of the acromion, and passed it through the musculotendinous junction of the cuff, up to the

Fig. 1 CONSORT statement



centre of the footprint. Through a five millimetre skin incision, we placed a bioabsorbable double loaded suture anchor (5.5-mm Bio-Corkscrew; Arthrex) into the centre of the footprint, proceeding closely to the needle and parallel to its direction. If the tear was greater than 1.5 cm, we inserted another anchor approximately one centimetre posterior to the first. All four suture limbs of the suture anchor were pulled out through the anterior portal. An 18-gauge spinal needle was inserted percutaneously just medial to the free edge of the torn tendon and a No. 1 PDS suture was passed through it and retrieved through the anterior working portal. After the spinal needle was removed, one end of the PDS suture was tied to a limb of the suture anchor outside the anterior portal, and the other end of the PDS suture was pulled out, outside the lateral aspect of the acromion. One suture limb of the suture anchor placed outside the lateral aspect of the acromion was passed through the healthy portion of the rotator cuff (Fig. 4). We repeated the same procedure for the remaining suture limbs of the suture anchor passing the cuff from posterior to anterior through different percutaneous spinal needle puncture sites. With the

arthroscope in the subacromial space, we made a lateral portal through which we retrieved all suture limbs in the subacromial space and tied on the bursal side of the cuff. A final intra-articular view allowed inspection of the final repair.

Tear completion and subacromial repair (Fig. 5)

The tear was completed from the corresponding bursal side with a shaver. After complete exposure and decortication of the footprint, we inserted a double-loaded suture anchor in the footprint. We performed all repairs in a single row fashion (Fig. 6).

Rehabilitation

All the patients followed the same postoperative rehabilitation protocol. Patients wore a sling at 0° of external rotation

Table 1 Patient features (average and range)

	Group 1	Group 2
Sex	18 M; 14 W	13 M; 15 W
Age	57.3 years (range 38–71)	55.6 years (range 34–69)
Time from symptoms to surgery	15.5 months (range 7–23)	14 months (range 6–19)



Fig. 2 Arthroscopic view showing the partial tear from the articular side

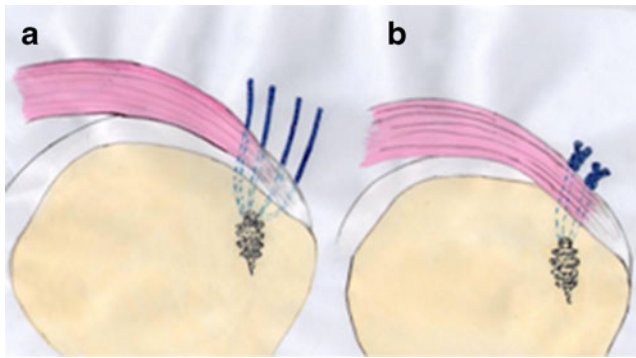


Fig. 3 Illustration showing a partial lesion treated by transtendon repair: **a** partial articular; **b** repaired lesion

and 15° of abduction for four weeks, and were immediately allowed active and passive flexion of the elbow, 0° passive external rotation with the arm at the side, capsular stretching exercises, and scapulothoracic motion (five minutes per hour). Patients commenced passive forward flexion as tolerated at one week. At two weeks, patients were reviewed for removal of stitches and dressings, and were recommended to start gentle active motion exercises supervised by an expert physiotherapist. Patients started water and elastic band exercises at four weeks, free ROM in all directions at six weeks, and resisted strengthening exercises at 12 weeks. Patients were also regularly evaluated at six and 12 months, and then at six-month intervals. All patients had regained full functional stability in the operated shoulder by four months.

Follow up

At the last examination, at a mean of 38 months (range 29 to 49 months, SD: 9.6), all patients underwent clinical examination which consisted of ROM measurement, assessment of the strength and administration of Constant-Murley and ASES scores. Constant-Murley and ASES final scores of 90–100 were considered as excellent, good from 89 to 80,

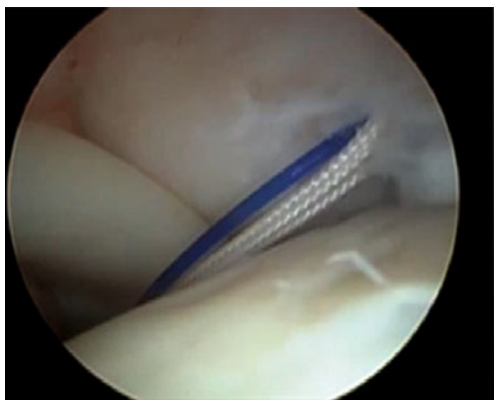


Fig. 4 Arthroscopic intra-articular view showing the passage of the suture through the tendon sided lesion, with a metallic anchor passing through the healthy tissue

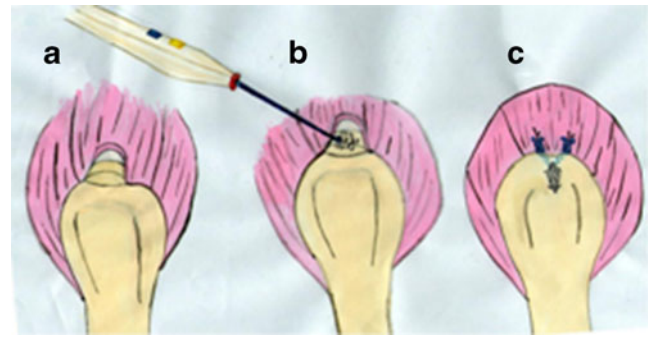


Fig. 5 **a** Illustration showing a partial lesion treated by tear completion and subacromial repair; **b** tear completion through electrocautery; **c** repair of the lesion using two metal anchors

fair from 79 to 70, and poor if less than 70. We considered failure a score less than 80. At the last follow-up, all patients underwent MRI assessment for rotator cuff tendon integrity and re-tear; a blinded musculoskeletal radiologist not involved in the study evaluated all images. The alterations in signal intensity were classified as grade I, when the tendon showed a light and diffused increase of the signal different from the appearance of the liquid; grade II when a focal increase of signal could be appreciated on the bursal or articular side without any appearance of damage to the cuff; grade III, when an increased signal intensity was present throughout the thickness of the tendon, regardless of the tendon retraction. Tendon integrity was defined as continuity with sufficient thickness of the repaired tendon (more than 50 %) and a homogeneous low-intensity or partial high-intensity area on MRI.

Statistical analysis

After assessment of the distribution with the Kolmogorov–Smirnov test, the Mann–Whitney test was used to compare pre vs postoperative ASES and Constant–Murley scores, and ROM measures. Independent-sample *t* tests were used to compare postoperative ASES and Constant–Murley



Fig. 6 Arthroscopic subacromial view of the final repair after tear completion

scores, and ROM measures between the groups. Mean, SD and 95 % confidence intervals were calculated. The χ^2 test was used to analyse dichotomous variables (imaging findings and return to sport activity). A p value <0.05 was considered to be statistically significant. SPSS version 17.0 (SPSS, Chicago, IL, USA) was used to analyse the data.

Results

Arthroscopic features

An intra-articular partial tear of the subscapularis tendon involving less than 50 % of its thickness was found in 18 patients, 11 in group 1 and seven in group 2: debridement was performed in 13 patients, anchor repair in five patients, two in group 1 and three in the group 2. Acromioplasty was performed in 23 patients, 14 in group 1 and nine patients in group 2, LHB tenotomy in ten patients in group 1 and seven in group 2. The average number of suture anchors used was 1.7 in group 1 (from one to two) and 1.8 (from one to three) in group 2. Type-2 SLAP lesions, found in nine patients (five in the group 1 and four in the group 2), were all repaired using one anchor suture.

Clinical findings and functional scores

At the last follow up range of motion, ASES and Constant shoulder scores were significantly improved compared to the preoperative status, without statistically significant intergroup differences (Table 2). When asked about return to daily life activities, all patients answered that they could successfully perform routine activities as before the onset of symptoms. In group 1, 15 of 20 patients (75 %) who practiced recreational sport activities had returned to sport at the same level as before the onset of symptoms, without any discomfort. No statistically significant inter-group difference was found in terms of return to pre-injury sport activity ($p=0.59$) (Table 3). In Group 1, of five patients who had not returned to the same level of sport as before the onset of symptoms, three had changed sport (two of whom had a type-2 SLAP), and two (one of whom had a type-2 SLAP) decided spontaneously to give up any sport. In group 2, all six patients who had not returned to the same level of sport activity (three of whom had a type-2 SLAP) had changed from contact (football, basketball) to non contact (running and cycling) sports.

Imaging findings

At the last follow up, rotator cuffs were healed in 31 patients of Group 1 and, in 27 patients of Group 2 ($p=0.83$). Of these patients, 21 patients in group 1 and 19 in group 2 reported grade 1 MRI alteration; ten in group 1 and eight in group 2

had grade 2 signal changes. The two patients with evidence of tendon re-tear, or grade 3 alterations, were not symptomatic, with ASES and Constant-Murley scores averaging 89 points.

Complications

Adhesive capsulitis occurred in three patients in group 1 and three in group 2 ($p=0.19$). Four were successfully treated conservatively and recovered by six months from the index surgery. The remaining two patients, both in group 2, were not responsive to conservative management, and underwent shoulder mobilisation under anaesthesia and arthroscopic capsular release. At the last follow up, all six patients had recovered shoulder motion and reported a mean ASES score of 88 points and a mean Constant score of 89 points.

Discussion

Surgical treatment of PTRCTs has evolved over time. Many studies have been published, but data reporting the outcomes of such surgery are sparse. Papalia et al. [1] performed a systematic review of the literature and summarised the results of 23 clinical studies, four of them describing outcomes after surgical repair, concluding that the heterogeneity of treatment options and outcome assessment methods made it difficult to compare the results of selected studies. The modern surgical approach is to repair lesions involving more than 50 % of tendon thickness. The main finding of our study is that transtendon repair and repair after tear completion are both effective to manage articular sided PTRCTs, both for clinical and imaging results. Repair after tear completion may be very satisfying [5, 14]: it allows freeing the tendon footprint from degenerated scar tissue potentially impairing the healing process, but some biomechanically functional healthy tendon may have to be sacrificed, making the repair weaker [15]. Complete removal of the cuff insertion makes also it difficult to anatomically repair the lesion and restore the native tendon footprint, resulting in biological and mechanical flaws. In transtendon repair, extensive retraction of the tendon may excessively medialise the cuff insertion, and alter both anatomy and mobility of the joint [7]. Pulling a retracted articular layer onto the original footprint may over-tighten the bursal aspect and, consequently, unbalance the tension in the remaining fibres [16], which may explain why transtendon repair is alleged to be more painful, take longer to recover, and be more likely to develop shoulder stiffness. Cadaveric studies suggest that transtendon repair technique is biomechanically superior to repair after tear completion, because of significantly smaller gap formation and higher ultimate tensile loads [17]. To avoid joint overconstraining and

Table 2 Comparison of pre- vs. post-operative range of motion, ASES and Constant–Murley scores (average±standard deviation, range)

	Group 1		Group 2		P Value	P value between two groups (last F-U)
	Baseline	Last follow-up	Baseline	Last follow-up		
External rotation (°)	45.6±14.5 (15–70)	59.8±9.6 (45–80)	50.3±12.7 (20–75)	61.1±10.2 (40–85)	0.0001	NS
Internal rotation (°)	a level between L3–S1	23 pts T8; 7 pts T9; 2 pts T10	a level between L3–S1	21 pts T8; 5 pts T9; 2 pts T10	0.0001	
Forward flexion (°)	132.8±13.0 (95–162)	171±10.4 (150–190)	129.2±18.2 (90–160)	169±10.9 (145–190)	0.0001	
ASES	456±8.1 (29–71)	91±6.6 (74–100)	47±10.6 (25–72)	90±7.9 (71–100)	0.0001	
CONSTANT MURLEY	48±8.2 (30–72)	92±7.1 (72–100)	46±8.6 (29–63)	91±7.3 (72–100)	0.0001	

Table 3 Return to sport activity

Return to sport	Group 1	Group 2
Total sport players	20	18
Return to preinjury level	15	12
Different kind of sport	3	6
No sport	2	0

tendon overstrain, some changes have been added to the traditional trans-tendon repair technique, such as all-inside repair technique, knotless interimplant mattress repair, and repair after articular-sided cuff reduction [9, 18]. The lower elasticity modulus and higher resistance to tensile strength of the bursal layer over the articular side could also justify the higher rate of re-tear observed at MRI in patients undergoing repair after tear completion [19]. We found comparable re-tear rates in the two groups. One reason for this can be that MRI over-estimates cuff defects [8]: we ignored many signal intensity alterations frequently seen after repair [20], considering a re-tear only when the tendon was missing and could not be visualised [21]. In line with previous studies [22], these patients were not symptomatic and had returned to their daily activity. At the last follow-up, we recorded significantly increased ROM measures in all planes, with no pain, and ASES and Constant scores were comparably improved in both groups. We found that 75 % and 67 % of patients returned to practice sport activity at the same level as before the onset of symptoms. This finding calls into question whether some of them abandoned any sport activity or changed to non contact sports as a consequence of the operation. Patients with combined PTRCT and type-2 SLAP lesions, all overhead athletes who are supposed to have an internal impingement, were more likely to change or definitively abandon any sport activity [23]. We managed both the lesions, even though literature on this issue is somewhat uncertain, with good excellent rates from 40 % to 94 % [23]. The rationale to repair them was that, in our experience, some stiffness and/or functional disability may persist when not repairing both lesions. The occurrence rate of capsular stiffness was lower than it was in the study by Gartman and Milne [24]. Even though Huberty et al. [16] have shown that repair of a PTRCT is one of the risk factors for development of postoperative shoulder stiffness, we have come to regard postoperative capsulitis as consequence of an inadequate rehabilitation protocol. The main limitation of our study is that there are no reliable methods for assessment of tendon thickness; intra-operative measurements were performed in a relatively empirical fashion as it was difficult to evaluate preoperatively the tear involvement with respect to tendon dimensions at MRI. This is a three-year follow-up study, but it is only a preliminary report, and we are continuing to follow-up patients to ascertain whether some disabilities

might develop over time, probably as expression of secondary degenerative changes. This study has several strengths. For example, it is a randomised controlled study, and only four patients were lost to follow-up. The senior author performed all surgical procedures and an independent investigator not involved at the index surgery examined the patients at follow-up.

The findings of this randomised controlled trial demonstrate that these procedures are safe, effective, and comparable for clinical, functional and MRI findings, but longer follow up level I studies are needed to draw definitive conclusions.

Conflict of interest The authors declare that they have no conflict of interest.

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