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*ORIGINAL STUDY*

# A comparative clinical evaluation of arthroscopic single-row versus double-row supraspinatus tendon repair

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**Cadaveric studies and commercial pressure have initiated a strong trend towards double-row repair in arthroscopic cuff surgery. The objective of this study was to evaluate if the biomechanical advantages of a double-row supraspinatus tendon repair would result in superior clinical outcome and higher abduction strength.**

**A retrospective study of two groups of 32 single-row and 33 double-row repairs of small to medium cuff tears was performed. The Simple Shoulder Test (SST) and a visual analog scale for pain were used to evaluate the outcome. The participation rate was 100%. A subset of patients was further investigated with the Constant Score (CS) including electronic strength measurement.**

**The double-row repair patients had significantly more (p = 0.01) yes answers in the SST than the single-row group, and pain reduction was slightly better (p = 0.03). No difference was found for the relative CS (p = 0.86) and abduction strength (p = 0.74). Patient satisfaction was 100% for double-row and 97% for single-row repair.**

**Single- and double-row repairs both achieved excellent clinical results. Evidence of superiority of double-row repair is still scarce and has to be balanced against the added complexity of the procedure and higher costs.**

**Keywords** : shoulder ; rotator cuff ; arthroscopy ; double-row ; single-row.

## INTRODUCTION

Arthroscopic rotator cuff repair has proved to produce equivalent or better functional results compared to open or mini-open cuff repair even at the beginning of the learning curve (*6*). There have been concerns about insufficient healing and high re-tear rates (*3,11*) of the standard arthroscopic single-row repair construct with lateral fixation. Incomplete healing does adversely affect strength (*4*), although re-tears after cuff repair are often clinically silent (*12*). Shoulder arthroscopists have therefore undertaken to increase the contact area of the cuff on the tuberosity by adding a medial row of anchors. The aim was to reproduce the supraspinatus footprint in order to achieve better healing and improved clinical results (*15*).

As the metaphor of "footprint-repair" almost magically promised superior results in arthroscopic cuff repair, it has triggered a considerable amount of research. Cadaveric studies of different fixation principles have generally shown that double-row repair outweighs single-row constructs (*18,19*). Several authors emphasize however, that clinical

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evidence of superiority of double-row repair versus single-row is not confirmed (*21*). Good results and low re-tear rates of double-row repair have been reported recently (*13*), but comparative clinical studies are still scarce (*10,22*). The purpose of our study was to evaluate if the *in vitro* biomechanical advantage of double-row reconstruction was actually evident in functional outcome. The hypothesis was that double-row repair should result in better clinical outcome and – more specifically – better abduction strength compared to single-row repair.

## PATIENTS AND METHODS

### Study Groups, Inclusion and Exclusion Criteria

A total number of 450 shoulders representing all tear sizes and patterns had undergone arthroscopic rotator cuff repair by one single surgeon between 2/2000 and 2/2005. All patients had a preoperative MRI. This study is limited to 85 patients in two subgroups with a small and medium tear size (i.e. < 3 cm after debridement).

An earlier group of 40 single-row repairs (1R) operated on between 2/2000 and 2/2001 was compared with a later group of 45 double-row repairs (2R) operated on between 12/2003 and 2/2005 with similar tear sizes. The outcome results of group 1R were available from a previously published study (*6*) comparing open and arthroscopic rotator cuff repairs.

Seven shoulders of group 1R, and 9 shoulders of group 2R were excluded because of a concomitant subscapularis tendon repair. Patients who underwent a simultaneous SLAP-repair or biceps tenodesis were not excluded, as these procedures were done "en passant" and not considered relevant to the outcome. Four more were excluded because of a mix of chronic shoulder pain with minor neurological disturbances, multiple prior operations and claims for disability benefits. The study groups thereafter consisted of 32 single-row repairs (group 1R) and 33 double-row repairs (group 2R) of supraspinatus tendon tears of 1 to 2.5 cm.

### Data Collection and Outcome Measurement

The early group 1R had a patient based (subjective) follow-up evaluation in 5/2002 using the Simple Shoulder Test (SST) for function, the Visual Analog Scale (VAS 10) for pain and the question for patient satisfaction. Mean follow-up for this group was 21 (range 16-28) months. Group 2R had an evaluation using the same questionnaire in 8/2006. Mean follow-up for this latter group was 25 (18-33) months. Participation rate was 100% with no drop-outs in both groups. An important source of information was the patient's history and the detailed operating reports including intraoperative video prints.

Pain preoperatively and at follow-up was measured using a visual analog scale (VAS) of ten points (0 = no pain, 10 = maximum pain). The questions in the Simple Shoulder Test (SST) of Matsen *et al* (*17*) represent a practical patient-based shoulder evaluation tool, including 12 'yes' or 'no' questions, 2 of which deal with pain, 4 with mobility, 3 with strength and 3 with function. A normal shoulder should generally receive 11 or 12 'yes'-answers.

The "best performing" 26 patients (13 from each group) were called back for a clinical evaluation with the Constant-Murley score (*8*).

The average follow-up of these patients was 78 (73-88) months for group 1R, and 35 (30-40) months for group 2R. The Constant Score (CS) was implemented by an independent examiner, who had not previously known the patients. Precise strength measurement was expected to provide the most reliable index of a successful and stable repair in the absence of imaging data.

Quantitative strength testing was performed using an electronic portable dynamometer (Isobex, Cursor, Berne, Switzerland). Strength was tested with the patient in the standing position and the arm in 90° of abduction in the scapular plane (elevation) and neutral rotation. The patient was instructed to hold this position with maximal force for three seconds. Three trials were performed for both shoulders and the average value was calculated.

### Surgical Procedures

The patients received a combination of regional and general anaesthesia and were subsequently placed in beach-chair position with 3 kg of anterior skin traction to the arm. Diagnostic arthroscopy confirmed a supraspinatus tear and possible concomitant lesions, such as partial subscapularis tears and biceps pathology. In repairing the supraspinatus, we created a footprint of cancellous bone and measured the size of the defect with a hook probe in steps of ½ cm ; the defects were classified into small (1 cm), medium (1-2.5 cm) and large (3-5 cm) tears. In this study we only deal with tears of less than 3cm as mentioned above.

Bursectomy and detachment of the coraco-acromial ligament were performed, but acromioplasty was generally delayed till the end of the operation for bleeding

***Fig. 1a.*** — After an inverted mattress suture has been passed through the cuff and a push-in anchor inserted in the greater tuberosity, a sliding knot is walked down.

***Fig. 1b.*** — Completed single row repair with two anchors

control purposes. The pump maintained a pressure of 50 mmHg and the systolic blood pressure was lowered to 90 mm Hg whenever possible.

*Single-row Repair* (fig 1 a & b)

We passed inverted mattress sutures through the edge of the cuff with curved suture hooks (Linvatec, Largo, FL) inserted through an anterolateral skin puncture. The sutures were passed through the tendon from anterior to posterior with the Spectrum needle 45° left-curve (for a right shoulder) and a PDS shuttle. One to 3 push-in suture anchors (GII Super Anchor ; Mitek, Westwood, MA, USA) were used according to tear size. We grasped a solid portion of tendon tissue and placed the anchors slightly over the edge of the tuberosity, which resulted in a tension-band like suture construct. The suture material we used at that time was Ethibond No. 3 (Ethicon, Somerville, NJ, USA).

*Double-row Repair* (fig 2 a & b)

After creating a stab incision at the acromial edge we introduced a medial anchor (GII Super Anchor, Mitek, Westwood, MA, USA) loaded with a FiberWire No 2 (Arthrex, Naples, FL,USA) into the bone directly at the cartilage limit in the center of the lesion. The anchor eyelet was oriented perpendicular to the cartilage border. The suture limbs were now retrieved through the tendon using the Neviaser portal and the Spectrum straight needle large curve with a PDS shuttle. This created a transverse mattress stitch that firmly pressed the tendon to the medial bony footprint. The edges of the residual defect were closed with a triangular inverted mattress stitch and a second push-in anchor.

**Ancillary Procedures and Rehabilitation**

The operative procedures performed in addition to the supraspinatus repair in the study groups were : SLAP-repair 13 times in group 1R versus 5 times in 2R ; biceps tenodesis 1 versus 2. All patients had a sling with a 15° abduction pillow (Ultrasling, DonJoy, Vista, CA, USA) for six weeks postoperatively. They were instructed to perform only pendulum exercises and assisted external rotation with a stick during the first 6 weeks ; assisted elevation with rope-and-pulley was started only at week 7. The rationale in delaying arm elevation was to avoid gap formation at the bone-to-tendon interface in the early healing phase.

**Statistical Analysis**

Statistical analyses were performed with the help of the mathematical department of the University of Fribourg. The test of proportion was used to determine differences between groups 1R and 2R for all binary data (sex and the 12 questions of the SST). Ordinal data were evaluated with the Mann-Whitney U-test (age, tear size, number of anchors, total number of SST Yes-answers,

*Fig. 2a.* — A medial anchor has been introduced at the cartilage limit and a transverse mattress stitch created.

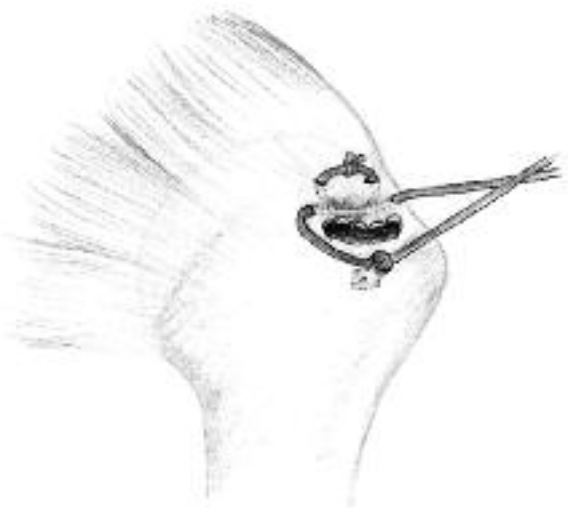

*Fig. 2b.* — Completing the double row repair with a lateral push-in anchor.

pain reduction at VAS and Constant Score). The level of significance was set at $p < .05$. All results are expressed as the mean and the standard deviation.

## RESULTS

The mean age in group 1R was 50.3 years (range 20-70 y), 31% of the patients (10/32) were women. The mean age in group 2R was 52.7 years (range 33-68 y), 61% (20/33) were women in this latter group. There was no statistically significant difference with respect to age ($p = 0.67$), but the sex ratio was different with $p = 0.03$. The average tear size in group 1R was 2.34 $cm^2$ (± 1.55) and 2.71 $cm^2$ (± 1.35) in group 2R, a difference that was not significant ($p = 0.09$) (table I).

The number of anchors per case was 1.25 (± .07) on average for group 1R and 2.03 (± .07) for 2R ($p < .001$). A history of trauma was noted in 69% of the patients in group 1R and 61% in 2R ($p = 0.37$). Shoulder strain at their regular work was medium to high (professions such as farmer, workman, craftsman or geriatric nurse) in 47% and 48% of the patients respectively ($p = 0.09$).

Pain diminished on the VAS in group 1R from 7.7 points (± 0.32) preoperatively to 1.05 points (± .25) postoperatively. In group 2R the corresponding values were 8.5 points (± 0.31) and 0.64 (± 0.25). This reduction in pain was highly significant ($p < 0.001$) for both groups. Pain reduction calculated as the difference in pain values pre- and postoperatively was 6.7 points (± 2.60) for group 1R and 7.9 points (± 1.87) for group 2R, a significant difference between the two groups with $p = 0.03$.

Statistically, both groups performed equally in the questions of the SST except for question 10 ("throw softball 20 yards overhand") with $p = 0.03$ and question 12 ("work fulltime at your regular job") with $p = 0.04$. In fact, 75% of patients in group 1R stated that they were able to work fulltime at their regular job, while this was the case for 94% in group 2R. The overall number of "yes" answers was significantly higher ($p = 0.01$) in group 2R with a mean of 11.2 than in group 1R with a mean of 10.2. Patient satisfaction showed equal results for group 1R with 97% of "yes" answers compared with 100% for group 2R ($p = 0.49$).

The 13 patients in each group who had 11 or 12 "yes "answers in the SST and no pain (VAS = 0) postoperatively returned for objective shoulder testing and strength measurement. For group 1R, the absolute mean CS of the affected shoulder was 88.8 points (± 9.3), for group 2R it averaged 83.9 points (± 7.9).

Table I. — Age, sex and tear size distribution

| | Group 1R (n = 32) | Group 2R (n = 33) |
|---|---|---|
| Age (years) | 50.3 | 52.7 |
| Sex (female)* | 10 / 32 | 20 / 33 |
| Tear size (in $cm^2$) | 2.34 (± 1.55) | 2.71 (± 1.35) |

*p < 0.05.

Table II. — Condensed results overview

| | Group 1R | Group 2R |
|---|---|---|
| Pain reduction (in points) | 6.7 (± 2.60)* | 7.9 (± 1.87)* |
| Yes answers in SST | 10.2 (± .36)* | 11.2 (± .25)* |
| Relative CS (in %) | 97.1 (± 8.8) | 97.5 (± 8.3) |
| Average strength (in %) | 102.7 (± 15.6) | 99.5 (± 31.1) |

Values are given as mean ± SD ; *p < 0.05.

Considering the different sex distribution, the age and sex-related normal values of the CS for the average Swiss population reported by Yian *et al* (*24*), were chosen as a reference. The relative CS of the affected shoulder in group 1R was 97.1% (± 8.8), group 2R averaged 97.5% (± 8.3). Statistical analysis showed no difference (p = 0.86) between the two groups. The mean CS of the contralateral shoulder did not differ either (p = 0.61), with 93.5% (± 9.2) points in 1R and 92.8% (± 14.4) in 2R, respectively.

Results of strength measurement were further investigated : In group 1R, the sex and age-corrected mean strength for the affected shoulder was 102.7% (± 15.6) ; mean strength of group 2R was 99.5% (± 31.1). With p = 0.74 there was no difference regarding postoperative strength. The contralateral shoulders performed with strength values of 88.0% (± 34.9) and 89.6% (± 33.2) respectively (p = 0.47). The main results are summarized in table II.

## DISCUSSION

Since 2000, arthroscopic rotator cuff repair has gradually become the gold standard of rotator cuff surgery. Proponents of the open technique have long since criticized the potentially weaker fixation of the cuff to bone, while arthroscopic surgeons were well aware of this challenge. Fixation has been improved step by step by adapting new biomechanical principles (*7*) and technical innovations. The most important technical innovations were the appearance of stronger suture material of the FiberWire type, and of the double-loaded screw-in anchors with high pull-out strength. One of the principal themes of discussion since 2003, however, is the possible advantage of double-row versus single-row fixation to increase contact of the tendon to the bony footprint (*15*).

The anatomy of the insertion of the rotator cuff tendons and their macroscopic and microscopic specifications has been well described. The insertion area of the supraspinatus is thought to average 23 × 16 mm (*9*), the posterior border of the tendon being overlapped by the infraspinatus. Several cadaveric studies highlighted the contact area and biomechanical properties obtained by different fixation principles like transosseous repair or single-row and double-row anchor based repair. Single-row fixation achieved a contact area of only 53% (*5*) to 67% (*2*) of the original footprint. This area was larger for transosseous repair with 87% in one study (*2*), while double-row repair was thought to reach up to 90-100% of footprint coverage (*5,18*). At biomechanical testing, double-row repair fared better than single-row and transosseous repair in most studies (*19*), while others reported no biomechanical advantage (*16*). Gap formation under cyclic loading (*19*), displacement on rotation of the humeral head (*1*) and contact pressure of different repair constructs were studied (*23*). More recently a group of investigators reported favourable results for so-called “transosseous equivalent” suture–bridge constructs (*20*).

There are, however, concerns about the widespread use of double-row repairs (*16*). They are technically more demanding and may not be suited for the transition from open to arthroscopic cuff repairs. Furthermore, double-row constructs require more anchors and longer operating time, thus producing a relevant increase in costs (*13*). The biology

of tendon healing might be adversely affected through strangulation of the cuff by medial fixation points. A tendency to over-reduce the cuff by pulling it too far laterally in order to achieve double-row fixation would create tension overload (*21*).

Our study shows that the clinical results of double-row repair were equal or slightly better than those of single-row repair as expressed by the patient-based Simple Shoulder Test (SST) and the Visual Analog Scale (VAS). Double-row fared significantly better in only two of twelve questions of the SST.

The hypothesis that double-row repair would result in more complete healing and hence better abduction strength was tested in the 13 best performing patients in the SST and VAS of both groups. The rationale of this approach lies in the assumption that the clinically manifest differences between the study groups would appear clearly in the SST and VAS applied to the whole group, while subtle differences in abduction strength would rather show up in those patients with an excellent clinical result. To our surprise, the 13 best performing patients of each group had identical values in the relative age- and sex-corrected Constant score (CS) and showed no difference in electronic strength measurement. The hypothesis that double-row fixation would lead to better strength was not confirmed by our study.

It is unlikely that decompression and debridement might have been the primordial gestures of improvement and that the quality of the final repair would not matter that much in these patients with small to medium tears. Acromioplasty and debridement alone do not protect the rotator cuff from undergoing further degeneration (*14*).

The two groups were comparable regarding age, history of trauma and occupation. The sex distribution was different, however, with twice as many women in the double-row group (61% vs. 31%). This difference can only be explained by the small size of the groups, as in the previously mentioned large study of 450 patients, which included both study groups, the proportion of women was 38%. As women have lower abduction strength (*8*), it was mandatory to use an age and sex correlated score in comparing the groups. One study (*24*) provided us with the normal values of a large sample (n = 1620) of a contemporary Swiss population. Constant had established his normal values based on an Irish population and stated that "deterioration in function which occurs as a physiological characteristic of ageing is not universal for all countries".

One weakness of our study is the lack of direct information about structural integrity of the repair obtained by imaging studies. Instead, precise strength measurement was used to indirectly assess the integrity of the tendon repair. Structural integrity has been shown to closely influence abduction strength, but not the clinical outcome and patient satisfaction (*3,12*). Our study also has advantages : Limitation to small and medium supraspinatus tears allows us to focus on the supraspinatus as the most important tendon in clinical practice. The participation rate of 100% is exceptionally high, due to the fact that we could test at their homes those patients who were reluctant to come back for objective examination.

The arthroscopic observation of reduction of gap formation by adding a medial row of anchors, together with increasing evidence from cadaveric studies, turns double-row repair into an attractive and, for most surgeons, desirable alternative to traditional single-row repair. However this will be achieved at the price of added complexity of the procedure and higher costs. Based on our experience in arthroscopic cuff repair since 2000 (*6*) and considering the results of this study, single-row repair continues to be an acceptable option.

In conclusion, our study demonstrated that single- and double-row repairs both achieve excellent clinical results and high patient satisfaction in small and medium supraspinatus tears. Pain reduction was slightly better for double-row, and double-row achieved more "Yes" answers in the SST. A higher percentage of double-row patients returned to their regular job. In strength measurement in a subset of patients no difference was noted. Clinical evidence of superiority of double-row repair is still scarce and has to be balanced against potential downsides. To the surgeon intending to shift from open to arthroscopic cuff repair, we recommend to start with a single-row technique.

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