ORIGINAL ARTICLE

Immediate passive motion versus immobilization after endoscopic supraspinatus tendon repair: A prospective randomized study

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KEYWORDS
Rotator cuff; Tendon healing; Rehabilitation; CT arthrography; Shoulder stiffness; Shoulder arthroscopy

Summary

Introduction: Rehabilitation programs after rotator cuff repair should allow recovery of shoulder function without preventing tendon healing. The aim of this randomized prospective study was to compare the clinical results after two types of postoperative management: immediate passive motion versus immobilization.

Patients and methods: We followed 100 patients, mean age 55 years old, who underwent arthroscopic repair of a non-retracted supraspinatus tear. Patients were randomized to receive postoperative management of immediate passive motion or strict immobilization for 6 weeks. A clinical evaluation was performed in 92 patients, and CT arthrography in 82. Mean follow-up was 15 months.

Results: The mean preoperative Constant score improved significantly from 46.1 points to 73.9 at the final follow-up. The rate of intact cuffs was 58.5%. Functional results were statistically better after immediate passive motion with a mean passive external rotation of 58.7° at the final follow-up versus 49.1° after immobilization (\(P=0.011\)), a passive anterior elevation of 172.4° versus 163.3° (\(P=0.094\)) respectively, a Constant score of 77.6 points versus 69.7 (\(P=0.045\)) respectively, and a lower rate of adhesive capsulitis and complex regional pain syndrome. Results for healing seemed to be slightly better with immobilization, but this was not statistically significant: the cuff had a normal appearance in 35.9% of cases after immobilization compared to 25.6% after passive motion, an image of intratendinous addition was found in 25.6% versus 30.2%, punctiform leaks in 23.1% versus 20.9%, and recurrent tears in 15.4% versus 23.3% respectively.

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Introduction

Rotator cuff tears are frequent, with a prevalence of 13% in subjects in the 50s and up to 50% after the age of 80 [1]. The capacity of the tendon to heal is limited and multifactorial, as shown by the rate of recurrent tears after repair, which varies from 16% in non-retracted tears in young subjects [2], to 94% in massive tears [3]. The aim of research today is to improve the intrinsic healing capacity of the tendon, both on a biological [4–6] and biomechanical level [7,8], and to try to improve surgical repair techniques [9,10].

Postoperative management of rotator cuff tears initially consisted of immobilization of the shoulder. Because of the significant rate of stiffness reported [11,12] with this approach, the use of passive motion has gradually gained acceptance, based on the management of other tendon repairs [13].

Postoperative management of rotator cuff tear repairs is an essential step. It should provide recovery of joint range of motion, muscular strength and shoulder function, without preventing healing of the repaired tendon. Very few studies have evaluated the consequences of postoperative management on tendon healing. Animal studies have only recently shown that healing may be improved following immobilization [14,15].

The aim of this prospective randomized study was to compare the clinical and anatomical results of tendon healing, passive range of motion and functional scores after two types of postoperative management of arthroscopic repair of the supraspinatus tendon: immediate passive motion versus mobilization. Our hypothesis was that immobilization does not influence postoperative functional and anatomical results.

Patients and methods

The series

This was a prospective, randomized, monocentric study which was preliminary to a Clinical Research Hospital Program (Programme hospitalier de recherche clinique [No. 4964]). One hundred patients were included who underwent arthroscopic repair of a distal or intermediate tear of the supraspinatus tendon between January 2008 and September 2009.

Inclusion criteria were a symptomatic, non-retracted, isolated supraspinatus tear that was refractory to medical treatment, with a mobile shoulder, with stage 2 or less fatty infiltration, and a preserved acromiohumeral distance. Extension of the tear in the form of anterior or posterior delamination were not criteria for exclusion.

Postoperative management was randomized after surgery to obtain two groups of 50 patients: the first received a protocol of immediate passive motion (the “Passive” group), and the second was immobilized for 6 weeks in a sling, which only allowed pendulum exercises (“Immobilization” group). Five patients were lost to follow-up (three for demographic reasons, one for other medical reasons and one for refusal due to dissatisfaction), one patient died, and two were excluded for early mechanical failure (pull-out of suture anchor at 6 weeks after surgery).

The series included 92 patients (34 men and 58 women) mean age 55.3 years old (37–71, E-T = 8 years) at surgery. The cuff tear was in the right shoulder in 71% of the cases and the dominant shoulder in 74%. Sixty-five percent were manual workers and 31% of the tears were due to work related accidents or professional injuries (W comp). The mean delay between the first symptoms and surgery was 205 months (2–100, E-T = 21 months).

Preoperative evaluation of lesions/injuries

The day before surgery, passive range of motion and the Constant score [16] were measured and showed a mean 173° of anterior elevation (140–180°), 58° of external rotation (30–80°), and a Constant score of 46.1 points (19–83, E-T = 12) (Table 1).

The initial clinical evaluation included a standard radiographic assessment associated with complementary imaging tests (CT arthrography in 73 cases, MRI in 14, and arthro-MRI in five). The mean acromiohumeral interval was 10.3 mm (7–15, E-T = 1.7), and the fatty infiltration index was 0.54. Acromioclavicular arthropathy was found in 54% of the cases.

Classification of the tear

The extent of the tear was evaluated in the coronal and sagittal planes preoperatively. The tear involved the supraspinatus tendon in all cases: it was partial in 24% and a full thickness tear in 76% of cases (including 52% stage I distal tears and 24% intermediate stage II anteroposterior tears) [17]. Analysis of the extent of the tear on the sagittal plane showed a tear that was limited to the supraspinatus in 54% of the cases, with anterior extension to the rotator interval or associated with an irregularity or delamination of the subscapularis in 23%, with posterior extension in the form of delamination of the upper third of the infraspinatus in 11%, and with anterior and posterior delamination in 12%.
Surgical technique

Cuff repair was performed arthroscopically in all cases with the patient in the beach chair position, by five different senior surgeons and under general anesthesia.

Repair of the supraspinatus tendon was performed by single row suture-reinsetion in 59% of the cases, in particular for partial tears and limited distal full thickness tears. Double row fixation was used in 41% of the cases, normally for intermediate full thickness tears and extensive distal tears. No tendon release was necessary.

A tenotomy of the long head of the biceps (LHB) was performed in 65% of the cases and a tenodesis in 11%. An acromioplasty was performed in 91% of the cases. Resection of the inferior osteophytes of the acromioclavicular joint was performed in 5% of the cases with complete resection in 15%.

Rehabilitation protocols

In the "Passive" group, rehabilitation began the day after surgery with three to five sessions per week depending upon the availability of the physical therapist. This included pendulum exercises, manual passive range of motion and work on a CPM machine [Continuous Passive Motion] without limitation of the range of motion. A sling was worn in between the rehabilitation sessions.

The "Immobilization" group included strict immobilization of the shoulder in a sling that was placed at the end of surgery and worn for 6 weeks, with no movement allowed except pendulum exercises.

Active rehabilitation was begun in both groups after the 6-week postoperative control, and was identical in both groups. Then 4 months after surgery the muscular strengthening phase was begun.

Postoperative evaluation

Functional evaluation

Ninety-two patients were evaluated for function during a control consultation after a mean follow-up of 16 months and a minimum of 12 months.

Shoulder stiffness was evaluated by measuring passive range of motion with a goniometer, in anterior elevation and external rotation (at 3, 6, 12 months and at the final follow-up). The level of functional recovery was evaluated by the Constant and Murley score [16].

Anatomical evaluation

Anatomical results were assessed in ninety-two patients by arthro-CT at a mean 14 months and a minimum of 6 months after surgery. Ten patients refused to undergo this examination because it was invasive and painful. Supraspinatus healing on the greater tubercle was classified into four stages according to the classification used during the 2004 symposium of the French Society of Arthroscopy (Société française d’arthroscopie) [2] (Fig. 1): normal cuff (stage I), intratendinous addition (stage II), punctiform leak (stage III), recurrent tear (stage IV).

Statistical evaluation

All of the data were analyzed with SPSS 13.0 statistical software (SPSS Inc., Chicago, Ill., USA). Measurements were expressed as means and standard deviations. Qualitative variables were analyzed using the Fisher exact test or the Pearson Chi² test. Continuous variables were compared using non-parametric tests (Mann-Whitney test, Kruskal-Wallis test, Wilcoxon test). P<0.05 was considered to be significant.

Results

Global postoperative results

A statistically significant improvement was found for all items of the Constant score, which went from a mean 46.1 points (19–83, E-T = 12) preoperatively, to 73/9 (24–99, E-T = 15.7) at the final follow-up (P<0.001) (Table 1). These results were classified as excellent in 47% (Constant Index [CI] 80 points or more), good in 26% (CI between 65–79), average in 18% (CI between 50–64) and poor in 9% (CI below 50), according to the Walch and Marechal classification [18].

Postoperative complications included 10 adhesive capsulitis, three complex regional pain syndromes, and two delayed anchor suture pull-out, which were not the same as the two early tears in the excluded patients (the first after 12 weeks which still had good functional results; the second after the 10th month requiring revision surgery with an average result).

CT arthroscopy showed that 58.5% of the cuffs were intact and 19.5% had recurrent tears (Table 2).
Study of the homogeneity of the two groups

A statistical study of homogeneity was performed, confirming that the two groups were homogeneous for all preoperative criteria: individual (age, gender, delay, W comp), clinical (mobility, Constant score), lesions (retraction and sagittal extension of the tear, fatty infiltration), surgical procedure, (single or double row fixation, acromioplasty, procedure on the LHB, acromioclavicular resection), and follow-up.

Functional results in relation to the rehabilitation protocol

The mean passive flexion at the final follow-up was 163.3° (90–180°, E-T=25.1°) in the "immobilization" group and 172.4° (130–180°, E-T=13°) in the "Passive" group with no significant difference between the groups (Table 3). Recovery of flexion was poorer and later in the "Immobilization" group and the short-term difference between the two groups was more marked and significant (P=0.001), while it gradually stabilized over time (P=0.094).

Passive external rotation (ER1) at the final follow-up was 49.1° (10–80°, E-T=18°) in the "Immobilization" and 58.7° (30–85°, E-T=12,9°) in the "Passive" group (Table 4). There was a significant and progressive loss of ER1 in the "Immobilization" group which was still present at the final follow-up (P=0.011).

Fourteen patients (32.6%) in the "Immobilization" group had an ER1 of less than 20° at the third postoperative month compared to five (10.2%) in the "Passive" (P=0.008) group,
and 13 patients (30.2%) had an ER1 of less than 30° at the sixth postoperative month compared to three (6.1%) (P=0.002) in the "Passive Group". We identified nine adhesive capsulitis and complex regional pain syndromes (20.9%) in the "Immobilization" group, compared to four (8.2%) in the "Passive" group (P=0.073).

The mean Constant score at follow-up was significantly higher (P=0.045) in the "Passive" group with 77.6 points (49–99, E-T=12.4), than in the "Immobilization" group with 69.7 points (24–96, E-T=18) (Table 5). Constant score results were good or very good in 82% of the "Passive" group compared to 63% of the "Immobilization" group (Fig. 2).

Thus, there was a correlation between better recovery of passive range of motion over time and the Constant score in the "Passive" group.

### Table 3 Comparison of passive anterior elevation between the two groups.

<table>
<thead>
<tr>
<th></th>
<th>Passive</th>
<th>Immobilization</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>174.9° ± 9.4</td>
<td>170.5° ± 12.9</td>
<td>0.001</td>
</tr>
<tr>
<td>3 months</td>
<td>142.1° ± 28.2</td>
<td>112.9° ± 37.6</td>
<td>0.046</td>
</tr>
<tr>
<td>6 months</td>
<td>158.4° ± 22.9</td>
<td>146.4° ± 30.0</td>
<td>0.076</td>
</tr>
<tr>
<td>12 months</td>
<td>171.9° ± 13.6</td>
<td>161.9° ± 26.2</td>
<td>0.094</td>
</tr>
<tr>
<td>Final follow-up</td>
<td>172.4° ± 13.0</td>
<td>163.3° ± 25.1</td>
<td>0.616</td>
</tr>
<tr>
<td>Difference preoperative – final follow-up</td>
<td>−2.4° ± 14.1</td>
<td>−7.2° ± 26</td>
<td></td>
</tr>
</tbody>
</table>

### Table 4 Comparison of passive external rotation between the two groups.

<table>
<thead>
<tr>
<th></th>
<th>Passive</th>
<th>Immobilization</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>ER1</td>
<td>58.4° ± 12.5</td>
<td>57.2° ± 13.9</td>
<td>0.001</td>
</tr>
<tr>
<td>3 months</td>
<td>45.6° ± 14.9</td>
<td>27.5° ± 19.4</td>
<td>0.020</td>
</tr>
<tr>
<td>6 months</td>
<td>54.3° ± 12.5</td>
<td>44.3° ± 19.4</td>
<td>0.010</td>
</tr>
<tr>
<td>12 months</td>
<td>58.1° ± 13.2</td>
<td>48.3° ± 18.2</td>
<td>0.011</td>
</tr>
<tr>
<td>Final follow-up</td>
<td>58.7° ± 12.9</td>
<td>49.1° ± 18.0</td>
<td>0.022</td>
</tr>
<tr>
<td>Difference preoperative – final follow-up</td>
<td>+0.3° ± 14.6</td>
<td>−8.1° ± 18.7</td>
<td></td>
</tr>
</tbody>
</table>

### Anatomical results depending on the rehabilitation protocol

Anatomical results in relation to the rehabilitation protocol are presented in Table 6.

The higher rate of complete healing and intact cuffs, as well as the lower rate of recurrent tears in immobilized patients suggests that results in the immobilization group were slightly better for the quality of tendon healing, although this was not statistically significant.

### Discussion

**Influence of postoperative immobilization on the anatomical results**

The anatomical studies in the literature comparing postoperative management after rotator cuff repair have mainly been performed in animal models. Results with immobilization are positive for the histological and biomechanical properties of the tendon [14,15,19,20].

Lewis et al. [19] found better load-to-failure and tendon stiffness after 6 weeks of immobilization in sheep. The other studies have been performed in the rat model which is very similar to the human shoulder in terms of bone, joint and range of motion anatomy. Thomopoulos [14] then Peitz [20] found that the structural composition of the tendon was closer to normal after immobilization following supraspinatus repair in the rat (better organization of collagen fibers, more marked expression of fibrocartilage genes) with better biomechanical properties. In fact activity seemed to be harmful by increasing the production of scar tissue with lower biomechanical properties. Thus it may be necessary to protect the bone-tendon interface to allow collagen fibers to integrate into the bone. The duration of immobilization also makes it possible to enhance the biomechanical properties of the healing tendon [15].

![Figure 2](image-url)
Immobilization has not been shown to be better for healing in man as the influence of the postoperative protocol on the anatomical results has rarely been studied. In our series there was a higher rate of complete healing and intact cuffs after immobilization as well as a lower rate of recurrent tears. This suggests that immobilization results in slightly better quality tendon healing, although these results were not statistically significant.

Deutsch et al. [21] identified a similar tendency with a more conservative protocol of passive rehabilitation that limited flexion to 4 weeks. The rate of healing evaluated by ultrasound at 6 months was 91% of intact cuffs in the “conservative” protocol group compared to 81% with the “standard” protocol, with no significant difference between the groups.

After 6 weeks of postoperative immobilization, Parsons et al. [22] separated patients into two groups according to their passive range of motion at the sixth week. An MRI performed at 1 year of follow-up showed a healing rate of 70% in the group that was stiff at 6 weeks compared to 36% in the non-stiff group ($P = 0.079$). However, all the patients in that study were immobilized therefore the influence of the postoperative protocol could not be evaluated.

### Influence of postoperative immobilization on functional results

Postoperative stiffness is the most frequent complication after arthroscopic rotator cuff repair. It occurs with a frequency of 3.1–23%, but the criteria to define stiffness vary widely from one study to another [2,22–25]. This stiffness can have many causes: adhesive capsulitis [26] (capsular and synovial inflammatory reaction, causing adhesions and capsular retraction), pseudotenodesis of the deltoid [27] (adhesions of the subacromial space), and complex regional pain syndrome. Shoulder stiffness is correlated to increased pain and poorer functional and quality of life scores [28].

In animal models, authors have found that the results of immobilization are harmful, with increased stiffness, which can compromise short-term functional results. Nevertheless this stiffness is transitory and does not persist in the long-term follow-up [29–31]. Schollmeier et al. [29] studied the effects of immobilization in the non-operated gleno-humeral joint in the dog. Results showed reduced joint range of motion and capsular volume, increased intraarticular pressure and histological modifications such as those found in adhesive capsulitis in man. However, all of these modifications were reversible once the joint was exercised [30]. After 4 weeks of immobilization following supraspina
tus repair in the rat, Sarver et al. [31] found a significant but transitory increase in stiffness during external rotation compared to that in the non-immobilized group.

In another study in the rat Peltz et al. [20,32] found the opposite results: early passive motion was shown to be harmful for joint range of motion. They attributed this loss of range of motion to the formation of scar adhesions in the subacromial space, favored by movement-induced

### Table 5 Comparison of Constant score between the two groups.

<table>
<thead>
<tr>
<th>Constant Score</th>
<th>Passive</th>
<th>Immobilization</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>$12.6 \pm 2.3$</td>
<td>$11.3 \pm 3.5$</td>
<td>$= 0.109$</td>
</tr>
<tr>
<td>Activity</td>
<td>$17.1 \pm 3.4$</td>
<td>$15.8 \pm 4.2$</td>
<td>$= 0.176$</td>
</tr>
<tr>
<td>Mobility</td>
<td>$35.7 \pm 4.7$</td>
<td>$32.3 \pm 8.2$</td>
<td>$= 0.124$</td>
</tr>
<tr>
<td>Strength</td>
<td>$12.3 \pm 4.8$</td>
<td>$10.3 \pm 4.7$</td>
<td>$= 0.037$</td>
</tr>
<tr>
<td>Global</td>
<td>$77.6 \pm 12.4$</td>
<td>$69.7 \pm 18.0$</td>
<td>$= 0.045$</td>
</tr>
<tr>
<td>Adjusted (%)</td>
<td>$92.5 \pm 10.6$</td>
<td>$84.5 \pm 19.4$</td>
<td>$= 0.134$</td>
</tr>
</tbody>
</table>

### Table 6 Comparison of anatomical results between the two groups.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Passive (%)</th>
<th>Immobilization (%)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact cuff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intact</td>
<td>55.8</td>
<td>61.5</td>
<td>$= 0.382$</td>
</tr>
<tr>
<td>Non-intact</td>
<td>44.2</td>
<td>38.5</td>
<td></td>
</tr>
<tr>
<td>SFA classification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal appearance (stage I)</td>
<td>25.6</td>
<td>35.9</td>
<td>$= 0.669$</td>
</tr>
<tr>
<td>Intratendinous addition (stage II)</td>
<td>30.2</td>
<td>25.6</td>
<td></td>
</tr>
<tr>
<td>Punctiform tear (stage III)</td>
<td>23.3</td>
<td>15.4</td>
<td></td>
</tr>
<tr>
<td>Recurrent tear (stage IV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete</td>
<td>25.6</td>
<td>35.9</td>
<td>$= 0.500$</td>
</tr>
<tr>
<td>Incomplete</td>
<td>51.1</td>
<td>48.7</td>
<td></td>
</tr>
<tr>
<td>Recurrent tear</td>
<td>23.3</td>
<td>15.4</td>
<td></td>
</tr>
<tr>
<td>Rate of recurrent tear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recurrent tear</td>
<td>23.3</td>
<td>15.4</td>
<td>$= 0.269$</td>
</tr>
</tbody>
</table>
mécanique. Cette mécanique peut causer une cascade inflammatoire via MAP-kinases, entraînant la prolifération de fibroblastes et la formation de capsulite adhérente [33].


On l’autre main, plusieurs auteurs ont montré qu’il y avait un effet bénéfique d’ajout de mouvement passif continu à un protocole standard de rééducation. Ce phénomène a été appuyé par des résultats de suivi après 16 mois de suivi. L’immobilisation a entraîné une meilleure mobilité, adhérente à la scapula et complexe de douleur régionale.

**Points forts et limites de cette étude**

Les points forts de cette étude sont sa prospective, design randomisé, taille de la population, taux de perte à 1 an et à 18 mois. Le suivi minimum d’un mois a été suffisant pour obtenir une interprétation fiable de l’anatomie et des résultats fonctionnels. L’arthro-CT est le meilleur outil pour évaluer le tendon rotateur cuffy. Sa spécificité et sensibilité pour le diagnostic de l’adhérente de plus de 1% de l’articulation scapulohumérale. Nos résultats sont limités car il s’agit d’une étude multicentrique.

**Conclusion**

La mobilité passive après réparation du tendon rotateur cuffy est plus corrélée au résultat que la mobilité passive. Dans notre série, après 16 mois de suivi, il y avait un déficit significatif dans la mobilité passive externe et dans le score de Constant. Ce groupe ne montre pas de différence dans les résultats de Constant.

La rééducation a été réalisée dans le cas des résultats plus favorables à la rééducation passive. Une courte période d’immobilisation aurait pu être bénéfique pour prévenir le résultat sans compromettre les résultats fonctionnels.

**Déclaration d’intérêt**

P. Clavert: consultant pour DePuy Mitek.

**Références**


