



# Rotator cuff injury

## Ozljede rotatorne manšete

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**Abstract.** One of the most frequent causes of shoulder pain is the damage of the rotator cuff tendon. Its etiology is multifactorial and the symptoms often require prompt medical intervention. It can be easily identified through thorough clinical exam using proper diagnostic methods. There are different kinds of tears, and consequently also different kinds of medical treatment options. The most common tear is that of the supraspinatus tendon. Nowadays, arthroscopic repair is the golden standard for the rotator cuff repair.

**Key words:** arthroscopy; rotator cuff repair; rotator cuff tear; shoulder

**Sažetak.** Jedan od najčešćih uzroka bolova u ramenu posljedica je ozljede tetiva rotatorne manšete. Etiologija ozljede je multifaktorijska, a simptomi često iziskuju hitan medicinski tretman. Uz pažljiv i detaljan klinički pregled, kao i pravilnu upotrebu dijagnostičkih metoda, ozljeda se može lako verificirati. Postoje različite vrste rupture rotatorne manšete i različiti načini pristupa njihovoj rekonstrukciji. Najčešće je riječ o rupturi tetive supraspinatusa. Artroskopska rekonstrukcija tetiva rotatorne manšete danas predstavlja zlatni standard.

**Ključne riječi:** artroskopija; rame; rekonstrukcija rotatorne manšete; rupturi rotatorne manšete

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## INTRODUCTION

The rotator cuff comprises four muscles; subscapularis, supraspinatus, infraspinatus and teres minor, which form the tendon cuff at the humeral tuberosities. The key function of the rotator cuff is to dynamically stabilize the humeral head in relation to shoulder-blade glenoid<sup>1</sup>. If the rotator cuff function is jeopardized, the humerus head will start migrating cranially, generated by the deltoid muscle. The repercussion will be weakness of the

Patients with rotator cuff tear often undergo unnecessarily time-consuming procedures of physical therapy under diagnosed periarthritis humeroscapularis. Such patients should be referred to specialized institutions in order to be adequately surgically treated. Today, arthroscopic rotator cuff repair is the gold standard for restoring a painless and functional shoulder.

arm and limited arm movement. The most frequent cause of shoulder pain in middle-aged people is the rotator cuff tendon damage<sup>2</sup>. A rotator cuff tear occurs as a consequence of degenerative changes or an injury. Most tears occur because of the wearing down of a tendon, which occurs gradually over time. The degenerating process is usually attributed to ageing: the older the person, the higher the probability of a rotator cuff tear<sup>3</sup>.

A few factors enhance the degeneration of tendons. Continuous repetition of the same movement, such as "over-head" movements in professional athletes or workers who, while doing their

job, have to hold their arms over their heads, which causes stress, micro-damage to tendons and bone spurs being developed along the anterior edge of the acromion and sclerosis of the greater tuberosity of the humerus. Ageing causes a lack of blood supply in tendons, therefore the repair possibilities are impaired<sup>3</sup>.

An acute rotator cuff tear usually appears after an injury. Most often it is the consequence of an accidental fall on a shoulder or arm, or of lifting and carrying a heavy weight in one's arms. Another kind of a traumatic rotator cuff tear appears in patients whose tendons have already undergone degenerative changes, when just a slightly stronger physical strain or a minor accidental fall will result in a rotator cuff tear. The most frequent outcome is supraspinatus tendon tear, whereas isolated subscapularis tear appears much less frequently.

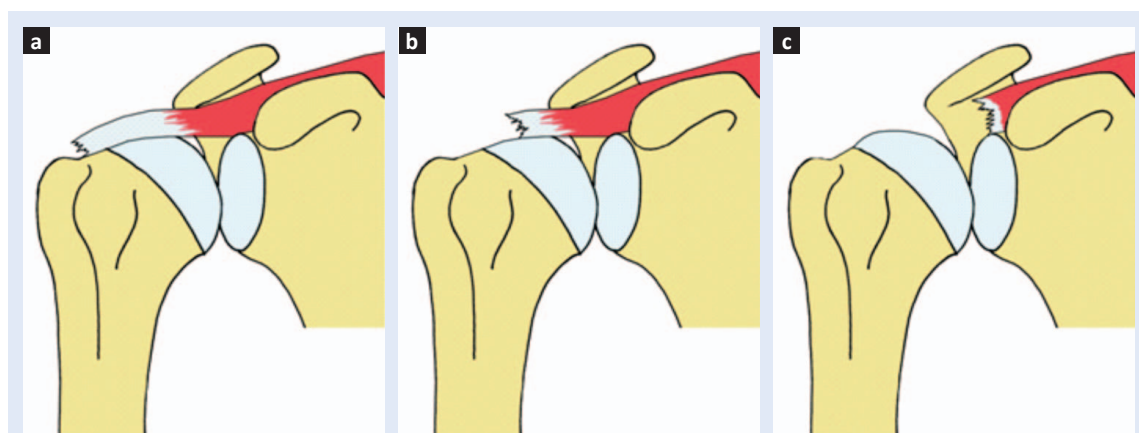
## CLASSIFICATION OF ROTATOR CUFF TEARS

A rotator cuff tear may be either full-thickness or partial.

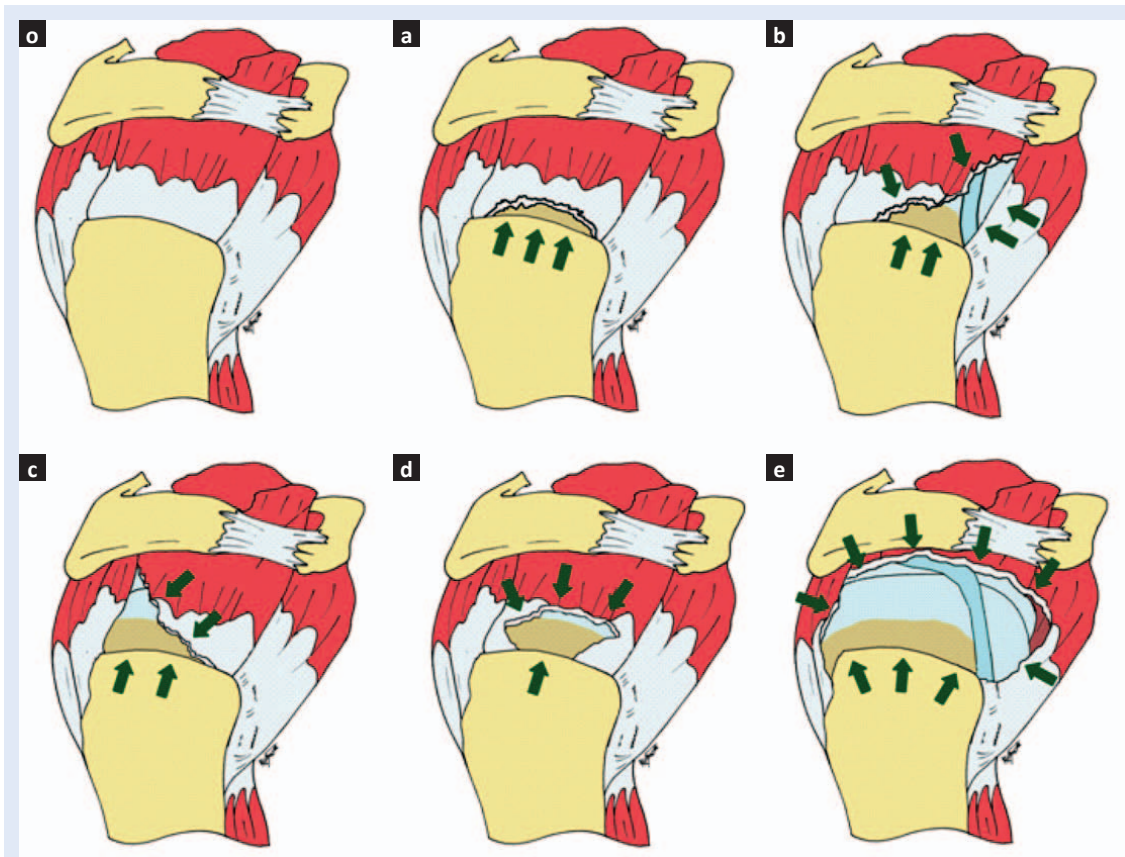
A full-thickness tear means that the tendon is no longer attached to the bone. In traumatic tears there is avulsion from the tuberosity, or a tendon is medially torn from the tendon insertion, so that one insertion part remains intact.

There are several full-thickness rotator cuff classifications, two of them being the most frequent. Cofield<sup>4</sup> divides full-thickness rotator cuff tears into the following ones:

- small, up to 1 cm,
- medium 1-3 cm,

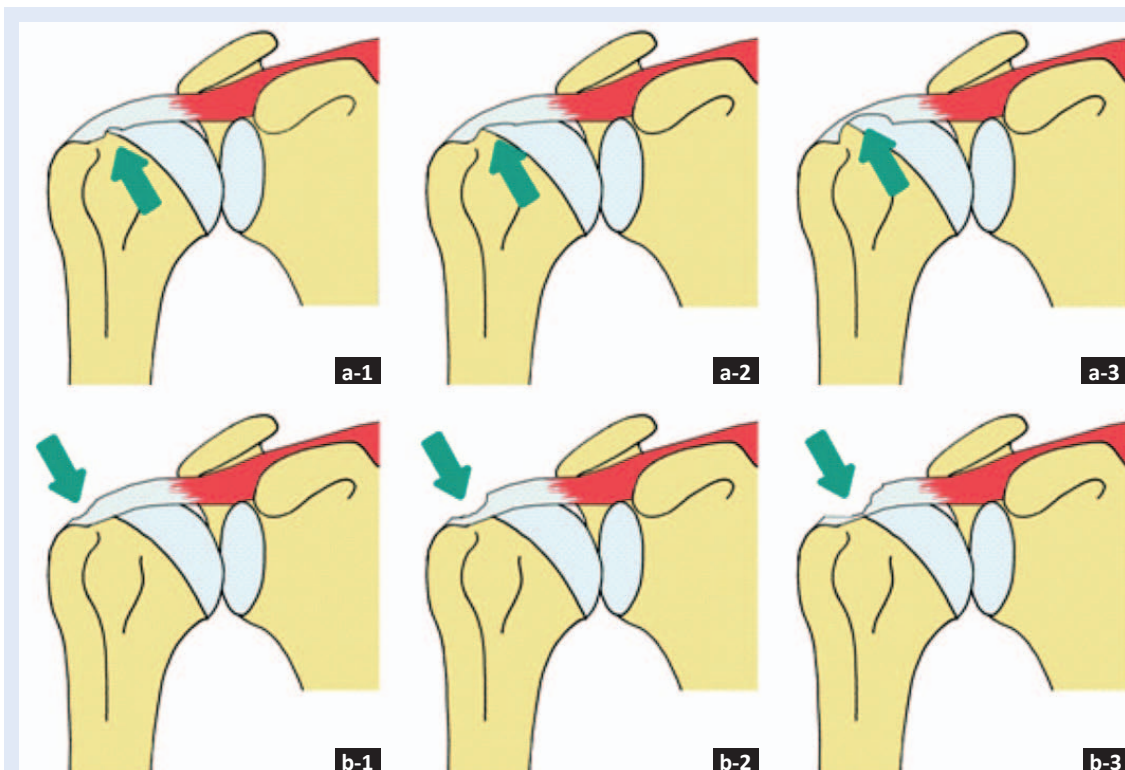


**Figure 1.** Patte classification of full-thickness rotator cuff tear: a) Stage 1: The proximal stump close to bony insertion; b) Stage 2: The proximal stump at the level of the humeral head; c) Stage 3: The proximal stump at glenoid level.



**Figure 2.** Ellman – Gartsman classification of full-thickness rotator cuff tears.

a) Crescent; b) Reverse L; c) L-shaped; d) Trapezoidal; e) Massive tear; o) Normal, intact tendon.



**Figure 3.** Ellman classification of partial rotator cuff tears. a) The articular surface; b) The bursal surface:

1. Grade 1: partial tear < 3 mm deep; 2. Grade 2: partial tear 3-6 mm deep; 3. Grade 3: partial tear > 6 mm deep.

- large 3-5 cm,
- massive, larger than 5 cm.

A massive rotator cuff tear is defined if the rupture is larger than 5 cm or when at least two tendons are affected. In medical practice, the massive tear term usually refers to rupture of two tendons, most often supraspinatus and infraspinatus, the rupture being larger than 5 cm. As a rule, tendons are drawn to the glenoidal level.

The second one is Patte Classification<sup>5</sup>: Cuff tear retraction in the frontal plane (Figure 1).

Alongside with arthroscopic reconstruction, the classification by Ellman and Gartsman<sup>6</sup> is being increasingly used (Figure 2).

Partial tear may be intra-articular, intra-tendinous or bursal. The Ellman classification of partial tears is used in clinical practice<sup>7</sup> (Figure 3).

Goutallier's classification<sup>8</sup> is based on fatty degeneration of cuff muscles.

Stage 0. Normal muscle

Stage 1. Some fatty streaks

Stage 2. Less than 50 % fatty muscle atrophy

Stage 3. 50 % fatty muscle atrophy

Stage 4. Greater than 50 % fatty muscle atrophy.

#### CLINICAL FINDINGS

Patients complain about feeling pain while lifting their arm or during the night. They also complain about not being able to sleep on the painful shoulder.

According to clinical findings, patients suffering from chronic rotator cuff tear are usually able to lift their arm above the shoulder, whereas in case of a traumatic injury they are not able to lift their arm off their body.

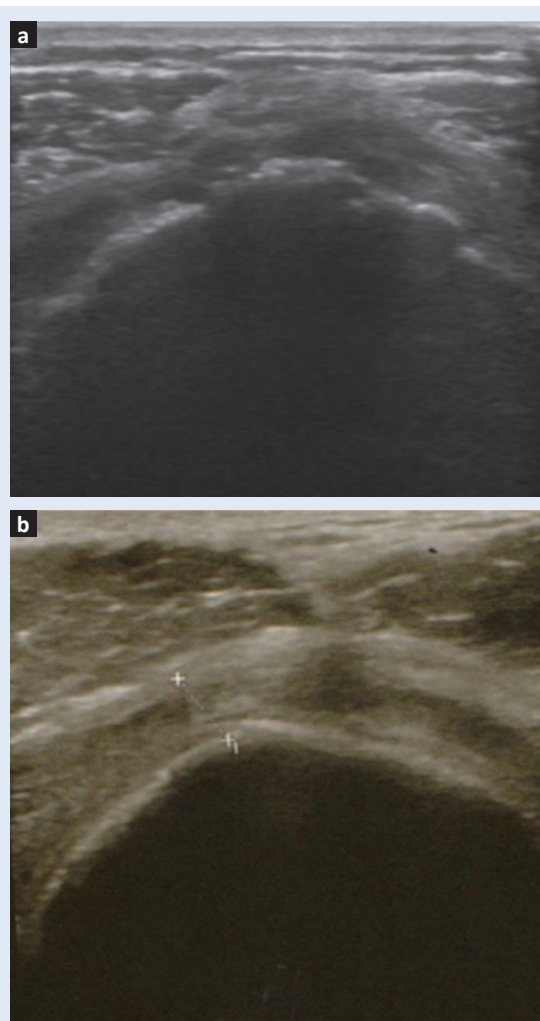
There is an emphasized weakness of external rotation and abduction of arm in loaded positions. In case of an isolated subscapularis tear, the patient is unable to lift the dorsum of the hand off their back (lift-off test<sup>9</sup>), press their belly with their palm (Napoleon sign<sup>10</sup>) or touch the opposite shoulder (bear-hug test<sup>11-13</sup>).

#### IMAGING

Ultrasound examination completes the patient's clinical findings. It provides high probability of finding a tendon tear and determining its size<sup>14,15</sup>. There are several signs which indicate a full-

-thickness rotator cuff tear. The most reliable sign is a complete absence of the rotator cuff, the deltoid muscle lying on the humeral head. This also indicates that the rotator cuff rupture is massive and that the tendons of supraspinatus and infraspinatus are affected. The focal thinning of the rotator cuff is another reliable indicator. The rolling sign in dynamic ultrasound is very reliable, rotator cuff convexity being lost and convexity converted into concavity. The secondary sign of a tear is the presence of fluid in subacromial or subdeltoid bursa<sup>16</sup>. Tendon echogenicity is not a reliable sign that the cuff is completely torn (Figure 4).

As opposed to full-thickness tears, partial-thickness ones are much more difficult to establish by ultrasound.



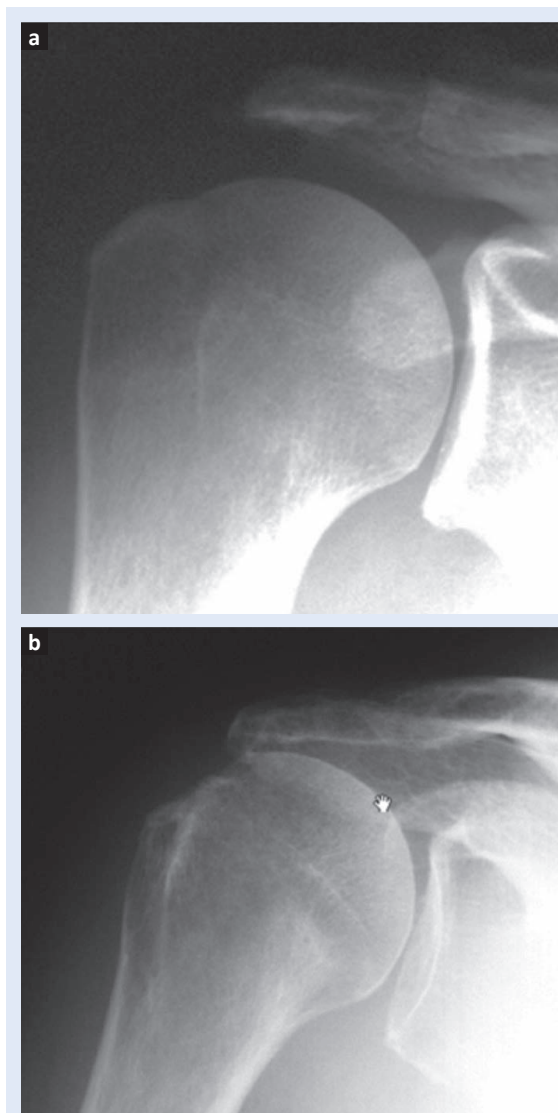
**Figure 4.** Ultrasound image of a) The massive rotator cuff tear (deltoid muscle lies on the humeral head); b) The focal thinning of the supraspinatus tendon.



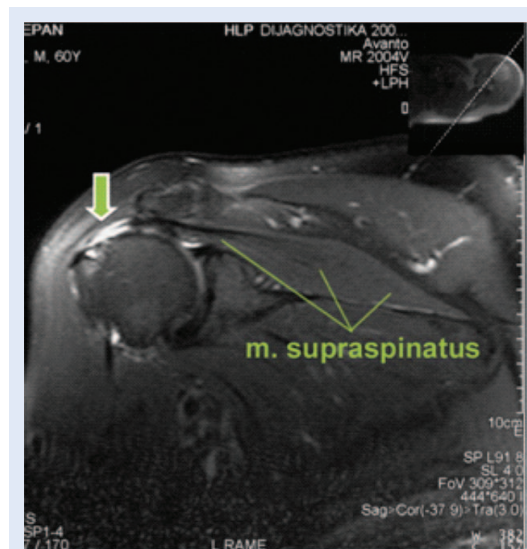
One of the drawbacks of the ultrasound diagnostics is that it largely depends on the operator's experience and the quality of the ultrasound equipment.

What radiology AP images of shoulder indicate in chronic tears is sclerosis and cystic changes of the greater tuberosity at the point of supraspinatus insertion, and sclerosis of anterior acromial edge. In massive rotator cuff tears there is a decreased width of the subacromial space due to the cranial migration of the humeral head (Figure 5).

MRI indicates a high level of reliability in diagnosing the rotator cuff tear<sup>17</sup>. MRI allows free access to the location and indicates the size of the tear



**Figure 5.** Radiology image of shoulder – chronic rotator cuff tear. a) Bony apposition on the lower anterior acromion and the greater tuberosity; b) Cranial migration of the humeral head.



**Figure 6.** MRI image of supraspinatus tendon rupture (arrow).

and the muscle condition. In contrast to the ultrasound, MRI shows the size of the tendon retraction and the condition of the muscle in relation to the fatty degeneration level (Figure 6).

## TREATMENT

### Non-operative treatment

Elderly patients suffering from minor difficulties are advised to undergo conservative treatment. They are advised not to strain their arm excessively during the day, to avoid doing activities which are causing pain and to take non-steroidal anti-inflammatory medications.

Strength and stretch exercises can improve the shoulder flexibility and arm mobility. If resting, medications and physical therapy do not manage to relieve the pain, then taking subacromial corticosteroid injections with local anesthetic is to be recommended.

Conservative treatment is highly likely to reduce the pain and avoid surgery, but the loss of arm function, in particular its strength, remains<sup>18</sup>. Over time, the size of the rotator cuff tear increases and eventually the patient is forced to reduce their physical activity.

### Surgical treatment

The most common reason why patients are treated surgically is pain. The indication for surgery is the tendon tear in active patients and profession-

al athletes. Elderly patients, who do not suffer from severe pain but are inactive and unwilling to cooperate after the surgery, do not make good candidates for surgery.

In case of an acute tear, it is required to perform surgery immediately, maximum 2 months after the injury, because of medial tendon retraction.

The surgical treatment techniques can be divided into three groups: open repair, mini-open repair and arthroscopy. Open repair techniques are less demanding, but their drawback is the limited access to the rotator cuff tissue and longer rehabilitation period, given that the tissue, which was incised in order to gain access to the tendon tear, needs to heal.

### **Open repair**

An open repair method requires detaching the deltoid muscle from the insertion to acromion and anterior acromioplasty in order to gain a better view of the subacromial space and access to the torn tendon. Less invasive methods are more popular and more often applied than the traditional open transosseous method.

### **Mini-open repair**

In mini-open approach, a 3-5 cm incision is made. The subacromial space is accessed through the deltoid muscle. This allows direct visualization, which is better for rotator cuff repair than performing the procedure by camera. Prior to that, diagnostic arthroscopy of intra-articular structures must be done, as well as an acromioplasty or biceps tenotomy, if necessary.

The mini-open repair is recommended if the surgeon decides to convert from the open repair to the arthroscopic method. The largest disadvantage of the mini-open procedure is the lack of access space to fixate the tendon to the bone, especially in cases of lengthy arthroscopy, since it results in soft tissue swelling, which hinders visualization.

### **Arthroscopic repair**

The arthroscopic procedures for torn rotator cuff repair require the surgical team to be technically well-equipped and the surgeon to be skilled and experienced. The arthroscopic method allows

better visualization of the damaged tissue, better mobilization options of the torn tendon, and eventually a quicker rehabilitation and recovery period.

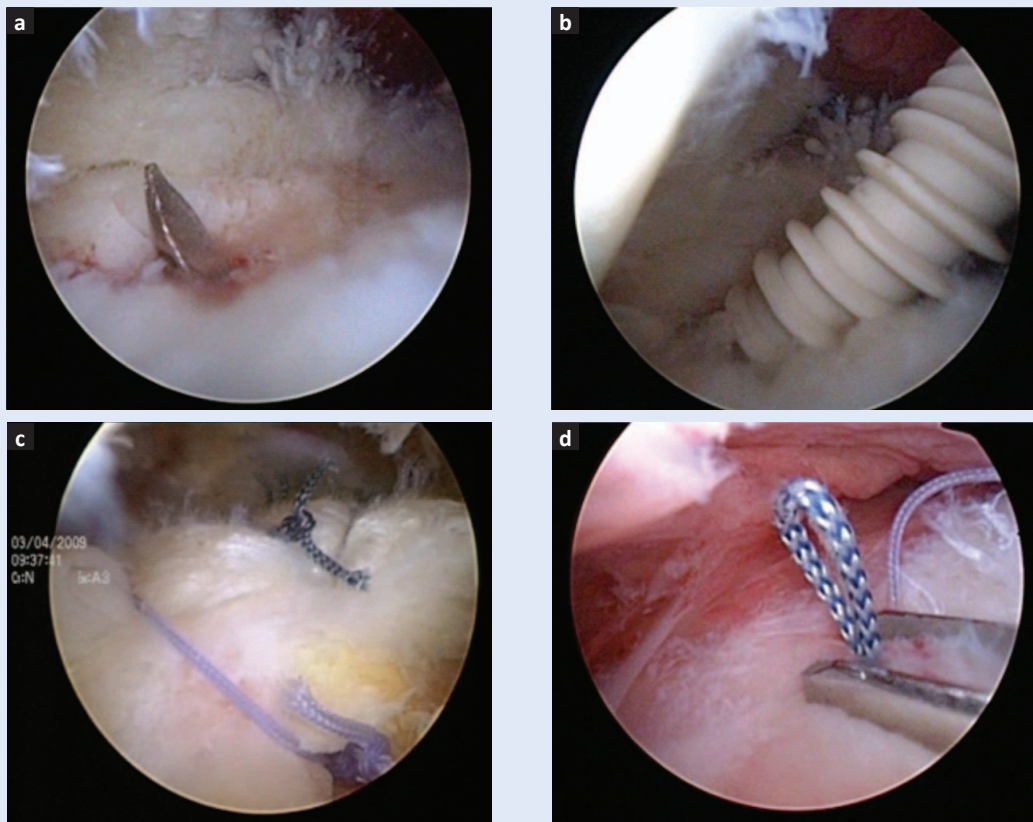
The arthroscopic rotator cuff repair is a standard method these days; it may be performed using several techniques. Both the single-row and the double-row suture anchor techniques have good clinical results in the long run<sup>19,20</sup>. The double-row technique allows better coverage of the humeral head footprint, a larger primary mechanical material strength and fewer micro-movements of the reconstructed tendon in comparison to the single-row technique<sup>21</sup>. One of the potential complications of the double-row technique is the supraspinatus tendon retear, medially from the medial anchor row, which largely complicates the revision and gives poor results. In addition to that, a large number of anchors are placed on a small footprint area (3-4 cm<sup>2</sup>), which decreases bone healing, diminishes the tendon-bone contact and increases the whole surgical procedure cost.

The transosseous method represents the golden standard in the open repair. In arthroscopy, however, it is extremely difficult to perform the curved bone drilling of the greater tuberosity, which is possible with the open repair method.

Nikola Čičak has implemented the method of arthroscopic transosseous rotator cuff fixation into routine clinical practice, which imitates the open repair technique of the rotator cuff tendon reconstruction by combining the suture anchor technique and the bone tunnel, in which a suture is threaded through in order to fixate the tendon<sup>22</sup> (Figure 7).

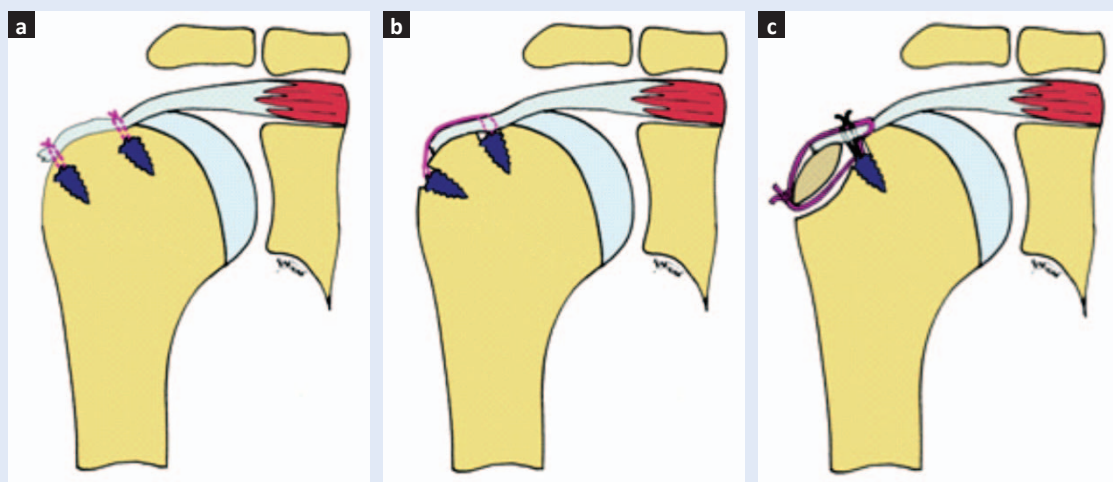
This method allows an optimal tendon-bone contact, which enables stronger fixation and faster healing of the tendon. The disadvantage of this technique is the insufficient precision of the drill through the greater tubercle on the footprint. Garofalo et al. have developed an instrument which drills the greater tuberosity with great precision and have performed the anchorless transosseous rotator cuff repair<sup>23</sup>.

This technique has disadvantages when osteoporotic bones are concerned, because the tendon cannot be firmly fixated to the bone. The non-resorbable suture is cutting into the bone and sliding cranially, decreasing the bone bridge.



**Figure 7.** Arthroscopic transosseous rotator cuff fixation.

a) A transosseous tunnel is created through the greater tuberosity by a sharp penetrator entering the footprint; b) Bioresorbable bone anchor is placed at the penetrator exit; c) Using a specially designed suture leader, the limb of the suture in the anchor which passes through the transosseous tunnel is pulled out. The other suture end is passed through the supraspinatus tendon and the knot is made on the lateral part of the greater tuberosity. d) The second suture is passed from the anchor through the supraspinatus tendon, as a mattress suture.



**Figure 8.** Arthroscopic rotator cuff repair techniques. a) The double-row anchor suture technique; b) The suture-bridge technique; c) The transosseous technique.

The latest technique is the suture-bridge<sup>24</sup> or transosseous-equivalent technique, which imitates the open transosseous technique by using double-row anchors that are tied by sutures

(Figure 8). This technique allows larger compression of the tendon to the bone and a better contact, which enables the tendon to heal faster.



### Arthroscopic surgical technique

#### *Arthroscopic repair of full-thickness rotator cuff tear*

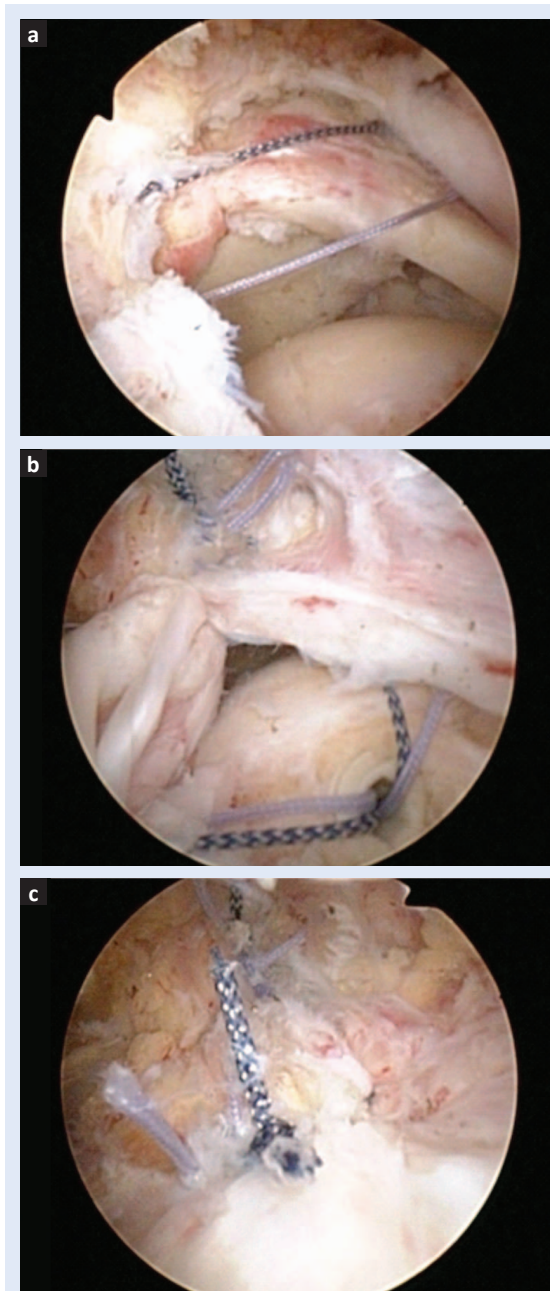
This is a description of the way it is done at Akromion Hospital.

The patient receives general anesthesia and interscalene block, and is put in a semi-seated position holding the arm in the Spider limb positioner (Tenet®, Smith-Nephew, USA). The standard posterior portal is laterally placed, providing access to the shoulder joint. Upon examining the intra-articular structures and deciding on the procedure, biceps tenotomy is carried out, and the subacromial space is accessed through the posterior portal. The surgeon places a camera, and then a drain is placed through the anterior portal, directly at the lateral edge of the coracoacromial ligament. After locating the posterior lateral portal, the camera displays pictures. Guided by the camera displays, the surgeon uses a needle to look for the most convenient anterior lateral portal position in order to perform the acromioplasty if needed, to position the anchor on the footprint at a particular angle, and at the same time to have access to all parts of the subacromial space. Upon cleaning the subacromial and subdeltoid bursa, the location of the rotator cuff tear is displayed, and then mobility and quality of the ruptured tendon must be examined. The abrader is used for footprint debridement. After that, a decision must be made about which method to use (Figure 9). If the patient's mobility and the quality of the ruptured tendon are lower and the patient is elderly, we choose to apply single-row or transosseous technique by using two bioresorbable anchors. If the tendon mobility is good and the lateral edge of the greater tuberosity can be covered easily, provided that the bone quality is good and the patient is younger, we choose to apply the transosseous anchorless technique.

The key factor of the reconstructive rotator cuff surgery is the suture management. If two anchors are positioned, then the sutures pass from the anterior anchor through the anterior portal, and the sutures from the posterior anchor pass through the posterior portal. The camera is placed in the posterior lateral portal. Suturing is performed from the back forward.

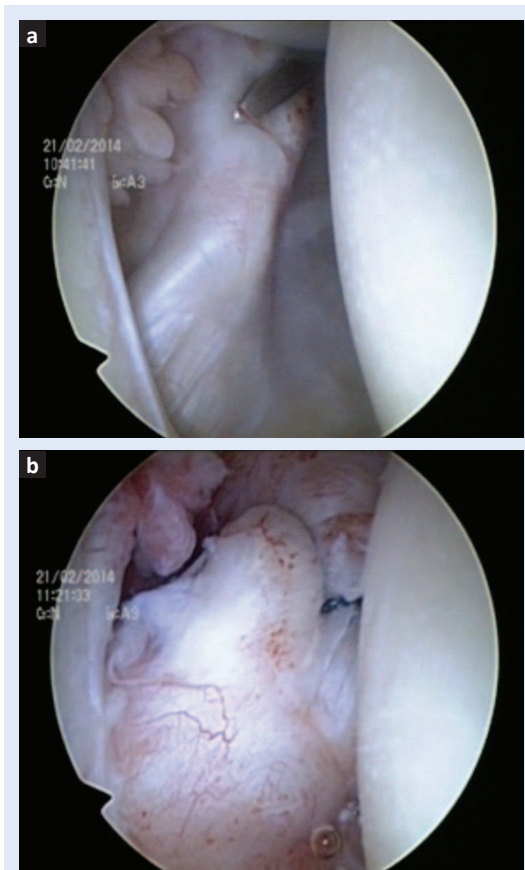
The described technique refers to the reconstruction of the supraspinatus, infraspinatus and teres minor, but not to the reconstruction of the subscapularis tendon.

Upon defining the size and mobility of the torn subscapularis tendon intra-articularly, a portal is placed right in front of the biceps tendon, i.e. biceps sulcus. A camera is placed in the lateral an-



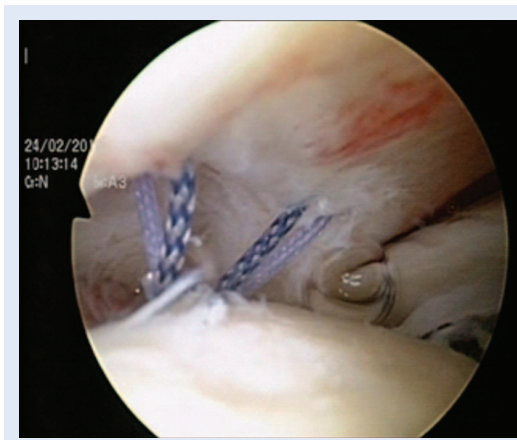
**Figure 9.** Arthroscopic massive rotator cuff repair.  
 a) Placement of the two transtendon sutures;  
 b) Partial covering of the cuff by transtendon sutures and placement of the bone anchor at the footprint;  
 c) Final result with complete covering of the footprint.





**Figure 10.** Arthroscopic subscapularis repair. a) Comassign arc formed by a portion of the superior glenohumeral ligament and coracohumeral complex; b) Fixation of the subscapularis to the lesser tuberosity.

terior portal, the subdeltoid and subcoracoid bursae are removed, and the anterior part of the subscapularis and coracoid processes are displayed. One or two anterior portals are positioned, depending on the size of the tear. The subscapularis tendon is mobilized intra- and extra-articularly, in particular its upper part, which is detached from the coracoid basis. Upon tendon mobilization, insertion to the lesser tuberosity is debrided after implementing the anchors. Suturing is done on the subscapularis tendon, the sutures on the distal anchor being used first (Figure 10). Traumatic tears result in tendon dislocation of the longhead of the biceps medially. Biceps tenodesis or tenotomy is usually performed, depending on the patient's age and gender, and the surgeon's experience. In subscapularis repair, we use two anterior canulas, in contrast to the repair of other rotator cuff parts, where canulas are not used.



**Figure 11.** Position of the bone anchor and the suture through the supraspinatus tendon (intraarticular view).

#### *Arthroscopic repair of partial supraspinatus tendon tear*

The patient is in a semi-seated position, and the surgeon makes a decision about tendon fixation. The indication we, at Akromion Hospital, use is the rupture size, where the 4.5 mm trocar fits between the point where footprint transits to cartilage and the rest of the supraspinatus tendon. The anterior portal is placed, which enables footprint refreshing. After that the surgeon accesses the subacromial space and removes the subacromial bursa. Then he goes back to the shoulder joint and searches the most appropriate way to pass through the tendon, using a needle. After making an incision, he places a bioresorbable anchor into the anterior part of the footprint (Figure 11). A special surgical tool is used to get through the medial part of the supraspinatus tendon, anchor sutures are prepared and passed into the subacromial space. At this point, the camera is placed in the lateral posterior portal and tendon suturing is performed. After the suturing is completed, it is necessary to put the camera back into the joint to check the fixation and the footprint coverage.

#### REHABILITATION

Upon surgery, patients are given orthoses, which they are supposed to wear for 4 weeks. While wearing orthoses, patients should perform passive shoulder exercises, or better to say a light

workout of their shoulder and elbow. Once the orthosis is removed, individual physical therapy is started, with a therapist assisting the patient's movements and eventually making them use their arm independently. Six weeks after the surgery, the patients can actively abduct and elevate their arm. Eight weeks after the surgery, the power exercise of the rotator cuff muscle is started. Two to three months after the surgery is the period in which most patients manage to acquire complete active mobility along with relative strength of the reconstructed tendon. Returning to a sport court is recommended four to six months after the surgery, depending on the type of sport and intraoperative results.

#### ARTHROSCOPIC ROTATOR CUFF REPAIR IN AKROMION HOSPITAL

We evaluated two groups of patients who underwent arthroscopic rotator cuff repair for partial supraspinatus tear and full-thickness tears with or without acromioplasty.

Arthroscopic rotator cuff repair was performed in 422 patients in the period from 2008 to 2012.

Arthroscopic rotator cuff repair – with or without acromioplasty – was done in 350 (83 %) patients with full-thickness tears; 197 women, 225 men, mean age 61 years (23-81 years). The average follow-up was 36 months. Acromioplasty in combination with rotator cuff repair was done in 158 patients (37 %).

Partial rotator cuff tears were treated by arthroscopic repair in 72 patients: 33 women, 39 men, mean age 36 years (32-79 years), with or without acromioplasty. The average follow-up was 36 months. Partial thickness supraspinatus tears were classified intraoperatively according to Habermeyer<sup>25</sup>. Twenty-four patients underwent acromioplasty in combination with suture anchor technique repair.

There were no intraoperative complications. One patient with partial tear had a mild inflammatory reaction around the anterior portal in the early postoperative period. One patient had a supraspinatus tendon retear, and he underwent a second tendon reconstruction procedure (Video). Five patients with full-thickness tears had retears and they underwent arthroscopic revision.

#### CONCLUSION

Arthroscopic rotator cuff repair improved the outcomes with regard to pain and shoulder function. Patients with partial supraspinatus tears had better functional results. Acromioplasty has no influence on the final functional result.

#### FUTURE ORTHOBIOLOGICS

Insufficient tendon tissue in large, particularly traumatic and massive, tears is an occasional problem that surgeons face when trying to perform a complete rotator cuff repair. There are products to be found nowadays, such as regenerating tissue structures, PRPs (platelet rich plasma) and hyaluronates<sup>26,27</sup>.

Biological matrices are "patches" containing collagen types I, III, IV and VII, elastin, chondroitin sulfate and proteoglycan. These products can be tailored and sutured and applied in situ (openly or arthroscopically). They can also be combined with PRPs.

Platelet rich plasma is based on collecting and concentrating active trombocytes, which are rich in growth factors and are capable of stimulating tissue healing<sup>28-30</sup>. Hyaluronate injections, which can soothe an infection and decrease adhesions, stimulate production of endogenous hyaluronates, enhance joint lubrication, inhibit phagocytes and decrease the prostaglandin and interleukin IL-1 levels, are used after surgical procedures.

These methods are still not routinely used and further research and guidelines in their application is required.

**Conflicts of interest statement:** The authors report no conflicts of interest.

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