Pregledni članek

Review article

Current concepts in arthroscopic rotator cuff reconstruction

Sodobna načela artroskopske rekonstrukcije rotatorne manšete

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Abstract

Tear of the rotator cuff is one of the most common causes of shoulder pain and dysfunction. Treatment of these tears has been significantly improved over the last few years as a result of our increased understanding of the mechanics and anatomy of the involved tissues and even more as a result of the increasing use of the arthroscope in the management of these injuries. All-arthroscopic cuff repair is probably the most technically challenging of the procedures commonly performed in the shoulder. The article presents current knowledge or aetiology and patterns of rotator cuff tears, describes different approaches to arthroscopic treatment of these tears and discusses most important controversies surrounding this therapy.

Key words. *Shoulder, rotator cuff, arthroscopy, repair.*

Izvleček

Raztrganina rotatorne manšete je eden najpogostejših vzrokov za bolečino in moteno funkcijo ramenskega sklepa. V zadnjih letih je zdravljenje raztrganin rotatorne manšete z boljšim razumevanjem mehanike in anatomije prizadetih kit ter z uvajanjem uporabe artroskopskih tehnik pri operativni oskrbi teh poškodb zelo napredovalo. Artroskopska rekonstrukcija rotatorne manšete je tehnično eden najbolj zahtevnih operativnih posegov, ki se rutinsko izvajajo na ramenskem sklepu. V članku so predstavljena sodobna spoznanja o etiologiji in mehaniki raztrganin rotatorne manšete, opisan je artroskopski pristop k zdravljenju teh poškodb, v razpravi pa so predstavljeni različni pogledi na nekatera še sporna vprašanja.

Ključne besede. Rama, rotatorna manšeta, artroskopija, rekonstrukcija.

Introduction

The treatment of rotator cuff tears has improved over the last few years as a result of an increased understanding of the mechanics and anatomy of the tissues involved. However, the quantum leap has occurred due to the increasing use of the arthroscope in the management of these injuries. Initially, the use of the tool was confined to the diagnosis and, occasionally, to the management of subacromial bone spurs. The thinking has now shifted to an all-arthroscopic treatment. This is reminiscent of the history of the treatment of meniscal tears, chronic ACL insufficiency, shoulder impingement and shoulder instability. Over time, clinical practice favors the arthroscopic treatment despite initial skepticism and lack of scientific evidence to support the procedures.

All-arthroscopic cuff repair is probably the most technically challenging of the procedures commonly done in the shoulder. It constitutes a natural extension of the arthroscopic-assisted mini-open repair. The latter has many of the advantages of an all-arthroscopic repair with less technical demands pertaining to the mobilization and securing of the rotator cuff to the greater tuberosity. Whatever the repair technique chosen, some fundamental principles of cuff repair should be applied. These include: preservation (or meticulous repair) of the deltoid, adequate subacromial decompression, surgical release to produce a freely mobile muscle-tendon unit, fixation of the tendon to the greater tuberosity, and closely supervised rehabilitation. There clearly is no best technique. The most important factor is the operating surgeon's experience and comfort level. A good open repair will always be superior to a badly performed arthroscopic one. There are also technical considerations related to size of tear, quality of tissue, available equipment, and patient expectations. Preoperative imaging can assist the surgeon with planning and discussing treatment options with the patient. The transition to arthroscopic repair should be done in a stepwise and careful fashion: mastery of arthroscopic acromioplasty and "mini-open" technique is a prerequisite for progression to all-arthroscopic techniques.

The history of arthroscopic rotator cuff repairs can be traced back to the pioneers of shoulder arthroscopy, such as Lanny Johnson, who began repairing rotator cuff tears with a removable staple. The use of suture anchors in the subacromial space was pioneered by Eugene Wolf, closely followed by Steven Snyder, who reported extensively on the suture anchor technique back in the 1980's (1). More recent advances in surgery were made by Stephen Burkhart, who used a variety of tools designed to expedite the surgical procedure (2).

The literature on arthroscopic cuff repair contains many retrospective studies reporting generally favorable results. The limitations of these studies are their retrospective and nonrandomized design, a relatively short follow up of only two to three years in most cases, and general lack of documenttation of the integrity of the repair. Multiple studies have shown that arthroscopic techniques are associated with significantly improved patient satisfaction, less pain and better functional results. The reported success rates are comparable to those documented with the use of the mini-open approach. Several authors have recently shown their outcomes to be comparable to those of the traditional open cuff repair in all measured parameters when dealing with small and medium tears (3-6).

In experienced hands, the arthroscopic technique can be applied to the treatment of essentially all tears. In one study, nine patients with massive cuff tears were treated with arthroscopic double interval slides, side-to-side fixation and suture anchor placement. At a mean follow-up time of 17.9 months, eight of the nine patients were satisfied with the results. The mean UCLA score increased from 10.0 preoperatively to 28.3 postoperatively, and all patients showed some improvement in either active motion, strength, or function. Active forward flexion improved significantly, from a preoperative mean of 108° to a postoperative mean of 146.1°(3).

Etiology of rotator cuff tears

A consensus has emerged that rotator cuff disease is multifactorial and that it develops under the influence of intrinsic and extrinsic factors. The intrinsic mechanism is defined as a tendon injury that originates within the tendon because of intrinsic inferior tissue mechanical properties, poor vascularity and intrinsic tendon degeneration with alterations in the tendon matrix composition. On the other hand, the extrinsic mechanism is associated with damage to the tendon produced through compression against surrounding structures by subacromial, coracoid and internal impingement, with repetitive tendon stress and tensile overload.

At present intrinsic factors are regarded as having a predominant role in the occurrence of rotator cuff tears (7), which is supported by the following findings: 40% of patients with cuff tear have never done strenuous physical work, 50% of patients with cuff tear do not recollect any shoulder trauma, and a large proportion have bilateral cuff defects (8) Recently, a strong genetic component has been identified as playing a role in the development of rotator cuff tears (9).

Age as a factor closely related to the process of intrinsic tendon degeneration has a very strong influence on the development of cuff tears. A study of rotator cuff integrity assessed by ultrasound in asymptomatic individuals revealed rotator cuff tears in 13% of patients in age group 50-59 years, 20% of patients aged 60-69 years, 31% of patients aged 70-79 years, and 50% of patients 80 years of age or older (10).

Patterns of rotator cuff tear

The advent of arthroscopy and arthroscopic repair techniques has refined both our understanding and our treatment of rotator cuff tears. While traditional open surgical management of rotator cuff tears is usually limited by an anterolateral exposure, arthroscopy is not restricted by spatial constraints. Using arthroscopic techniques surgeons can now assess and treat rotator cuff tears from several different angles, with minimal disruption of the overlying deltoid muscle. On the basis of this new perspective of evaluation and treatment of rotator cuff tears, Burkhart (2) has described four basic patterns of cuff tears. These are: crescent-shaped tear, U-shaped tear, L-shaped tear and the massive contracted immobile tear. The crescent-shaped tear has no significant retraction, the tendon is mobile and can usually be repaired to bone with minimal tension. In the U-shaped tear the free edge of the tendon is retracted much more medially and cannot be pulled over the greater tuberosity without excessive tension. It is important to be aware that these tears have a significant mediolateral component. They should be repaired by following the margin convergence principle described by Burkhart (2), who recommended that first a mediolateral component of tear should be repaired by side-to-side sutures and than the free edge of tendon should be attached to cuff footprint on the greater tuberosity. L-shaped tears are very similar to U-shaped tears, however, one of the leaves is more mobile than the other and can be easily pulled to the greater tuberosity attachment and towards the other leaf. Like in U-shaped tears, a side-to-side component should be repaired first, and then a free edge of the tendon should be attached to the bony footprint. According to Burkhart (2), these first three tear patterns account for over 90% of posterosuperior rotator cuff tears, and can be repaired without any extensive tendon mobilization. The remaining are massive retracted immobile cuff tears that require the use of advanced tendon mobilization techniques, such as the anterior or double interval slides. They can sometimes be repaired only partially to achieve balance of force couples between the anterior and posterior part of the cuff and thereby improve shoulder kinematics and function.

The rotator cuff tear pattern has been identified as a significant factor influencing the rate of cuff healing after repair. Boileau (11), in his study on rotator cuff healing after arthroscopic repair, demonstrated that tear extension in the sagittal plane with associated tendon delamination has a greater influence on cuff healing than the extent of the coronal plane tendon retraction. Similarly, Gazielly (12) observed that in isolated supraspinatus tears, anterior extension of tear into the rotator interval was a poor prognostic factor for cuff healing, and that it increased the rate of re-tears by threefold. These studies suggest that in tears with large sagittal extension it is very important to achieve appropriate cuff mobilization allowing tension free repair, but also to recognize and to take into account the tear pattern when repairing the tendon. In that way anatomical restoration of the rotator cuff can be achieved, and best possibilities for eventual cuff healing provided.

Repair of anterosuperior and isolated subscapularis tears

The term anterosuperior rotator cuff tear is defined as a full-thickness tear of the supraspinatus tendon that extends anterior to its border involveing rotator interval structures and potentially affecting the subscapularis tendon. There are few studies that have reported on the repair of these tears. Warner (13) has analyzed the results of open reconstruction in anterosuperior cuff tears in 19 patients and has demonstrated a significant correlation between lower postoperative Constant scores and duration of symptoms of more than six months. Further he noted that physical findings indicative of subscapularis insufficiency persisted in 14 of the 19 patients..

The recent introduction of arthroscopy in the treatment of anterosuperior cuff tears and isolateed subscapularis tears has notably improved our understanding of these lesions. Bennett (14,15) has decribed an arthroscopic approach to the identification of rotator interval and partial subscapularis lesions, and has proposed a classification system for these lesions. Several studies (14,16,17) have demonstrated a relatively high incidence of rotator interval and partial subscapularis tendon lesions found during diagnostic shoulder arthroscopy, i.e. up to 17% for pulley lesions, and up to 35% for partial subscapularis tendon lesions. When performing diagnostic shoulder arthroscopy it is very important to precisely evaluate the insertion of subscapularis tendon, as well as the stability of the biceps tendon and the adjacent structures forming the biceps pulley, such as the superior glenohumeral ligament and the coracohumeral ligament. Arthroscopic biceps tenodesis or tenotomy remains the treatment of choice in identified rotator interval lesions with biceps tendon instability, because it has been extensively demonstrated that it reliably alleviates pain and causes no significant functional deficits of the shoulder. There have been some reports on arthroscopic reconstruction of the biceps pulley lesions (18), and the results of newer anatomic techniques of the primary repair of torn structures look promising. This treatment, however, cannot be widely recommended because of the lack of reliable randomized prospective studies that would clearly demonstrate the advantages of such reconstruction over biceps tenotomy or tenodesis.

Arthroscopic repair of subscapularis tears, either isolated or combined with a tear of other rotator cuff tendons, is becoming a standard method of treatment. Several authors (19,20) have described techniques for arthroscopic subscapularis tendon visualization, and have demonstrated that only the upper third of the tendon can be evaluated from the intraarticular aspect For the repair of large subscapularis tears extending into the inferior 2/3 of the tendon, a subacromial approach should be used. In this case it is of crucial importance to stay lateral from the coracoid process in order to decrease the risk of possible iatrogenic neurovascular damage. Like other rotator cuff tendon tears, those of the subscapularis tendon seem to have multiple factors contributing to their development. Recently, subcoracoid impingement has been identified as one of the major causes of these tears, and arthroscopic coracoplasty through the rotator interval, in addition to the subscapularis repair, have been advocated for the treatment of all lesions with a coracohumeral interval of less than six mm (17,21) In 2002, Burkhart (22) was the first to report on the technique and outcomes of arthroscopic subscapularis tendon repair. Good to excellent results were achieved in 92% of patients in his series. Similarly, Bennett (23) demonstrated that arthroscopic repair of isolated subscapularis tear provides the patient with realistic expectations for pain reduction and improvement in function, particularly in the use of the arm behind the back, and for return of active normal internal rotation.

Repair of posterosuperior cuff tears

The most frequently encountered type of tear involves the majority, if not the entirety, of the supraspinatus, and often a part of the infraspinatus. The controversies surrounding these types of tears focus on how to render the outcomes more predictable. Efforts have been made to shed more light on the response that occurs with repairs. It has been assumed that a robust vascular response at the tendon to bone interface during rotator cuff repairs is an integral part of the healing process. In one study, the results of Power Doppler sonography employed prospectively in a group of patients undergoing rotator cuff repairs were compared to those obtained in an asymptomatic control group (24). The patients underwent the Doppler analysis at six weeks, three months and six months postoperatively. A predictable, significant decrease in vascular scores occurred after the rotator cuff repair over time. The most robust flow was found at the peritendinous region and the lowest at the anchor site or cancellous trough. Forty-eight percent of the patients had a persistent defect at the final follow-up examination, but the results did not correlate with objective or subjective findings. No significant vascular response was noted in the asymptomatic group, but interestingly, thirty-three percent had a full thickness rotator cuff tear measuring 7 mm^2.

Effective mobilization and restoration of an effective and functional cuff is of utmost importance (25), and many surgical techniques have been described with respect to the specifics of individual types of tears. Determining the configuration of the tear (tear pattern) is essential for effective management of the tear in a near anatomic fashion. Surgical approach to a simple 2-cm tear differs from the technique used in a retracted L-shaped tear that involves the supraspinatus and the major part of the infraspinatus (26). The operating surgeon must be comfortable with the release of the known contracted tissues from anterior to posterior in order to effect some closure of the cuff tissues and thereby improve the overall biomechanical situation (25).

Single row versus double row repair

The type of anchor repair has been extensively discussed in the recent literature. After the initial controversy over whether the arthroscopic rotator cuff repair is a viable procedure or not, the technique has been acknowledged as equally predictable as the traditional open surgery and the mini-open procedures (27,28), yet the debate on the most effective repairs continued. While the traditional single row repair has certainly fared well in the literature (2,4,5,29), there is a perceived need to improve the results of these types of repairs because of the failure rate reported in some studies (11,12,30).

One of the latest advances in this field has been the understanding of the benefits offered by a novel double-row cuff rotator fixation in terms of anatomic restoration of the footprint in order to mimic normal anatomy more closely, as well as in terms of increased initial fixation strength, which allows for a more vigorous and expeditious rehabilitation, and thereby for a marked decrease in overall disability associated with the repairs (31,32).

In a cadaveric study, twenty fresh-frozen shoulders were randomly assigned to four arthroscopic repair techniques (31), using either a single-row or one of three double-row fixation variants. Footprint length and width were quantified before and after the repair, and displacement with cyclic loading and load to failure were determined. While no significant difference was found between the single-row and double-row repair as concerns cyclic loading and load to failure, which was greater than 250N in all groups, double-row techniques provided a significantly larger supraspinatus footprint length and width.

In another cadaveric study examining the strength of the traditional single-row technique as compared with the double-row repair with medial anchors with mattress sutures and lateral anchors with simple sutures, gap formation was found to be significantly smaller for the double-row repair than for the single-row suture (32). In addition, the initial strain over the footprint area in the double-row repair was nearly one third the strain of the single-row repair. Adding a medial row of anchors increased the stiffness of the repair by 46%, and the ultimate failure load by 48% (32).

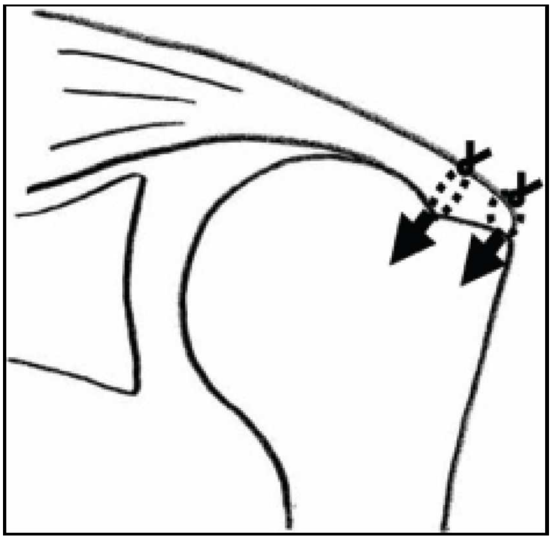

Figure 1
Shematic representation of double-row repair technique.

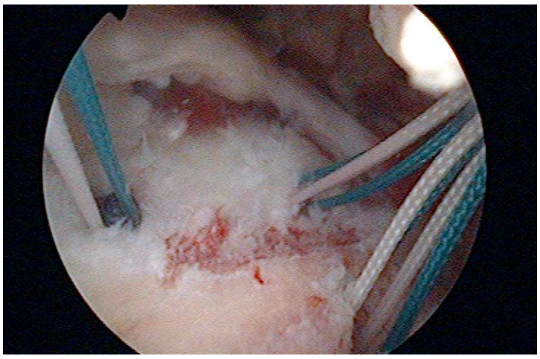

Figure 2
Placement of medial and lateral suture anchors for double-row repair.

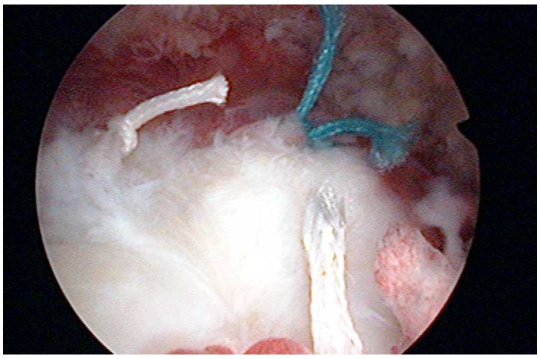

Figure 3
Reconstructed rotator cuff tear after double-row repair.

To achieve maximal initial fixation strength and minimal gap formation for rotator cuff repair, reconstructing the footprint attachment with two rows of suture anchors should be considered. Reproducing a larger footprint seems to improve the surface area available for healing, yet this improvement has yet to be substantiated by clinical studies. The perceived clinical benefits offered by the procedure must be weighed against its cost, since it doubles the amount of suture anchors necessary.

Biological scaffolds

Another controversy is the use of augmentation devices in the repair of rotator cuffs. Autogenous and allograft tissue used in the past for the reconstruction of the rotator cuff has proved to be of little value (33). The current approach is to create a local milieu conducive to healing by decreasing tension within the reparative tissue with the use of scaffolds. The results reported, however, indicate that much work remains to be done to develop an appropriate scaffold material and design the best form of implantation.

In one study, patients with large and massive rotator cuff tears treated by open repair and porcine small intestinal submucosa (SIS) reinforcement or interpositional grafting were evaluated clinically and by MRI at six months postoperatively (34). Eleven consecutive patients who underwent open rotator cuff repair with SIS augmentation for large or massive tears were selected retrospectively for clinical and MRI evaluation. MRI showed retear in ten of the 11 patients; one repair remained intact. Clinically, there was no statistically significant difference between preoperative and postoperative shoulder scores; five patients had worse scores postoperatively. The authors concludeed that, though SIS xenografting may be effective in tendon healing in other areas of the body, it does not improve clinical outcome when used for reinforcement of large and massive rotator cuff repairs.

Two recent studies have shown that the use of a porcine SIS patch in controlled series provides no benefit with respect to tendon healing or clinical outcomes (35,36). In fact, there was a tendency for the patients treated with this patch to have less favorable clinical outcomes (35). Moreover, one study documented a 20% rate of inflammatory reaction to the implant, necessitating implant removal between two and four weeks after surgery (36).

Rehabilitation

Effective rehabilitation is predicated on a successful repair that incorporates all of the principles discussed above. The most important factors include the degree of immobilization determined to be necessary, as well as limitations in active motion that need to be applied for fear of disrupting the repair.

Ideally, physical therapy is instituted immediately, i.e. within 48 hours of the procedure, with the sling being removed several times per day for pendulum exercises and passive range of motion, including supine and upright motion with passive assistive devices as tolerated by the patient The positions to avoid include horizontal extension and external rotation when the shoulder is abducted. In most cases, passive motion to 90 degrees of abduction and forward flexion are allowed immediately after the operation and for the first six weeks. Elbow range of motion and grip strengthening are also encouraged in the early stages provided that tissue quality is good and the cuff has been reconstructed in an anatomical fashion. In patients with a suboptimal repair and poor tissue quality, the institution of physical therapy and any motion may be delayed for up to six weeks. While this policy delays the patient's return to full activity, it certainly prevents a recurrence of the cuff tear.

Active exercises are begun six weeks postoperatively and the range of motion is increased as tolerated at this point. A general strengthening program should then be instituted, focusing on the lower extremities, trunk and scapula, especially in throwing athletes (37)**.** Unrestricted activities, such as contact sports, are allowed at four months. In throwing athletes, a functional program is initiated at about four months postoperatively with unrestricted throwing being allowed only after the completion of the program, but certainly not before six months after the operation. The criteria that should be met before instituting the throwing program include: full shoulder motion, restoration of trunk, scapula, and rotator cuff muscle endurance, balance and strength; and no pain during activity or examination (38).

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