

Rotator cuff tears: repair and reconstruction

Authors: VN. Gibbs, P. Raval, J. Rees, S.E Gwilym

- 1) Miss. Victoria Naomi Gibbs, BA(oxon), MBBS, MRCS
Trauma and Orthopaedic Speciality Trainee
Northampton General Hospital
Clifton Road
Northamptonshire, NN1 5BD, United Kingdom
vnaomigibbs@doctors.org.uk
- 2) Mr. Parag Raval, BSc (Hons), MBBS, MRCS
Trauma and Orthopaedic Speciality Trainee
Northampton General Hospital
Clifton Road
Northamptonshire, NN1 5BD, United Kingdom
Praval@doctors.org.uk
- 3) Jonathan L Rees MBBS FRCS (Eng), MD, FRCS (Tr&Orth)
Professor of Orthopaedic Surgery and Musculoskeletal Science
Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Science
Botnar Research Institute
University of Oxford
Old Road
Headington
Oxford, OX3 7LD
jonathan.rees@ndorms.ox.ac.uk
- 4) Stephen E Gwilym. MBBS, BSc, DPhil, FRCS (Tr & Orth).
Honorary Senior Clinical Lecturer & Consultant Orthopaedic Surgeon.
Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Science
Botnar Research Institute
University of Oxford
Old Road
Headington
Oxford, OX3 7LD
Steve.gwilym@ndorms.ox.ac.uk
Tel: 01865741155

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Abstract

Rotator cuff management amongst surgeons can vary widely.¹ In recent years, there have been increasing efforts to standardise treatment, however the evidence base for repair and reconstruction for rotator cuff tears is limited.² In this article we review some of the current evidence available for the management of rotator cuff tears and aim to better equip the surgeon in the decision making process. The article focuses on the surgical options for the management of the rotator cuff tears and aims to inform on how to repair torn rotator cuff tendons including techniques for repair and current concepts on reconstruction, discussion on timing of repair and the pitfalls and challenges which can be faced when attempting to repair large tears.

Keywords

Rotator cuff tear, rotator cuff repair, rotator cuff reconstruction, arthroscopic cuff repair, open cuff repair, single row, double row, augmentation

Introduction

Rotator cuff tears refer to the structural failure in one or more of the four muscles and tendons that form the rotator cuff. It is estimated that the overall prevalence of tears is 34% and that the risk increases significantly with age.³ Predicting which patients become symptomatic, which tears are likely to enlarge quickly, which tears are reparable and the optimum time for surgical intervention remains a challenge. Currently in clinical practice, the surgical management of rotator cuff tears can vary widely and is influenced by referral patterns from primary care and decision making and attitudes of patients and surgeons. Attempts have been made to create guidelines to help standardise treatment however, many unknowns persist.¹

In this review we aim to discuss the merits of the surgical management in treating symptomatic rotator cuff tear patients. This includes; the rationale behind repairing torn tendons, when to consider surgical repair, techniques for repair and reconstruction, and options in patients when repair is not possible.

Why repair

Degeneration of the rotator cuff is a common pathology that is thought to be associated with the process of ageing. The development of chronic tears does not always result in pain and functional loss, suggesting that the shoulder joint has some capacity to adapt to these changes. It is considered that acute traumatic rotator cuff tears result in sudden functional loss and more pain than degenerative tears.

Shoulder pain is the third most common type of musculoskeletal pain in primary care. Amongst the elderly, around 1 in 5 patients suffer with shoulder pain and of those, rotator cuff disease appears to be the most common cause.⁴ Many patients with a full thickness rotator cuff tear are asymptomatic or respond satisfactorily to conservative treatment, these patients whom have no compromise in their activities of daily living and remain pain free do not necessarily need to be considered for further intervention.

In general there are three reasons to consider operative intervention: 1) to reduce pain and disability in patients whom conservative treatment has failed 2) to reduce the risk of tear

progression, which could lead to a tear which becomes irreparable and 3) to reduce the risk of cuff tear arthropathy.

For patients who suffer significant limitations and pain, surgery may serve to offer symptom relief and there is now a reasonable evidence base in support of open/arthroscopic rotator cuff repair surgery.³ In patients who subsequently undergo surgical rotator cuff repair, good outcomes are reported in a significant proportion of patients even though re-rupture of the cuff may occur in over half of these patients post-operatively. Outcomes following surgery range from 85%-91% satisfactory at mid to long term follow up.^{5, 3}

The prospect of tear progression can lead to a degree of ambiguity for shoulder surgeons as to the ideal time for operative intervention. Patients may present with only mild symptoms or occasional problems. The issue here is with the possibility of the tear worsening and enlarging, becoming more difficult to repair and sometimes becoming irreparable. Several studies have demonstrated that the function and appearance of a torn rotator cuff has been shown to deteriorate with time^{6, 7}. Surgery therefore may subsequently become more technically demanding, with poor biological cuff tissue and in the case of massive tears, often requiring more advanced experimental techniques with augments or even reverse shoulder replacement surgery. The predictive rate of rotator cuff tear progression in patients over time is difficult to assess. However, from the literature, certain risk factors may make disease progression more likely. Apart from increasing age, the most significant of those identified risk factors for tear progression appears to be tear severity, smoking and hand dominance.^{6, 7} Full thickness tears compared with partial thickness tears are more likely to enlarge. Whilst hand dominance initially suggested that that activity level may increase the development of disease progression, the authors of the paper found that shoulder activity level and occupational demand level were not predictive of tear enlargement.

As a result of these factors and our inability to reliably predict how rapidly rotator cuff tears progress the optimum time for surgical intervention can be difficult to determine and is therefore likely best decided clinically on an individual patient-by-patient basis. It has been suggested that following patients up regularly, with appropriate imaging, may be helpful in determining when a small tear is worsening or when an asymptomatic tear is progressing to a symptomatic one. However this would be very resource intensive and probably not justified for all in this large patient population.⁶ A more pragmatic approach maybe to inform the patient of the symptoms which should encourage them to seek further review.

Finally, the third indication for repair is to reduce the risk of cuff tear arthropathy. This results from a torn rotator cuff which has persisted leading to arthropathic changes in the shoulder over time. The exact cause for cuff tear arthropathy is unknown, and is likely multifactorial. One theory is that it is a result of mechanical and nutritional factors.⁸ Mechanical factors associated to a cuff tear can lead to shoulder imbalance and wearing of the glenohumeral joint surface from repetitive abnormal motion. The nutritional factors are related to disruption of the normal joint environment, leading to loss of fluid pressure. This may result in a reduction in quality of the synovial fluid causing bone and cartilage atrophy. Over time chronic shoulder weakness, superior migration of the humeral head and significant pain ensues such that the function of the shoulder is markedly reduced.

When to repair

In consideration of repair it is pertinent to consider the typical patient pathway in those suffering rotator cuff tears. The BESS/BOA patient care pathways provide a helpful guide to the clinician. It reiterates the importance of history and examination in the primary care setting with a useful algorithm embedded in the document.⁹

The pathway stresses the significance of being aware of those patients who may have had trauma to the shoulder with pain and weakness which could be due to an acute rotator cuff tear. In these circumstances an urgent referral to a shoulder specialist should be made and/or consideration of imaging of the rotator cuff. If an acute tear is sustained, there is some evidence that early repair (<8 weeks) improves the chances of long term repair integrity and function.^{10, 11}

Primary care treatment should explore conservative and medical therapy; rest, analgesia, physiotherapy and injection if possible. Although an ultrasound or MRI scan can be of value, some people over 65 years have asymptomatic cuff tears as previously discussed above and guidelines suggest that MRI and USS are rarely needed in primary care and so imaging should therefore be requested and interpreted in this context.

Referral to secondary care is merited if there is poor response to conservative and medical therapy or should the patients' suffer severe symptoms and disability. Surgical decision here then refers to the consideration of repair acutely versus delayed repair the timing of which remains controversial with no definitive evidence.

A systematic review in 2013 demonstrated that clinical outcomes do not significantly vary depending on time to surgery for acute rotator cuff repair comparing those operated in under 3 months, from presentation, to those over 3 months. Whilst both groups demonstrated clinical improvement with surgical repair no definitive consensus could be drawn for when rotator cuff repair should be performed for optimal post-operative outcomes. However their conclusion suggested that there was a trend for earlier time to surgery producing better post-operative Constant scores and range of movement. The authors highlight the difficulty in distinguishing between acute tears, acute tear on chronic tears, or acute symptoms of a chronic tear which provides a degree of ambiguity and a confounding factor when attempting to draw salient conclusions.¹¹

How to repair

Following failed conservative treatment (rest, physiotherapy and a cortisone injection) surgical management may be considered. There are several options for surgery. The decisions to consider when repairing cuff tears include: 1) open or arthroscopic 2) with or without subacromial decompression 3) single row or double row repairs 4) the use of augments.

Open or arthroscopic cuff repair

The aim of reparative and reconstructive surgery is to reattach torn tendons to the tuberosities of the humeral head. Arthroscopic rotator cuff surgery has seen an increase of 600% in the United States in the last 10 years whilst open rotator cuff repair increased by only 34%.¹² A recent multicentre randomised control surgical trial in the United Kingdom found there to be no difference

in clinical outcome when comparing open rotator cuff repair vs arthroscopic rotator cuff repair at 2 years follow up.³ The study, which analysed data from 273 patients across 19 centres, reports that the mean Oxford Shoulder Score improved from 26.3 to 41.7 at 24 months for arthroscopic surgery and from 25 to 41.5 at 24 months for open surgery. In addition the study found no significant difference in terms of overall clinical cost or tear re-rupture rate between the two methods.

Clearly, the most important aspect for a successful rotator cuff repair, is that the surgeon is able to perform a procedure which allows for healing whilst withstanding physiological loads. Suture material which is sufficiently strong and the use of anchors along with a reliable operative technique and configuration should be used to ensure a strong repair but without compromising tissue biology. Many anchor implant products exist, all with claimed advantages but with little real evidence to support the use of one type over another. For example bioabsorbable anchors are said to offer an advantage over non-absorbable plastics anchors or metal anchors in that there is no lasting foreign object, a graduated loss of strength to help the healing process, no imaging artefact and eyelet structures that are favourable with regards to suture abrasion.¹³ However the disadvantage to bioabsorbable anchors is that if degradation occurs too quickly the construct may fail, the eyelet can rupture or a reaction to a foreign body can occur.

With or without arthroscopic decompression

Rotator cuff surgery in the UK generally involves arthroscopic rotator cuff repair with subacromial decompression. However, despite its prevalence, presently there is limited evidence that performing a subacromial decompression along with a cuff repair will significantly improve the patients outcome.¹⁴ The rationale behind performing a subacromial decompression is related to the theory of subacromial impingement which is based on the principle that acromial morphology is the initial cause of rotator cuff dysfunction and subsequent tear. However, an alternative explanation could include rotator cuff failure as a consequence of eccentric tensile overload at a rate greater than the ability of the cuff to repair itself.¹⁴ The advantages of performing a subacromial decompression are that it can improve the surgical field of view and encourage bleeding into the subacromial space which may improve healing in a more spacious environment. The disadvantages include the possibility of adhesion formation between the acromion and tendon which may limit smooth motion post cuff repair.

Single or double row repairs

Rotator cuff repair can involve either a single row repair or a double row repair.

FIGURE 1

There are several reasons which convince many surgeons to carry out a double row repair but in general the double row repair seems to perform better in the current literature available.¹⁵ Double row repairs, and the variant of that which is a suture bridge repair, are likely to offer more biomechanical stability. The reasons include (1) providing a larger surface area where the tendon is in contact with the bone, extending the healing surface available; (2) sutures passing from medial to lateral serve to strengthen the area in contact with the bone restoring the tendon footprint; (3) improved biomechanical strength with multiple points of fixation increasing the cyclic load to failure and reducing post-operative motion at the repair site. However of course, suture to bone techniques do rely on the quality of the tendon and bone which is in turn related to the suture-holding ability and tendon to bone healing.

Use of Augments

Failure rates for large and massive rotator cuff repairs remains high, which is attributed mainly to suture pull-out at the suture–tendon interface. This has led to continued interest in repair strategies that can augment a repair by structurally reinforcing it, while biologically enhancing the intrinsic healing potential within the tendon.¹⁶

A variety of patch augmentation materials have been developed and used clinically, which include degradable, non-degradable, synthetic scaffolds, and extracellular matrix-based patches¹⁶. Patch-augmented rotator cuff repair is usually indicated for those patients with massive retracted rotator cuff tears whom have healthy muscle but likely poor tendon quality. This frequently occurs in a revision surgery situation after a prior failed primary rotator cuff repair. Rotator cuff repair with patch augmentation is performed using either an open or arthroscopic technique according to the size and configuration of the tear.

Tendon transplant may be used to augment the repair in order to reduce the repair tension between bone and the tendon. Using tendons can aid the biological recovery process, by providing a growth scaffold for cells or by populating the bone-tendon junction with donor cells and growth factors. These tendons can either be allograft or autograft for augmentation purposes. Autograft may be the preferred choice of cellular graft material owing to their reduced likelihood of rejection, the biceps, latissimus dorsi and fascia lata are some areas that can be used for grafting. Research is limited, some have assessed the efficacy of cellular autograft treatments for rotator cuff tears using the tenotomised biceps tendon¹⁷.

Extra cellular matrix (ECM) augmentation to rotator cuff repairs minimises the potential problem of graft rejection by using acellular material. ECM formed from xenogenic or allogenic material must first be rigorously processed in order to remove any cellular material. Allogenic ECM is thought to be more superior to xenogenic material. When allogenic ECM augmentation was used for rotator cuff augmentation they out performed their control group, with greater overall force to failure, and achieved better histological and mechanical outcomes throughout the study¹⁸ suggesting allograft a superior option over xenograft. Synthetic ECMs are an alternative viable option enabling a suitable scaffold for cellular and fibrotic growth, while reducing the risk of an inflammatory reaction compared to their allograft counterparts. Several animal studies have investigated the benefit of augmenting rotator cuff repair with synthetic ECMs with little biomechanical effect¹⁹.

Building upon the effectiveness displayed with ECM augmentation, research aimed at targeting cellular repair using a new generation of synthetic, biocompatible and degradable polymeric scaffolds has been developing. This approach hypothesises that self-healing can be stimulated by providing a non-permanent scaffold, with the patch resorbing. This current implant group of degradable polyesters include Poly-L-lactic acid, Polylactic-co-glycolic acid, Polycaprolactone and Polydioxanone are among the most promising materials for creating this new generation of rotator cuff implants with improved biocompatibility. Whilst preliminary results have shown good biological enhancements there remains some healing concerns about the degradation products associated with these products, their clearance and their toxic impact upon tissue long term¹⁶.

Studies have shown that augmenting repairs may serve to aid healing and improve outcomes of rotator cuff repair clinically and biomechanically¹⁹ but currently a better understanding of the mechanical suitability of repair grafts for supporting human rotator cuffs is needed if repair patches are to provide a solution and therefore further more robust clinical research is still required.

Surgical steps (releases, techniques and tips)

The choice of repair technique is dependent upon the tear pattern and the ability to appropriately reduce the tendon once it has been mobilised. Tears are often described based on their perceived shape such as crescent, U, L or V shapes. The important aspect of a repair is to assess the character of the tear so the surgeon knows how best to reduce it back to the tuberosity.

FIGURE 2

Many small to medium tears reduce very easily and minimal releases are needed. For large chronic tears, the technique of mobilisation and repair begins with an initial release of the cuff. Structures which may cause tension on the repair include the capsule, the coracohumeral ligament, the sub acromial and sub deltoid bursa, and rotator interval tissue. The aim of the release therefore is to deal with soft tissue restrictions within the bursa and the joint and to recreate a space that is normally present between the under surface of the cuff and the superior aspect of the glenoid labrum. Performed appropriately, it allows for a more tension free mobilisation and helps to create a medial gutter between the rotator cuff and the capsule.

The size of the tear and pattern will determine to how much of a release is performed. Commonly, any adhesions are released progressing from an anterior to posterior direction. Release of the coracohumeral ligament from the base of the coracoid on the bursal side of the cuff may be done for small tears. In medium sized tears, the coracoacromial ligament is additionally released along with the subacromial and subdeltoid bursa and possibly the capsule. For larger tears, without proximal migration of the humeral head on the glenoid, the capsule beneath supraspinatus, infraspinatus and teres minor tendons, coracohumeral ligament, subacromial and subdeltoid bursa and the bursa beneath the AC joint may all require release. Care needs to be taken over the degree of release as overly aggressive cuff mobilisation and traction may result in over tensioning of the rotator cuff and possible failure of the repair. In addition, it could result in damage to the suprascapular nerve, leaving the repaired cuff non-functional.

Along with tendon to bone sutures, for larger tears e.g large 'U' tears, surgeons may implement the principle of marginal conversion. This technique is used to reduce strain along the cuff margin such that the weaker areas of tissue fixation are much less likely to fail. It is achieved by performing a side-to-side repair effecting a margin convergence of the tear towards the greater tuberosity, which moves adjacent tissue into the defect and thereby increasing the cross sectional area of the tendon. In addition, it decreases the medial-to-lateral dimension of the cuff tear. The associated strain reduction helps to protect the bone-tendon repair during the healing process, whilst additionally assisting to protect against suture failure and propagation of the tear if repair of the cuff repair was incomplete.

What if you can't repair (SCR or arthroplasty)

Massive chronic irreparable rotator cuff tears provide a significant challenge to the shoulder surgeon due to inevitable poor quality inelastic tendon, tendon retraction, atrophy of the muscles, bursal scarring and inclusion of fatty infiltrates. The most common symptoms of an irreparable rotator cuff include subacromial pain, limitation of arm elevation and weakness of the shoulder.²⁰ These signs and symptoms predominantly result from loss of superior glenohumeral joint stability due to the

absence of the superior cuff. Repairing massive tears is technically difficult and healing of such tears is more dubious as reflected in the significantly higher recurrence rate following surgery.⁵ Multiple surgical techniques have been attempted to repair massive cuff tears and while some tears can be repaired successfully a proportion are not repairable.

Arthroscopic superior capsular reconstruction (SCR) may provide an alternative surgical strategy for irreparable rotator cuff tears and has grown in popularity in recent years. The technique was first published by Minohata et al. and aims to address the absent superior cuff.²¹ The procedure initially involved using an autograft from the fascia lata harvested from the patient's leg which is subsequently secured between the glenoid and the greater tuberosity. The principle behind this technique is to restore the normal superior anatomical constraint of the humeral head from migrating proximally, which occurs with a deficient rotator cuff. In addition, it stabilises the humeral head in the anteroposterior plane and relies largely on the deltoid for shoulder elevation. In their paper they describe several cases which resulted in the reversal of pseudo paralysis. They found this to be a reproducible procedure which had fewer short term complications than procedures such as the reverse shoulder arthroplasty. Since then, the technique has been developed by various shoulder surgeons and in current practice largely includes the use of allografts and patches instead of the fascia lata to similar clinical effect.²²

The advantages of SCR are that it allows for a strong repair which subsequently allows for early mobilisation and renders a large autograft unnecessary. It is however a very challenging procedure arthroscopically. It does however still provide the option for a reverse shoulder arthroplasty to remain a salvage procedure if the desired outcome is not achieved.

Arthroplasty remains a last resort for rotator cuff tears which remain irreparable. The main indication for a reverse shoulder arthroplasty is the still painful, rotator cuff insufficient and non-functioning shoulder in older patients.

Summary

There is a diverse range of surgical treatment modalities for the symptomatic rotator cuff patient at the shoulder surgeon's disposal and arguably the exact optimal timing and management strategy of rotator cuff tears remains open for debate. Significant research advances in the last 5-10 years are helping to better shape management and certainly larger trials such as the UKCUFF trial have helped to shed light on the long standing arthroscopic vs open rotator cuff repair debate. The management of large and massive rotator cuff tears with techniques such as the superior capsular reconstruction along with augmenting patches remains an exciting field for the future and the initial results from the above studies show some promise. However, further robust evidence from larger trials with longer term follow up results for these techniques are still required.

Overall, despite the likely variable clinical practice for the management of rotator cuff tears, diversity in patient selection and surgical technique, the majority of rotator cuff repair and reconstruction yield good outcomes post-operatively with overall improved patient satisfaction.²³ Clearly the surgeon needs to draw on experience and evidence base to help decide what treatment is optimal for each individual patient presenting with a symptomatic rotator cuff tear. In the UK in general, the commonest primary surgical management for the rotator cuff tear remains subacromial decompression, and repair of the cuff by either an open or arthroscopic repair using single or double

row anchors. The UKUFF study suggests this approach is clinically and cost effective in the NHS. The management of larger complex tears remains an evolving field and is the subject of continuing important clinical research because of the increasing prevalence of this problem

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