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Irreparable rotator cuff tears: current treatment options

Abstract

Irreparable rotator cuff tears are a challenging problem facing orthopedic surgeons. Multiple treatment strategies have been proposed depending on patient factors such as age, activity, and the quality of the rotator cuff tendon. The clinical presentation of a patient with an irreparable rotator cuff tear is variable with respect to pain, function, and disability, necessitating a thorough, detail-oriented clinical evaluation. Initial imaging should include plain radiographs and magnetic resonance imaging (MRI) to evaluate tendon quality. Computed tomography (CT) arthrography may be used if MRI is contraindicated. Non operative treatment is generally reserved for low demand patients with minimal pain, while debridement, partial-repair, and subacromial decompression with or without biceps tenodesis versus tenotomy have been advocated in low demand patients with significant pain. However, these treatment modalities often result in unpredictable and marginal improvements in functional outcomes. Tendon transfers including the latissimus dorsi, pectoralis major, and trapezius muscles have been used to improve function. Scaffold devices have more recently been used as a biologic patch graft and augment. Superior capsule reconstruction is a novel technique that has been shown to restore glenohumeral stability. Reverse total shoulder arthroplasty and hemiarthroplasty can be used as salvage options in patients with rotator cuff tear arthropathy.

Keywords: Rotator Cuff, Irreparable Rotator Cuff Tear, Tendon Transfer

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Abbreviations

CT: Computed Tomography, MRI: Magnetic Resonance Imaging, RCT: Rotator cuff tears, AHI: Acromio Humeral Interval, AP: Anterior Posterior, AC: Acromio Clavicular, NSAIDs: Non-Steroidal Anti-Inflammatory Drug, ECM: Extra Cellular Matrix, ASCR: Arthroscopic Superior Capsule Reconstruction, CTA: Cuff Tear Arthropathy, RTSA: Reverse Total Shoulder Implant

Introduction

Rotator cuff tears (RCT) are one of the most commonly treated orthopedic pathologies. Controversy exists with regard to the management of these injuries. Most surgeons agree that an acute painful tear in a young person should be treated operatively in order to decrease pain and provide satisfactory long-term function. However, great controversy exists with regard to tears that are large, chronic in nature, and not amenable to repair by standard means. These tears, deemed "irreparable" or "massive", provide an ongoing challenge for the orthopedic surgeon. Authors have attempted to classify these tears based on their size and location.[1] Cofield et al.[2] described a massive tear as greater than 5cm2. Others consider a massive rotator cuff tear to be one involving two or more tendons. Posterosuperior tears involve the supraspinatus and infraspinatus and are more common than anterosuperior tears, which involve the supraspinatus and subscapularis tendons. The size and reparability of a tear are not always related, nor are they mutually exclusive descriptions. A massive tear is not necessarily irreparable and an irreparable tear does not mean it is massive in size. However, an irreparable tear can be defined surgically as a tear in which direct tendon-to-bone repair and healing is not possible. An irreparable tear was described by Warner et al.[3] as "the inability to achieve a direct repair of the native tendon to the humerus despite mobilizing the soft tissues".[3] Small chronic tears in contradistinction to massive tears may be small and friable and unable to be repaired primarily to bone. Goutallier et al.[4] described fatty degeneration of the rotator cuff through CT scans and graded the muscle quality with grades 0-IV.[4] Irreparable rotator cuff tears are usually large and retracted with nonfunctional muscle bellies and severe fatty degeneration. The true determination of an irreparable cuff tear, however, is definitively performed under direct visualization during surgery.

Irreparable RCTs may occur through different mechanisms including acute (i.e. traumatic), acute on chronic, and chronic (i.e. degenerative) tears. Generally, acute massive tears greater than 5 cm are repairable, assuming fatty degeneration is minimal. However, an acute tear with thin friable tissue may be irreparable if it is unable to be mobilized. Some studies have analyzed the acromiohumeral interval (AHI) to determine whether a RCT is repairable. An AHI of less than 7 mm has been associated with decreased likelihood of a repairable tear.[5] Gerber et al.[6] showed that fatty infiltration in a sheep model of rotator cuff tears is a necessary consequence following macro-architectural change rather than degenerative process.[6] As the tendon tears and the muscle retracts, the pennation angle of the muscle decreases, enabling the space between individual muscle fibers to become replaced with fat. As the muscle retracts and becomes filled with fat, it becomes stiffer and less compliant.

The muscles of the rotator cuff provide dynamic stability to the shoulder. EMG studies have demonstrated that the rotator cuff muscles fire prior to deltoid activity which prepares the shoulder for movement by the periscapular muscles.[7] Burkhart described the force-couple concept of the rotator cuff after performing fluoroscopic evaluations of patients with massive rotator cuff tears. He stated that normal shoulder function is possible as long as there are balanced forces between the two force couples; i.e. the first force couple in the transverse plane (subscapularis and teres minor/infraspinatus), and the second force couple in the coronal plane (deltoid and inferior cuff).[8]

Clinical evaluation

Irreparable rotator cuff tears are notoriously unpredictable with respect to their clinical presentation. The spectrum of pain and functional disability varies widely. A shoulder may function well in the setting of a painless tear, whereas a small painful tear may result in substantial shoulder dysfunction and disability.

The physical exam should begin with inspection of both upper extremities with the shoulders exposed. The supraspinatus and infraspinatus fosse should be closely examined for signs of atrophy, which signify chronic involvement. If the patient is able to maintain the 90-90 position with the shoulder abducted to 90 degrees and fully externally rotated, this generally excludes the diagnosis of an irreparable tear and indicates an intact teres minor and infraspinatus.[9] The supraspinatus can be examined with resisted forward flexion in the plane of the scapula with the thumb turned towards the floor, while the infraspinatus is examined with resisted external rotation with the shoulder adducted. The subscapularis is assessed with multiple tests, including the abdominal compression test, lift off test, and bear hug test. The belly press test specifically tests the superior supraspinatus while the lift-off test specifically tests the lower subscapularis fibers.[10] Posterosuperior cuff tears are associated with a positive lag sign when the patients is unable to maintain the shoulder externally rotated at 90 degrees of abduction and adducted to the side.

Imaging of the shoulder should include a standard set of four X-rays. A true anterior-posterior (AP) view of the shoulder (i.e. Grashey view) identifies pathology of the glenohumeral joint as well as superior migration of the humeral head. An AP view of the shoulder will identify acromioclavicular (AC) joint pathology, including sub luxation and degenerative changes. The axillary view assesses the position of the humeral head within the glenoid in the anterior-to-posterior direction. Anterior sub luxation of the head in this view may indicate an incompetent subscapularis. The scapular-Y view gives a clear view of the supra scapular outlet as well as the humeral head position relative to the glenoid. Acromial morphology is also clearly delineated on this view. The acromiohumeral interval (AHI) measures 7 to 14 mm in healthy shoulders on the standard shoulder AP, and may indicate rotator cuff tear when the AHI falls below 5 mm.[11]

MRI of the shoulder is useful for evaluating rotator cuff tear as well as examining the muscle bellies on T1-weighted sagittal oblique cuts. The Goutallier[4] classification is used for grading fatty degeneration of the rotator cuff muscles and is useful in identifying irreparable rotator cuff tears. CT arthrography is useful in the setting of a contraindication to an MRI study.[4] Ultrasound has shown to be a valuable technique in detecting rotator cuff tears, with moderate to excellent (72-100%) accuracy in detecting fatty degeneration.[12] Ultrasound, however, is highly operator dependent and is unable to penetrate bone. It is therefore less accurate in identifying large rotator cuff tears retracted medial to the lateral acromial border.[13]

Management options

Non operative treatment

Non operative treatment for patients with an irreparable RCT is generally reserved for low demand patients who are not experiencing significant pain. The mainstay of non operative management is physical therapy, subacromial injections, and non-steroidal anti-inflammatory drug (NSAIDs). Physical therapy focuses on deltoid reconditioning and periscapular strengthening.[14,15] Subacromial steroid injections as well as non-steroidal anti-inflammatory medications may be helpful in alleviating pain in conjunction with physical therapy. In a study from the Reading Shoulder Unit, Levy et al.[16] described a non operative rehabilitation program for patients with massive RCT in which patients underwent a program focusing on anterior deltoid strengthening. Constant scores increased from 26 to 60 at a minimum of 9 months following treatment and forward flexion increased from 40 degrees to 160 degrees.[16] They recommended routine use of this deltoid rehabilitation protocol in properly selected elderly patients who were unfit for surgery.

Operative treatment

When patients have failed non operative management, surgical treatment should be considered. According to the AAOS guidelines, the only recommendation regarding irreparable rotator cuff tears was for partial repair when possible, debridement, or muscle transfers which all earned a weak recommendation.[17]

Debridement versus partial repair

Many patients with rotator cuff tears experience significant levels of pain despite non operative management. Those who are low demand with an irreparable RCT may benefit from partial repair, debridement, subacromial decompression and/or acromioplasty, which may help alleviate pain. These procedures, however, generally offer little improvement in terms of functionality. A study by Melillo et al.[18] concluded that improvements in pain may be short-lived and patients frequently have recurrent pain and continued poor function.[18] Any attempt at repair of the cuff is preferred over debridement with no attempt at repair. Rockwood et al. published a series of 57 patients with irreparable RCTs treated with a modified Neer acromioplasty, subacromial decompression, and debridement of massive tears of the supraspinatus and infraspinatus. At 6.5-year follow-up, 83% of patients had a satisfactory result and 17% of patients had an unsatisfactory result. Poor results were associated with a weak or dysfunctional anterior deltoid or previous acromioplasty or attempt at rotator cuff repair.[19]

Biceps tenotomy/tenodesis

The biceps tendon has been a topic of debate in the evolving treatment of painful rotator cuff tears. The biceps tendon was once thought to be a superior stabilizer of the humeral head but recent data has shown no superior humeral head migration when a biceps tenotomy is performed. In a series of 307 patients, Walch et al.[20] erformed a biceps tenotomy on patients with irreparable RCT with 2-14 year follow up. All patients had symmetric passive shoulder range of motion as the contralateral "well" shoulder, as well as an increase in Constant score from 48.4 to 67.6 after tenotomy. Eighty seven percent of patients were either satisfied or very satisfied with their surgery.[20] Boileau et al.[21] treated 39 irreparable RCTs with a biceps tenotomy and 33 irreparable RCTs with a biceps tenodesis. At 35 months, 75% of patients were satisfied with their surgical outcome, and Constant score increased from 46.3 to 66.5, showing similar results to the study by Walch et al.[20] There is no consensus in the literature regarding the superiority of biceps tenotomy versus tenodesis. In a meta-analysis by Slenker et al.[22] they found an 8% rate of cosmetic deformity in the tenotomy group with no clinical differences between groups in terms of satisfaction with the procedure.[22]

Tendon transfers

Numerous tendon transfers for the treatment of irreparable RCTs have been proposed including pectoralis major, latissimus dorsi, supraspinatus, subscapularis, trapezius, teres major, long head of the triceps, lateral deltoid, long head of the biceps, and teres minor. One cadaveric study showed that transfer of the teres major to the

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supraspinatus insertion improved the moment arm, muscle length, and muscle force of the rotator cuff complex. They authors suggested that this improvement is largely attributed to the greater physiologic cross-sectional area of the teres major. However, the latissimus dorsi transfer is preferred because the teres major is often bulky and has an extremely short tendon that is difficult to grasp, prone to pullout, and often does not reach farther than the infraspinatus insertion once it is mobilized.[23]

Latissimus dorsi transfer

The latissimus dorsi muscle has multiple actions on the shoulder including extension, internal rotation, and adduction. The tendon is useful for transfer as it has 33.9 cm of excursion and has a predictable insertion anterior to the teres major tendon and 7 mm lateral.[23,24] Initially, latissimus dorsi tendon transfers were used to treat patients with brachial plexopathies who lacked external rotation. However, the latissimus dorsi transfer was adopted by Gerber et al.[6] in the 1980s for irreparable RCTs. According to Gerber et al.[6] study, indications for tendon transfer in the setting of an irreparable RCT include at least two tendons with retraction that are unable to reach the anatomic footprint with the arm in less than 60 degrees of abduction.[25] Latissimus dorsi tendon transfer may be used in patients with refractory pain and weakness in patients with an otherwise normal joint space and an irreparable posterosuperior rotator cuff defect. The weakness must be mild to moderate weakness (i.e. patients with severe weakness may not improve following tendon transfer and RTSA may be indicated). Furthermore, superior migration of the humeral head must be minimal with an AHI greater than 5 mm. Improvement in external rotation is thought to be due to either active muscle contraction or a tenodesis effect. EMG studies have shown conflicting evidence regarding muscle activation after latissimus tendon transfer.[26,27]

The latissimus transfer can either be done with a single-incision[28] or two-incision technique.[25] The tendon is sharply removed from the bone and reattached to the supraspinatus footprint with suture anchors or a transosseous technique. Others have advocated for tendon transfer with osteotomy for direct bone healing which has shown improved clinical outcomes.[29] Poor outcomes have been associated with subscapularis dysfunction, teres minor dysfunction, glenohumeral osteoarthritis, and AC joint arthritis.[30] Outcomes after latissimus transfer in properly selected patients show significant pain relief; however, functional outcome is much less predictable. Specifically, subscapularis dysfunction appears to be a relative contraindication to latissimus transfer with several studies associated with poor clinical outcomes.[31,32] It has been postulated that the vertical nature of the tendon may help reduce superior migration of the humeral head, however, this has not been shown to occur clinically.

Most postoperative protocols include 4 to 6 weeks of immobilization in a rigid orthosis in full external rotation and slight abduction of the shoulder. Internal rotation and adduction are not allowed, however, gentle passive abduction and external rotation may begin immediately postoperatively. The brace may be removed with initiation of active motion at 6 weeks. Biofeedback programs are then started to retrain the muscle for functional gains. The patient may be expected to continue with therapeutic improvement up to 1 year after surgery.

Pectoralis major transfer

The pectoralis major muscle acts on the shoulder by aiding in flexion, internal rotation, and adduction. The pectoralis major tendon is also useful for transfer as it has the second longest excursion of 18.8 cm.[24] Indications for pectoralis major transfer are similar to latissimus transfer, however, generally this procedure is reserved for patients with more severe weakness caused by anterosuperior RCTs. Pectoralis major transfers were first described by Wirth and Rockwood for irreparable tears of the subscapularis[33] and later modified by Resch et al.[29] who described transferring the upper two third of the tendon under the conjoined tendon to more closely reproduce the anatomy of the subscapularis.[34] This technique later evolved into transfer of the entire pectoralis tendon under the conjoined tendon.[35] Warner described a modified technique in order to avoid injury to the musculocutaneous nerve, which is at risk during this transfer. He transferred the inferior sternal portion of the pectoralis major and transferred this beneath the clavicular head and superficial to the conjoined tendon.[36] Similar to latissimus transfer, patients may expect a reasonable amount of pain relief from the surgery, however, functional gains are much more variable.

Most postoperative protocols include 4 to 6 weeks of immobilization in a rigid orthosis. Gentle passive motion generally begins at 4 to 6 weeks postoperatively. Active motion is usually postponed until 6 weeks. Biofeedback programs are not routinely done. The patient may be expected to continue with therapeutic improvement up to 1 year after surgery.

Trapezius transfer

The lower trapezius transfer was originally described as an option to increase function in patients with rotator cuff deficient shoulders secondary to brachial plexus palsy.[37,38] The lower trapezius tendon may be an alternative treatment for patients with a posterosuperior deficient rotator cuff. In a biomechanical study, the pull of the trapezius external rotation moment arm were significantly higher with the humerus in 0 degrees of adduction than the latissimus dorsi tendons.[39] The tendon transfer involves first identifying the interval between the upper and lower trapezius which was recently quantified in a cadaver study by Omid et al.[40] The lower trapezius was found to insert at the dorsum of the scapular spine and the middle trapezius insertion was at the superior surface of the scapular spine.[40] The lower trapezius tendon is then isolated and an Achilles allograft tendon is then fixed to the tendon for increased length. The tendon is then tunneled under the deltoid and transosseous sutures are used to fix the tendon to the infraspinatus footprint.[38] A biomechanical study by Omid et al.[40] compared the latissimus transfer to the trapezius transfer in 0, 30, and 60 degrees of abduction. The authors concluded that the trapezius transfer is superior to latissimus transfer in restoring glenohumeral kinematics and force couples.[41]

Postoperatively, patients are kept in a brace for 6 weeks. Passive range of motion is allowed with the help of a therapist with mild abduction, flexion, and external rotation. Internal rotation is a prohibited movement during this part of the rehabilitation. Active range of motion is started after the 6-week mark and unrestricted activities are allowed after 6 months to a year postoperatively.

Scaffold devices for patch grafts

Over the past decade there have been multiple attempts at biologic and non-biologic augments to rotator cuff tendon healing. Mammalian derived extracellular matrix (ECM) and human derived dermal allograft (Graft Jacket, Arthroflex) are currently approved for use by the FDA, although recent AAOS clinical guidelines have recommended against the use of xenograft for augmentation of rotator cuff repair.[42] In a study of 16 patients with massive retracted RCT, Bond et al. used a Graft Jacket (Wright Medical Technology, Arlington, TN) dermal allograft to repair the cuff tendon stump to the greater tuberosity with suture anchors. Fifteen of 16 patients were

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satisfied with the procedure and UCLA scores improved from 18.4 to 30.4 postoperatively, Constant scores increased from 53.8 to 84.0 and there were no complications reported.[43] In a biomechanical study, Mura used a synthetic patch graft to bridge the gap after simulated supraspinatus, infraspinatus, and subscapularis defects. Abduction torque was increased in the supraspinatus by 61%, infraspinatus by 68% or subscapularis by 80%.[44] In a clinical study by Gupta et al. using human dermal allograft, they found significant improvement in patient pain, range of motion, strength, and overall shoulder function.[45]

Superior capsule reconstruction

Mihata et al.[46] recently described a novel technique termed arthroscopic superior capsule reconstruction (ASCR) to restore stability of the glenohumeral joint after irreparable RCT.[46] A patch graft was used to reconstruct the superior capsule of the glenohumeral joint; medially the graft is attached to the superior glenoid and laterally attached to the greater tuberosity. The graft demonstrated biomechanical evidence to decrease subacromial contact pressures.[47] In a clinical study of 24 patients with large or massive irreparable RCT, ASES scores improved from 23.5 to 92.9 postoperatively and 84% of patients were free from graft tear at a mean of 34 month follow up.[46]

Reverse total shoulder arthroplasty

Glenohumeral arthritis may develop as a long or short-term consequence of severe rotator cuff deficiency. Total shoulder arthroplasty is not possible in a rotator cuff-deficient shoulder due to unacceptably high rates of glenoid component loosening and poor functional outcomes. Hemiarthroplasty may help control pain in some patients, however, it is not routinely used in rotator cuff tear arthropathy (CTA) due to unpredictable long-term results.[48] The Grammont style reverse total shoulder implant (RTSA) is the ideal implant for CTA. This implant improves function of the cuff deficient shoulder in three important ways: the center of rotation of the glenohumeral joint is medialized which converts the superior force of the humeral head into a compressive force on the glenosphere, the humeral steam distalizes the arm which tightens the deltoid thus improving its lever arm, and a semi-constrained articulation which converts the superior-directed pull of the deltoid into a rotational motion. The preoperative evaluation of the patient's external rotation strength is an important determinant to their postoperative external rotation strength. The deltoid fibers become the sole abductors and elevators of the glenohumeral joint and thus lose their ability to externally rotate the humerus. In patients with teres minor or infraspinatus weakness, they may require a tendon transfer in addition to RTSA to improve function postoperatively. Simovitch et al.[49] showed that patients with an intact teres minor tendon retained external rotation compared to those with absent tendons or fatty infiltration.[49] Although RTSA is most indicated in CTA, there have been reports regarding its efficacy in the treatment of massive irreparable RCTs in the absence of glenohumeral arthritis. Mulieri et al. showed improvement of ASES scores from 33.3 to 75.4, Simple Shoulder Test (SST) scores from 1.6 to 6.5 and significant pain improvement based on the visual analogue scale (VAS). Most patients had significant clinical improvement and predictable improvement in pain.

Summary

Irreparable rotator cuff tears can be a challenging task for the orthopedic surgeon. Treatment depends of patient functional status as well as the skill of the surgeon. Tendon transfer has become more recently popularized, with lower trapezius tendon transfer on the horizon. Salvage options for continued pain and decreased function include reverse total shoulder arthroplasty and hemiarthroplasty. Dermal allograft augmentation has shown some promise in small clinical and biomechanical series, however larger long-term studies need to be done before definitive conclusions can be made.

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None.

Conflicts of interest

None.

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