World Journal of Orthopedics

Online Submissions: http://www.wjgnet.com/esps/
Help Desk: http://www.wjgnet.com/esps/helpdesk.aspx
DOI: 10.5312/wjo.v5.i5.557

World J Orthop 2014 November 18; 5(5): 557-565
ISSN 2218-5836 (online)

TOPIC HIGHLIGHT

WJO 5th Anniversary Special Issues (2): Arthroscopic

Arthroscopic treatment options for irreparable rotator cuff tears of the shoulder

Cameron M Anley, Samuel KL Chan, Martyn Snow

Cameron M Anley, Samuel KL Chan, Martyn Snow, Arthroscopy Division, The Royal Orthopaedic Hospital, Birmingham B31 2AP, United Kingdom

Author contributions: Anley CM designed and contributed to all the subsections and responsible for revisions and submission; Chan SKL contributed to the design all the subsections of the paper and reviewed the paper prior to submission; Snow M (senior author) contributed to the overall design and each section, final editing prior to submission.

Correspondence to: Cameron M Anley, MBChB, FCS (Ortho) SA, Arthroscopy Division, The Royal Orthopaedic Hospital, Bristol Road South, Birmingham B31 2AP, United Kingdom. cam_anley@yahoo.com
Telephone: +44-121-6854000 Fax: +44-121-6854213

Received: December 29, 2013 Revised: May 9, 2014
Accepted: June 10, 2014
Published online: November 18, 2014

Abstract

The management of patients with irreparable rotator cuff tears remains a challenge for orthopaedic surgeons with the final treatment option in many algorithms being either a reverse shoulder arthroplasty or a tendon transfer. The long term results of these procedures are however still widely debated, especially in younger patients. A variety of arthroscopic treatment options have been proposed for patients with an irreparable rotator cuff tear without the presence of arthritis of the glenohumeral joint. These include a simple debridement with or without a biceps tenotomy, partial rotator cuff repair with or without an interval slide, tuberplasty, graft interposition of the rotator cuff, suprascapular nerve ablation, superior capsule reconstruction and insertion of a biodegradable spacer (Inspace) to depress the humeral head. These options should be considered as part of the treatment algorithm in patients with an irreparable rotator cuff and could be used as either as an interim procedure, delaying the need for more invasive surgery in the physiologically young and active, or as potential definitive procedures in the medically unfit. The aim of this review is to highlight and summarise arthroscopic procedures and the results thereof currently utilised in the management of these challenging patients.

Key words: Irreparable; Arthroscopy; Rotator cuff; Repair; Massive

Core tip: This paper reviews the current literature and available techniques to arthroscopically address irreparable rotate cuff tears. It includes all historic and recent innovative methods to address this difficult and challenging clinical problem. Readers of this article will be in a position to make an informed decision as to the most appropriate treatment for their patients based on the most up to date literature.

Anley CM, Chan SKL, Snow M. Arthroscopic treatment options for irreparable rotator cuff tears of the shoulder. *World J Orthop* 2014; 5(5): 557-565 Available from: URL: http://www.wjgnet.com/2218-5836/full/v5/i5/557.htm DOI: http://dx.doi.org/10.5312/wjo.v5.i5.557

INTRODUCTION

The management of patients with irreparable rotator cuff tears (IRCT) without the presence of arthritis remains a challenge for orthopaedic surgeons. Currently, the reverse shoulder arthroplasty is advocated for patients with[1-3] and more recently without[4,5] glenohumeral arthritis in the presence of an IRCT. Although early to midterm results are promising, the long term results are still questioned[1] as highlighted by a recent paper reviewing the satisfaction in patients under 60 years of age[2]. In addition the complication rate varies from 4.3% to 50 %[3,6] with a revision rate of 10%[6]. The subsequent treat-

ment options in a failed reverse shoulder arthroplasty are complex and limited. An alternative in younger patients with an IRCT without arthritis is a tendon transfer[7]. Although Gerber *et al*[8] have recently presented promising long term results (> 10 years) the overall outcome is still variable with unpredictable results[7].

It is important to differentiate between massive and irreparable rotator cuff tears, as not all massive tears are irreparable[7]. By definition, massive tears have been described as > 5 cm[7,9] and tears involving two or more tendons[10]. An IRCT, as the name suggests, is any RCT which cannot be repaired back to the rotator cuff footprint on the greater tuberosity of the humerus or as Gerber *et al*[1] suggested, any repair that is successful but will almost certainly be associated with structural failure[1]. Reparability is influenced by a variety of factors and the exact incidence of IRCT is unknown[7]. Warner suggested that it may be as high as 30% in a dedicated shoulder practice[11], while other studies have quoted an incidence of 6.5%-22.4%[12-14].

Although the final decision on reparability of the rotator cuff is made intraoperatively, various symptoms, signs and radiology findings may suggests irreparability prior to surgery allowing for appropriate preoperative planning. Classically patients will present with pain and disability, these symptoms however do not correlate directly with the size or reparability of the tear. Clinical signs which suggest that a repair is unlikely to be successful include static anterosuperior subluxation and associated pseudoparalysis on anterior elevation[1]. Tears associated with dynamic anterosuperior subluxation of the humerus upon resisted abduction[1], a lag sign and a positive Hornblowers sign[15,16] are also poor prognostic signs.

Superior migration of the humerus, with an acromiohumeral interval of < 7 mm on a standard anterior-posterior shoulder radiograph, is highly suggestive that a repair may fail[1,17]. Superior migration can be accentuated by taking the radiograph with the arm in slight abduction due to pull of the deltoid muscle overriding the deficient force coupling of the incompetent rotator cuff[7]. The amount of tendon retraction and fatty infiltration can be assessed on ultrasound[7,18], Computed tomography (CT)[1,7] and/or magnetic resonance imaging (MRI)[1,7]. Grade 3 and 4 fatty infiltration according to the Goutallier is commonly considered irreparable[1,19], although Burkhart has disputed this is a recent study[20].

Once a rotator cuff is deemed irreparable, a variety of arthroscopic treatment options have been proposed to reduce pain and improve function in patients with IRCT. These options should be considered as part of the treatment algorithm and include simple debridement with or without a tenotomy, partial rotator cuff repair with or without interval slide, tuberplasty, graft interposition of the rotator cuff, suprascapular nerve ablation, superior capsule reconstruction and insertion of a biodegradable spacer (Inspace). Although these procedures vary in terms of outcome and operating time, they are generally considered less invasive with a lower complication rate compared to tendon transfers and reverse arthroplasty.

This paper reviews the current literature and available techniques to arthroscopically address irreparable rotate cuff tears. It includes all historic and recent innovative methods to address this difficult and challenging clinical problem.

DEBRIDEMENT WITH OR WITHOUT BICEPS TENOTOMY

A debridement of the rotator cuff and subacromial decompression was first proposed by Rockwood *et al*[21] in 1995 as a treatment option for patients with an irreparable rotator cuff tear. In this study, 50 patients (53 shoulders) where followed up at an average of 6.5 years, with 83% of patients having a satisfactory outcome with a significant decrease in pain. The average active elevation improved from an average of 105° to 140°[21]. Further to this study, Kempf *et al*[22] showed a significant improvement in pain following a biceps tenotomy in a trial involving 210 patients. Although a variety of studies have shown that this remains a viable option in the elderly and low demand patient, it does not slow the progression of osteoarthritis[1].

PARTIAL ROTATOR CUFF REPAIR

In 1993, Burkhart *et al*[23] first introduced the biomechanical concept of the "suspension bridge" in the rotator cuff. This theory evolved into the functional rotator cuff and provided a rationale for partial repair of the rotator cuff. This involves the restoration of the cables involved in force transmission as well as force couples around the shoulder. The rotator cables have been defined anatomically at the level of the biceps tendon above supraspinatus anteriorly and the lower border of infraspinatus posteriorly. Most irreparable tears have a degree of extension anteriorly or posteriorly, which also affect the transverse couples. The importance of addressing the imbalance between the transverse couples (consisting of subscapularis and infraspinatus-teres minor complex) has been stressed. Repair must include all of subscapularis as well as the inferior half of infraspinatus as a minimum. This restores the transverse force couples and allows a stable fulcrum for normal shoulder kinematics. Burkhart *et al*[24] also warned against subscapularis tendon transposition to cover the residual defect as it alters the centroid (line of action) so that it lies above the centre of rotation and destroys the coronal plane force couple between subscapularis and deltoid, thus contributing to superior migration of the humeral head. In the context of the irreparable rotator cuff tear, it was felt that these tears could be partially repaired to fulfil the above criteria and hence, improve function[25].

Suitable patients include those who clinically have an imbalance in subscapularis and infraspinatus function and have difficulty with overhead function. Burkhart identified this cohort using lift-off and resisted external rotation tests. There have been several studies assessing

the outcomes of partial repair although initial studies were performed as open procedures. Burkhart's original paper showed an improvement in various parameters including active elevation (improved from 59.6° to 150.4°), strength (0-5 scale) (improved from 2.1 to 4.4) and UCLA score (improved from 9.8 to 27.6). In his cohort of 14 patients, one patient had a poor result. Duralde *et al*[26] reported similar outcomes to Burkhart in their retrospective study with statistically significant improvements in American Shoulder and Elbow (ASES) index, pain and active elevation.

Berth *et al*[27] have since described arthroscopic partial repair of large and massive rotator cuff tears. In their series, partial repair was compared to debridement[27]. Both treatment arms showed similar improvements although several studies suggest that the partial repair provides a longer lasting improvement when compared to debridement alone[28]. It was noted that 52% had structurally failed when imaged using ultrasound at 24 mo, although this rate of failure is similar to the current literature for cuff repairs[29]. Therefore, partial repair represents a reasonable option in this challenging subset of patients by providing pain relief and restoring function[25].

INTERVAL SLIDE

Tauro[30] popularised the arthroscopic technique of the interval slide after it was originally described by Bigliani as an open procedure[31]. This involves release of the supraspinatus tendon from the rotator interval to improve mobility. Burkhart redefined this as the anterior interval slide and described a second interval slide between the supraspinatus and the infraspinatus tendon as the posterior interval slide[32]. These techniques allowed isolated mobilisation of the supraspinatus tendon laterally to its bony footprint and subsequent repair.

Lo *et al*[32] showed statistically significant improvements in mean pain scores (from 2.1 to 8.7), forward elevation (108.9 to 146.1), mean strength (2.2 to 3.6) and UCLA score (10.0 to 28.3). Numerous studies have corroborated the results of arthroscopic interval slide repairs[33-35]. The advantages of this technique are thought to be a more anatomical and reliable repair. However, studies comparing the results of partial repair with interval slide and found no significant difference in outcomes[34,35].

Concerns regarding this technique include devascularisation of the supraspinatus tendon and defunctioning of an already impaired muscle tendon unit from the interval slide[34]. Despite these concerns, Iagulli only had one re-tear secondary to trauma. This underwent revision repair with a fair result[34]. Although, Kim *et al*[35] found that 91% of complete repairs had re-tears, this did not clinically correlate with outcomes in terms of pain or function.

TUBEROPLASTY

The concept of tuberoplasty is to create an acromiohumeral articulation; it was first introduced by Fenlin *et al*[36] as an open procedure in 2002. The goal is to contour and reshape the greater tuberosity to create a smooth and congruent articulation between the greater tuberosity of the humerus and the under surface of the acromion. The initial study[36] in 2002 included 20 patients at an average age of 63 years (44-82 years), with a mean follow-up of 27 mo (7-58 mos). Overall the average UCLA scores improved from 9.3 to 27.7, with 95% satisfactory results (12 excellent, 6 good and 1 fair) and only one poor result.

Inevitably, an arthroscopic approach to this procedure was presented by Scheibel *et al*[37] in 2004, who described the reversed arthroscopic subacromial decompression. This study presented the results in 23 patients with an average age of 69 years (range 60-81) at a mean follow-up of 40 mo (range 20-58). One patient who underwent revision surgery at 6 mo was excluded. The mean weighted Constant score improved significantly ($P < 0.001$) from 65.9% to 90.6%, with significant improvements in pain, range of motion and activities of daily living. Although there was progression of osteoarthritis by 1 grade in the majority of patients, this was not reflected in the eventual outcome with 14 excellent, 5 good, 2 satisfactory and 1 poor results according to the Constant score.

Subsequently, two studies have been published confirming the benefits of an arthroscopic tuberoplasty with[38] and without acromioplasty[39] as a treatment option in patients with irreparable rotator cuff tears. Verhelst *et al*[38] followed up 34 shoulders (33 patients) with an average age of 69.6 years at 38 mo (21-52), while Lee *et al*[39] reported on 32 patients with an average age of 62.5 at 40 mo (24-63). Both studies showed a significant improvement in range of motion and decrease in pain following surgery with 84.4% and 81% patients reporting excellent or good results. While there was no significance difference in the improvement related to gender, age and preoperatively range of motion, poor outcomes where attributed to increased preoperative pain, patients with pseudoparalysis[38] and a disruption of the inferior scapulohumeral line[39].

The importance of maintaining the coracoacromial arch as a passive stabiliser to anterior and superior subluxation of the proximal humerus was highlighted in all 4 studies. These studies concluded that this remains an excellent treatment option in patients with an irreparable rotor cuff tear.

GRAFT INTERPOSITION

The first reported use of a graft interposition in IRCT is by Neviaser *et al*[40] in 1978, who used freeze-dried rotator cuff allograft to restore the continuity between the retracted irreparable rotator cuff tendon and the greater tuberosity in 16 patients. Although a standardised scoring system was not used, 13 of the 16 patients reported good to excellent results with all having pain relief at an average age of 20 mo follow-up. These results where however contradicted a decade later by Nasca[41] in his report on 7 patients with a similar technique. Only 2 had reasonable function although 5 had pain relief following the surgery and the authors concluded that freeze dried allografts do not appear to be of significant value in patients with

chronic massive rotator cuff tears[41].

A variety of biological and synthetic interposition grafts have been suggested. Biological grafts used include allografts such as freeze dried rotator cuff[41,42], quadriceps tendon[12], patellar tendon[12] achilles tendon[12], dermal matrix (Graftjacket)[12,42-46], tensor fascia lata[47] and autografts such as the biceps tendon[48,49] and tensor fascia lata[50]. Xenografts have also been used for interposition and include porcine dermal collagen[51,52] and porcine small intestinal submucosa[53]. A variety of synthetic grafts have been researched including Polyester ligament (Dacron)[54], Gore-Tex soft tissue patch[13], Mersilene mesh[55], Teflon felt[14] and Carbon fibre patches[56].

In 2008, the Snyder group were the first to present results of an arthroscopic interposition technique using Human dermal allograft (Graftjacket)[42]. Graftjacket is currently only registered for augmentation of rotator cuff repairs and not interposition grafting to bridge gaps[44,57]. Despite this many of the studies on interposition have used Graftjacket as a graft. The choice of graft is influenced by a variety of factors including mechanical properties, host response and potential for ingrowth.

The mechanical properties of biological allografts have been shown to be inferior to both autografts and synthetic grafts[57]. With regards to host response, xenografts appear to induce the most significant hypersensitivity, thought to be related to the galactose-a (1,3)-galactose (a-Gal) terminal disaccharide[57]. Although it appears to be low, more work is required to assess the host response to synthetic grafts. An important factor in the longevity and strength of a graft is the amount of ingrowth. This is thought to be influenced by the surface topography and porosity of the graft and been shown to be favourable in biological grafts, due to type 1 collagen, when compared to synthetic grafts.

The majority of the studies published on interposition grafting were performed via an open or mini open approach, a study[49] which included patients with both open and arthroscopic surgery showed there was no difference in outcome between the two approaches. Although Moore *et al*[12] questioned the use of allograft interposition based on a high failure rate on MRI and results equivocal to a simple debridement, the majority of studies reporting the use of graft interposition as a treatment option for IRCT support their use with a statistically significant decrease in pain, improvement in subjective scores and improvement in Range of Motion (Tables 1-4).

Only one randomised prospective study[50] has compared interposition (done with autograft tensor fascia lata) and partial repair in irreparable rotator cuff tears. This randomised trial included 48 patients in two groups of similar demographics and tear patterns. Although there was a significant improvement in clinical outcomes in both groups, there were significantly less retears of the infraspinatus muscles in the patchgraft group (8.3% *vs* 41.7%)[50] . In addition, shoulders with retears of the ISP had significantly inferior clinical outcomes when compared to those without retears ($P < 0.001$).

SUPRASCAPULAR NERVE ABLATION

The suprascapular nerve is derived from the upper trunk of the brachial plexus and is a mixed motor and sensory nerve. It provides the main sensory innervation to the posterior shoulder joint capsule, acromioclavicular joint, subacromial bursa, coracoclavicular and coracohumeral ligament[58]. Blockade of the suprascapular nerve has been shown to improve chronic pain in numerous studies[59].

In the irreparable rotator cuff, suprascapular nerve ablation is a salvage procedure. The main indication is in poor surgical candidates with significant medical co-morbidities and/or poor glenoid bone stock and end-stage rotator cuff arthropathy. Patients are often considered for nerve ablation after conservative therapies have been exhausted[60]. Different techniques have been described including percutaneous SSN pulsed radiofrequency and arthroscopic SSN neurectomy[61].

Pulsed radiofrequency techniques were originally described in the treatment of chronic back pain[62]. It is thought to be a non-destructive modality and works by delivering an electrical field to neural tissue rather than thermal coagulation[63]. The theoretical advantage is that it affects the smaller, pain fibres more than the larger motor fibres, thus preserving any residual motor function. Since its inception, pulsed radiofrequency has been applied to a wider range of clinical conditions including its use on the suprascapular nerve as a percutaneous technique[64].

Shah *et al*[65] first described this technique in a case report of a polytrauma patient with post-traumatic osteoarthritis, who had gained temporary pain relief after a suprascapular nerve block. The patient subsequently underwent four cycles of pulsed radiofrequency to the suprascapular nerve over 16 mo, with an improvement in numerical rating scale (NRS-11) score from 7-8 to 2-3. The duration of pain relief varied from 12-18 wk[65].

Kane *et al*[60] showed that pulsed radiofrequency to the suprascapular nerve in a cohort of twelve patients with painful cuff tear arthropathy resulted in a significant improvement in Constant, Oxford and Visual Analogue scores at three months. However, it was felt that efficacy of the treatment was wearing off by the six month end point in up to 50% of the patients[60].

Nizlan *et al*[66] described an arthroscopic SSN neurectomy technique in patients who were poor surgical candidates for shoulder arthroplasty with significant chronic pain. 75% of patients reported good to excellent pain relief and 80% noted an improvement in quality of life in this cohort. However, no assessment or comment was made with regard to outcomes due to loss of residual infraspinatus function[66].

ARTHROSCOPIC SUPERIOR CAPSULE RECONSTRUCTION

The superior capsule of the glenohumeral joint lies on the inferior surface of the supraspinatus and infraspinatus tendons and in conjunction with the rotator cuff plays a role in providing superior stability to the joint[67]. Rotator

Table 1 Results of allograft interposition

Study and graft	Number	Ave age (yr)	F/U (mo)	Outcome score Pre/post/*P* value	ROM Pre/post/*P* value	Conclusion
Neviaser *et al*[40] Freeze dried rotator cuff	16	58	20	13/16 excellent results Criteria used: Nocturnal pain Degree of abduction	> 160:6 120-160:3 90-120:5 < 90:2 Average: 122.5	In our patients there has been no sign that the grafts were rejected and the goals of the procedure to improve motion and to relieve pain usually were attained
Nasca *et al*[41] Freeze dried rotator cuff	7	62	42	Good 2, fair 2, poor 3	FF: 78/90 Abd: 69.2/84	Freeze dried rotator cuff allografts do not appear to be of significant value in the surgical management of chronic massive rotator cuff tears
Venouziou *et al*[43] HDA	14	54.6	30.2	ASES: 23.8/72.3/*P* = 0.001	FF: 73.6/129.3/*P* = 0.002 ABD: 67.5/117.9/*P* = 0.002 ER: 7.9/ 43.2/*P* = 0.001	The ROM and the functional outcome were all improved in the patients with less than 2 cm tendon gap. In the case of larger tendon defects the outcome is unpredictable
Moore *et al*[12] 26 Patellar 5 Achilles 1 Quadriceps	32	59.1	31.3	UCLA: 12.1/26.1/*P* < 0.001 Excellent 3, good 12, fair 8, poor 5	Active FF UCLA: 3/3.8/*P* < 0.17 Resisted FF UCLA: 2.9/3.7/*P* < 0.002	15/15 showed failure on MRI. Allograft reconstruction for massive, irreparable rotator cuff tears is not recommended
Bond *et al*[42] HDA	16	54.4	28.8	UCLA: 18.4/30.4/*P* = 0.0001 Excellent 4, good 9, Fair 3, Poor 0 53.8/84/*P* = 0.0001	FF: 106/142/*P* = 0.0001 ER: 43/47.2/NR	Our study supports the hypothesis that GJA is a viable treatment option for surgical salvage in select cases of symptomatic massive, irreparable rotator cuff pathology
Gupta *et al*[44] HDA	24	63	36	ASES: 66.6/88.7/*P* = 0.003 SF-12: 48.8/56.8/*P* = 0.03	FF: 111.7/157.3/*P* = 0.0002 ABD: 105/151.7/*P* = 0.0001 ER: 46.2/65.1/*P* = 0.001	Human dermal interposition repair of massive rotator cuff tears through a mini-open approach is a reproducible technique that leads to significant improvement in pain, ROM, strength and subjective scores
Wong *et al*[45] HDA (Extreme)	45	53.6	24 min	UCLA: 18.4/27.5/*P* < 0.001 ASES: 84.1 (post)		Arthroscopic rotator cuff reconstruction with GraftJacket (Human dermal allograft) is safe and is associated with high patient satisfaction, without the morbidity of tendon transfer or arthroplasty
Ito *et al*[47] Allograft fascia lata	9	62.8	35	JOA: 47.9/91.7/*P* = 0.0059	FF: 84.4/159.6/*P* < 0.005 ADB: 62.2/163.3/*P* < 0.005 ER: 43.9/41.7/NR	Patch Grafts are considered to have the advantages of achieving anatomical repair with minimal restriction of range of motion and minimal occurrence of re-tearing
Modi *el al*[46] HDA	61	62.6	42	OSS: 26/42/*P* = 0.001	FF: 97/160/*P* = 0.001 ABD: 90/155/*P* = 0.001 ER: 42/60/0.04	GraftJacket allograft regenerative tissue matrix provides a very good option for bridging irreparable rotator cuff tears in the short to medium term

HDA: Human Dermal allograft; FF: Forward flexion; Abd: Abduction; ER: External rotation; UCLA: University of California-Los Angeles; ASES: American Shoulder and Elbow Surgeon evaluation form; JOA: Japanese Orthopaedic Association; OSS: Oxford shoulder score.

cuff tears are therefore associated with a defect of the superior capsule. Mihata *et al*[67,68] recently described an arthroscopic technique to reconstruct the superior capsule in patients with an irreparable rotator cuff tear in order to prevent superior migration of the humeral head with associated impingement.

Although this procedure is presented as an arthroscopic technique, it can be performed via open surgery if preferred by the surgeon. After an acromioplasty to avoid abrasion of the graft, a partial repair of infraspinatus and a repair of the subscapularis should be undertaken. The reconstruction of the capsule is undertaken with a tensor fascia lata autograft, with thick (doubled or tripled to size of 6-8 mm) and large grafts being better. The graft is attached laterally to the greater tuberosity by using a double row anchor technique and medially to superior aspect of the glenoid. The graft is then sutured to the residual infraspinatus posteriorly and if required to the subscapularis or subscaularis tendon anteriorly with side to side sutures. This is thought to restore the force coupling of the joint. Attention should be paid to the correct tension of the anterior sutures to prevent contractures. If the medial, lateral and posterior is satisfactory, the anterior suture is not necessary. Postoperative rehabilitation is required for 6-12 mo[68].

In order to assess the superior stability provided by the Arthroscopic Superior Capsule Reconstruction the authors undertook a cadaver study[67] which concluded that superior capsular reconstruction completely restored superior stability and thus prevented impingement, while interposition patch grafting to the torn tendon only partially restored stability allowing impingement of the interposition[67].

A clinical trial published by the same authors[68], a to-

Table 2 Results of autograft interposition

Study and graft	Number	Ave age (yr)	F/U (mo)	Outcome Score Pre/post/*P* value	ROM Pre/post/*P* value	Conclusion
Mori *et al*[50] Tensor fascia	24	65.9	35.5	ASES: 40.8/94.1/$P < 0.001$ Constant: 37.4/81.1/$P < 0.001$	FF: 114/160.8 ER: 27.9/46	The patch graft procedure showed an 8.3% retear rate for the repaired ISP with improved clinical scores and recovery of muscle strength
Sano *et al*[48] Biceps	14	64	28	JOA: 13.1/22.9/$P = 0.0019$	Active elevation 69/149/$P = 0.0010$	LHB tendon patch grafting provided significant improvement in both the active elevation angle and for the JOA score. The LHB tendon patch grafting seems to be one of the useful options for surgical treatment of irreparable massive rotator cuff tears
Rhee *et al*[49] Biceps 15 open 16 arthro	31	61	32	Constant 48.4/81.8/$P < 0.001$ UCLA 12.5/31.1/$P < 0.001$	FF: 124/162/$P < 0.001$ ABD: 134/168/$P < 0.001$ ER: 38/47/$P = 0.46$	An augmentation technique using the tenotomised biceps as a potential graft for rotator cuff tears is particularly useful in bridging the gap in immobile massive rotator cuff tears with posterior defects and retraction. Differences in postoperative clinical results between the open and arthroscopic groups were not statistically significant

FF: Forward flexion; Abd: Abduction; ER: External rotation; UCLA: UCLA: University of California-Los Angeles; ASES: American shoulder and elbow surgeon evaluation form; JOA: Japanese orthopaedic association.

Table 3 Results of Xenograft interposition

Study	Number	Ave age (yr)	F/U (mo)	Outcome score Pre/post/*P* value	ROM Pre/post/*P* value	Conclusion
Badhe *et al*[51] PDC (Permacol)	10	65.7	54	Constant: 42/62/$P = 0.0004$	Post-operative: Active abd: 89 Passive abd: 98	Porcine dermal collagen is effective as an augmentation graft in the treatment of chronic extensive rotator cuff tears, providing excellent pain relief with a moderate improvement in active ranges of motion and strength
Soler *et al*[52] PDC (Permacol)	4	76		Reduced range and strength, increased pain	Mean active ER: 50 Not recorded	While the use of porcine dermal collagen (Permacol) has many obvious advantages, we do not advocate using it to bridge irreparable defects

PDC: Porcine dermal collagen; FF: Forward flexion; Abd: Abduction; ER: External rotation.

tal of 23 patients (24 shoulders) with irreparable rotator cuff repair where reviewed between 24 and 51 mo (average 34.1) following an arthroscopic superior capsular repair. The average age of the patients was 65.1 years. Patients demonstrated a significant improvement in clinical scores, ASES 23.5 to 92.1 ($P < 0.0001$) and range of motion, elevation 84° to 148° ($P < 0.001$) and external rotation 26° to 40° ($P < 0.01$). Radiographically the acromiohumeral distance increased significantly from 4.6 mm to 8.7 mm ($P < 0.0001$) postoperatively, with no progression of osteoarthritis of the glenohumeral joint. A postoperative MRI scan confirmed that 20 patients (83.3%) had an intact graft, with no progression of muscle atrophy. The authors surmised that the reconstruction of the superior capsule restored the force coupling due to suturing the graft to the infraspinatus posteriorly and the residual supraspinatus or subscapularis anteriorly (Figure 1).

BIODEGRADABLE SPACER

The most recent treatment modality proposed for an irreparable rotator cuff tear is the InSpace system[69]. This device is a biodegradable spacer (balloon shape) which is implanted between the acromion and the humeral head in an attempt to restore the shoulder biomechanics by reducing subacromial friction through lowering the humeral head during abduction[69]. The spacer is made of a copolymer poly-L-lactide-co-ε-capro-lactone which biodegrades over 12 mo, during which stage the force coupling should return and allow for long term improvement in the glenohumeral joint movement.

The insertion method is reported to be simple, safe and reproducible[69]. After a standard arthroscopy including debridement and bursectomy, the rotator cuff is assessed for reparability. Once deemed irreparable, the correct size is selected by the measuring between the lateral border of the acromion and superior rim of the glenoid rim. The rolled up spacer is inserted through a lateral portal and inflated with saline to fill the subacromion space. The shoulder is then taken though a full range of motion to ensure stability. The InSpace system can be used in patients with tears of SST, IS although it is preferable for Subscapularis to be intact or repaired. Contraindications include arthritis, allergies to the device materials and active infections. Potential complications include foreign body response, local irritation or inflammation, tissue necrosis and device displacement.

Senekovic *et al*[70] published their early results of 20

Table 4 Results of Synthetic interposition

Study	Number	Ave age (yr)	Follow-up (mo)	Outcome Score Pre/post/*P* value	ROM Pre/post/*P* value	Conclusion
Nada *el al*[54] Polyester ligament (Dacron)	21	66.5	36	Constant: 46.6/84.5/$P < 0.001$ Excellent 17, good 2, fair 1, poor 1	FF: 65/120/$P < 0.001$ Abd: 60/120/$P < 0.001$ ER: 39/57/$P = 0.01$	Polyester (Dacron) ligament augmentation can result in a pain free successful return of function in active symptomatic patients with massive chronic tears of the rotator cuff
Hirooka *et al*[13] Gore-Tex soft tissue patch	26	62	44	JOA: 57.8/86/NR		Good clinical results, especially pain relief, could be achieved with this procedure in both the small- and the large-patch groups, but good abduction strength was obtained only in the small-patch group
Audenaert *et al*[55] Mersilene mesh	41	67	43	Constant: 25.7/72.1/$P < 0.001$	FF: 69.2/136/$P < 0.001$ Abd: 68.4:133.7/$P < 0.001$	A polyester patch for the closure of massive rotator cuff tears is a satisfying procedure in this complex and technically challenging group of patients
Ozaki *et al*[14] Teflon felt	25	67.3	42	23: No pain, 2: Some pain	ER: 32.4/38.2/$P < 0.05$ 16: Normal, 7: > 120 2: < 30	Of 25 patients with massive rotator cuff tears, 23 had satisfactory functional results
Visuri *et al*[56] Carbon fibre patch	10	53.9	50.4	Excellent 7, good 2, poor 1	Abd: 73/166/NR	A carbon fiber tow application combined with Neer's anterior acromioplasty seems useful in the reconstruction of large tears of the rotator cuff

FF: Forward flexion; Abd: Abduction; ER: External rotation; JOA: Japanese Orthopaedic Association.

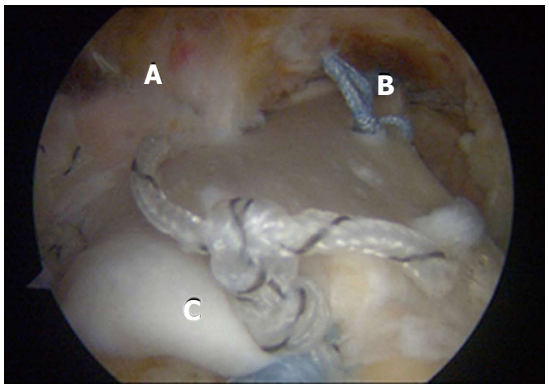

Figure 1 Arthroscopic view of a superior capsular repair with (A) the irreparable rotator cuff, (B) attachment of the Graftjacket to the superior glenoid and (C) Attachment of the Graftjacket to the rotator cuff footprint.

Figure 2 Inspace balloon insertion system.

patients treated with the InSpace system. The average age in this cohort was 70.5 years (range 54-85 years) and the follow up period was 34.7 mo (range 4-95 mo). The average total Constant score increased from 33.4 to 65.4 points, with a statistically significant improvement in all aspects of the constant score. Although improvement in power became evident at 18 mo the improvement in shoulder function was sustained at 3 years. Once again, prospective randomised trials and longer follow up is required in order to confirm promising early results (Figures 2 and 3).

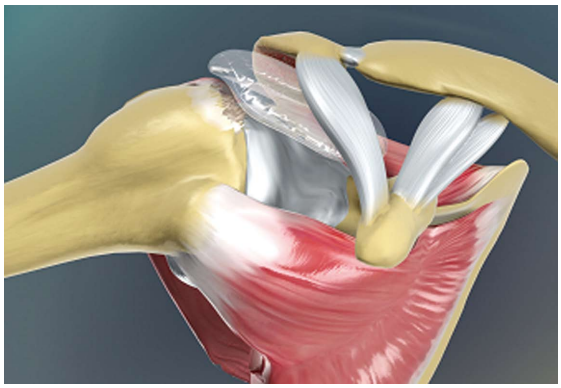

Figure 3 An illustration of the Inspace balloon between the acromion and the humeral head.

CONCLUSION

The management of patients with an irreparable rotator cuff tear remains a challenge. A variety of less invasive arthroscopic techniques have been presented in the literature, the majority of which have reported satisfactory results. These treatments can be considered as a potential therapy with a decision as to which one based on a thorough clinical assessment, an individual's requirements and co-morbidities.

REFERENCES

1 **Gerber C**, Wirth SH, Farshad M. Treatment options for massive rotator cuff tears. *J Shoulder Elbow Surg* 2011; **20**: S20-S29

[PMID: 21281919 DOI: 10.1016/j.jse.2010.11.028]
2 **Muh SJ**, Streit JJ, Wanner JP, Lenarz CJ, Shishani Y, Rowland DY, Riley C, Nowinski RJ, Edwards TB, Gobezie R. Early follow-up of reverse total shoulder arthroplasty in patients sixty years of age or younger. *J Bone Joint Surg Am* 2013; **95**: 1877-1883 [PMID: 24132362 DOI: 10.2106/JBJS.L.10005]
3 **Groh GI**, Groh GM. Complications rates, reoperation rates, and the learning curve in reverse shoulder arthroplasty. *J Shoulder Elbow Surg* 2014; **23**: 388-394 [PMID: 24021159 DOI: 10.1016/j.jse.2013.06.002]
4 **Harreld KL**, Puskas BL, Frankle M. Massive rotator cuff tears without arthropathy: when to consider reverse shoulder arthroplasty. *J Bone Joint Surg Am* 2011; **93**: 973-984 [PMID: 21593377]
5 **Mulieri P**, Dunning P, Klein S, Pupello D, Frankle M. Reverse shoulder arthroplasty for the treatment of irreparable rotator cuff tear without glenohumeral arthritis. *J Bone Joint Surg Am* 2010; **92**: 2544-2556 [PMID: 21048173 DOI: 10.2106/JBJS.I.00912]
6 **Zumstein MA**, Pinedo M, Old J, Boileau P. Problems, complications, reoperations, and revisions in reverse total shoulder arthroplasty: a systematic review. *J Shoulder Elbow Surg* 2011; **20**: 146-157 [PMID: 21134666 DOI: 10.1016/j.jse.2010.08.001]
7 **Omid R**, Lee B. Tendon transfers for irreparable rotator cuff tears. *J Am Acad Orthop Surg* 2013; **21**: 492-501 [PMID: 23908255 DOI: 10.5435/JAAOS-21-08-492]
8 **Gerber C**, Rahm SA, Catanzaro S, Farshad M, Moor BK. Latissimus dorsi tendon transfer for treatment of irreparable posterosuperior rotator cuff tears: long-term results at a minimum follow-up of ten years. *J Bone Joint Surg Am* 2013; **95**: 1920-1926 [PMID: 24196461 DOI: 10.2106/JBJS.M.00122]
9 **Cofield RH**, Parvizi J, Hoffmeyer PJ, Lanzer WL, Ilstrup DM, Rowland CM. Surgical repair of chronic rotator cuff tears. A prospective long-term study. *J Bone Joint Surg Am* 2001; **83-A**: 71-77 [PMID: 11205861]
10 **Gerber C**, Fuchs B, Hodler J. The results of repair of massive tears of the rotator cuff. *J Bone Joint Surg Am* 2000; **82**: 505-515 [PMID: 10761941]
11 **Warner JJ**. Management of massive irreparable rotator cuff tears: the role of tendon transfer. *Instr Course Lect* 2001; **50**: 63-71 [PMID: 11372361]
12 **Moore DR**, Cain EL, Schwartz ML, Clancy WG. Allograft reconstruction for massive, irreparable rotator cuff tears. *Am J Sports Med* 2006; **34**: 392-396 [PMID: 16260463 DOI: 10.1177/0363546505281237]
13 **Hirooka A**, Yoneda M, Wakaitani S, Isaka Y, Hayashida K, Fukushima S, Okamura K. Augmentation with a Gore-Tex patch for repair of large rotator cuff tears that cannot be sutured. *J Orthop Sci* 2002; **7**: 451-456 [PMID: 12181658 DOI: 10.1007/s007760200078]
14 **Ozaki J**, Fujimoto S, Masuhara K, Tamai S, Yoshimoto S. Reconstruction of chronic massive rotator cuff tears with synthetic materials. *Clin Orthop Relat Res* 1986; (202): 173-183 [PMID: 3955946]
15 **Hertel R**, Ballmer FT, Lombert SM, Gerber C. Lag signs in the diagnosis of rotator cuff rupture. *J Shoulder Elbow Surg* 1996; **5**: 307-313 [PMID: 8872929]
16 **Walch G**, Boulahia A, Calderone S, Robinson AH. The 'dropping' and 'hornblower's' signs in evaluation of rotator-cuff tears. *J Bone Joint Surg Br* 1998; **80**: 624-628 [PMID: 9699824]
17 **Ellman H**, Hanker G, Bayer M. Repair of the rotator cuff. End-result study of factors influencing reconstruction. *J Bone Joint Surg Am* 1986; **68**: 1136-1144 [PMID: 3771595]
18 **Wall LB**, Teefey SA, Middleton WD, Dahiya N, Steger-May K, Kim HM, Wessell D, Yamaguchi K. Diagnostic performance and reliability of ultrasonography for fatty degeneration of the rotator cuff muscles. *J Bone Joint Surg Am* 2012; **94**: e83 [PMID: 22717835 DOI: 10.2106/JBJS.J.01899]
19 **Goutallier D**, Postel JM, Gleyze P, Leguilloux P, Van Driessche S. Influence of cuff muscle fatty degeneration on anatomic and functional outcomes after simple suture of full-thickness tears. *J Shoulder Elbow Surg* 2003; **12**: 550-554 [PMID: 14671517 DOI: 10.1016/S1058-2746(03)00211-8]
20 **Burkhart SS**, Barth JR, Richards DP, Zlatkin MB, Larsen M. Arthroscopic repair of massive rotator cuff tears with stage 3 and 4 fatty degeneration. *Arthroscopy* 2007; **23**: 347-354 [PMID: 17418325]
21 **Rockwood CA**, Williams GR, Burkhead WZ. Débridement of degenerative, irreparable lesions of the rotator cuff. *J Bone Joint Surg Am* 1995; **77**: 857-866 [PMID: 7782358]
22 **Kempf JF**, Gleyze P, Bonnomet F, Walch G, Mole D, Frank A, Beaufils P, Levigne C, Rio B, Jaffe A. A multicenter study of 210 rotator cuff tears treated by arthroscopic acromioplasty. *Arthroscopy* 1999; **15**: 56-66 [PMID: 10024034]
23 **Burkhart SS**, Esch JC, Jolson RS. The rotator crescent and rotator cable: an anatomic description of the shoulder's "suspension bridge". *Arthroscopy* 1993; **9**: 611-616 [PMID: 8305096]
24 **Burkhart SS**. Reconciling the paradox of rotator cuff repair versus debridement: a unified biomechanical rationale for the treatment of rotator cuff tears. *Arthroscopy* 1994; **10**: 4-19 [PMID: 8166901]
25 **Burkhart SS**, Nottage WM, Ogilvie-Harris DJ, Kohn HS, Pachelli A. Partial repair of irreparable rotator cuff tears. *Arthroscopy* 1994; **10**: 363-370 [PMID: 7945631]
26 **Duralde XA**, Bair B. Massive rotator cuff tears: the result of partial rotator cuff repair. *J Shoulder Elbow Surg* 2005; **14**: 121-127 [PMID: 15789003]
27 **Berth A**, Neumann W, Awiszus F, Pap G. Massive rotator cuff tears: functional outcome after debridement or arthroscopic partial repair. *J Orthop Traumatol* 2010; **11**: 13-20 [PMID: 20198404 DOI: 10.1007/s10195-010-0084-0]
28 **Melillo AS**, Savoie FH, Field LD. Massive rotator cuff tears: debridement versus repair. *Orthop Clin North Am* 1997; **28**: 117-124 [PMID: 9024436]
29 **Sugaya H**, Maeda K, Matsuki K, Moriishi J. Repair integrity and functional outcome after arthroscopic double-row rotator cuff repair. A prospective outcome study. *J Bone Joint Surg Am* 2007; **89**: 953-960 [PMID: 17473131]
30 **Tauro JC**. Arthroscopic "interval slide" in the repair of large rotator cuff tears. *Arthroscopy* 1999; **15**: 527-530 [PMID: 10424557]
31 **Bigliani LU**, Cordasco FA, McLlveen SJ, Musso ES. Operative repair of massive rotator cuff tears: Long-term results. *J Shoulder Elbow Surg* 1992; **1**: 120-130 [PMID: 22971604 DOI: 10.1016/1058-2746(92)90089]
32 **Lo IK**, Burkhart SS. Arthroscopic repair of massive, contracted, immobile rotator cuff tears using single and double interval slides: technique and preliminary results. *Arthroscopy* 2004; **20**: 22-33 [PMID: 14716275]
33 **Tauro JC**. Arthroscopic repair of large rotator cuff tears using the interval slide technique. *Arthroscopy* 2004; **20**: 13-21 [PMID: 14716274]
34 **Iagulli ND**, Field LD, Hobgood ER, Ramsey JR, Savoie FH. Comparison of partial versus complete arthroscopic repair of massive rotator cuff tears. *Am J Sports Med* 2012; **40**: 1022-1026 [PMID: 22415210 DOI: 10.1177/0363546512438763]
35 **Kim SJ**, Kim SH, Lee SK, Seo JW, Chun YM. Arthroscopic repair of massive contracted rotator cuff tears: aggressive release with anterior and posterior interval slides do not improve cuff healing and integrity. *J Bone Joint Surg Am* 2013; **95**: 1482-1488 [PMID: 23965698 DOI: 10.2106/JBJS.L.01193]
36 **Fenlin JM**, Chase JM, Rushton SA, Frieman BG. Tuberoplasty: creation of an acromiohumeral articulation-a treatment option for massive, irreparable rotator cuff tears. *J Shoulder Elbow Surg* 2002; **11**: 136-142 [PMID: 11988724]
37 **Scheibel M**, Lichtenberg S, Habermeyer P. Reversed arthroscopic subacromial decompression for massive rotator cuff tears. *J Shoulder Elbow Surg* 2004; **13**: 272-278 [PMID: 15111896]
38 **Verhelst L**, Vandekerckhove PJ, Sergeant G, Liekens K, Van

Hoonacker P, Berghs B. Reversed arthroscopic subacromial decompression for symptomatic irreparable rotator cuff tears: mid-term follow-up results in 34 shoulders. *J Shoulder Elbow Surg* 2010; **19**: 601-608 [PMID: 20056453 DOI: 10.1016/j.jse.2009.10.001]

39 **Lee BG**, Cho NS, Rhee YG. Results of arthroscopic decompression and tuberoplasty for irreparable massive rotator cuff tears. *Arthroscopy* 2011; **27**: 1341-1350 [PMID: 21873021 DOI: 10.1016/j.arthro.2011.06.016]

40 **Neviaser JS**, Neviaser RJ, Neviaser TJ. The repair of chronic massive ruptures of the rotator cuff of the shoulder by use of a freeze-dried rotator cuff. *J Bone Joint Surg Am* 1978; **60**: 681-684 [PMID: 681390]

41 **Nasca RJ**. The use of freeze-dried allografts in the management of global rotator cuff tears. *Clin Orthop Relat Res* 1988; **(228)**: 218-226 [PMID: 3342571]

42 **Bond JL**, Dopirak RM, Higgins J, Burns J, Snyder SJ. Arthroscopic replacement of massive, irreparable rotator cuff tears using a GraftJacket allograft: technique and preliminary results. *Arthroscopy* 2008; **24**: 403-409.e1 [PMID: 18375271 DOI: 10.1016/j.arthro.2007.07.033]

43 **Venouziou AI**, Kokkalis ZT, Sotereanos DG. Human dermal allograft interposition for the reconstruction of massive irreparable rotator cuff tears. *Am J Orthop* (Belle Mead NJ) 2013; **42**: 63-70 [PMID: 23431549]

44 **Gupta AK**, Hug K, Berkoff DJ, Boggess BR, Gavigan M, Malley PC, Toth AP. Dermal tissue allograft for the repair of massive irreparable rotator cuff tears. *Am J Sports Med* 2012; **40**: 141-147 [PMID: 22215726 DOI: 10.1177/0363546511422795]

45 **Wong I**, Burns J, Snyder S. Arthroscopic GraftJacket repair of rotator cuff tears. *J Shoulder Elbow Surg* 2010; **19**: 104-109 [PMID: 20188275 DOI: 10.1016/j.jse.2009.12.017]

46 **Modi A**, Singh HP, Pandey R, Armstrong A. Management of irreparable rotator cuff tears with the GraftJacket allograft as an interpositional graft. *Shoulder and Elbow* 2013; **5**: 188–194 [DOI: 10.1111/sae.12021]

47 **Ito J**, Morioka T. Surgical treatment for large and massive tears of the rotator cuff. *Int Orthop* 2003; **27**: 228-231 [PMID: 12827299]

48 **Sano H**, Mineta M, Kita A, Itoi E. Tendon patch grafting using the long head of the biceps for irreparable massive rotator cuff tears. *J Orthop Sci* 2010; **15**: 310-316 [PMID: 20559798 DOI: 10.1007/s00776-010-1453-5]

49 **Rhee YG**, Cho NS, Lim CT, Yi JW, Vishvanathan T. Bridging the gap in immobile massive rotator cuff tears: augmentation using the tenotomized biceps. *Am J Sports Med* 2008; **36**: 1511-1518 [PMID: 18443279 DOI: 10.1177/0363546508316020]

50 **Mori D**, Funakoshi N, Yamashita F. Arthroscopic surgery of irreparable large or massive rotator cuff tears with low-grade fatty degeneration of the infraspinatus: patch autograft procedure versus partial repair procedure. *Arthroscopy* 2013; **29**: 1911-1921 [PMID: 24169146]

51 **Badhe SP**, Lawrence TM, Smith FD, Lunn PG. An assessment of porcine dermal xenograft as an augmentation graft in the treatment of extensive rotator cuff tears. *J Shoulder Elbow Surg* 2008; **17**: 35S-39S [PMID: 18201655 DOI: 10.1016/j.jse.2007.08.005]

52 **Soler JA**, Gidwani S, Curtis MJ. Early complications from the use of porcine dermal collagen implants (Permacol) as bridging constructs in the repair of massive rotator cuff tears. A report of 4 cases. *Acta Orthop Belg* 2007; **73**: 432-436 [PMID: 17939470]

53 **Iannotti JP**, Codsi MJ, Kwon YW, Derwin K, Ciccone J, Brems JJ. Porcine small intestine submucosa augmentation of surgical repair of chronic two-tendon rotator cuff tears. A randomized, controlled trial. *J Bone Joint Surg Am* 2006; **88**: 1238-1244 [PMID: 16757756]

54 **Nada AN**, Debnath UK, Robinson DA, Jordan C. Treatment of massive rotator-cuff tears with a polyester ligament (Dacron) augmentation: clinical outcome. *J Bone Joint Surg Br* 2010; **92**: 1397-1402 [PMID: 20884978 DOI: 10.1302/0301-620X.92B10.24299]

55 **Audenaert E**, Van Nuffel J, Schepens A, Verhelst M, Verdonk R. Reconstruction of massive rotator cuff lesions with a synthetic interposition graft: a prospective study of 41 patients. *Knee Surg Sports Traumatol Arthrosc* 2006; **14**: 360-364 [PMID: 16252125]

56 **Visuri T**, Kiviluoto O, Eskelin M. Carbon fiber for repair of the rotator cuff. A 4-year follow-up of 14 cases. *Acta Orthop Scand* 1991; **62**: 356-359 [PMID: 1882676]

57 **Ricchetti ET**, Aurora A, Iannotti JP, Derwin KA. Scaffold devices for rotator cuff repair. *J Shoulder Elbow Surg* 2012; **21**: 251-265 [PMID: 22244069 DOI: 10.1016/j.jse.2011.10.003]

58 **Aszmann OC**, Dellon AL, Birely BT, McFarland EG. Innervation of the human shoulder joint and its implications for surgery. *Clin Orthop Relat Res* 1996; **(330)**: 202-207 [PMID: 8804294]

59 **Emery P**, Bowman S, Wedderburn L, Grahame R. Suprascapular nerve block for chronic shoulder pain in rheumatoid arthritis. *BMJ* 1989; **299**: 1079-1080 [PMID: 2511970]

60 **Kane TP**, Rogers P, Hazelgrove J, Wimsey S, Harper GD. Pulsed radiofrequency applied to the suprascapular nerve in painful cuff tear arthropathy. *J Shoulder Elbow Surg* 2008; **17**: 436-440 [PMID: 18328740 DOI: 10.1016/j.jse.2007.10.007]

61 **Talbot TC**, Limb D. The management of irreparable rotator cuff tears. *Orthopaedics Trauma* 2012; **26**: 367-373

62 **Sluijter ME**. The role of radiofrequency in failed back surgery patients. *Curr Rev Pain* 2000; **4**: 49-53 [PMID: 10998715]

63 **Munglani R**. The longer term effect of pulsed radiofrequency for neuropathic pain. *Pain* 1999; **80**: 437-439 [PMID: 10204759]

64 **Byrd D**, Mackey S. Pulsed radiofrequency for chronic pain. *Curr Pain Headache Rep* 2008; **12**: 37-41 [PMID: 18417022]

65 **Shah RV**, Racz GB. Pulsed mode radiofrequency lesioning of the suprascapular nerve for the treatment of chronic shoulder pain. *Pain Physician* 2003; **6**: 503-506 [PMID: 16871304]

66 **Nizlan NM**, Skirving AP, Campbell PT. Arthroscopic suprascapular neurectomy for the management of severe shoulder pain. *J Shoulder Elbow Surg* 2009; **18**: 245-250 [PMID: 19081272 DOI: 10.1016/j.jse.2008.09.001]

67 **Mihata T**, McGarry MH, Pirolo JM, Kinoshita M, Lee TQ. Superior capsule reconstruction to restore superior stability in irreparable rotator cuff tears: a biomechanical cadaveric study. *Am J Sports Med* 2012; **40**: 2248-2255 [PMID: 22886689 DOI: 10.1177/0363546512456195]

68 **Mihata T**, Lee TQ, Watanabe C, Fukunishi K, Ohue M, Tsujimura T, Kinoshita M. Clinical results of arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. *Arthroscopy* 2013; **29**: 459-470 [PMID: 23369443 DOI: 10.1016/j.arthro.2012.10.022]

69 **Savarese E**, Romeo R. New solution for massive, irreparable rotator cuff tears: the subacromial "biodegradable spacer". *Arthrosc Tech* 2012; **1**: e69-e74 [PMID: 23766979 DOI: 10.1016/j.eats.2012.02.002]

70 **Senekovic V**, Poberaj B, Kovacic L, Mikek M, Adar E, Dekel A. Prospective clinical study of a novel biodegradable subacromial spacer in treatment of massive irreparable rotator cuff tears. *Eur J Orthop Surg Traumatol* 2013; **23**: 311-316 [PMID: 23412287 DOI: 10.1007/s00590-012-0981-4]

P- Reviewer: Kumar VP, Shafi M **S- Editor**: Song XX
L- Editor: A **E- Editor**: Wu HL

Published by **Baishideng Publishing Group Inc**
8226 Regency Drive, Pleasanton, CA 94588, USA
Telephone: +1-925-223-8242
Fax: +1-925-223-8243
E-mail: bpgoffice@wjgnet.com
Help Desk: http://www.wjgnet.com/esps/helpdesk.aspx
http://www.wjgnet.com