CURRENT CONCEPTS REVIEW

Superior Capsule Reconstruction: What Do We Know?

Richard A. C. Dimock, MEng, MBBS, MRCS; Sheraz Malik, MBBS, MSc, FRCS; Paolo Consigliere, MD; Mohamed A. Imam, MD, MSc,PhD, FRCS; A. Ali Narvani, BSc, MBBS, MSc, FRCS, MFSEM

Research performed at The Rowley Bristow Unit, Ashford and St. Peter's NHS, Trust, Chertsey, UK; Fortius Clinic, London, UK

Received: 14 June 2018 *Accepted: 06 October 2018*

Abstract

The management of irreparable rotator cuff tears remains challenging. Since its introduction by Mihata in 2012, superior capsule reconstruction (SCR) has grown in popularity at an astonishingly rapid rate. The aim of this article is to provide a comprehensive review of the available literature, in order to highlight what has so far been published on SCR, covering all aspects including biomechanical, clinical and radiological studies as well as descriptions of the various techniques for performing the procedure.

The short-term clinical results of SCR are promising, but there is need for further long-term studies, as well as randomised controlled trials comparing SCR to other treatment modalities for irreparable rotator cuff tears. Further imaging studies looking at graft healing rates are also required as the healing rates published so far are variable. Additionally, the mechanism of action by which SCR delivers good short-term functional outcomes needs further clarification, as does the importance of the choice of graft type and thickness.

Level of evidence: III

Keywords: Irreparable rotator cuff tears, Rotator cuff tears, Superior capsule reconstruction

Introduction

Despite tremendous advances in technology and arthroscopic techniques, some rotator cuff repairs remain irreparable. The management of this group of patients remains challenging as none of the treatment options, including anterior deltoid exercises, debridement with or without long head of biceps tenotomy, tuberoplasty, partial rotator cuff repair, interval slide, muscle transfer, patch augmentation and reverse shoulder arthroplasty, are without issues.

In 2012, Mihata el al described a new surgical treatment, superior capsule reconstruction (SCR), for management of irreparable rotator cuff tear with the aim of restoring the superior stability of the shoulder joint (1). Mihata's technique involved using a fascia lata allograft patch. Subsequently Hirahara and Burkhart popularised the technique in the western world using extracellular matrix patches (2, 3). This has led to a rapid rise in the number of SCR performed in a relatively short period of time (over 15,000 performed in US already). Today, it is difficult to attend a shoulder conference where there are no session assigned to SCR or where there is no demonstration of the technique. The aim of this article is to highlight what has been published about SCR including indications and the different techniques described. Additionally we will review the latest evidence for its biomechanical, clinical and radiological outcomes.

Literature Search

A comprehensive literature search was performed in May 2018 using Medline, CINAHL (Cumulative Index to Nursing and Allied Health Literature) and PubMed search engines, as well as the central register of controlled trials for all peer-reviewed literature published between January 2010 to May 2018. A search strategy was formulated using keywords: shoulder, superior capsule, superior capsule reconstruction, superior capsular reconstruction, rotator cuff tear, rotator cuff repair, and irreparable rotator cuff tear. To ensure all possible articles were considered, references from all articles were also checked and manually included.

We included all publications on superior capsule of the shoulder and on superior capsule reconstruction for the shoulder.

Corresponding Author: A. Ali Narvani, Rowley Bristow Unit, Ashford and St Peter's NHS Trust, Chertsey, UK; Fortius Clinic, London, UK
Email: alinarvani@shoulder-elbowsurgery.com

THE ONLINE VERSION OF THIS ARTICLE ABJS.MUMS.AC.IR

Anatomy & function of the normal superior capsule

The superior capsule is formed by a thin continuous sheet of interwoven collagen fibrils, which extend from the glenoid labrum medially to the humerus laterally (4). It is 4.4 to 9.1mm thick at its attachment to 30 to 61% of the greater tuberosity (3, 5). Therefore, it may occupy as much as, or even more of the greater tuberosity footprint than the supraspinatus (3). It is thought that the superior capsule may play an important role in the passive stability of the glenohumeral joint (6). In a biomechanical study Ishihara et al demonstrated that a tear of the superior capsule significantly increased the anterior and inferior translation, whereas a superior capsular defect significantly increased glenohumeral translation in all directions compared to the intact capsule (6). Additionally, with the superior capsular defect, there were significant increases in the contact pressures between the humerus and the coracoacromial arch (6). These and other similar findings have led authors to suggest that the superior capsule may act as a hammock overlying the joint and prevent the humeral head from making contact with the deep surface of the acromion (7). Furthermore, Adams et al. proposed that the defect in the superior capsule may be the "essential lesion" in patients with superior cuff tear, as opposed to the tear in the rotator cuff itself and rotator cuff repairs that do not involve restoration of the normal superior capsule anatomy may result in sub-optimal outcomes (7).

Biomechanical

There are a number of biomechanical studies that have investigated the influence of the superior capsule reconstruction on the superior stability of the shoulder joint (8-12). In a cadaveric study involving eight shoulders, Mihata et al (no.). compared the superior translations of the proximal humerus in five conditions: intact rotator cuff, excised supraspinatus, reconstructed supraspinatus using a bridging graft connecting the remnant of the supraspinatus to the greater tuberosity, reconstructed superior capsule with graft attached to the glenoid and the greater tuberosity, reconstructed superior capsule and supraspinatus with the patch (8). They demonstrated that excising the supraspinatus tendon resulted in a significant increase in the superior translation of the proximal humerus, which was fully restored only when the superior capsule was reconstructed with the graft (8). Supraspinatus reconstruction with the graft only resulted in a partial restoration of superior translation (8).

In another biomechanical study, Mihata et al demonstrated an 8mm thick fascia lata graft resulted in a greater superior stability than a 4mm thick graft (9). A significant decrease in superior translation was only witnessed with 8mm thick graft as compared to the 4mm thick graft (9).

In a more recent biomechanical study, the ability of fascia lata to restore superior stability was compared to that of human dermal allograft (10). In this study, SCR using fascia lata allograft completely restored superior translation, subacromial contact pressure and superior glenohumeral joint force. SCR using human dermal allograft on the other hand, only partially restored superior glenohumeral stability (however, it did completely restore contact pressure and superior glenohumeral joint force) (10). Furthermore, the human dermal graft had elongated by 15% during testing whereas there was no elongation with the fascia lata graft (10).

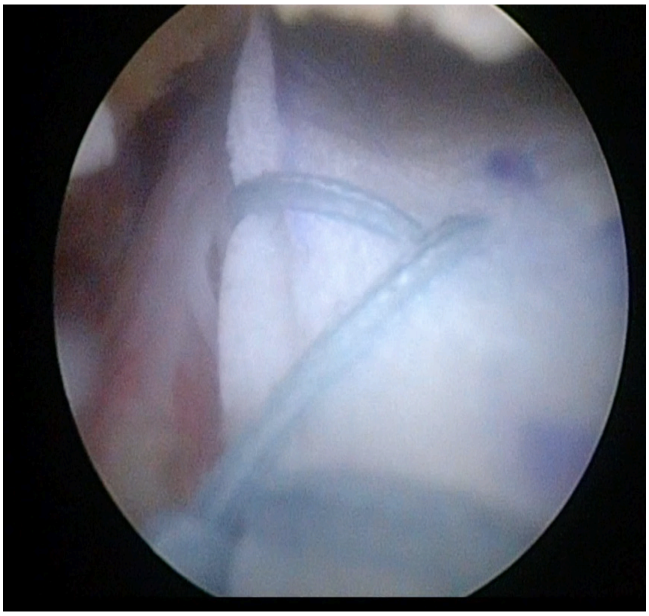

Figure 1. Arthroscopic view through the lateral port of right shoulder showing the repaired graft to infraspinatus remnants.

Mihata's team also investigated the effects of acromioplasty on shoulder biomechanics after superior capsule reconstruction (11). They illustrated that adding acromioplasty to SCR with fascia lata significantly decreased the subacromial peak contact area compared to SCR without acromioplasty, without altering the humeral head position, superior translation or subacromial peak contact pressure (11). Based on their findings the authors suggested that when performing SCR, acromioplasty may help to decrease the post operative risk of abrasion and tearing of the graft beneath the acromion, without increasing the risk of superior translation (11).

When performing SCR, it is also indicated that addition of posterior side-to-side suturing between the graft and residual infraspinatous tendon increases the superior stability of the proximal humerus [Figure 1] (12). In a biomechanical study, SCR without posterior side-to-side suturing, did not inhibit glenohumeral superior translation, whereas addition of posterior side-to-side suturing resulted in significantly reduced superior translation (12).

Indications

As with all new procedures, it is important to define clear indications for SCR as there is worry that the procedure may be performed in inappropriate patients with a danger of giving it a bad reputation, even in patients in whom it may be suitable.

The indications for SCR as suggested by Mihata's original paper include irreparable tear in patients who do not have severe bone deformity (Hamada classification type V), severe superior migration of the humeral head that does not correct by the traction of the arm, nerve or deltoid dysfunction, and infection (1). Most authors agree the that the procedure is indicated for patients with a symptomatic irreparable rotator cuff tear, who do not have a significantly degenerative glenohumeral joint but possess a fully functioning deltoid, A number of authors have indicated that the best clinical outcomes are obtained in patients in whom subscapularis is intact, therefore suggesting that patients should also have either an intact subscapularis or repairable subscapularis tear before they are considered for SCR (13-15). Concerns have also been raised over performing SCR in elderly patients with poor bone stock, multiple failed cuff repairs, chronic pseudoparalysis, frank anterior superior escape or recurrent shoulder instability (16). In these patients, reverse arthroplasty may be a more appropriate treatment choice (16).

Techniques

There are a variety of reported techniques for performing SCR depending on the type of the graft (fascia lata, extracellular matrix dermal grafts, long head of biceps and tendon allografts), whether performed in an open manner or arthroscopically, the mode of the glenoid and greater tuberosity fixation, and whether the anchors are all inserted before or after passage of the graft (1, 13, 16-19).

The original arthroscopic technique described by Mihata involved using fascia lata autograft fashioned to a thickness of 6mm to 8mm, which was attached medially to the glenoid using 2 fully threaded titanium suture anchors, laterally to the greater tuberosity with a combination of a double-row technique and the suture bridge (1). The graft was further stabilised with a side-to-side suture posteriorly to the residual infraspinatus and anteriorly either to the residual anterior-superior tendon or to subscapularis (1).

Hirahara et al modified the original technique by using human dermal extra-cellular matrix graft instead of the fascia lata (13). Their technique involved insertion of both glenoid and medial row greater tuberosity anchors before the passage of the graft into the bursa (13). Two 3.0mm SutureTak (Arthrex) anchors were used for the glenoid fixation and SwiveLock anchors (Arthrex) for the tuberosity fixation. The sutures were then brought outside the patient, passed through the graft and then the graft is manoeuvred inside the bursa using the "double-pulley" technique. There have been various modifications of this technique, which also include use of two rows of medial anchors, however the potential difficulties with this technique and its various modifications are suture management and the tangling of the anchor suture limbs as the graft is passed inside the bursa. We have described a further modification of the technique, which may address some of the suture management challenges (17). In this technique, the greater tuberosity anchors were inserted after the matrix has been pulled through to the correct position in the subacromial space so, during the passage of the graft, there were fewer sutures to deal with and therefore the risk of sutures becoming tangled was reduced [Figure 2]. Only once the graft was

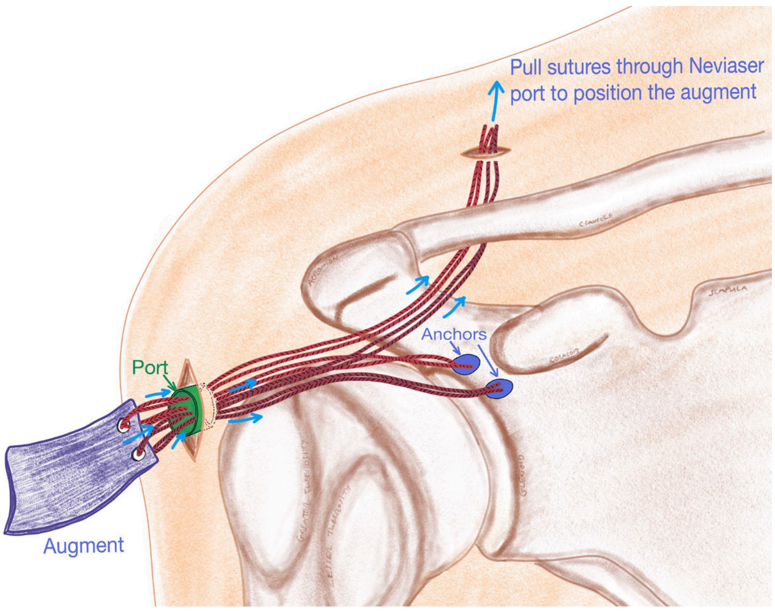

Figure 2. Diagram demonstrating the "Pull-Over technique for SCR as described by the senior author (AN)(17). In this technique, the greater tuberosity anchors were inserted after the matrix has been pulled through to the correct position in the subacromial space so, during the passage of the graft, there were fewer sutures to deal with and therefore the risk of sutures becoming tangled was reduced.

stabilised to the glenoid (using 2.3 all-suture anchors) were the greater tuberosity anchors inserted and the patch attached to the greater tuberosity in a double row manner in a similar fashion to a standard rotator cuff repair [Figures 3-6] (17).

There have also been a number of descriptions for the use

Figure 3. Arthroscopic view through the posterior port of right shoulder demonstrating the stabilization of the graft to the glenoid.

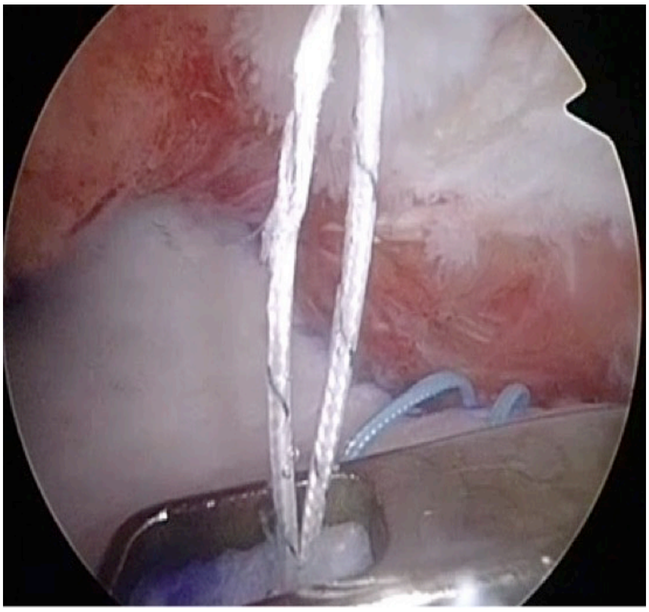

Figure 4. Arthroscopic view through the posterior port of right shoulder illustrating the passing through of anchor suture limbs through the graft and the repair of the lateral end of the graft to greater tuberosity in a double row manner.

Figure 5. Arthroscopic view through the posterior port of right shoulder showing the repaired lateral end of the graft to the greater tuberosity.

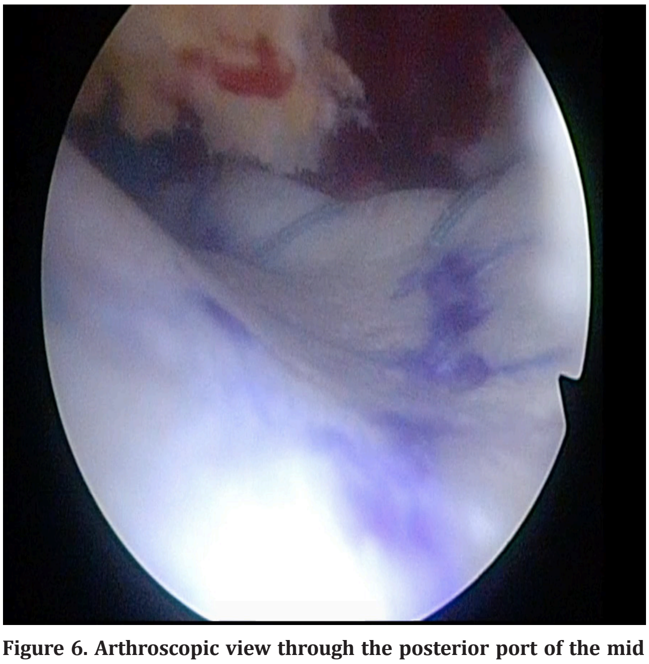

Figure 6. Arthroscopic view through the posterior port of the mid portion of the grafting following repair.

of LHB as a graft in SCR (20, 21). In these techniques, the LHB insertion into the glenoid is preserved while laterally it is tenotomised, transferred and attached to the greater tuberosity. The issue with use of LHB is that commonly irreparable RC tears are associated with pathologies of LHB, where it may act as pain generator. Similarly LHB may be absent, torn or very degenerative. Nevertheless, there are some advantages, which include possibly better vascularity of the graft, no need for insertion of anchors into the glenoid (reduced risk of suprascapular injury), a cheaper and quicker technique, no risk of inflammatory response to xenograft or allograft ECM patches, no risk of donor site morbidity when fascia lata is used and, finally, possibly a reduced risk of infection as the graft is not brought outside the body. Additionally it may play a role in situations and countries where ECM patches are not available. However, further biomechanical studies are required to evaluate whether LHB may provide the superior stability required.

Post Operative Rehabilitation

Most authors use a rehabilitation protocol similar to that for their large and massive rotator cuff repairs (14, 15, 22-24). This entails either a sling or abduction wedge for a period of 4 to 6 weeks. Some authors start passive motion early but most wait until the sling or the wedge comes off before permitting progressive range of motion and allow pendulum exercises only while the patients is immobilized (14, 15, 22-24). Similarly most surgeons start strengthening exercises at 12 weeks, however, there are those who start strengthening as early as 8 weeks (14, 15, 22-24).

Clinical Outcomes [Table 1]

Mihata et al were first to release their clinical outcome for SCR (1). Their series included 24 shoulders where SCR with fascia lata was performed with an average follow up of over 34 months. They reported significant improvement in active abduction, external rotation and the American Shoulder and Elbow Surgeon (ASES) scores (1). Hirahara et al published their outcome in 9 patients who underwent SCR using dermal allograft with a minimum follow up of 2 years (mean follow up was 32.4 months) (2). There were significant improvements

Table 1. Clinical Outcomes of different SCR studies

	Number of patients	Min. FU/ Months	Mean FU/ Months	Mean ASES Pre-surgery	Mean ASES Post-surgery	Mean Elevation Pre	Mean Elevation Post	Mean ER Pre	Mean ER Post	VAS score Pre	VAS score Post
Mihata et al 2013 (1)	23 (24 shoulders)	24	34.1	23.5	92.9	84	148	26	40	-	-
Hirahara et al 2017 (2)	8	24	32.3	43.5	86.5	-	-	-	-	6.3	0.4
Denard et al 2018 (24)	59	12	17.7	43.6	77.5	130	158	36	45	5.8	1.7
Pennington et al 2018 (14)	86	12	Range=16-28	52	82	103 (abduction)	159 (abduction)	-	-	4.0	1.5
Mihata et al 2018 (23)											
Overall	100	24	48	36	92	91	147	26	41	-	-
Those who did sports before	26	24	48	38	97	109	160	32	44	-	-
Those who did not do sports before	74	24	38	35	91	86	146	24	41	-	-
Those who did physical work before	34	24	48	33	93	88	153	22	41	-	-
Those who did not do physical work before	66	24	48	37	92	96	148	29	42	-	-

in ASES score and VAS pain scores (2).

In a further study, involving 59 patients who underwent SCR with dermal allograft, at a minimum follow up of 1 year, there were significant improvements in forward flexion, external rotation, VAS and ASES scores (24). However, eleven patients (18.6%) underwent a revision procedure, including seven reverse shoulder arthroplasties (24).

More recently Pennington et al published their outcomes with 86 patients in whom SCR was performed with dermal allograft (14). At a minimum follow up of one year (range 16-28 months), they reported significant improvements in ASES and VAS scores (14).

Radiological

There are a number of parameters that have been used to evaluate radiological outcomes of SCR (1, 2, 14, 24-26). These include radiographic imaging to assess the degree of superior migration of the humerus and soft tissue imaging (either with ultrasound (US) or magnetic resonance imagine (MRI) to investigate graft healing.

Radiograph Imaging [Table 2]

A number of investigators have measured acromio-humeral distance (ADH), as described by Ellman et al using standard antero-posterior plain radiographs to assess superior stability (1, 2, 14, 24, 25). In Mihata's original series of 24 patients, ADH increased from 4.6mm preoperatively to 8.7mm postoperatively following SCR with fascia lata (1). Similarly Hirahara et al showed an increase in ADH from 4.5mm pre-operatively to 8.48mm immediately post surgery and 7.60mm at 2 years after SCR with human dermal allograft (2). In another study of 59 patients undergoing SCR again with human dermal allograft with a mean follow up period of 17.7months (minimum 12 months), ADH increased from 6.6mm pre-operatively to 7.6mm at 2 weeks post surgery but decreased to 6.7mm at the final follow up (24). More recently, Pennington et al reported an increase in AD from a pre-operative mean value of 7.1mm to a mean value of 9.7mm at one year in a series involving 86 patients undergoing SCR with human dermal allograft (14).

One potential problem of using ADH to evaluate proximal humeral migration is that the humerus is referenced to the acromion therefore the angle of x-ray beam may influence the actual distance and introduce a variable factor (24,26). In order to address this potential issue, Pennington et al have lately introduced the concept of "superior capsular distance", which references the position of the humerus relative to the glenoid (14). In their series, there was a significant decrease in the superior capsular distance at one-year post SCR (from a mean value of 52.9mm pre-operatively to 46.2mm at 1 year) (14).

Soft Tissue Imaging

Both US and MRI have been used to evaluate graft healing with SCR (1, 2, 24, 27) [Figures 7a; 7b]. In their series of 8 patients, Hirahara et al reported that between 25 and 36 months post SCR, US revealed an intact graft construct in 5 patients (2). Twenty out of 24 patients had no evidence on graft re-tear on MRI (at a minimum follow-up of 24 months) with Mihata's original series with fascia lata graft (1). In another study, "complete" healing was observed in 9 out of the 20 patients who had MRI at one-year post SCR with human dermal allograft (24). The graft failed at the glenoid side in one patient, on the humeral side in 7 cases and at an intra-substance location in 3 patients (24). MRI failure rates of 30.7% have also been demonstrated at 5 months post surgery in another study that involved 28 patients who underwent SCR with fascia lata (27). Most of the failures were that the lateral anchor area (27).

Discussion

In recent years, there has been a rapid exponential rise in the number of superior capsule reconstructions performed in the western world. There is no doubt that

Table 2. Radiographic outcomes of the different studies for SCR

Study	Number of patients	Min. FU/ Months	Mean FU/ Months	Type of Graft	Graft thickness/mm	Pre-AHD/ mm	Post-AHD/mm
Mihata et al 2013 (1)	23 (24 shoulders)	24	34.1	Fascia Lata	6-8	4.6	8.7
Hirahara et al 2017 (2)	8	24	32.3	Human dermal allograft	-	4.5	8.48 (immediate post surgery) 7.6 (2yrs post) -
Denard et al 2018 (24)	59	12	17.7	Human dermal allograft	1 in 5 cases 2 in 2 cases 3 in all other cases	6.6	7.6 (2wks) 6.7(final follow up)
Pennington et al 2018 (14)	86	12	Range=16-28	Human dermal allograft	2.75-3.25	7.1	9.7 (1 year)

SCR appears to be an attractive option in a difficult group of patients with irreparable tears where none of the other surgical options are without concerns. The early clinical results are very encouraging with significant improvements in shoulder functional scores, range of movement and visual analogue scores. However, there are a number of issues that need clarification before SCR is performed on a large scale. Firstly, the clinical outcomes reported are short-term and we need to explore mid- and long-term outcomes. Secondly, there is a need for randomised controlled trials comparing SCR to physical therapy, debridement, partial repairs and even inter-space balloon-plasty. Thirdly, we need more studies investigating the healing rate of the graft, ideally with MRI. The MRI healing rate with Mihata's original series using fascia lata was very good (22 out of the 24 patients) (1). However, this has not been matched by other investigators (24, 27). Denard et al reported that only 9 out of the 20 patients has evidence of complete graft healing on the MRI (24). These MRI findings raise the fourth and fifth issues. If the clinical outcome is good despite a poor radiological outcome (lack of graft healing), is there some other mechanism other than providing superior stability that may explain the good clinical outcomes? Is the graft just acting as a spacer? Finally, could the difference between healing rates of Mihata's and Denard's reports be explained be explained by the fact that Mihata uses fascia lata of 6-8mm thickness whereas that used in Denard's report was human dermal extracellular allograft with

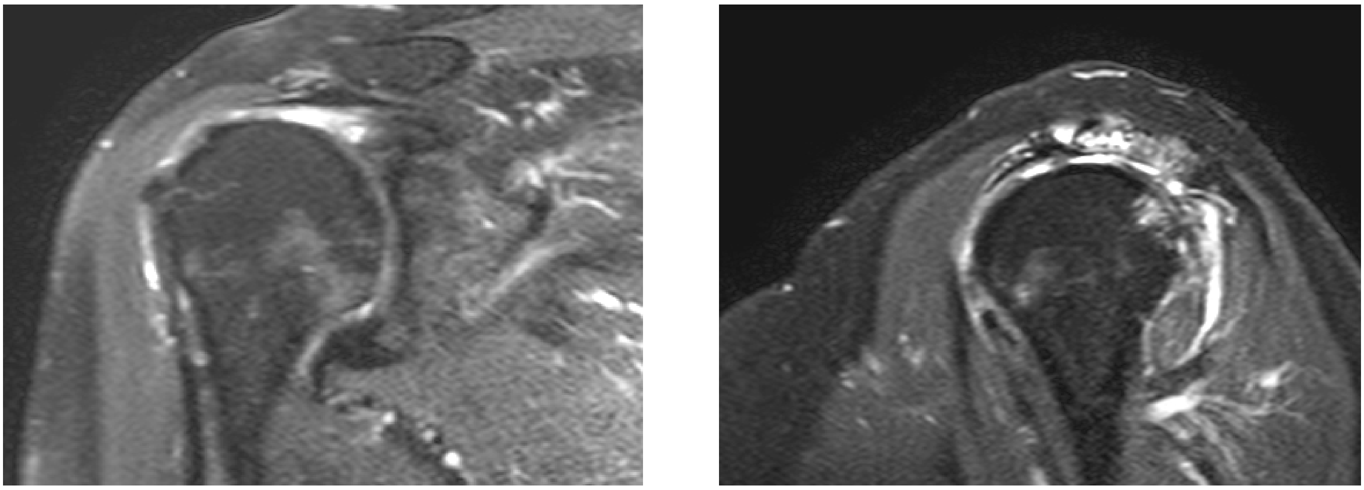

Figure 7a. MRI images pre-surgery illustrating massive irreparable tear.

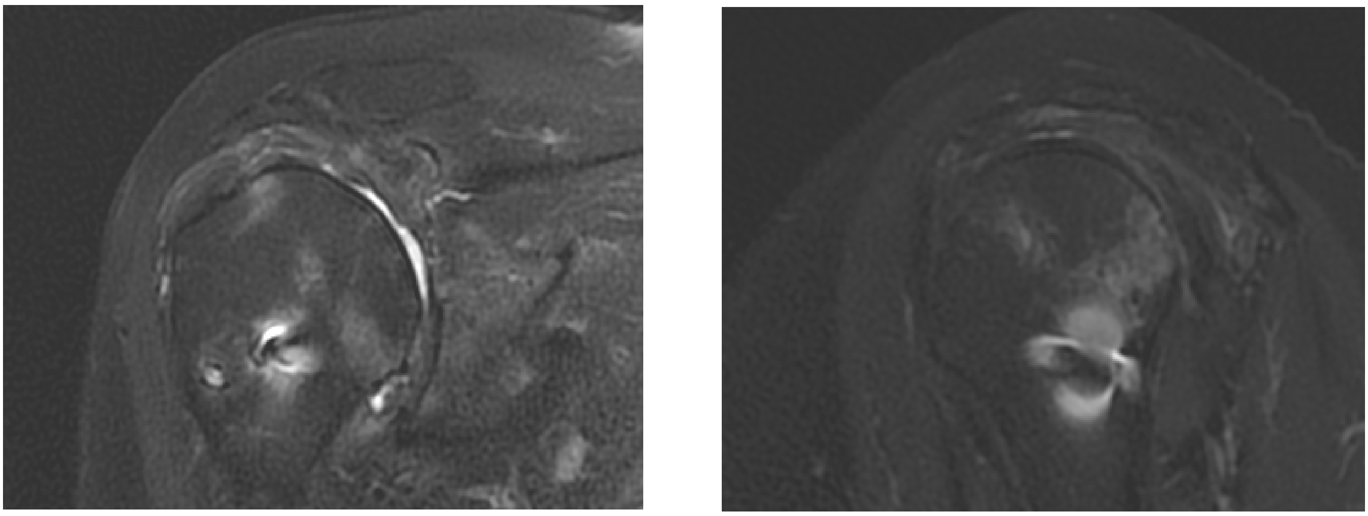

Figure 7b. MRI images one year following SCR showing healed graft.

Table 3. Issues that require further clarification

What are the long-term clinical outcomes?
Need for randomised controlled trial comparing SCR to other treatment options.
Does the graft heal?
What is the main mechanism of action responsible for the good short-term clinical outcomes?
What is the ideal graft and how thick should it be?

a maximum thickness of 3mm. Is a 3mm thick human dermal allograft thick and stiff enough to provide the superior stability that is required? Mihata has previously demonstrated that a significant decrease in superior translation can only be seen with 8mm thick graft as compared to the 4mm thick graft (9).

In summary, the short-term clinical outcomes with SCR are good and it may well have a place in management of selective difficult patients with irreparable tears where other surgical options may not be attractive. Despite this and the huge industrial support driving it forward, as discussed above there are some concerns that need to be answered before the rapid exponential rise in the number of cases performed (particularly with allograft) continues [Table 3]. Additionally, as with other innovative newly introduced procedures, there is also a danger that the indications for performing it are extended inappropriately which, in the long-term, may harm its reputation where it may be truly indicated.

Richard A. C. Dimock MEng MBBS MRCS
Sheraz Malik MBBS MSc FRCS
Paolo Consigliere MD
Mohamed A. Imam MD MSc PhD FRCS
Rowley Bristow Unit, Ashford and St Peter's NHS Trust, Chertsey, UK

A. Ali Narvani BSc MBBS MSc FRCS MFSEM
Rowley Bristow Unit, Ashford and St Peter's NHS Trust, Chertsey, UK
Fortius Clinic, London, UK

References

1. Mihata T, Lee TQ, Watanabe C, Fukunishi K, Ohue M, Tsujimura T, et al. Clinical results of arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. Arthroscopy. 2013; 29(3):459-70.
2. Hirahara AM, Andersen WJ, Panero AJ. Superior capsular reconstruction: clinical outcomes after minimum 2-year follow-up. Am J Orthop. 2017; 44(6):266-78.
3. Burkhart SS, Denard PJ, Adams CR, Brady PC, Hartzler RU. Arthroscopic superior capsular reconstruction for massive irreparable rotator cuff repair. Arthrosc Tech. 2016; 5(6):e1407-18.
4. Clark JM, Harryman DT 2nd. Tendons, ligaments, and capsule of the rotator cuff. Gross and microscopic anatomy. J Bone Joint Am. 1992; 74(5):713-25.
5. Nimura A, Kato A, Yamaguchi K, Mochizuki T, Okawa A, Sugaya H, et al. The superior capsule of the shoulder joint complements the insertion of the rotator cuff. J Shoulder Elbow Surg. 2012; 21(7):867-72.
6. Ishihara Y, Mihata T, Tamboli M, Nguyen L, Park KP, McGarry MH, et al. Role of the superior shoulder capsule in passive stability of the glenohumeral joint. J Shoulder Elbow Surg. 2014; 23(5):642-8.
7. Adam CR, De Martino AM, Rego G, Denard PJ, Burkhart SS. The rotator cuff and the superior capsule: why we need both. Arthroscopy. 2016; 32(12):2628-37.
8. 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(10):2248-55.
9. Mihata T, McGarry MH, Kahn T, Goldberg I, Neo M, Lee TQ. Biomechanical effect of thickness and tension of fascia lata graft on glenohumeral stability for superior capsule reconstruction in irreparable supraspinatus tears. Arthroscopy. 2016; 32(3):418-26.
10. Mihata T, Bui CNH, Akeda M, Cavagnaro MA, Kuenzler M, Peterson AB, et al. A biomechanical cadaveric study comparing superior capsule reconstruction using fascia lata allograft with human dermal allograft for irreparable rotator cuff tear. J Shoulder Elbow Surg. 2017; 26(12):2158-66.
11. Mihata T, McGarry MH, Kahn T, Goldberg I, Neo M, Lee TQ. Biomechanical effects of acromioplasty on superior capsule reconstruction for irreparable supraspinatus tendon tears. Am J Sports Med. 2016; 44(1):191-7.
12. Mihata T, McGarry MH, Kahn T, Goldberg I, Neo M, Lee TQ. Biomechanical role of capsular continuity in superior capsule reconstruction for irreparable tears

of the supraspinatus tendon. Am J Sports Med. 2016; 44(6):1423-30.
13. Hirahara AM, Adams CR. Arthroscopic superior capsular reconstruction for treatment of massive irreparable rotator cuff tears. Arthroscopy Tech. 2015; 4(6):e637-41.
14. Pennington WT, Bartz BA, Pauli JM, Walker CE, Schmidt W. Arthroscopic superior capsular reconstruction with acellular dermal allograft for the treatment of massive irreparable rotator cuff tears: short-term clinical outcomes and the radiographic parameter of superior capsular distance. Arthroscopy. 2018; 34(6):1764-73.
15. Noyes MP, Denard PJ. Arthroscopic superior capsular reconstruction: indications and outcomes. Oper Techn Sport Med. 2018; 26(1):29-34.
16. Hartzler RU, Burkhart SS. Superior capsular reconstruction. Orthopaedics. 2017; 40(5):271-80.
17. Narvani AA, Consigliere P, Polyzois I, Sarkhel T, Gupta R, Levy O. The 'pull-over' technique for arthroscopic superior capsular reconstruction." Arthrosc Tech. 2016; 5(6):e1441-7.
18. Petri M, Greenspoon JA, Millett PJ. Arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. Arthrosc Tech. 2015; 4(6):e751-5.
19. Sutter EG, Godin JA, Garrigues GE. All-arthroscopic superior shoulder capsule reconstruction with partial rotator cuff repair. Orthopedics. 2017; 40(4):e735-8.
20. Kim YS, Lee HJ, Park I, Sung GY, Kim DJ, Kim JH. Arthroscopic in situ superior capsular reconstruction using the long head of the biceps tendon. Orthosc Tech. 2018; 7(2):e97-103.
21. Boutsiadis A, Chen S, Jiang C, Lenoir H, Delsol P, Barth J. Long head of the biceps as a suitable available local tissue autograft for superior capsular reconstruction: 'the Chinese way". Arthrosc Tech. 2017; 6(5):e1559-66.
22. Sethi P, Franco WG. The role of superior capsule reconstruction in rotator cuff tears. Orthop Clin North Am. 2018; 49(1):93-101.
23. Mihata T, Lee TQ, Fukunishi K, Itami Y, Fujisawa Y, Kawakami T, et al. Return to sports and physical work after arthroscopic superior capsule reconstruction among patients with irreparable rotator cuff tears. Am J Sports Med. 2018; 46(5):1077-83.
24. Denard PJ, Brady PC, Adams CR, Tokish JM, Burkhart SS. Preliminary results of arthroscopic superior capsule reconstruction with dermal allograft. Arthroscopy. 2018; 34(1):93-9.
25. 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(8):1136-44.
26. Burkhart S. Editorial commentary: superior capsule reconstruction with dermal allograft: achieving the goal of joint preservation. Arthroscopy. 2018; 34(6):1774-5.
27. Al Ramadhan H, Sungjoon L, In-Ho J. Early MRI findings of arthroscopic superior capsule reconstruction (ASCR): how to prevent early failure. Arthroscopy. 2017; 33(6):e21.