REVIEW ARTICLE

Advancement in Arthroscopic Superior Capsular Reconstruction for Irreparable Massive Rotator Cuff Tear

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Irreparable massive rotator cuff tear (IMRCT) was one of the causes of shoulder dysfunction, despite technical improvement, the failure rate of IMRCT was still demonstrated to be high. Traditional treatments like non-surgical treatments, partial rotator cuff repair, and tendon transfers could only achieve a slight improvement. A potential cause for high failure rate was the fact that traditional treatments cannot restore the superior stability of glenohumeral joint, and thus restricted the movement of shoulder joint severely. Superior capsular reconstruction (SCR) using a variety of grafts (autograft, allograft, xenograft, or synthetic grafts) provided a promising option for IMRCT. In surgery, graft was fixed medially to superior glenoid and laterally to the footprint of humeral greater tuberosity. SCR could increase the stability of the superior glenohumeral joint, decrease the subacromial pressure and acromiohumeral distance. This review summarized the relevant literature regarding the alternative grafts, surgery indications, operative techniques and clinical outcomes of SCR. we compared the different grafts, key surgical steps, the advantages and disadvantages of different surgical methods to provide clinicians with new surgical insights into the treatments of IMRCT. In conclusion, IMRCT without severe glenohumeral arthritis was the best suitable indication for SCR. The clinical outcomes were positive in the short-term and middle-term following-up. More studies were necessary to determine long-term results of this surgical procedure.

Key words: Graft; Indications; Irreparable massive rotator cuff tear; Superior capsular reconstruction; Surgery

Introduction

Massive rotator cuff tear (RCT) refers to a defect that exceeds 5 cm or involves two or more rotator cuff tendons[1], when it cannot be totally repaired because of tendon retraction, fat infiltration or muscle atrophy, it is termed irreparable massive rotator cuff tear (IMRCT)[2]. Patients with IMRCT show significant shoulder dysfunction[3].

Traditional treatments for IMRCT including conservative treatment[4], biceps tenotomy[5], partial rotator cuff repair[6], patch augmentation technique[7], tendon transfers[8,9], and reverse total shoulder arthroplasty[10]. Despite all of these options, the failure rate of IMRCT was still high. SCR, first described by Mihata in 2013[11], played an important role in restoring superior stability of glenohumeral joint by substituting a graft between the superior glenoid labrum and humeral head. As a new arthroscopic technique, SCR with autografts such as fascia lata and the long head of biceps tendon (LHBT), acellular dermal allograft, xenograft or synthetic graft showed significant clinical results in pain, range of motion (ROM), strength, graft healing, and the function[12]. A lot of surgical procedures and indications were addressed because of the discrepancy of the grafts[13–18].

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The purpose of this review was providing clinicians with new surgical insights into the treatments of IMRCT by a summary of the alternative grafts, indications, operative technique and clinical outcomes of SCR.

Methods

A literature search was conducted in Pubmed and Web of science, including the following key words: rotator cuff tear(s), superior capsule re, superior capsular reconstruction, indications, graft and massive. The publication date was set between 2000 and 2020. The boolean algorithm: ((superior capsule reconstruction) or (superior capsular reconstruction)) and ((rotator cuff tear) or (rotator cuff tears)) and ((indications) or (graft) or (massive)). Publications were considered if they reported any sort of indications, surgical techniques and clinical outcome of SCR. The exclusion criteria were: (i) non-irreparable rotator cuff tear; (ii) not relevant for SCR; (iii) animal, virtual and cadaveric models; (iv) editorial commentary and case report; v) unable to obtain full text; (vi) papers in languages other than English or Spanish.

The Alternative Grafts

Capsule, as a static stabilizer, provides stability at the extremes of motion. Based on the biomechanical effect, SCR can be used in RCT with poor tissue quality, tendon retraction or muscle atrophy[19–21]. Different grafts were used in clinic and achieve preliminary success[14,16,21,22].

The grafts used in SCR were commonly either acellular dermal allografts or fascia lata autografts. In 2013, Mihata[11] reported the outcomes of 24 shoulders in 23 consecutive patients with irreparable RCT using fascia lata autograft. Postoperative shoulder joint function of these patients improved significantly. In some more recent studies, Mihata[23] reported the outcomes of 100 patients and Lee *et al.*[24] reported the outcomes of 32 patients (36 shoulders) treated with SCR using fascia lata autograft, both achieved good short-term clinical effects.

In contrast to Mihata, other researchers like Denard[25], Pennington[26], and Hirahara[27] chose acellular dermal as allograft in SCR. In Denard's study, of the 59 patients, approximate 70% achieved successful primary effects. Pennington revealed that arthroscopic superior capsular reconstruction (ASCR) with acellular dermal allograft had an effect in reducing pain and improving the function of shoulder joints. Compared with acellular dermal allograft, the fascia lata autograft seemed to have superior clinical outcomes and showed a superior healing rate in SCR. Mihata[28] had compared those two grafts in a biomechanical cadaveric study, showing that the dermal allograft significantly elongated by 15% during testing, whereas the fascia lata autografts were unchanged.

The long head of biceps tendon (LHBT), hamstring tendon autograft and biological scaffolds composed xenogeneic or allogeneic cell-extracellular matrix (ECM) had been lately used in both preclinical studies and clinical settings[29–33]. LHBT had been used in many trails to support RCT repair. Comparing with fascia lata autograft or dermal allograft, it can reduce operation time and lower the risk of infection, however it cannot be used in patients whose LHBT was completely torn. When it came down to synthetic grafts or other biological scaffolds, cost and complication had to be considered. Polacek[34] used porcine dermal xenograft as a graft in SCR, this procedure had a 30% complication rate, including 15% rate of immunologic rejection.

For ensuring a good healing between graft and host tissue, the soft tissue that attached to the graft must be cleaned, and an appropriate thickness was the key to reduce re-tearing rates. For the thickness of grafts in SCR, acellular dermal allograft was usually 3 to 4 mm thick and fascia lata allograft was 6 to 8 mm thick. Mihata[35] compared a 4-mm-thick fascia lata graft with an 8-mm-thick fascia lata graft, biomechanical analysis showed that both the 4- and 8-mm-thick grafts had decreased subacromial contact pressure, the 8-mm-thick graft was better in reducing superior translation. Considering the balance between mechanical advantages and the risk of impact under the acromion, the thickness between 3 to 8 mm may be the best action.

Indication of Superior Capsular Reconstruction

SCR can increase the stability of the superior glenohumeral joint, reduce the subacromial pressure and moderate AHD. It was difficult to predict which patients were perfect indicated for this surgical procedure for lacking of long-term clinical outcome data, and the indications for SCR were often depending on the severity of lesions and surgical methods[36]. Here, four main indications were summarized for SCR.

Irreparabale Massive Rotator Cuff Tear

Irreparable RCT can be defined surgically as a tear in which directly tendon-to-bone repair and healing was impossible[2]. IMRCT had a relatively high re-tearing rate among all rotator cuff tears and was often debilitating patients[37]. In the past, surgeons relied on nonoperative methods, partial rotator cuff repair, graft augmentation technique, tendon transfer or reverse total shoulder arthroplasty. However, none of these options were optimal as an alternative to complete rotator cuff repair due to inherent complications with each of these procedures and poor clinical effects. SCR could reduce the complications through restoring superior stability and avoid the side effects of muscle atrophy, retraction and fatty infiltration. Most surgeons agreed that IMRCT without severe glenohumeral arthritis can be the best indication for SCR.

Massive Rotator Cuff Tear with Pseudoparalysis

Pseudoparalysis is defined as less than 90° of active elevation caused by an IMRCT[38]. Patients with pseudoparalysis were candidates for SCR. Burkhart *et al.*[39] found that profound pseudoparalysis of the shoulder (active elevation less than 45°) in IMRCT without arthritis was reversed in 90% of patients

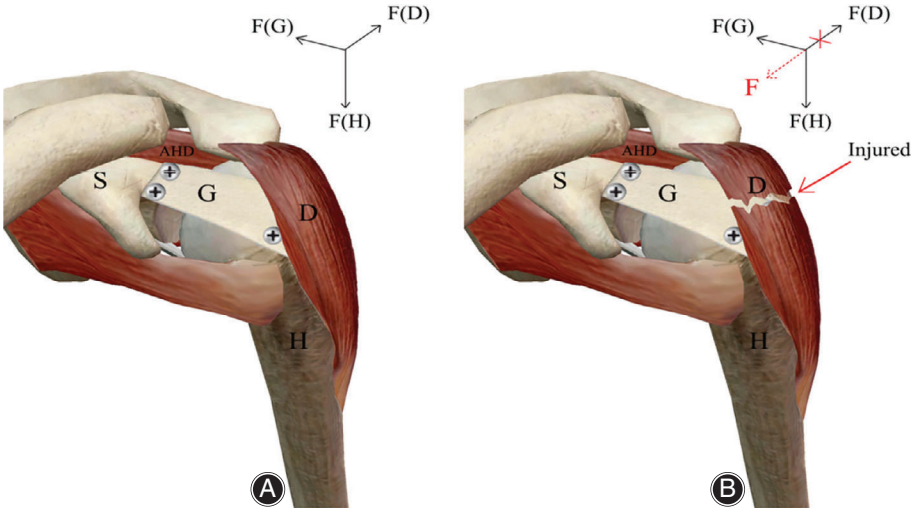

Fig. 1 The structure of glenohumeral joint after superior capsular reconstruction. (A) The force of the deltoid (D) combines the force produced by graft (G) and the gravity of humerus worked together to stabilize the humeral head in the glenohumeral joint. (B) After injured, the force generated by a dysfunctional deltoid was weakened (the red cross), the humeral head moved downward (the read dotted arrow) and the AHD was widened. (H, humeral head; S, scapula; AHD, acromiohumeral distance).

after arthroscopic SCR. Mihata[40] found pseudoparalysis was reversed in 96% (27 of 28) of patients with preoperative moderate pseudoparalysis and 93% (14 of 15) with preoperative severe pseudoparalysis, and concluded that SCR can eliminate pseudoparalysis in patients with IMRCT.

A Functional Deltoid

The superior capsule is attached to the undersurface of the supraspinatus and infraspinatus muscle-tendon units[3]. In the coronal plane, the deltoid muscle combines with the supraspinatus tendon and the superior capsule function as a coordinated couple. A deficit supraspinatus muscle or tendon leads to superior instability and downward migration of humeral head. The deltoid can restore downward force on the humerus to minimize laxity and improve joint kinematics and function (Fig. 1A). When the deltoid was insufficient, the force generated by the deltoid was weakened, as a result, the humeral head moves downward, the stability of the glenohumeral joint was damaged, and the AHD was widened (Fig. 1B). Thus, a functional deltoid was an essential for SCR.

A Failed Nonoperative Management

Currently, the main treatments of nonoperative management for IMRCT involved physical therapy and non-steroidal anti-inflammatory medication (NSAIDs). Levy *et al.*[41] assessed 17 patients who underwent an anterior deltoid training program, the constant scores increased from 26 to 60 after 9 month following-up, and the range of motion in forward elevation improved from a mean of 40° to 160°, however, the long-term outcomes were poor, especially for elderly patients. Subacromial corticosteroid injections as well as NSAIDs may be helpful in alleviating pain in conjunction with physical therapy, but offered only short-term effects. In these situations, SCR was a viable surgical option for patients who had undergone failed nonoperative treatments.

The overall indications for SCR continue to be evolving, like patients diagnosed with the IMRCT coupled with Bankart injures, severe degenerated medium to large RCT or delaminated RCT were all the possible candidates for SCR. It was generally accepted that this procedure was best utilized for patients with truly irreparable rotator cuff tears involving the supraspinatus and infraspinatus, for these patients who had undergone a failed rotator cuff repair procedure with poor tissue quality[42], SCR can be also a good choice.

Surgical Techniques

The surgical techniques of SCR derived from Mihata in 2007[11]. Following that, a variety of techniques have been reported[14,16,31,32,34,43–47]. According to the type of grafts, we summarized two main surgical procedures, one was the ASCR with fascia lata autograft or acellular dermal allograft, another was ASCR with the LHBT.

Arthroscopic Superior Capsular Reconstruction with Fascia Lata Autograft or Acellular Dermal Allograft

Patients performed this procedure in beach chair position or lateral position utilizing general endotracheal anesthesia. Firstly, a diagnostic arthroscopy was performed by using standard posterior and anterior mid-glenoid portals. Later, the subacromial space and glenohumeral joint were explored through the posterior portal. Checking the condition of LHBT and glenoid labrum, making sure whether a biceps tenotomy or tenodesis was needed. Pulling the torn tendon to the greater tuberosity by using tissue grasper, and making ensure the tendon cannot be completely repaired. The size of RCT and superior capsule were evaluated in both the anteroposterior and mediolateral directions at 45° shoulder abduction by using a measuring probe. Then, removing the pathologic bursal tissue that impeded clearance of the space, an arthroscopic subacromial decompression and a debridement were needed to ensure the healing of shoulder function. After that, debriding the superior glenoid and footprint of

the greater tuberosity to expose cortical bone by using a burr[11,19,20,27,48].

Two threaded anchors were inserted 5–6 mm above the medial of superior glenoid labrum according to the surgical condition. Mihata[11] recommended that the two anchors were inserted behind the midline of scapula, at 10 to 11 o'clock and 11 to 12 o'clock positions, while Sanchez[20] suggested these anchors should be inserted in the position of 1 and 2 o'clock in front of the midline of the scapula. In addition, Petri *et al.*[19] suggest three threaded anchors, one at the 12 o'clock position on the glenoid, and the other two at 10 o'clock and 2 o'clock. For the outer anchors, a double-row repair technique was performed on the humeral great tuberosity, for the inner, the anchors were inserted near the articular surface, one on the front and the other on the back. Meanwhile, considering using three anchors if the tears were wide enough [49]. The outer anchor was fixed after the graft was placed onto the shoulder joint.

In terms of harvesting grafts, for acellular dermal allograft, making sure this graft was 3 to 4 mm in thickness and using the data that was previously measured, the graft was cut to size, leaving 5mm of extra tissue anteriorly, posteriorly and medially, as well as 10 mm of extra tissue laterally[42]. For fascia lata autograft, making a vertical skin incision over the lateral thigh around the greater trochanter of the femur and harvesting a section of fascia lata 2 to 3 times the size of the superior capsular defect, the thickness after folding was guaranteed to be 6–8 mm. Punching the graft and passing the suture from the tunnel *in vitro* by using a suture tool, and the graft was pushed into the joint using a structure similar to a "pulley." Tighten the sutures and fixed the graft medially to superior glenoid labrum and laterally to the footprint of humeral greater tuberosity[11,27]. After the operation, the shoulder was fixed in the external location at an angle of 20°-45°. Hirahara[27] recommended fixing the shoulder joint in a neutral position. The surgical key steps with pearls and pitfalls were summarized in Table 1.

TABLE 1 Surgical key steps with pearls and pitfalls

Surgical key steps	Pearls	Pitfalls
Diagnostic arthroscopy	Check the condition of LHBT, rotator cuff and superior glenoid labrum, ensure that the humeral head is reducible	If there is severe rotator cuff arthropathy (Hamada Grade ≥ 3) or glenohumeral arthritis, this technique cannot be performed
Acromioplasty and debridement	Acromioplasty and debridement are performed to view entire cuff tear and glenoid	-
Humeral and glenoid bone bed preparation	Take care not to disrupt the superior labrum	If the labrum is not preserved, this technique will fail
Anchors insertion	Glenoid anchors should be placed 5 mm from the articular surface and ensure these anchors to an appropriate orientation	If not in properly orient, anchors may violate the articular cartilage
Graft preparation and passage	Make sure leaving extra tissue in the margin. Suture management is crucial for successful graft passage	Careless suture management may lead to a poor graft orientation
Graft fixation	The graft is tensioned and fixed into place with the shoulder abducted to 45°, Side-to-side repairing of the graft and remaining rotator cuff is important to improve force coupling of the shoulder	Fixation of the graft when the arm is at the side may not adequately tension the graft to ensure superior stability

LHBT, long head of biceps tendon.

Arthroscopic Superior Capsular Reconstruction with the Long Head Biceps of Tendon

ASCR had been demonstrated to be an efficient tool to manage IMRCT by using fascia lata autograft or acellular dermal allograft. Meanwhile, because of the proximity of the LHBT to the rotator cuff, many trials had used LHBT to support RCT repair[29,31,32,50–52]. Here, three main methods of ASCR with LHBT were concluded.

The Chinese Way

Under general anesthesia and additional interscalene never block, the patient was placed in the beach-chair position. Establishing six standard arthroscopic portals: posterior, posterolateral, lateral, anterolateral, anterior, and Neviaser portals. Later, making a careful check on the condition of LHBT quality, the rotator cuff lesion and the glenohumeral cartilage. Then the arthroscope was introduced into the subacromial space, an extensive bursectomy and release of the rotator cuff (RC) tendons adhesions were performed by using a motorized shaver and a radiofrequency electrocautery device. With a tendon grasper, an evaluation of RC retraction and degeneration was also performed. Later, refreshing the footprint of greater tuberosity using a burr.

One suture anchor was inserted approximately in the middle of greater tuberosity, passing all the sutures through intact LHBT using a suture passer and performing a "lasso-loop"[53] configuration. With the aid of the radiofrequency cautery device, the biceps tendon was dissected and tenotomized approximately at the middle of the bicipital groove. Sequentially, transferring the distal of LHBT at the footprint of supraspinatus tendon. No tenodesis was performed regarding the distal part of the LHBT.

If there was a remaining torn infraspinatus tendon, a partial repair was attempted and the sutures of LHBT were passed through the infraspinatus tendon to perform a side-to-side repair later. Two extra anchors were used in repairing the infraspinatus and subscapularis tendons. Finally, a side-to-side, tension-free marginal repair of the LHBT with both the infraspinatus and subscapularis tendons was performed.

Comparing with the method described by Mihata[11], the insertion of LHBT onto the glenoid was carefully preserved[29], and the distal part into the bicipital groove of LHBT was tenotomized, transferred, and fixed onto the middle part of the greater tuberosity, and the residual part of biceps was left untreated.

Arthroscopic in situ Superior Capsular Reconstruction

For those patients diagnosed with IMRCT with a functional LHBT, arthroscopic *in situ* SCR using LHBT can be performed[32]. The former steps were similar with the Chinese way, the difference lay in the handling of LHBT, refreshing the bone bed of footprint through the anterolateral portal and using a retriever to posteriorly reposition of the LHBT to the greater tuberosity. Then it came down to the fixation of LHBT, after anchor insertion at the lateral aspect of footprint, a suture hook preloaded with No. 1 PDS (Ethicon) was introduced through the anterior portal to make a lasso-loop tie[53] and then passing it through the body of the LHBT. Later, another anchor was inserted at the junction of joint cartilage and the footprint, one lasso-loop tie and two wrap-around ties were made for the medial fixation of LHBT. This was the final procedure of arthroscopic *in situ* SCR using an LHBT procedure *via* a re-routing technique. A tenotomy of the LHBT can be performed at the distal aspect of the lateral anchor if tendon integrity was not sufficient to maintain itself.

After finishing the arthroscopic *in situ* SCR with the LHBT, the rotator cuff repair should be performed. An additional anchor can be inserted posterolaterally into the greater tuberosity of the humeral head just behind the LHBT for repair of the posterior rotator cuff. The sutures from the two previously inserted anchors that served to fix the LHBT can be used to repair the rotator cuff. And for massive rotator cuff tear, a partial repair was acceptable through arthroscopic *in situ* SCR with the LHBT. The shoulder was fixed with an abduction brace.

The Snaked Technique

Kim *et al.*[53] described a modified technique for ASCR using biceps to preserve the LHBT anchors to the glenoid labrum (the snake technique). The indications for this technique concluded a good quality of the LHBT (normal or 20% partial tear) and minimal to no glenohumeral arthritis.

The patients were positioned in the beach-chair position with arms externally rotated 30° abducted while under general anesthesia. Checking the condition of glenohumeral joint, the AHD, the cuff tissue and the attachment of the LHBT to the glenoid labrum through anterior and posterior portals. Bursectomy was performed with a shaver through the lateral portal. An acromioplasty and a coracoacromial ligament release were performed if needed. The humeral head and the glenoid were decorticated with a burr.

After confirming the quality of the LHBT, it came to the harvest of biceps autograft and open subpectoralis tenodesis. An approximately 3-cm longitudinal skin incision was made at the inferior border of the pectoralis major tendon and anteromedial aspect of the humerus. The length of biceps autograft was based on the tenotomy level, approximately 14 cm of the LHBT. The biceps tenotomy was performed and subpectoralis biceps tenodesis was performed with an anchor, cleaning the surrounding soft tissue including the mesotendon attached to the biceps autograft.

A laser-marked probe was used to measure anterior-to-posterior and medial-to-lateral cuff tear size, diameter of the LHBT, and length of intra-articular portion of LHBT. The distal part of the harvested biceps autograft was pulled to the subacromial space, the first bundle of the biceps autograft was fixed at the greater tuberosity by using am inserted anchor. The biceps should be fixed with the arm in neutral rotation at 30° of abduction. Later, an anchor was inserted into the posterior glenoid through the Neviaser portal and pulled the biceps autograft through a posteromedial portal and fixing it with proper tension. Considering this may not be enough to restore the superior capsule with two bundles, a third bundle was needed, the remainder of the biceps autograft was pulled through the lateral portal and fixed with an anchor inserted into the greater tuberosity of the humerus posteriorly. The rotator cuff partial repair was performed after SCR. After surgery, the patients were applied with a shoulder abduction brace.

LHBT as a graft in SCR has been promoted in recent years, the key steps of those three surgical methods were summarized in Table 2, and the final surgery outlines of different surgical methods can be seen in Fig. 2.

Clinical Outcomes

Despite a lack of long-term follow-up, the clinical outcome for SCR demonstrated to be great in the short-term. Mihata[11] reported the cases of 23 patients (24 shoulders), postoperative MRI scans showed that 20 patients (83.3%) had no graft tear or tendon re-tearing during an average following-up of 34.1 months. Mean active elevation increased significantly from 84°to 148°and external rotation increased from 26°to 40°. The American Shoulder and Elbow Surgeons (ASES) score improved from 23.5 to 92.9 points and there were no cases of progression of osteoarthritis or rotator cuff muscle atrophy. Also, no cases of arthritis progression or rotator cuff muscle atrophy occurred. No complications such as neural injury, infection, or suture anchor problems were found. More recently, in other research, Mihata *et al.*[23] published the results of 100 patients undergoing SCR with fascia lata autograft. All 26 patients who played sports before their

TABLE 2 Comparison of surgical key steps about different arthroscopic SCR using LHBT

The Chinese way	Arthroscopic *in Situ* SCR	The snake technique
1. Diagnostic arthroscopy	1. Diagnostic arthroscopy	1. Diagnostic arthroscopy
2. Bursectomy and cleaning of the subacromial	2. Debridement of the sofe tissue around the LHBT	2. Bursectomy, aromioplasty and coraoaromial ligament release
3. Humeral bone bed preparation and anchors insertion	3. Humeral bone bed preparation for rerouting the LHBT	3. Humeral and glenoid bone bed preparation and anchors insertion
4. Dissect the LHBT approximately at the middle of the bicipital groove	4. Lateral insertion of anchor to fix the LHBT	4. Biceps tenodesis, harvest of biceps autograft and open subpectoralis
5. Transfer the LHBT and fix it onto the greater tuberosity	5. One lasso-loop and two wrap-around ties were made at the lateral anchor	5. First bundle, the biceps are fixed onto the greater tuberosity
6. No tenodesis of the distal part of LHBT is performed.	6. Medial insertion of another anchor and fixation of the medial LHBT	6. Second bundle, the biceps are fixed onto the glenoid
7.Partial repair of infraspinatus tendon	7. Insertion of additional anchor just posterior to the lateral LHBT anchor	7. Third buddle (if necessary), the biceps are fixed onto the greater tuberosity posterior to the second bundle
8. Final construct, secure the sutures of the anchor by performing a side-to-side, tension-free marginal repair of the rotator cuff with LHBT	8. Rotator cuff repair with sutures from 3 anchors	8. Partial repair (if needed)

SCR, superior capsular reconstruction; LHBT, long head of biceps tendon

injuries returned fully to playing sports, 32 of 34 patients returned fully to their previous physical work. The AESE scores increased from 36 ± 19 points preoperatively to 92 ± 12 points postoperatively and the Japanese Orthopedic scores increased from 53 ± 13 points to 91 ± 11 points. Mean active ROM increased significantly at final following-up: for elevation, by 56° (from 91° to 147°); for external rotation, by 15° (from 26° to 41°); and for internal rotation, by three vertebral bodies (L4 to L1). A rate of 16% complications occurred after surgery, including two deep infections, four suture anchors loose, two severe shoulder contractures, three infraspinatus tendon retearing of repaired infraspinatus tendon and five graft retearing.

Denard *et al.*[25] summarized the results of 59 patients performed with SCR using dermal allograft, the forward flexion improved from 130° preoperative to 158° postoperative, and external rotation improved from 36° to 45°in a minimum following-up of 1 year. Comparing with the preoperative scores, the visual analog scale (VAS) decreased from 5.8 to 1.7, the ASES score improved from 43.6 to 77.5, and the subjective shoulder value (SSV) score improved from 35.0 to 76.3. According to the postoperative MRI, 45% (9 of 20) of the grafts demonstrated complete healing. Forty-six (74.6%) cases were considered a success. Overall, a 67.8% success rate was reported. Burkhart *et al.*[49] were optimistic that SCR with dermal allograft may be an alternative method for patients with IMRCT. Pennington *et al.*[26] reviewed 86 patients (88 consecutive shoulders) presenting with IMRCT that treated with SCR using acellular dermal allograft. The outcomes revealed the VAS scores improved from 4 to 1.5, the ASES scores increased from 52 to 82 at 1-year follow-up. ROM improved in both abduction and forward flexion: 39° for forward flexion and 56° for abduction. The overall satisfaction was 90% and only a few complications were reported. Three graft tears were revealed, one patient experienced increased pain and lack of function, and one patient experienced a revision surgery.

Rosales-Varo[54] reviewed 8 patients diagnosed with irreparable RCT underwent SCR using autologous hamstring graft. After 1- year follow-up, the constant scores increased from 49 to 77.25, the active flexion improved from 99.3° to 142.5°. Polacek[34] observed 19 patients (20 shoulders) for a mean of 12 months after ASCR with porcine acellular dermal matrix xenograft. The mean Shoulder Pain and Disability Index score showed significant improvement from 51.3% to 10.4%. Active abduction improved from 65.4° to 149.3° and active forward flexion improved from 68.6° to 151.4°, the overall satisfaction came to 60% in all case. However, the procedure had a 30% complication rate, including a 15% rate of immunologic rejection of the xenograft.

Considering the overall complications, the fascia lata autograft seemed to have better clinical results and healing rate than allograft and xenograft. Here, a comparison about advantages and disadvantages with different grafts were summarized in Table 3.

Summary

The treatment of IMRCT had always been a problem that needed to be solved urgently, because of the poor clinical outcomes of traditional methods, SCR, as a newly surgical alternative, was promoted by many surgeons. Comparing with the traditional patch transplantation, SCR had the effect of stabilizing the glenohumeral joint, enhancing the AHD, and preventing the humeral head from moving upwards.

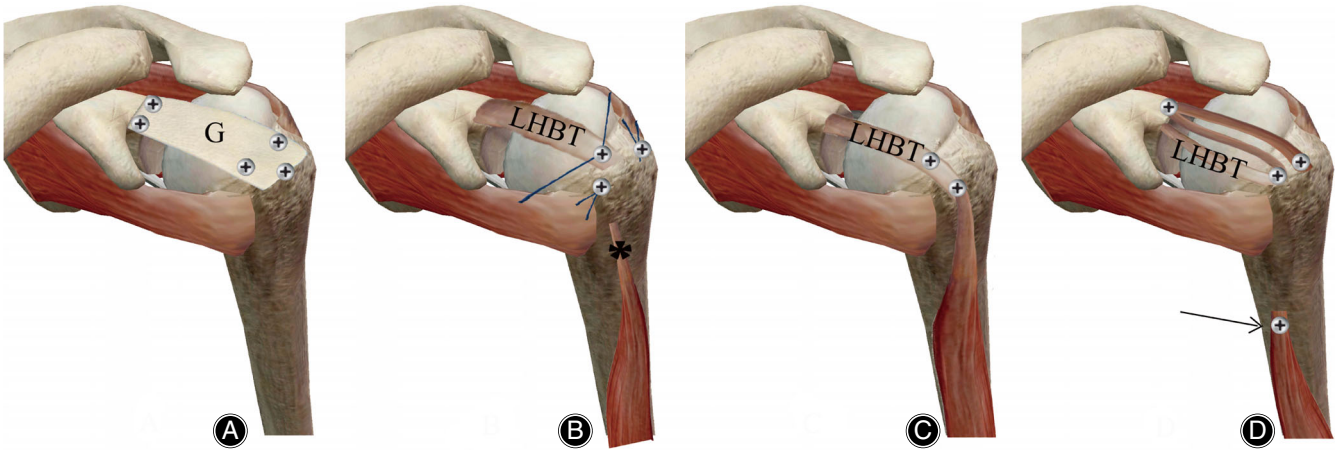

Fig. 2 The final surgery outlines of different surgical methods. (A) Arthroscopic superior capsular reconstruction with fascia lata autograft or acellular dermal allograft. Graft (G) was fixed medially to superior glenoid labrum and laterally to the footprint of humeral greater tuberosity. (B) The Chinese way. The distal of LHBT was fixed by an anchor, the infraspinatus and subscapularis tendons were sutured, a side-to-side repair of the LHBT with both the infraspinatus and subscapularis tendons was performed, the residual part of the LHBT (asterisk) was left free. (C) Arthroscopic *in situ* SCR using LHBT. The LHBT was re-routed onto the medial glenohumeral joint by a lateral anchor and a medial anchor, a tenotomy of the LHBT can be performed at the distal aspect of the lateral anchor if tendon integrity was not sufficient to maintain itself. (D) The snake technique. A tenotomy of the LHBT was performed under the subpectoral and subpectoralis biceps tenodesis was performed with an anchor (the black arrow). Two bundles were needed in the fixation of LHBT, if the tears were wide enough, the third bundle was used. (LHBT, long head of biceps tendon).

Table 3 Advantages and disadvantages of arthroscopic SCR using different grafts

Surgical method	Common advantages	Different advantages	Disadvantages
Arthroscopic SCR using LHBT	1.Safe and effective procedure for IMRCT 2 .Restoring the superior stability of glenohumeral joint and allowing for the humeral head back to its anatomical position 3. Lowering the subacromial pressure and acromiohumeral distance	1. Reduce operation time and the risk of infection 2. LHBT tissue can be used as a scaffold during SCR 3. technically easier than SCR with fascia lata or acellular dermal allograft 4. No donor site morbidity 5.LHBT tenodesis effect	1. Possible pain from stretched LHBT 2. Not feasible for patients whose LHBT is completely torn 3. Cannot be used in excessive degeneration of LHBT and patients with rotator cuff arthropathy (Hamada Grade ≥ 4)
Arthroscopic SCR using dermal allograft		1. No outside joint procedure 2. Can be performed in a failed rotator cuff repair and the retracted tendons does not allow for an anatomical repair 3. No donor morbidity associated with the graft	1. Technical demand is higher 2. High cost 3. The RCT is not an anatomical repair 4. Cannot be used in severe rotator cuff arthropathy (Hamada Grade ≥ 3) or glenohumeral arthritis
Arthroscopic SCR using fascia lata autograft		1. A greater graft strength. 2. Avoid the elongation of graft	1. Technical demand is higher 2. High cost 3. Additional skin incision 4. A donor-site morbidity
Arthroscopic SCR using xenograft		1. No outside joint procedure 2. No donor morbidity associated with the graft 3. Reduce operation time	1. The strength of graft is poor 2. Graft-related complications 3. The immunologic response is high

SCR, superior capsular reconstruction; LHBT, Long head of biceps tendon; IMRCT, Irreparable massive rotator cuff tear.

The IMRCT without severe glenohumeral arthritis was the best suitable indication for SCR. The surgical methods were mostly depending on the surgical indications and the condition of rotator cuff. Comparing with LHBT and xenograft, the fascia lata autograft and the dermal allograft were the most commonly used grafts in clinic, however, there

was no uniform standards in regard of choosing graft, additional researches can be carried out around the selection of graft materials. The key for a successful SCR was a good adhesion of graft. The clinical outcomes were positive in the short-term and middle-term following-up. More studies were necessary to determine long-term results of this surgical procedure.

Author contribution

Binghua Zhou and Kanglai Tang are responsible for the conception and design of the literature review, and participated in the critical revision of the review for important intellectual content, critically reviewing the intellectual content of the article; Huaisheng Li is responsible for data collection and article writing.

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