Current Concept

Clin Shoulder Elbow 2023;26(4):438-444
https://doi.org/10.5397/cise.2023.00514

CiSE
Clinics in Shoulder and Elbow

eISSN 2288-8721

Superior capsular reconstruction for irreparable rotator cuff tear: a review of current methods

Seok Won Chung[1], Dong-Hyun Kim[2], Hyun Joo Lee[2], Won Ki Hong[2], Seung Ho Chung[2], Jong Pil Yoon[2]

[1]*Department of Orthopedic Surgery, Konkuk University Medical Center, Seoul, Korea*
[2]*Department of Orthopedic Surgery, Kyungpook National University Hospital, Daegu, Korea*

Irreparable massive rotator cuff tears can significantly impact daily life; and these types of tears can be difficult to repair completely, especially in younger patients who are more active and have higher functional requirements. Since its introduction by Mihata and the colleagues, superior capsular reconstruction (SCR) has gained popularity in the treatment of irreparable massive rotator cuff tears and has shown promising short-term results. A variety of studies have focused on the clinical and biomechanical outcomes of this procedure. This article reviews the biomechanics, indications for the surgical procedure, graft options, surgical technique, and rehabilitation from SCR.

Keywords: Shoulder; Rotator cuff; Massive; Reconstruction

INTRODUCTION

Irreparable massive rotator cuff tears are a serious, painful problem that can significantly impact daily life. Routine tasks such as bathing, dressing, sleeping, housework, meal preparation, overhead activities, and work present challenges. These types of tears can be difficult to repair completely and have a high risk of re-rupture, leading to poor postoperative results. For elderly patients with fewer functional requirements, several surgical options are available; but these options are not as suitable for younger patients who have higher functional requirements. Younger patients can only be treated with tendon transfer or patch augmentation. Reverse total shoulder arthroplasty is effective in elderly patients with severe rotator cuff tears but has a high rate of complications and failure in younger, active patients under the age of 65. For this group, this procedure is not a long-term solution [1].

Superior capsular reconstruction (SCR), a surgical technique using autologous tissue or allograft that was first proposed by Mihata et al. [2], has gained popularity in treatment of irreparable rotator cuff tears and has shown promising short-term results. Many research efforts have focused on the clinical and biomechanical outcomes of this procedure. One prior study indicated that the procedure has the potential to decrease pressure on the acromion, enhance humeral translation, and yield favorable clinical outcomes in the short term [3]. The purpose of this article is to review the biomechanics associated with the procedure; indications for performing the procedure; graft type, thickness, size, and tensioning; surgical technique; and rehabilitation from the procedure.

BIOMECHANICS

In the glenohumeral joint, rotator cuff muscles and the deltoid

Received: June 22, 2023 Revised: August 20, 2023 Accepted: August 30, 2023
Correspondence to: Jong Pil Yoon
Department of Orthopedic Surgery, Kyungpook National University Hospital, School of Medicine, Kyungpook National University, 130 Dongdeok-ro, Jung-gu, Daegu 41944, Korea
Tel: +82-53-200-5628, Fax: +82-53-422-6605, E-mail: altjp1@gmail.com, ORCID: https://orcid.org/0000-0001-6446-6254

muscle cooperate to maintain the shoulder joint balanced. The rotator cuff helps stabilize the joint and prevents the humeral head from moving upwards when the deltoid muscle contracts. A massive tear in the rotator cuff can disrupt the balance of forces in the shoulder, causing superior humeral head migration and altering the amount and direction of force at the shoulder joint. This imbalance in the shoulder joint due to a massive tear can make lifting and moving the arm difficult and decrease the overall function of the shoulder joint. If the imbalance continues, further damage to the rotator cuff and degeneration of the shoulder joint are the result [4].

Beneath the rotator cuff, a thin layer of continuous collagen sheet, the superior capsule, is present. This capsule extends from the glenoid labrum medially to the humerus laterally. A previous anatomical study showed that maximum capsular thickness should be 9.1 mm at its attachment to the greater tuberosity for stabilizing superior humeral head translation [5]. Ishihara et al. [6] previously demonstrated that the capsule also plays a significant role in glenohumeral joint function. The capsule is also completely torn in cases of massive rotator cuff tear, causing the superior migration of the humeral head. Therefore, reconstructing the superior capsule through SCR is an appropriate way to restore superior stability in the glenohumeral joint.

SURGICAL INDICATIONS

There have been few SCR studies, and thus the indications for SCR surgery have not been thoroughly established. However, based on current evidence, SCR is a viable option for patients with massive and irreparable rotator cuff tears with severe muscle atrophy and fat infiltration. These patients should have minimal to no rotator cuff arthropathy (Hamada grade 1, 2). Young patients in whom RSA is not an acceptable option, particularly those with minimal rotator cuff tear arthropathy (Hamada grade 1, 2) in whom rotator cuff repair was unsuccessful, are candidates for SCR. Mihata et al. [7] demonstrated that SCR was able to reverse preoperative pseudoparalysis in patients with irreparable rotator cuff tears. Therefore, patients with preoperative pseudoparalysis who are not suited for RSA could be potential candidates for SCR. However, SCR is not recommended for patients who have severe cuff tear arthropathy (Hamada grade ≥3) or who have a non-functional deltoid muscle. When patients have severe cuff tear arthropathy, a SCR will not restore the glenohumeral joint space; affected patients can be better served with shoulder arthroplasty [8]. If deltoid function is insufficient, the force generated by the deltoid is weakened; and, as a result, the humeral head moves downward, the stability of the glenohumeral joint is damaged, and the acromiohumeral distance is widened. Thus, a functional deltoid is essential for SCR [9]. Further study is especially needed for elderly patients with irreparable rotator cuff tears without severe cuff tear arthropathy.

GRAFT TYPE

Mihata et al. [2] initially reported using a fascia lata autograft for SCR. This method showed promising early results, but the thickness of the fascia lata graft was not sufficient and required doubling of the construct. Additionally, concerns were raised regarding potential complications at the donor site resulting from the large incision required for graft harvesting. Acellular dermal allografts have been suggested as an alternative. These are potentially stronger and virtually eliminate donor site morbidity [10]. Acellular dermal allografting has minimal immunologic risk, and these grafts have been shown to integrate well, provide a scaffold for neovascularization, and maintain structural integrity. The advantages of this graft include no donor site morbidity, ease of preparation, thickness and strength of the construct, and biologic incorporation. Several studies have reported on the biomechanical properties and clinical outcomes of these grafts. In a cadaveric study comparing two different types of grafts for use in SCR, a fascia lata allograft totally restored superior stability in the shoulder joint; however, an acellular dermal allograft only partially restored the stability [11]. Another biomechanical study compared the use of two different thicknesses of acellular dermal allografts in SCR. In this study, a graft with a thickness of 6 mm demonstrated superior restoration of joint position and forces compared to a graft with a thickness of 3 mm [12]. A third study compared three different types of grafts, fascia lata allograft, double layered acellular dermal allograft, and single layered acellular dermal allograft, used in SCR and found that all three were able to restore superior humeral translation and subacromial contact pressure and varying glenohumeral abduction angle. The fascia lata allograft and double layer dermal allograft were, however, more effective than the single layer dermal allograft [13]. Furthermore, the utilization of a 6-mm-thick dermal allograft proved to be equally effective as a fascia lata allograft in terms of restoring the subacromial space and minimizing peak subacromial contact pressures [14]. Mihata et al. [15] conducted a study to evaluate the clinical and radiological outcomes of SCR after 5 years of follow-up. The results showed that SCR was successful in restoring shoulder function and allowing patients to return to sports and work. None of the patients who experienced successful healing of the graft exhibited worsening of cuff tear arthropathy. However, three patients who experienced graft failure showed progression

of cuff tear arthropathy by the end of the 5-year follow-up period [15]. In a recent systematic review, five studies were analyzed. In two, the patients underwent a fascia lata autograft procedure; in the other three, the patients received an acellular dermal allograft. All the studies showed statistically significant improvements in active elevation, American Shoulder and Elbow Surgeons (ASES) score, and Constant score after a mean follow-up of 12 to 48 months postoperatively. The graft tear rate in those receiving a fascia lata autograft ranged from 5% to 32%, while the graft tear rate in those receiving an acellular dermal allograft ranged from 20% to 75% [16]. Another systematic review analyzed nine clinical studies involving the use of fascia lata autografts and human dermal allografts for SCR. The fascia lata autograft studies showed improvements in the ASES score, forward elevation, external rotation, and acromiohumeral distance. Acellular dermal allograft studies showed improvements in forward elevation, acromiohumeral distance, ASES score, and visual analog scale score [17]. Recently, some groups reported studies related to a new graft type based on the fascia lata autograft reinforced with a non-resorbable suture mesh that precludes the need for large amounts of fascia lata autograft. These studies showed improvements in clinical outcome scores and the range of motion [18]. Dermal allograft and fascia lata autograft for SCR showed similar improvements in results, and the rates of graft tear and reoperation were clinically similar. One notable disadvantage of fascia lata autograft is donor site morbidity, and recent advances such as minimally invasive harvesting have reduced the rates of donor site morbidity. Donor site morbidities include slightly lower functional scores of the affected thigh, subjective loss of strength, and local complications [19]. These results suggest that donor site morbidity after fascia lata autograft is an important consideration when choosing graft type but should not disqualify the use of fascia lata autograft for SCR. The previous studies regarding graft type are summarized in Tables 1 and 2 [16,18,20-35].

GRAFT THICKNESS AND SIZE

A previous study reported that the thickness of the superior capsule ranged from 4.1 to 9.1 mm [5]. Biomechanically, using a fascia lata allograft that was either 4-mm- or 8-mm-thick reduced subacromial peak pressure. However, only an 8-mm-thick fascia lata allograft was successful in decreasing the superior translation of the shoulder joint [36]. A human dermal allograft with 6-mm thickness had equivalent results in terms of maximum abduction angle, subacromial peak pressure, superior translation, and cumulative force of the deltoid muscle compared to the normal state. However, comparing 3-mm-thick to 6-mm-thick allografts, there were significant differences in superior translation of the glenohumeral joint [12]. Also, a single 6-mm-thick acellular dermal allograft was just as effective as a 8-mm-thick fascia lata allograft in terms of peak subacromial pressures and acromiohumeral distance [14]. The results showed that the thickness of the graft material affects the amount of superior translation of the humeral head, and a graft thickness of 6 mm or more is optimal.

Table 1. Summary of previous clinical studies using tensor fascia-lata autograft for superior capsular reconstruction

Study	Graft type	Graft thickness (mm)	Graft tensioning (position of shoulder during fixation)	Margin convergence	Fixation technique
Mihata et al. (2018) [20]	Tensor fascia lata autograft	6–8	30°–45° Abduction	Yes (anterior, posterior)	Med, 2 anchors; Lat, 2 by 2 double row
Yoon et al. (2018) [21]	Tensor fascia lata autograft	NA	NA	Yes (anterior, posterior)	Med, 2 anchors; Lat, 2 by 2 double row
Lee and Min (2018) [22]	Tensor fascia lata autograft	6	30° Abduction	Yes (posterior)	Med, 2 anchors; Lat, 2 anchors single row
Lim et al. (2019) [23]	Tensor fascia lata autograft	>6	NA	Yes (posterior)	Med, 2 or 3 anchors; Lat, 2 by 2 double row
Gracitelli et al. (2019) [24]	Tensor fascia lata allograft	4–6	45° Abduction	Yes (posterior)	Med, 2 anchors; Lat, 2 anchors single row
de Campos Azevedo et al. (2020) [16]	Tensor fascia lata autograft	5–8	10° Abduction	Yes (anterior, posterior)	Med, 2 anchors; Lat, 2 by 2 double row
Kholinne et al. (2020) [25]	Tensor fascia lata autograft with mesh	>6	NA	Yes (anterior, posterior)	Med, 3 anchors; Lat, 2 by 2 double row
Polacek et al. (2020) [18]	Tensor fascia lata autograft with mesh	6–8	30° Abduction	Yes (anterior, posterior)	Med, 2 anchors; Lat, 2 by 2 double row

Med: medial, Lat: lateral, NA: not available.

https://doi.org/10.5397/cise.2023.00514

Table 2. Summary of previous clinical studies using acellular dermal allograft for superior capsular reconstruction

Study	Graft type	Graft thickness (mm)	Graft tensioning (position of shoulder during fixation)	Margin convergence	Fixation technique
Petri et al. (2015) [26]	Acellular dermal allograft	3	NA	Yes (anterior, posterior)	Med, 3 anchors; Lat, 2 by 2 double row
Sutter et al. (2017) [27]	Acellular dermal allograft	3.5	30° Abduction	Yes (posterior)	Med, 2 anchors; Lat, 2 by 2 double row
Andersen et al. (2017) [28]	Acellular dermal allograft	1.5, 3.5	NA	Yes (anterior, posterior)	Med, 2 anchors; Lat, 2 by 2 double row
Pogorzelski et al. (2017) [29]	Acellular dermal allograft	3	NA	Not available	Not available
Denard et al. (2018) [30]	Acellular dermal allograft	1–3	20°–30° Abduction	Yes (anterior, posterior)	Med, 2 anchors; Lat, 2 by 2 double row
Tokish et al. (2018) [31]	Acellular dermal allograft	NA	NA	Yes (posterior)	Med, 3 anchors; Lat, 2 anchors single row
Altintas et al. (2018) [32]	Acellular dermal allograft	2.5	NA	Yes (anterior, posterior)	Med, 3 anchors; Lat, 2 by 2 double row
Laskovski et al. (2018) [33]	Acellular dermal allograft	3.5	30° Abduction	Yes (anterior, posterior)	Med, 2 anchors; Lat, 2 anchors single row
Pennington et al. (2018) [34]	Acellular dermal allograft	3	45° Abduction	Yes (anterior, posterior)	Med, 3 anchors; Lat, 2 by 2 double row
Burkhart et al. (2020) [35]	Acellular dermal allograft	3	20°–30° Abduction	Yes (anterior, posterior)	Med, 2 anchors; Lat, 2 by 2 double row

NA: not available, Med: medial, Lat: lateral.

GRAFT TENSIONING

Graft tensioning is important for proper glenohumeral contact fixation. According to recent studies, the ideal abduction angles during graft fixation vary depending on the type of material used. The method of graft tensioning involves abduction of the glenohumeral joint while performing the fixation process [36]. Mihata et al. [36] reported that an arm abduction angle ranging from 15° to 45° during reconstruction are important for successful reconstruction of the superior capsule. Different abduction angles using acellular dermal allografts have been reported; the best angle and graft tension for SCR has yet to be determined [10]. In a biomechanical study, Adams et al. [37] showed that when the SCR was tensioned at 15° of glenohumeral abduction, the deltoid muscle required similar amounts of force to abduct as in the intact state. Dyrna et al. [38] conducted a study involving 10 cadaveric shoulders and found that using a tensioned graft for SCR resulted in a statistically significant increase in maximum shoulder abduction compared to a non-tensioned graft. However, the maximum abduction achieved was still less than that of an intact shoulder. Specifically, using a tensioned SCR helped to restore a maximum abduction of 81% of the normal range of motion [38].

In practice, many surgeons follow Mihata et al.'s guidance to fix SCR grafts at shoulder abduction angles ranging from 10° to 45°. However, there is insufficient clinical evidence to determine the best abduction angle to use for different types of SCR grafts.

SURGICAL TECHNIQUES

Since Mihata et al.'s technique [2] was first described, various techniques have been developed for SCR. An arthroscopic procedure was developed to confirm the rotator cuff tear pattern and severity, especially the extent of retraction and mobility of the rotator cuff tendon. After the rotator cuff tear is determined to be irreparable, acromioplasty is performed to create a smoother surface and prevent potential damage to the repaired tissue after the surgery. Mihata et al. [2] recommend including acromioplasty during SCR as acromioplasty can decrease the subacromial contact area. However, according to other studies, acromioplasty is not always necessary in SCR and was not conducted in all studies [39]. Surgeons may choose to perform acromioplasty if there is evidence of abrasion below the acromion. The subscapularis needs to be examined and, if necessary, repaired. Then, either a biceps tenodesis or tenotomy is performed. All soft tissues around the superior glenoid and footprint of the greater tuberosity are debrided. After performing decortication around the footprint of the greater tuberosity, graft sizing is conducted with the shoulder abducted. Two suturing devices are placed in the upper part of the glenoid. The initial anchor in the glenoid is inserted

behind the edge of the remaining interval tissue or subscapularis, while the second glenoid anchor is inserted in front of the edge of the remaining infraspinatus or teres minor tissue. Then, two suture anchors are positioned next to the joint margin. For preparation of the graft, the graft is folded in half, creating a 6-mm thickness with its fold oriented towards the back. Precision is ensured during hole creation in the graft using an 11-blade scalpel, leaving approximately 3 to 5 mm of the graft at its respective edge. The graft is inserted into the subacromial area under the guidance of suture threads passed through the lateral portal. The medial portion of the graft is tied with a knot; and during the fixation, the medial edge of the graft is firmly attached to the glenoid neck inferior to any residual rotator cuff tissue. The lateral portion of the graft is secured using a double-row or single-row suture bridge technique. To our knowledge, no clinical outcome studies have compared double-row to single-row SCR graft fixation for the lateral portion of graft. However, in one study in which single-row SCR graft fixation was used, a high magnetic resonance imaging graft failure rate and high reoperation rate were observed. This suggests that greater tuberosity fixation should be performed with an equivalent double-row transosseous fixation [22]. Margin convergence sutures are placed between the graft and the remaining infraspinatus or teres minor posteriorly and the interval tissue or subscapularis anteriorly. Anterior margin convergence can aid in graft tensioning, but the rotator interval tissues may sometimes be absent. Care should be taken not to over-constrain the shoulder anteriorly by attaching the graft to the subscapularis. This would be equivalent to closing the rotator interval. Posterior margin convergence is necessary to prevent subluxation of the humeral head and to allow restoration of the rotator cable. Furthermore, posterior or anterior margin convergence may increase the survival rate of graft by accelerating the vascularization, which results in graft structural strength reinforcement. Mihata et al. [2] suggested that using side-to-side suturing between the graft and the infraspinatus or subscapularis tendons is beneficial. However, a biomechanical study reported that SCR without additional side-to-side suturing did not significantly reduce the superior translation of the glenohumeral joint.

Nevertheless, the inclusion of side-to-side suturing resulted in the restoration of superior stability to a level comparable to that of the normal state [40].

REHABILITATION

After undergoing SCR, the rehabilitation protocol is similar to that of repairing massive rotator cuff tear. The shoulder is maintained in a stable position for a duration of 6 weeks using a shoulder abduction brace set at an angle of 30° to 45° of abduction [41]. Pendulum exercises with passive elevation are allowed 6 weeks after surgery. If the expected range of motion is achieved at 3 months after surgery, then the next exercises need to focus on strengthening the rotator cuff and muscles around the shoulder. Complete participation in sports activities are permitted around 6 months after the surgical procedure [42].

CONCLUSIONS

The treatment of irreparable rotator cuff tears remains challenging. SCR is a promising treatment option especially for certain indications. After its introduction by Mihata et al., various studies of its biomechanical properties and clinical outcomes have been conducted. Further research on long-term clinical outcomes and other contributing properties are needed to fully understand the factors that can affect SCR outcomes.

NOTES

ORCID

Seok Won Chung https://orcid.org/0000-0002-8221-9289
Dong-Hyun Kim https://orcid.org/0000-0001-9078-5953
Hyun Joo Lee https://orcid.org/0000-0003-2837-3434
Won Ki Hong https://orcid.org/0000-0003-1076-9369
Seung Ho Chung https://orcid.org/0000-0001-7432-724X
Jong Pil Yoon https://orcid.org/0000-0001-6446-6254

Author contributions

Conceptualization: SWC, JPY. Data curation: SWC, DHK, HJL, WKH, SHC. Resources: SWC. Supervision: SWC, JPY. Validation: SWC. Writing – original draft: SWC, DHK, WKH, SHC, JPY. Writing – review & editing: SWC, DHK, WKH, SHC, JPY.

Conflict of interest

Jong Pil Yoon is an editorial board member of the journal but was not involved in the peer reviewer selection, evaluation, or decision process of this article. No other potential conflict of interest relevant to this article was reported.

Funding

This study was supported by the National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIT) (NRF-2022R1A2C1005374).

Data availability

None.

https://doi.org/10.5397/cise.2023.00514

Acknowledgments
None.

REFERENCES

1. Otto RJ, Clark RE, Frankle MA. Reverse shoulder arthroplasty in patients younger than 55 years: 2- to 12-year follow-up. J Shoulder Elbow Surg 2017;26:792–7.
2. Mihata T, Lee TQ, Watanabe C, et al. Clinical results of arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. Arthroscopy 2013;29:459–70.
3. Smith TJ, Gowd AK, Kunkel J, Kaplin L, Waterman BR. Superior capsular reconstruction provides sufficient biomechanical outcomes for massive, irreparable rotator cuff tears: a systematic review. Arthroscopy 2021;37:402–10.
4. Thompson WO, Debski RE, Boardman ND 3rd, et al. A biomechanical analysis of rotator cuff deficiency in a cadaveric model. Am J Sports Med 1996;24:286–92.
5. Nimura A, Kato A, Yamaguchi K, et al. The superior capsule of the shoulder joint complements the insertion of the rotator cuff. J Shoulder Elbow Surg 2012;21:867–72.
6. Ishihara Y, Mihata T, Tamboli M, et al. Role of the superior shoulder capsule in passive stability of the glenohumeral joint. J Shoulder Elbow Surg 2014;23:642–8.
7. Mihata T, Lee TQ, Hasegawa A, et al. Arthroscopic superior capsule reconstruction can eliminate pseudoparalysis in patients with irreparable rotator cuff tears. Am J Sports Med 2018;46:2707–16.
8. Bernstein JM, Perez JR, Shah HA, et al. MRI of superior capsular reconstruction. Radiographics 2020;40:454–67.
9. Li H, Zhou B, Tang K. Advancement in arthroscopic superior capsular reconstruction for irreparable massive rotator cuff tear. Orthop Surg 2021;13:1951–9.
10. Tokish JM, Beicker C. Superior capsule reconstruction technique using an acellular dermal allograft. Arthrosc Tech 2015;4:e833–9.
11. Mihata T, Bui CN, Akeda M, 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;26:2158–66.
12. Scheiderer B, Kia C, Obopilwe E, et al. Biomechanical effect of superior capsule reconstruction using a 3-mm and 6-mm thick acellular dermal allograft in a dynamic shoulder model. Arthroscopy 2020;36:355–64.
13. Cline KE, Tibone JE, Ihn H, et al. Superior capsule reconstruction using fascia lata allograft compared with double- and single-layer dermal allograft: a biomechanical study. Arthroscopy 2021;37:1117–25.
14. Shah SS, Kontaxis A, Jahandar A, et al. Superior capsule reconstruction using a single 6-mm-thick acellular dermal allograft for massive rotator cuff tears: a biomechanical cadaveric comparison to fascia lata allograft. J Shoulder Elbow Surg 2021;30:2166–76.
15. Mihata T, Lee TQ, Hasegawa A, et al. Five-year follow-up of arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. J Bone Joint Surg Am 2019;101:1921–30.
16. de Campos Azevedo CI, Andrade R, Leiria Pires Gago Ângelo AC, Espregueira-Mendes J, Ferreira N, Sevivas N. Fascia lata autograft versus human dermal allograft in arthroscopic superior capsular reconstruction for irreparable rotator cuff tears: a systematic review of clinical outcomes. Arthroscopy 2020;36:579–91.
17. Makovicka JL, Chung AS, Patel KA, Deckey DG, Hassebrock JD, Tokish JM. Superior capsule reconstruction for irreparable rotator cuff tears: a systematic review of biomechanical and clinical outcomes by graft type. J Shoulder Elbow Surg 2020;29:392–401.
18. Polacek M, Nyegaard CP. Superior capsular reconstruction using 3-layered fascia lata autograft reinforced with a nonresorbable suture mesh. Arthrosc Sports Med Rehabil 2020;2:e489–97.
19. Ângelo AC, de Campos Azevedo CI. Minimally invasive fascia lata harvesting in ASCR does not produce significant donor site morbidity. Knee Surg Sports Traumatol Arthrosc 2019;27:245–50.
20. Mihata T, Lee TQ, Fukunishi K, 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;46:1077–83.
21. Yoon JY, Kim PS, Jo CH. Clinical and radiological results after arthroscopic superior capsular reconstruction in patients with massive irreparable rotator cuff tears. Clin Shoulder Elb 2018;21:59–66.
22. Lee SJ, Min YK. Can inadequate acromiohumeral distance improvement and poor posterior remnant tissue be the predictive factors of re-tear?: preliminary outcomes of arthroscopic superior capsular reconstruction. Knee Surg Sports Traumatol Arthrosc 2018;26:2205–13.
23. Lim S, AlRamadhan H, Kwak JM, Hong H, Jeon IH. Graft tears after arthroscopic superior capsule reconstruction (ASCR): pattern of failure and its correlation with clinical outcome. Arch Orthop Trauma Surg 2019;139:231–9.
24. Gracitelli ME, Beraldo RA, Malavolta EA, Assunção JH, Oliveira DR, Ferreira Neto AA. Superior capsular reconstruction with

fascia lata allograft for irreparable supraspinatus tendon tears. Rev Bras Ortop (Sao Paulo) 2019;54:591–6.
25. Kholinne E, Kwak JM, Kim H, Koh KH, Jeon IH. Arthroscopic superior capsular reconstruction with mesh augmentation for the treatment of irreparable rotator cuff tears: a comparative study of surgical outcomes. Am J Sports Med 2020;48:3328–38.
26. Petri M, Greenspoon JA, Millett PJ. Arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. Arthrosc Tech 2015;4:e751–5.
27. Sutter EG, Godin JA, Garrigues GE. All-arthroscopic superior shoulder capsule reconstruction with partial rotator cuff repair. Orthopedics 2017;40:e735–8.
28. Andersen WJ, Panero AA. Superior capsular reconstruction: clinical outcomes after minimum 2-year follow-up. Am J Orthop 2017;46:266–72.
29. Pogorzelski J, DelVecchio BM, Hussain ZB, Fritz EM, Godin JA, Millett PJ. Superior capsule reconstruction for massive rotator cuff tears: key considerations for rehabilitation. Int J Sports Phys Ther 2017;12:390–401.
30. Denard PJ, Brady PC, Adams CR, Tokish JM, Burkhart SS. Preliminary results of arthroscopic superior capsule reconstruction with dermal allograft. Arthroscopy 2018;34:93–9.
31. Tokish JM, Momaya A, Roberson T. Superior capsular reconstruction with a partial rotator cuff repair: a case report. JBJS Case Connect 2018;8:e1.
32. Altintas B, Higgins B, Anderson N, Millett PJ. Superior capsule reconstruction for the treatment of irreparable rotator cuff tears. Oper Tech Orthop 2018;28:226–31.
33. Laskovski JR, Boyd JA, Peterson EE, Abrams JS. Simplified technique for superior capsular reconstruction using an acellular dermal allograft. Arthrosc Tech 2018;7:e1089–95.
34. 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;34:1764–73.
35. Burkhart SS, Pranckun JJ, Hartzler RU. Superior capsular reconstruction for the operatively irreparable rotator cuff tear: clinical outcomes are maintained 2 years after surgery. Arthroscopy 2020;36:373–80.
36. 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;32:418–26.
37. Adams CR, Comer B, Scheiderer B, et al. The Effect of glenohumeral fixation angle on deltoid function during superior capsule reconstruction: a biomechanical investigation. Arthroscopy 2020;36:400–8.
38. Dyrna F, Berthold DP, Muench LN, et al. Graft tensioning in superior capsular reconstruction improves glenohumeral joint kinematics in massive irreparable rotator cuff tears: a biomechanical study of the influence of superior capsular reconstruction on dynamic shoulder abduction. Orthop J Sports Med 2020;8:2325967120957424.
39. Badman BL, Baessler AM, Moor M. Short-term clinical outcomes and comparison of ultrasound versus magnetic resonance imaging of superior capsular reconstruction. Arthrosc Sports Med Rehabil 2020;2:e229–35.
40. 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;44:1423–30.
41. Gimbel JA, Van Kleunen JP, Williams GR, Thomopoulos S, Soslowsky LJ. Long durations of immobilization in the rat result in enhanced mechanical properties of the healing supraspinatus tendon insertion site. J Biomech Eng 2007;129:400–4.
42. Trenerry K, Walton JR, Murrell GA. Prevention of shoulder stiffness after rotator cuff repair. Clin Orthop Relat Res 2005;(430):94–9.

https://doi.org/10.5397/cise.2023.00514