Arthroscopic Superior Capsular Reconstruction With Knotless Double-Row Dermal Allograft and Margin Convergence Augmentation

Jonathan D. Groothoff,*† MA, Thomas W. Mason,† BS, Anthony P. Fiegen,†‡ MD, Jelle P. van der List,†‡ MD PhD, and Brian R. Waterman,†‡ MD
Investigation performed at Wake Forest University School of Medicine, Winston-Salem, North Carolina, USA

Background: Superior capsular reconstruction (SCR) is an effective treatment option for rotator cuff injury. A variety of techniques and grafts can be used, and no clear method of graft fixation has been established.

Indications: SCR is indicated for the treatment of irreparable rotator cuff tears refractory to conservative measures, as was observed in this 58-year-old male patient. This procedure reduces superior translation of the humeral head and strengthens the superior capsule of the shoulder.

Technique Description: The patient was positioned in the beach-chair position. Three knotless anchors were placed onto the superior glenoid neck. Anchors were placed into the greater tuberosity adjacent to the articular margin to serve as medial row anchors for final double-row fixation. A dermal allograft was then shuttled into the subacromial space and secured to the glenoid neck. After completion of the SCR, margin convergence-style repair was performed to pull the biceps tendon and infraspinatus tendon over the top of the allograft for additional support.

Results: Complication rates following SCR vary. The most common complication is graft retear, which typically occurs at the medial anchor. Thus, many surgeons prefer a double-row technique for fixation. Graft augmentation to strengthen the overall construct reduces this risk. Dermal allografts less than 3 mm thick are associated with greater failure rates. At 6 months postoperatively, this patient reported 0 out of 10 pain, possessed full range of motion, and continued to gain strength through an at-home physical therapy program.

Discussion/Conclusion: Knotless double-row dermal allograft SCR with additional incorporation of the infraspinatus and biceps tendons is a viable option for patients experiencing rotator cuff injuries unresponsive to conservative management. Literature indicates that patient outcomes following this procedure are positive, with high patient satisfaction rates and improved anatomic and functional scores.

Patient Consent Disclosure Statement: The author(s) attests that consent has been obtained from any patient(s) appearing in this publication. If the individual may be identifiable, the author(s) has included a statement of release or other written form of approval from the patient(s) with this submission for publication.

Keywords: superior capsular reconstruction; rotator cuff; rotator cuff tear; knotless dermal allograft; shoulder arthroscopy

VIDEO TRANSCRIPT

This video demonstrates our technique for a superior capsular reconstruction (SCR) with knotless double-row dermal allograft and augmentation using margin convergence suturing of the biceps and infraspinatus tendons. Here are our disclosures. This is an overview of our presentation.

BACKGROUND

SCR for irreparable rotator cuff tears was first described in 2012 by Mihata et al[15] in the *American Journal of Sports Medicine*. This procedure reduces superior translation of the humeral head and strengthens the superior capsule of the shoulder. A variety of techniques can be used depending on the choice of graft.[5] Dermal allografts are the most common, although the use of autografts and synthetic grafts is also described in the literature.[7,8] No clear method of graft fixation has been established; however, many surgeons prefer a double-row technique for fixation at the greater tuberosity.[7]

Video Journal of Sports Medicine (VJSM®), 5(3), 26350254241299461
DOI: 10.1177/26350254241299461

Mesh augmentation has been shown to improve outcomes following SCR.[10] Side-to-side repair of the posterior margin is also possible to prevent humeral head subluxation.[11] However, concomitant procedures to reinforce the construct are technically complex and thus are less commonly performed.

CASE PRESENTATION

Here is our case presentation. In this case, we opted for SCR with dermal allograft, secured with a double-row construct. Additionally, the infraspinatus and biceps tendons were incorporated in marginal convergence fashion over the top of the SCR.

The patient is a 58-year-old, left-hand dominant male with chronic left shoulder pain that had been present for about 8 months. He had no history of corticosteroid injections, although he had tried physical therapy and home-based exercise programs, without resolution of symptoms. At presentation in our clinic, he reported 30% of normal function.

On physical examination of the patient's left shoulder, the patient had full passive range of motion and active range of motion to 180° of forward flexion, 180° of abduction, 90° of external rotation, and internal rotation to T7. He had 4 of 5 strength in the supraspinatus and infraspinatus muscles. Neer and Hawkins tests were positive. The patient reported pain over the acromioclavicular (AC) joint and subacromial tenderness to palpation at the lateral outlet. O'Brien's test also resulted in tenderness over the long head of the biceps tendon sheath.

Radiographic imaging revealed superior migration of the humeral head and a Hamada grade of 2. Magnetic resonance imaging showed posterosuperior labral fraying, and the supraspinatus tendon possessed a full-thickness, full-width tear with approximately 4 cm of retraction and moderate muscular atrophy. The infraspinatus tendon demonstrated a full-thickness, partial-width tear of the anterior fibers with retraction but no muscular atrophy. Mild subscapular tendinosis was present.

TECHNIQUE DESCRIPTION

To prepare for this surgery, the patient was placed in a beach-chair position and draped in sterile fashion. Diagnostic arthroscopy of the glenohumeral joint showed diffuse synovitis and a type 2 degenerative superior labral tear without significant chondrosis. The axillary pouch was free of loose bodies or pathology. We then inserted a wand through the rotator interval. The intact subscapularis tendon can be seen below, and the intact biceps tendon is visible in the top left of the image. The long head of the biceps tendon was released from the bicipital groove and rerouted for lateral centralization and margin convergence with the infraspinatus tendon.

The subacromial space was entered, and a radiofrequency wand was used to perform the initial subacromial decompression. A motorized 4-mm burr shaver was then used to continue subacromial decompression and acromioplasty to achieve a smooth subacromial contour and to increase the working space for future SCR and rotator cuff repair. We released soft tissue adhesions from the rotator cuff tendon to improve tendon mobility. A cuff grasper was used to evaluate mobility of the torn and retracted rotator cuff.

Three knotless anchors were then placed onto the superior glenoid neck through an accessory Neviaser portal. In this image, we see a 3.9-mm knotless BioComposite corkscrew suture anchor at the 10-o'clock position and 1.8-mm Fibertak knotless suture anchors at the 12- and 2-o'clock positions. These anchors will be used to shuttle the SCR graft as well as perform final graft fixation to the glenoid neck.

Two 4.75-mm BioComposite SwiveLock (Arthrex) anchors were placed into the greater tuberosity adjacent to the articular margin to serve as medial row anchors for the final double-row knotless fixation construct. Following anchor placement, we measured the distances between each anchor to determine the footprint for trimming the dermal allograft. Measurements for the dermal allograft were performed at 30° of abduction using an arthroscopic measuring tool inserted through the posterior portal. The footprint was marked on the allograft, which was then trimmed appropriately. We selected a 3-mm-thick allograft due to greater success rates, pain relief, and American Shoulder and Elbow Surgeons scores compared to thinner allografts.[3,4] The ArthroFlex (Arthrex) dermal allograft was then shuttled into the subacromial space through a laterally based 7-mm passport cannula. To perform this step, shuttle sutures from the 3 superior glenoid neck anchors were passed through the cannula and then through the corresponding locations on the allograft. The dermal allograft was then passed through the passport cannula, into the subacromial space, and secured medially to the glenoid neck. Next, suture tapes from the medial row anchors were

*Address correspondence to Jonathan D. Groothoff, MA, Wake Forest University School of Medicine, 1 Medical Center Blvd, Winston-Salem, NC 27157, USA (email: jgrootho@wakehealth.edu).

†Wake Forest University School of Medicine, Winston-Salem, North Carolina, USA.

‡Department of Orthopaedic Surgery and Rehabilitation, Atrium Health Wake Forest Baptist, Winston-Salem, North Carolina, USA.

Submitted June 28, 2024; accepted October 17, 2024.

One or more of the authors has declared the following potential conflict of interest or source of funding: B.R.W. is a board or committee member of AAOS, the American Orthopaedic Society for Sports Medicine, and the Arthroscopy Association of North America; is an unpaid consultant for Sparta Science and Kaliber AI; is a paid consultant for FH Ortho; has stock or stock options in Kaliber AI and Vivorte; receives research support from Arthrex; is a paid presenter or speaker for Vericel; receives publishing royalties or financial or material support from Elsevier and *Arthroscopy*; and is on the editorial or governing board for *Arthroscopy* and *Video Journal of Sports Medicine*. J.P.V. is on the editorial or governing board of *Arthroscopy*. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

passed through the graft and out through the cannula using an arthroscopic Scorpion (Arthrex) suture passer. Suture tapes were retrieved laterally in anticipation of securing the graft into lateral row anchors.

An awl was used to create a pilot hole for the first lateral row anchor. A SwiveLock anchor with 1 suture tape from the anterior medial row anchor and 1 suture tape from the posterior medial row anchor was secured. A second lateral row anchor was placed more posteriorly to complete the double-row fixation construct of the SCR.

After completion of the SCR, mobility of the infraspinatus and biceps tendons was evaluated for possible incorporation into the repair. A Scorpion suture passer was then used to pass suture tape through the infraspinatus tendon and the biceps tendon in a mattress fashion. We used an arthroscopic knot pusher to perform a marginal convergence-style repair and pull the biceps tendon and infraspinatus tendon over the top of the SCR. An additional biceps tendon to infraspinatus tendon suture tape was passed and tied in a marginal convergence-type fashion. Suture from the posterior medial row anchor was passed through the infraspinatus tendon using a Scorpion suture-passing device and tied using an arthroscopic knot pusher for additional fixation. Final arthroscopic view of the SCR shows augmentation with a side-to-side margin convergence pattern using the infraspinatus and biceps tendons overlying the SCR construct.

The patient was placed in a shoulder immobilizer immediately following this procedure and began physical therapy the following week. The first 6 weeks of recovery are focused on regaining passive range of motion of the shoulder. From 6 to 8 weeks, active range of motion is improved, with the goal of restoring full active range of motion. Once full active range of motion is restored, the patient can move to more advanced strengthening exercises that include resistance. Sport-specific rehabilitation is typically initiated at 4.5 months, with overhand throwing beginning at 6 months. Maximum improvement is expected by 12 months.

RESULTS

In addition to standard anterior, posterior, and mid-lateral portals, we recommend the use of an accessory anterolateral portal for viewing and a Neviaser portal for knotless anchor placement on the superior glenoid neck. For this procedure, effective suture management is critical. Using a suture retriever to sequentially pull sutures through the lateral portal helps avoid suture entanglement before graft passage. The suture retriever should be run along each withdrawn suture before retrieving the next suture, and all sutures should be pulled externally before allograft entry. When introducing the dermal allograft, guiding the leading edge of the graft through the lateral cannula with a suture retriever while maintaining tension on the glenoid sutures protects against twisting of the dermal allograft.

Complication rates following SCR vary. A 2021 systematic review by Sommer et al[19] published in *Arthroscopy* reported complication rates between 5% and 70%. However, other studies report strong survival rates.[1,13] The most common complication is graft retear, which typically occurs at the medial anchor.[12] Risk of retear is increased in female patients and patients undergoing revision surgery.[20] Low surgeon experience is also associated with greater rates of retear.[1]

DISCUSSION/CONCLUSION

There is no consensus regarding the use of an allograft versus an autograft for SCR. However, donor site morbidity is a concern with autografts that is not a concern when using an allograft.[17] Dermal allografts are the most commonly used graft for SCR among orthopaedic surgeons, demonstrating improvements in functional scores and patient-reported outcomes.[4,8] The thickness of the allograft can influence graft success, and literature supports the use of 3-mm thickness to provide adequate strength when using a dermal allograft.[3,4]

Patient outcomes following SCR are generally positive. A systematic review by Smith et al[18] found that SCR improves superior humeral translation, subacromial contact force, and glenohumeral contact force. Side-to-side suturing is associated with greater stability by achieving capsular continuity in the transverse direction.[14] Mean patient satisfaction scores are at or above 70%, which makes sense given that most patients have unsuccessful treatments before this procedure.[4,16]

Arthroscopic SCR with augmentation is associated with superior patient-reported outcomes and functional measurements compared to SCR without augmentation.[6,9] Cho et al[2] reported that using the long head of the biceps tendon for SCR augmentation led to fewer failures and comparable clinical outcomes compared to nonaugmented repairs. Additionally, when compared to arthroscopic partial repair, biceps tendon augmentation has improved the postoperative acromiohumeral interval.[9]

Our patient is now 6 months postoperative and reports 0 out of 10 pain. His active range of motion has increased to 180° of forward flexion, 180° of abduction, 90° of external rotation, and internal rotation to T7. He can work and fish without restriction and is participating in an at-home physical therapy program to regain full strength, which he estimates is at 70% of normal. Thank you for your time.

ORCID iDs

Jonathan D. Groothoff https://orcid.org/0009-0006-7419-6781
Jelle P. van der List https://orcid.org/0000-0002-7940-5152

REFERENCES

1. 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(2):373-380. doi:10.1016/j.arthro.2019.08.035

2. Cho NS, Yi JW, Rhee YG. Arthroscopic biceps augmentation for avoiding undue tension in repair of massive rotator cuff tears. *Arthroscopy*. 2009;25(2):183-191. doi:10.1016/j.arthro.2008.09.012
3. Claro R, Fonte H. Superior capsular reconstruction: current evidence and limits. *EFORT Open Rev*. 2023;8(5):340-350. doi:10.1530/EOR-23-0027
4. Denard PJ, Brady PC, Adams CR, Tokish JM, Burkhart SS. Preliminary results of arthroscopic superior capsule reconstruction with dermal allograft. *Arthroscopy*. 2018;34(1):93-99. doi:10.1016/j.arthro.2017.08.265
5. Dimock RAC, Malik S, Consigliere P, Imam MA, Narvani AA. Superior capsule reconstruction: what do we know? *Arch Bone Jt Surg*. 2019;7(1):3-11.
6. Funakoshi T, Takahashi T, Murayama T, et al. Arthroscopic superior capsule reconstruction augmentation using a semitendinosus autograft in massive reparable rotator cuff tears. *JSES Int*. 2024;8(1):32-40. doi:10.1016/j.jseint.2023.08.020
7. Gao I, Sochacki KR, Freehill MT, Sherman SL, Abrams GD. Superior capsular reconstruction: a systematic review of surgical techniques and clinical outcomes. *Arthroscopy*. 2021;37(2):720-746. doi:10.1016/j.arthro.2020.09.016
8. Hankins AC, Griffin JW, Taliaferro JP, Werner BC, Bonner KF. The number of surgeons using superior capsular reconstruction for rotator cuff repair is declining. *Arthrosc Sports Med Rehabil*. 2022;4(6):e2089-e2098. doi:10.1016/j.asmr.2022.10.002
9. Kawashima K, Terabayashi N, Asano H, Akiyama H. Arthroscopic long head of the biceps transposition for superior capsular augmentation results in comparable clinical outcomes to arthroscopic partial repair for irreparable rotator cuff tears. *Arthrosc Sports Med Rehabil*. 2022;4(2):e425-e434. doi:10.1016/j.asmr.2021.10.020
10. Kholinne E, Jeon I-H. Superior capsular reconstruction with mesh augmentation: a perspective from bench to bedside. *Orthop J Sports Med*. 2019;7(11)(suppl 6):2325967119S00460. doi:10.1177/2325967119S00460
11. Kim DH, Jung YS, Kim KR, Yoon JP. The best options in superior capsular reconstruction. *Clin Shoulder Elb*. 2021;24(2):114-121. doi:10.5397/cise.2021.00136
12. 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(2):231-239. doi:10.1007/s00402-018-3025-7
13. Mihata T, Lee TQ, Watanabe C, et al. Clinical results of arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. *Arthroscopy*. 2013;29(3):459-470. doi:10.1016/j.arthro.2012.10.022
14. 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):1423-1430. doi:10.1177/0363546516631751
15. 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):2248-2255. doi:10.1177/0363546512456195
16. 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):1764-1773. doi:10.1016/j.arthro.2018.01.009
17. Saithna A. Editorial commentary: human dermal allograft is preferable to fascia lata autograft based on similar outcomes without donor-site morbidity. *Arthroscopy*. 2021;37(9):2797-2799. doi:10.1016/j.arthro.2021.05.037
18. 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(1):402-410. doi:10.1016/j.arthro.2020.09.007
19. Sommer MC, Wagner E, Zhu S, et al. Complications of superior capsule reconstruction for the treatment of functionally irreparable rotator cuff tears: a systematic review. *Arthroscopy*. 2021;37(9):2960-2972. doi:10.1016/j.arthro.2021.03.076
20. Woodmass JM, Wagner ER, Borque KA, Chang MJ, Welp KM, Warner JJP. Superior capsule reconstruction using dermal allograft: early outcomes and survival. *J Shoulder Elbow Surg*. 2019;28(6S):S100-S109. doi:10.1016/j.jse.2019.04.011