Arthroscopic Superior Capsule Reconstruction Technique in the Setting of a Massive, Irreparable Rotator Cuff Tear

George Sanchez, B.S., William H. Rossy, M.D., Kyle P. Lavery, M.D., Kevin J. McHale, M.D., Marcio B. Ferrari, M.D., Anthony Sanchez, B.S., and Matthew T. Provencher, M.D., M.C., U.S.N.R.

Abstract: Massive, irreparable rotator cuff tears are challenging to treat and associated with pain and severe limitation in shoulder elevation due to the proximal migration of the humeral head and, consequently, subacromial impingement. Furthermore, retraction of the tendons in combination with fat infiltration and muscular weakness results in unpredictable treatment outcomes. While conservative treatment may be warranted for low-demand patients, surgical treatment is often indicated for a successful return to activities of daily living as well as an improved quality of life. The reported failure rate of rotator cuff repair for the treatment of a massive rotator cuff tear varies. However, this failure is often found at the interface between the tendon and tendon footprint. Several techniques have been reported to address this pathology, including muscular transfer, arthroscopic debridement, augmentation procedures, and superior capsule reconstruction. In particular, superior capsule reconstruction has been reported as a safe and effective method to treat a massive, irreparable rotator cuff tear. The purpose of this Technical Note is to describe our preferred technique of a superior capsule reconstruction for the treatment of a massive, irreparable rotator cuff tear.

Massive rotator cuff tears have long been recognized as a cause of significant pain and dysfunction.[1,2] The outcomes after surgical repair of these lesions have been less than reliable as they demonstrate significantly higher failure rates than small- to medium-sized tears.[3] Technical advances have undoubtedly improved the outcomes of operative management of these lesions over the years. Despite this, if the torn rotator cuff tendon is significantly retracted and found to have lost its normal plasticity through chronic degeneration and fatty infiltration, it may not be amenable to surgical repair. In this instance, the most appropriate surgical intervention to optimize patient function remains an active topic of debate.

Traditionally, surgical options for the management of massive, irreparable rotator cuff tears causing pain and dysfunction have included subacromial decompression with biceps tenotomy, rotator cuff debridement without repair, partial tendon repair, muscle-tendon transfers (latissimus dorsi, pectoralis major), or implantation of a reverse total shoulder prosthesis.[4-6] Each of these options is associated with distinct disadvantages. More recently, patch graft surgical repairs have been introduced as a way to either bridge the gap between a retracted tendon and its greater tuberosity footprint, augment a partial repair, or reconstruct the superior articular glenohumeral joint capsule.

Biomechanical studies have demonstrated a significant increase in contact pressures within the subacromial space in patients with massive rotator cuff tears.[7] These findings are felt to be caused by the superior instability that occurs within the glenohumeral

From the Steadman Phillipon Research Institute (G.S., M.B.F., M.T.P.), Vail, Colorado; Princeton Orthopaedic Associates (W.H.R.), Princeton, New Jersey; UMass Memorial Medical Center (K.P.L.), Leominster, Massachusetts; University of Pennsylvania Orthopaedics, Cape Regional Physicians Associates (K.J.M.), Cape May Court House, New Jersey; Jackson Memorial Hospital (A.S.), Miami, Florida; and The Steadman Clinic (M.T.P.), Vail, Colorado, U.S.A.

The authors report the following potential conflicts of interest or sources of funding: G.S., W.H.R., K.P.L., K.J.M., M.B.F., and A.S. have received research grants from Health South East, Norway, and from Arthrex. M.T.P. is a consultant for Arthrex and JRF Ortho; has patent numbers issued: 9226743, 20150164498, 20150150594, 20110040339; and receives publishing royalties from Arthrex and SLACK. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received February 22, 2017; accepted May 21, 2017.

Address correspondence to Matthew T. Provencher, M.D., M.C., U.S.N.R., Steadman Philippon Research Institute, The Steadman Clinic, 181 W Meadow Drive, Suite #400, Vail, CO 81657, U.S.A. E-mail: mprovencher@thesteadmanclinic.com

2212-6287/17230/$36.00

http://dx.doi.org/10.1016/j.eats.2017.05.020

joint in the setting of a massive, retracted tear. The resultant superior migration leads to impingement and is likely a major cause of significant pain and dysfunction in these patients.

As a result of these findings, a recent surgical technique aimed at restoring superior stability while minimizing the risk of patch graft failure has gained popularity. Arthroscopic superior capsule reconstruction (ASCR) has been shown to restore the native superior stability within the glenohumeral joint and minimize both glenohumeral and subacromial contact pressures.[7] The purpose of this study was to describe our technique for an ASCR.

Operative Indications

Operative indications for ASCR include restricted active range of motion caused by massive rotator cuff tear. Passive range of motion in these patients should remain unaffected. Rotator cuff muscle strength testing often demonstrates significant weakness of the affected muscle-tendon complex. Magnetic resonance imaging should be consistent with an irreparable rotator cuff tendon tear and demonstrate greater than 3 cm of retraction, along with ≥grade 3 changes of the supraspinatus or ≥grade 2 changes of the infraspinatus on sagittal oblique imaging.[8] Plain radiographs also need to be obtained to rule out significant arthritis and confirm superior instability and superior dislocation of the humeral head.

Ultimately, the decision to characterize a rotator cuff tear as irreparable is finalized at the time of surgery. Diagnostic arthroscopy is performed to confirm that the retracted tendon is not amenable to repair due to its inability to be brought back to the original footprint on the greater tuberosity. Inferior translation of the humeral head should also be assessed at this time to ensure that reduction will be possible on completion of the superior capsule reconstruction.

Patient Positioning and Anesthesia

The patient is placed in the beach chair position after receiving a preoperative nerve block and general anesthesia (Video 1). Once all bony prominences are well padded, the patient is secured in place and the extremity is prepped and draped in the usual sterile fashion. The operative arm is then secured in a pneumatic limb positioner (Smith & Nephew, Andover, MA) that was prefastened to the surgical table to ensure adequate and secure arm position throughout the case.

Surgical Technique

Portal Placement/Diagnostic Arthroscopy

After confirmation of an irreparable rotator cuff tear on diagnostic arthroscopy and confirming that the humeral head is reducible with inferior traction of the upper extremity, an ASCR is undertaken.

The arthroscope is placed in the standard posterior viewing portal allowing visualization of the superior and posterior rotator cuff tendons. Because of the significant retraction that is necessarily present with these tears, the retracted tendon is typically medial to the glenoid. This high degree of retraction typically allows direct visualization of the subacromial space from within the glenohumeral joint.

As this surgery is often performed in a revision setting, the biceps tendon may not be present at its typical superior glenoid insertion due to prior tenodesis or tenotomy. If the biceps tendon is present, a tenotomy should be performed using an arthroscopic scissors or a radiofrequency device. On completion of the ASCR, a mini-open subpectoral biceps tenodesis can be performed.

Preparation of the Superior Aspect of the Glenoid

Once the superior glenoid is exposed after biceps tenotomy, a combination of a radiofrequency wand and a bone shaver is used to debride the anterior superior, middle, and posterior superior aspect of the glenoid down to a bleeding bony bed, taking care to avoid lesions to the suprascapular nerve (Fig 1). At this time, a subacromial decompression may also be performed to increase the working space for the remainder of the case. Once the superior glenoid is well visualized, attention is turned laterally to the rotator cuff footprint on the humeral head. This area is also debrided to a healthy bleeding surface. In many cases, the SCR is performed as a revision of a failed rotator cuff repair. Therefore, it is important to thoroughly search for all suture material and subsequently remove all suture material from the previous repair.

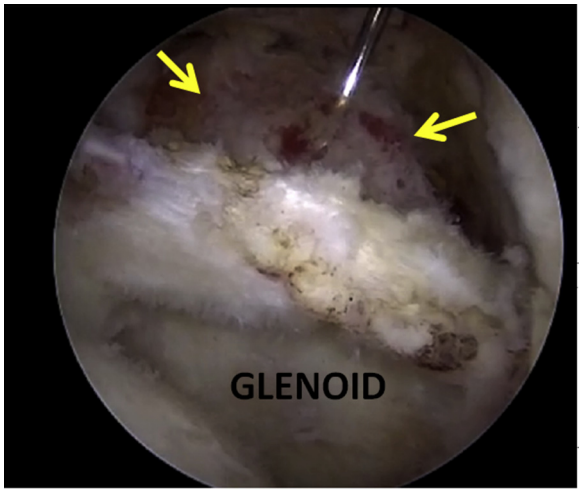

Fig 1. A combination of an arthroscopic shaver, radiofrequency wand, and high-speed arthroscopic burr is used on the anterior, middle, and posterior portion of the superior aspect of the glenoid of the right shoulder (yellow arrows). Care must be taken to avoid damage to the articular cartilage and supraspinatus nerve.

Anchor Placement on the Superior Aspect of the Glenoid

With the arthroscope moved to the lateral portal for direct visualization of the glenoid, two 3.0-mm PEEK (polyether ether ketone) SutureTak anchors with No. 2 High Strength sutures (Arthrex, Naples, FL) are placed into the glenoid 5 mm medial to the articular surface (Fig 2). These anchors are placed through the Neviaser portal, to allow the most appropriate trajectory and avoid violation of the articular cartilage. Placement should be slightly anterior to the mid-sagittal line of the glenoid at the 1 o'clock and 2 o'clock positions, respectively. The No. 2 High Strength sutures are then retrieved from the shoulder—one suture is brought posteriorly through the Neviaser portal and the other is brought out anteriorly through a separate anterolateral portal (Fig 3).

Measurement of Defect Size Dimensions

A sizing device (Arthrex) is then used to measure the appropriate anteroposterior and medial-lateral dimensions of the defect (Fig 4). In our case, these measurements were 32 mm anterior-to-posterior and 44 mm medial-to-lateral.

Graft Preparation and Passage

A dermal allograft (Arthrex) is prepared on the back table. Once cut to the appropriate dimensions, a suture strand from each anchor is retrieved and passed through the graft extra-corporally with the aid of an antegrade suture passer device. The graft is then shuttled through a Passport cannula (Arthrex) by pulling tension on the medial glenoid sutures (Fig 5). A tissue grasper can be used to ensure proper maintenance of graft orientation during passage.

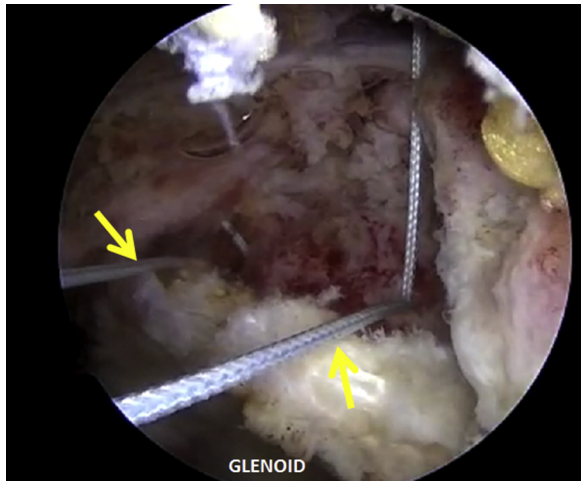

Fig 3. Once anchor placement on the superior aspect of the glenoid of the right shoulder is complete, arthroscopic visualization using a 30° arthroscope is done to identify the sutures (yellow arrows) and retrieve them from the intra-articular portion. These sutures will be used for graft passage into the joint.

Initial Graft Fixation

After successfully passing the graft, the glenoid sutures are tied down to the anchors, thereby securing the graft medially over the glenoid. In addition, 2 (1 anteriorly and 1 posteriorly) additional 2.9 PushLock PEEK anchors are used with FiberTape (Arthrex) to provide excellent fixation of the graft onto the glenoid.

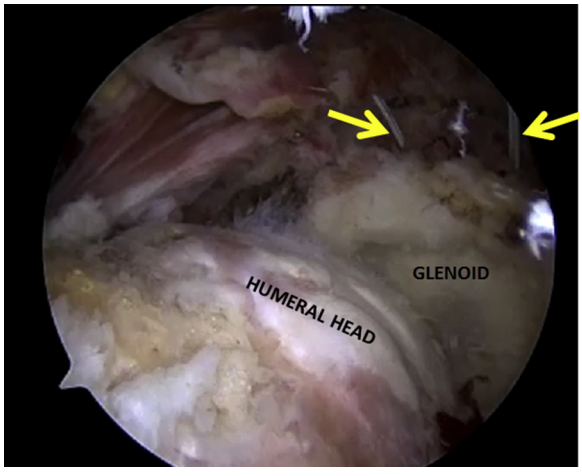

Fig 2. Arthroscopic visualization of a superior capsule reconstruction procedure using a 30° arthroscope. After the preparation of the superior aspect of the glenoid, two 3.0-mm PEEK (polyether ether ketone) SutureTak biocomposite anchors with No. 2 High Strength sutures (yellow arrows) are placed into the glenoid of the right shoulder at a location approximately 5 mm medial to the articular surface.

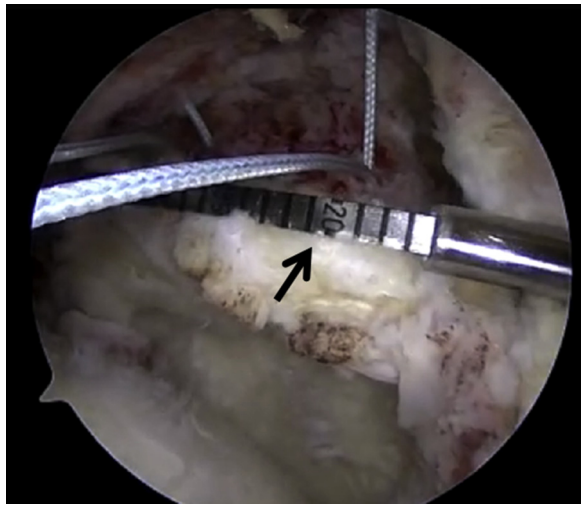

Fig 4. After the preparation of the humeral head of the right shoulder, a sizing device (black arrow) is used to measure the anterior-to-posterior and medial-to-lateral distances and estimate the necessary graft size. These measurements are extremely important to allow for the optimal preparation of the graft. In this case, the measurements were 32 mm anterior-to-posterior and 44 mm medial-to-lateral.

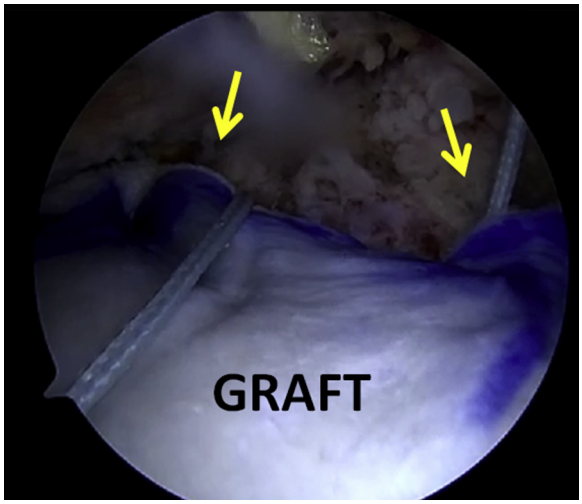

Fig 5. Arthroscopic visualization of the right shoulder using a 30° arthroscope. The previously retrieved sutures are used to guide the graft to the correct position over the superior aspect of the glenoid (yellow arrows). An arthroscopic grasper or Kocher clamp can also be used to guide the graft to its correct position.

Preparation of Greater Tuberosity and Anchor Placement

Attention is then turned to the humeral footprint. Similarly to the glenoid, a combination of a radiofrequency wand and a bone shaver is used to prepare the site of anchor insertion. In a similar fashion, two 4.75-mm anchors (Arthrex) are placed within the supraspinatus footprint. If a significant portion of the infraspinatus is torn from its footprint and retracted, an additional anchor can be placed more posteriorly within its footprint. After this, an inferior force is applied on the humeral head to reduce the humeral head back to its anatomical position.

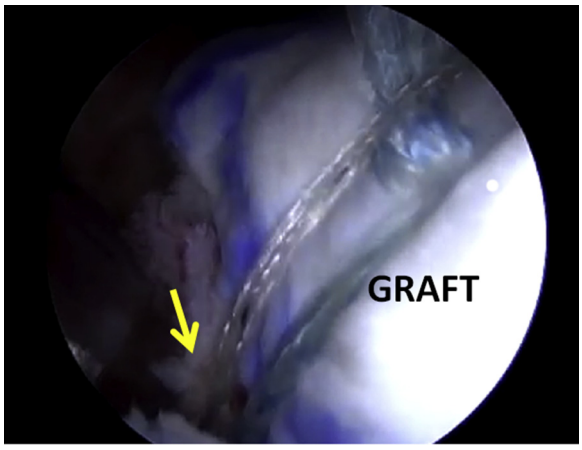

Fig 6. Once the graft is secured on the glenoid, an inferior force is applied on the humerus to reduce the humeral head of the right shoulder to its anatomical position in relation to the glenoid articular surface. After this, the graft is secured to the humeral head using the sutures from the previously placed anchors. We suggest tying the sutures with the arm in 45° of abduction.

Final Graft Fixation

The sutures previously passed through the humeral anchors are tied, with the arm in 45° of abduction to secure the graft to the center of the humeral head footprint (Fig 6). Once tied, these suture strands are then further secured through 2 additional laterally placed anchors completing a standard, double row fixation technique. Lastly, side-to-side sutures are passed through the graft and the remaining infraspinatus tendon to improve force coupling of the shoulder joint.

On completion of graft fixation, the shoulder is assessed under direct visualization with the arthroscope in the subacromial space by applying a superior directed force to the humerus. With proper tensioning of the graft, the reconstructed superior capsule should act as a restraint to superior translation of the humeral head. In our case, the subacromial space increased from 1 mm before surgery to 10 mm after the surgery.

Pearls and pitfalls of this surgical technique are summarized in Table 1, whereas Table 2 lists the advantages and disadvantages associated with the technique.

Postoperative Rehabilitation

After surgery, the patient will be placed in a sling with an abduction pillow. The sling should remain in place

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Ensure that the humeral head is reducible during diagnostic arthroscopy to ensure appropriate reduction with the graft in place	If care not taken to properly orient anchors on the glenoid, they may violate the articular cartilage with anchor passage given the concavity of the glenoid surface
Glenoid anchors should be placed 5 mm from the articular surface. Easiest to use the Neviaser portal when placing these anchors to ensure appropriate orientation	Careless suture management will lead to difficulty with graft passage and intra-articular issues with graft orientation
Suture management is crucial for successful graft passage. A tissue grasper can be used through the Passport cannula to further assist proper maintenance of graft orientation	Fixation of the graft when the arm is at the side may not adequately tension the graft to ensure superior stability
The graft is tensioned and fixed into place with the shoulder abducted to 45°	Fixation of the graft when the shoulder is abducted to 90° may overtension the graft and lead to tearing when the arm is brought back to its side
Side-to-side repair of the graft to remaining rotator cuff is important to improve force coupling of the shoulder	Performing an ASCR in a patient with advanced glenohumeral arthritis is unlikely to alleviate pain

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
Safe and effective procedure for massive, irreparable rotator cuff tear	Technically demanding
Allows for the correction of the humeral head back to its anatomical position	High cost
May be performed in a revision setting after a failed rotator cuff repair, in which fat infiltration and inelasticity of the retracted tendons does not allow for an anatomical repair	Although it provides an anatomical repositioning, this technique is not an anatomical repair of the rotator cuff tendon
No donor morbidity associated with the graft	

for a total of 6 weeks. The patient will be allowed to perform gentle, passive range of motion in the plane of the scapula only. In an effort to minimize stress on the graft, no forward elevation beyond 90° or abduction beyond 60° will be permitted for a total of 6 weeks. After 6 weeks, both active and passive range of motion will be permitted under the direct supervision of a physical therapist. Strengthening activities will slowly be initiated 3 months after surgery, with an ultimate goal of returning to activities at 6 months.

Discussion

This Technical Note details our technique for an ASCR of the glenohumeral joint. The surgical management of irreparable rotator cuff tears is one that has been debated in the literature for many years. The surgical complexity of these cases, along with their inferior outcomes compared with more straightforward tears, is undoubtedly responsible for this lack of consensus. As our understanding of the biomechanics of the glenohumeral joint evolves, it is important to note that an evolution in treatment options is also occurring. We believe that superior capsule reconstruction is a new, viable option for patients with pain and limitation due to significant impingement caused by superior escape of the humeral head.

Although patch graft surgery for irreparable rotator cuff tears is not a new concept, Mihata et al.[7] were the first to describe the use of a patch to reconstruct the superior capsule of the glenohumeral joint in 2012. This was immediately preceded by the work of Nimura et al.[9] when they redefined the anatomical insertion of the superior capsule. Their findings suggested that the superior capsule played a more significant role in superior stability than previously suspected.

Biomechanical testing has since demonstrated the superiority of superior capsule reconstruction alone in obtaining superior stability when compared with massive rotator cuff repair using an interpositional patch graft. Also noted was a significant decrease in subacromial contact pressures and a return to near normal glenohumeral joint forces when superior capsule reconstruction was performed; neither of these findings were noted after rotator cuff repair using an interpositional graft.[7]

Prior reports clearly demonstrate a high retear rate in patients undergoing rotator cuff repair with the aid of a patch graft.[10-12] These prior works, along with more recent biomechanical data, suggest that continued superior instability may predispose interpositional patch grafts to failure as the undersurface of the acromion abrades the graft. Recent cadaveric work in conjunction with short-term clinical results suggests that reconstruction of the superior capsule of the glenohumeral joint restores superior stability, thereby minimizing graft failures and optimizing functional outcomes.[7,13]

Given the current available literature, we recommend our approach for ASCR to manage those patients with massive, irreparable rotator cuff tears accompanied by significant pain and limited function. Although short-term results have been shown to significantly improve overall forward elevation and strength, future long-term studies with larger samples are needed to assess long-term durability of patient reported outcomes.

References

1. Osti L, Papalia R, Del Buono A, Denaro V, Maffulli N. Comparison of arthroscopic rotator cuff repair in healthy patients over and under 65 years of age. *Knee Surg Sports Traumatol Arthrosc* 2010;18:1700-1706.
2. Ostor AJ, Richards CA, Prevost AT, Speed CA, Hazleman BL. Diagnosis and relation to general health of shoulder disorders presenting to primary care. *Rheumatology (Oxford)* 2005;44:800-805.
3. Goutallier D, Postel JM, Gleyze P, Leguilloux P, Van Driessche S. Influence of cuff muscle fatty degeneration on anatomic and functional outcomes after simple suture of full-thickness tears. *J Shoulder Elbow Surg* 2003;12:550-554.
4. Franceschi F, Papalia R, Palumbo A, Del Buono A, Maffulli N, Denaro V. Operative management of partial and full thickness rotator cuff tears. *Med Sport Sci* 2012;57:100-113.
5. Khair MM, Gulotta LV. Treatment of irreparable rotator cuff tears. *Curr Rev Musculoskelet Med* 2011;4:208-213.
6. Franceschi F, Papalia R, Vasta S, Leonardi F, Maffulli N, Denaro V. Surgical management of irreparable rotator cuff tears. *Knee Surg Sports Traumatol Arthrosc* 2015;23:494-501.
7. Mihata T, McGarry MH, Pirolo JM, Kinoshita M, Lee TQ. Superior capsule reconstruction to restore superior instability in irreparable rotator cuff tears: A biomechanical cadaveric study. *Am J Sports Med* 2012;40:2248-2255.
8. Yoo JC, Ahn JH, Yang JH, Koh KH, Choi SH, Yoon YC. Correlation of arthroscopic repairability of large to

massive rotator cuff tears with preoperative magnetic resonance imaging scans. *Arthroscopy* 2009;25:573-582.
9. Nimura A, Akita K, Yamaguchi K, et al. The superior capsule of the shoulder joint complements the insertion of the rotator cuff. *J Shoulder Elbow Surg* 2012;21:867-872.
10. Sclamberg SC, Tibone JE, Itamura JM, Kasraeian S. Six-month magnetic resonance imaging follow-up of large and massive rotator cuff repairs reinforced with porcine small intestinal submucosa. *J Shoulder Elbow Surg* 2004;13:538-541.
11. Soler JA, Gidwani S, Curtis MJ. Early complications from the use of porcine dermal collagen implants as bridging constructs in the repair of massive rotator cuff tears. A report of 4 cases. *Acta Orthop Belg* 2007;73:432-436.
12. Audenaert E, Van Nuffel J, Schepens A, Verhelst M, Verdonk R. Reconstruction of massive rotator cuff lesions with a synthetic interposition graft: A prospective study of 41 patients. *Knee Surg Sports Traumatol Arthrosc* 2006;14:360-364.
13. Mihata T, Lee TQ, Watanabe C, et al. Clinical results of arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. *Arthroscopy* 2013;29:459-470.