Outcome of biceps suspensionplasty for recurrent multidirectional shoulder instability ☆,☆☆

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ABSTRACT

Introduction: Recurrent multidirectional shoulder instability after failed capsular repair/plication, is a challenging treatment problem. The long head of the biceps has been identified as a structure that may be utilized as a checkrein to stop abnormal anterior and inferior translation of the humeral head. The purpose of this study is to analyse the outcomes of biceps suspensionplasty (BS) in the treatment of recurrent shoulder instability.
Methods: A retrospective review identified patients with recurrent multidirectional instability that underwent BS as part of a revision shoulder stabilization procedure. Clinical records were reviewed for demographics, pain, complications, recurrent instability, reoperations, and range of motion. Patients were also administered ASES/SST/SANE/Rowe and Oxford instability questionnaire at minimum of 2-year clinical follow-up.
Results: Five patients (7 shoulders) were included with a mean follow-up of 3.2 years (2–7 years). Patients had an average of 1.6 prior procedures (1–3). Average patient age was 24.2 years (18.7–32.4 years) and all were female. Four shoulders were treated open while 3 were treated arthroscopically with a capsular shift and biceps suspension. Four shoulders also underwent capsular reconstruction with allograft. At final follow-up three shoulders had recurrent inferior subluxation, although all patients considered their shoulders to be much better (4) or somewhat better (3) and none have undergone repeat surgery.
Conclusion: In our series of patients, we found BS may be useful as an adjunct to a revision capsular shift or reconstruction. While 42.8% of patients experienced recurrent subluxations, this high-risk population demonstrated encouraging subjective results and avoiding joint arthrodesis in the short-term.

1. Introduction

Multidirectional instability of the shoulder which has failed non-operative management has been successfully treated by capsular reconstructive procedures such as the inferior capsular shift as described by Neer and Foster.[1–14] Recurrent shoulder instability following stabilization procedures is a challenging clinical problem for shoulder surgeons as this population can experience disabling glenohumeral instability often accompanied by recalcitrant shoulder pain.[15] Krishnan et al. described these patients as most commonly having profound inferior instability of the glenohumeral joint, with an inferior subluxed resting position of the humeral head compared with the contralateral asymptomatic side. Factors that contribute to recurrent dislocations of

the shoulder after surgical repair include excessive capsular laxity, technical problems, and reinjury.[15] One salvage option for patients with recurrent glenohumeral instability after operative fixation is arthrodesis; however, complications and motion limitations introduced with arthrodesis have led surgeons and patients to seek alternative soft-tissue procedures.[15,16]

Nicola first described utilizing the long head of the biceps tendon as a check ligament to stop abnormal forward and downward motion of the humeral head on the glenoid fossa.[17] His technique included drilling a hole in the bicipital groove at the level of the lower edge of the transverse humeral ligament and directed proximally to emerge at the center of the head of the humerus. The divided, proximal end of the long head of the biceps is then threaded through the drilled hole and resutured to

the distal end under tension. In his reported series no patients had recurrence of their instability.[17] A later study by Krishnan et al. which utilized a combination of the Nicola biceps tenodesis, humeral based inferior capsular shift and rotator interval augmentation showed success in reducing or eliminating glenohumeral instability.[15] More recently, Namdari et al. described the results of the biceps suspension procedure for painful inferior glenohumeral subluxation in hemiplegic patients with good stability and pain relief achieved.[18]

The purpose of this study was to retrospectively analyse the results of revision capsulorraphy performed in conjunction with rotator interval imbrication and the Nicola biceps suspensionplasty procedure in the treatment of recurrent multidirectional shoulder instability following prior surgical intervention.

2. Materials and methods

2.1. Data collection

After obtaining Institutional Review Board approval, we identified patients that underwent biceps suspensionplasty at our institution from December 2010 to March 2015. The study population was identified by Common Procedural Terminology codes of 23466 (Capsulorrhaphy, glenohumeral joint, any type multi-directional instability) and 29806 (arthroscopy, shoulder, surgical; capsulorrhaphy). Patient operative reports were screened to include all patients who had biceps suspensionplasty as part of their shoulder stabilization procedure. Patients in whom capsulorraphy procedure was performed without biceps suspensionplasty were excluded from further review. Surgical procedures were performed by one of two senior authors.

Demographics such as age, gender, and BMI were recorded. Clinical data such as side of injury, presence of Ehlers-Danlos syndrome, hand dominance, occupation, mechanism (traumatic or atraumatic), number of dislocations, prior surgeries, comorbidities, range of motion, and exam findings of instability such as sulcus, apprehension and jerk test were recorded. Grades of glenohumeral joint laxity during examination under anaesthesia were recorded. Preoperative radiographs and MRI were used to confirm humeral head subluxation as well as to determine the presence of other bone and soft tissue pathology. Preoperative American Shoulder and Elbow Society (ASES) score, Simple Shoulder Test (SST), and Visual Analog Scale (VAS) for pain score were recorded. A Rowe score was given to each patient, based upon severity of instability, motion and function on clinical presentation.

Postoperative patient outcome data was obtained by chart review and phone interview. Patients were asked about recurrence of instability, reoperations, and overall level of improvement following surgery. Regarding level of improvement postop, patients were instructed to take into account their functional ability as well as symptoms of pain and were asked whether they felt the surgical procedure resulted in a shoulder that was: "much better", "somewhat better", "the same", "somewhat worse" or "much worse". ASES score, SST, VAS score, Oxford instability score, Rowe instability score and Single Alphanumeric Evaluation (SANE) scores were obtained.

2.2. Indications for biceps suspensionplasty

Patients were considered candidates for revision capsulorraphy and biceps suspensionplasty if they presented with recalcitrant multidirectional shoulder instability despite prior shoulder stabilization procedure and physical therapy. The diagnosis of recalcitrant instability was based upon the combination of patient history of feeling shoulder subluxation as well as exam findings of increased glenohumeral translation and/or apprehension with provocative maneuvers. Patient counselling emphasized that revision capsulorraphy with biceps suspensionplasty was a salvage procedure alternative to arthrodesis with anticipated limited range of motion, particularly in external rotation after the procedure. Furthermore, it was emphasized that lifelong restrictions with regard to

shoulder function would be recommended after recovery, including limitation of excessive external rotation, lifting less than 15–20 lbs, and avoidance of contact sports.

Biceps suspensionplasty was performed in conjunction with anterior capsulorraphy with or without allograft tissue to augment the anterior capsule. The initial cases were performed open, but later cases were performed arthroscopically. The benefit of the arthroscopic approach was the added ability to perform a posterior capsular shift in conjunction with the anterior capsular shift and biceps suspensionplasty procedures. In all cases, the rotator interval was imbricated. The use and choice of allograft was at the discretion of the surgeon based upon intraoperative determination of thin patulous capsular tissue. Graft tissue used for this procedure included Achilles, semitendinosus and fascia lata grafts.

2.3. Technique of open biceps suspensionplasty and capsulorraphy

Open procedures were performed with the patient in beach-chair position with a combination of general and regional anaesthesia. The first portion of the procedure was focused on superior capsular shift with or without augmentation of the anterior capsule with allograft tendon. A standard deltopectoral approach was utilized with a subscapularis tenotomy. At the inferior-most extent of the subscapularis tenotomy, a freer-elevator was utilized to separate the subscapularis tendon from the inferior glenohumeral ligament (IGHL). The inferior glenohumeral ligament was incised leaving 5–10 mm of capsular tissue along the anatomic neck of the humerus. With the axillary nerve protected, a lateral-to-medial capsulotomy was performed along the superior aspect of the IGHL creating an anterior-inferior capsular flap that would later be incorporated into a superior capsular shift. The residual middle glenohumeral ligament (MGHL) capsular tissue was kept with the subscapularis tendon.

In cases of severe capsular deficiency, allograft tendon was utilized to recreate the capsule. To do so, a single 3.0-mm bio-composite SutureTak anchor (Arthrex, Naples, FL, USA) was placed at the mid-portion of the glenoid rim. The sutures were passed through residual labral tissue and into the mid-portion of a tendon graft and securely tied. This generated two graft limbs, one to reconstruct the anterior-superior aspect of the IGHL and the other for reconstruction of the MGHL. After superior capsular shift, the tendon graft tails were utilized by placing two 5.5-mm bio-composite corkscrew suture anchors (Arthrex, Naples, FL, USA) just lateral to the native capsular insertion along the anatomic neck. The #2 non-absorbable suture in each anchor was used to secure each tail of the tendon graft. To reconstruct superior aspect of the IGHL, the shoulder was placed in 45-degrees of abduction and 45-degrees of external rotation and the inferior tendon graft tail was then sutured to the humerus with the sutures from the inferior-most anchor. To reconstruct the MGHL, the shoulder was placed in 25-degrees of abduction and 25-degrees of external rotation and the superior tendon graft tail was sutured with the superior-most anchor sutures. The subscapularis tenotomy was closed with side-to-side #2 Ethibond (Ethicon, Somerville, NJ, USA) sutures.

A soft-tissue tenodesis of the LHB was performed to the upper border of the pectoralis major tendon. The LHB was then tenotomised just proximal to the tenodesis site, resulting in a 7–8 cm limb of LHB tendon that remained attached to the superior labrum available for suspensionplasty. The LHB was elevated out of the intertubercular groove and the groove was prepared with a pine-cone burr to generate a bone tunnel with the superior hole at the level of the native superior glenohumeral ligament insertion. The LHB was then passed through the superior hole to the inferior hole and folded back upon itself. The distal aspect of the LHB was then tensioned and secured to the proximal aspect of the LHB with #2 Ethibond sutures to complete the biceps suspensionplasty. Rotator interval imbrication with incorporation of the biceps suspensionplasty was performed with #2 Ethibond sutures.

2.4. Technique of arthroscopic biceps suspensionplasty and capsulorraphy

Arthroscopic procedures were performed using a standard posterolateral-viewing portal to perform a diagnostic arthroscopy of the glenohumeral joint with a 30-degree scope. Outside-in technique was then utilized to establish an anterior-inferior portal just above the subscapularis and in-line with the glenoid surface as well as a more lateral anterior-superior portal through the rotator interval. If a posterior labral detachment was present it was repaired and a superior capsular shift of the posterior capsule was performed concomitantly with a series of suture anchors placed at the chondrolabral junction. Next a superior capsular shift of the anterior-inferior capsule was performed. The rotator interval was imbricated with sutures from an anchor placed in the glenoid anterior to the biceps origin on the superior labrum. The sutures from the anchor were placed through the origin of the superior and middle glenohumeral ligaments to shift the capsule superiorly.

If an allograft augment of the capsular tissue was required, it was also performed arthroscopically in one case. This was performed in patient #5, who had deficient posterior capsule. First, the necessary length of graft tissue was measured from the glenoid margin to the anatomic neck of the humerus. A graft twice this length was prepared which would allow for two graft tails to be anchored to the humerus. The mid-point of the graft was secured to the glenoid with a suture anchor. The graft tails were then brought out laterally and secured to the anatomic neck of the humerus with additional suture anchors. Concentric reduction of the humeral head was maintained as the lateral graft tails were sutured.

After capsulorraphy procedures were completed, the biceps suspensionplasty was performed. The shoulder was maintained in 0-degrees of external rotation and the humeral head was concentrically reduced onto the glenoid. The arthroscope was placed in the posterolateral portal and the anterior-superior portal was dilated and a cannula was placed to create a working portal. The LHB was retracted anteriorly with a probe through the anterior-inferior accessory portal to expose the insertion site of the superior glenohumeral ligament at the superior aspect of the lesser tuberosity. Through the anterior-superior working portal this area was prepared for biceps tenodesis. The Arthrex biceps tenodesis system was utilized and an 8 mm drill hole was established. A biocomposite tenodesis screw (8 mm × 19 mm) was then utilized to capture and tension the LHB, while maintaining concentric reduction of the glenohumeral joint.

Postoperatively, patients were maintained in a sling for a period of 4 weeks. Following this period of immobilization, they were started in physical therapy with a focus on regaining range of motion. Postoperative precautions included limiting shoulder external rotation to less than 10°. Scapular stabilization and rotator cuff strengthening exercises were emphasized as patients regained their motion.

2.5. Statistical analysis

Preoperative and postoperative range of motion and functional questionnaire scores were analyzed through paired t-tests and Holm Bonferroni adjustments for p-values. A p-value of < 0.05 was considered significant.

3. Results

Our institutional database search identified 8 subjects (10 shoulders) with 5 subjects (7 shoulders) meeting our 2-year minimum follow up criteria (Table 1). The mean duration of patient follow-up was 3.2 years (range: 2–7). All patients were females with a mean age of 24.2 years (range: 18.7–32.4) with an average BMI of 25.7 (range: 18.7–32.4) and had an average of 1.6 prior capsulorraphy procedures (range: 1–3). The cohort included 3 students, 1 teacher, and 1 truck driver. All patients had experienced multiple episodes of subluxation. One patient, a truck driver, had an active workers compensation claim. Four of the initial shoulder dislocations were traumatic in nature. Both patients who had

Table 1
Patient demographics and procedure details.

Patient	Age	Sex	Side	Hand Dominance	BMI	Occupation	History of Trauma	# of Prior Surgeries	Prior Surgeries	Inferior Instability	Anterior Instability	Posterior Instability	Procedure Details	Allograft Used
1	24	F	R	A	18.2	Student	N	1	Arthroscopic capsulorraphy	3+	2+	1+	Arthroscopic anterior and posterior capsular shift, biceps suspension	N
1	19	F	L	A	18.2	Student	N	1	Arthroscopic capsulorraphy	3+	3+	2+	Open anterior capsular shift, anterior capsular reconstruction, biceps suspension	Y
2	32	F	L	R	27.4	Teacher	Y	2	Arthroscopic capsulorraphy x1 Arthroscopic capsulorraphy w/rotator interval closure x1	3+	3+	1+	Open anterior capsular shift, anterior capsular reconstruction, biceps suspension	Y
3	21	F	R	A	22.5	Student	Y	3	Arthroscopic capsulorraphy x1 Open capsular shift x1	3+	2+	1+	Open anterior capsular shift, anterior capsular reconstruction, biceps suspension	Y
4	20	F	L	R	22.7	Student	Y	1	Arthroscopic capsulorraphy	3+	3+	1+	Arthroscopic anterior and posterior capsular shift, rotator interval imbrication, biceps suspension	N
4	21	F	R	R	22.7	Student	N	1	Arthroscopic capsulorraphy	3+	2+	2+	Open anterior capsular shift, biceps suspension, pectoralis to scapular muscle transfer	N
5	32	F	R	R	37.8	Truck Driver	Y	2	Arthroscopic labral repair x1 Arthroscopic capsular shift x1	3+	2+	3+	Arthroscopic anterior and posterior capsular shift, posterior capsular reconstruction, biceps suspension	Y

BMI, Body Mass Index; F, Female; R, Right; L, Left; A, Ambidextrous; Y, Yes; N, No.

undergone bilateral biceps suspensionplasty procedures had a diagnosis of Ehlers-Danlos syndrome. Four patients were smokers. No patients had radiographic evidence of arthritis.

Four shoulders were treated open, while 3 were treated arthroscopically. Three shoulders underwent a revision anterior capsular shift without allograft, while four shoulders underwent concomitant capsular reconstruction with allograft tendon. Three of the four capsular augmentations with allograft were performed to augment deficient anterior capsular tissue and were performed with the open technique. One of these allograft capsular augmentations was for deficient posterior capsular tissue and was performed arthroscopically (patient #5). One patient underwent a concomitant pectoralis major transfer for scapular stabilization. The two patients with Ehlers-Danlos syndrome had the biceps suspensionplasty procedure performed with open technique on one shoulder and arthroscopic technique on the contralateral side.

At final follow-up, three patients (three shoulders) reported multiple episodes of sensation of inferior subluxation. Two of the patients with inferior subluxation had been treated arthroscopically and one was treated open. Allograft was utilized for capsular reconstruction in two of the patients with inferior subluxation (one open and one arthroscopic). Three of the four shoulders in the patients with Ehlers-Danlos syndrome did not have any episodes of inferior subluxation. The average ASES, SST, and ROWE scores all improved significantly post-operatively (Tables 2 and 3). Although, the average VAS pain score improved, it did not reach statistical significance. In one patient the VAS pain score increased from the preoperative level. The average postoperative SANE score was 65.4 (range: 30–90) and the average postoperative Oxford Instability score was 30.6 (2–43). Active external rotation (AER) decreased significantly from 70 to 5° (p = 0.002). In the patients with recurrent subluxations, one of these occurred after a fall in a patient previously doing well for 1-year, one occurred in a patient without traumatic event two years postoperatively and one occurred in a patient with an active worker's compensation claim. Patients without symptoms of instability rated their shoulders as "much better" (4) while those that experienced some episodes of recurrent instability felt their shoulders were "somewhat better" (3) at final follow-up. No complications were observed and no patients underwent reoperation during the study period.

4. Discussion

Recalcitrant multidirectional shoulder instability is a difficult problem to manage, as patients often have deficient or non-functional capsular tissue available for reconstruction. The Nicola biceps suspensionplasty utilizes the long head of biceps tendon to suspend the humeral head from the biceps attachment at the superior glenoid labrum. In this study, we review the outcomes of patients in whom a modification of the original Nicola technique was combined with revision capsulorraphy, with or without allograft augmentation, to treat recalcitrant multidirectional instability.[17] In our study group, the surgical technique evolved from an open to an arthroscopic procedure. In both approaches,

Table 3
Preoperative and postoperative outcome comparison.

	Preoperative	Postoperative	p-value
ASES	35.9 (17–46.6)	68.7 (21.6–90)	0.037
SST	5 (2–7)	8 (2–10)	0.024
Rowe	29.3 (15–40)	60 (15–75)	0.017
VAS	5.9 (4–8)	3.4 (0–8)	0.137
Active ER	70 (45–85)	5 (0–30)	0.002
Active FE	153 (90–180)	124 (90–155)	0.052

ASES, American Shoulder and Elbow Surgeons; SST, Simple Shoulder Test; VAS, Visual Analog Scale; ER, External Rotation; FE, Forward Elevation.

the goal was to perform a revision capsular shift of the anterior capsule, biceps suspensionplasty and rotator interval imbrication. The arthroscopic approach also permitted a capsular shift to be performed on the posterior capsule. In both approaches, it was possible to augment deficient capsular tissue with allograft tendon.

Overall, all patients in our series considered their shoulder to be improved after surgery; however, the clinical failure rate could be considered 42.8%, based upon three patients experiencing recurrent episodes of shoulder subluxation. Two of the failures occurred in patients in whom allograft capsular reconstruction was performed. Additionally, two of the failures occurred in patients in whom the arthroscopic technique was utilized. Our limited numbers of patients undergoing each technique and with or without allograft preclude the ability of determining whether these factors correlated with an increased risk of failure. None of the patients underwent further operation for shoulder instability; however, the patient with an active worker's compensation claim is considering glenohumeral fusion as a salvage procedure. There were no major complications in our series.

Compared with the study by Krishnan et al. we had a similar size cohort of patients being treated for recalcitrant multidirectional instability.[15] In their series, they emphasized three key components of the procedure collectively called the "kitchen-sink" including: an open humeral-based inferior capsular shift, biceps suspensionplasty, and reconstruction of the coracohumeral ligament and rotator interval capsular tissue. Similarly, in all of our patients an inferior capsular shift was performed in conjunction with biceps suspensionplasty and rotator interval imbrication. If capsular tissue was deficient, it was augmented with allograft tendon in a technique similar to that described by Iannotti et al.[19] Of the 10 patients in the Krishnan study, five experienced substantial improvement in pain relief from preoperative levels, while the remaining five patients had persistent pain and continued to utilize a sling to support their inferior subluxation.[15] Overall they did not find any improvement in postoperative ASES scores, but they did note that patients with no pain were able to achieve greater active forward elevation compared to those with a persistently painful shoulder (100° vs 45°) despite no difference in supine passive elevation (155° vs 150°).

Similar to the Krishnan study, we noted a high rate of postoperative inferior subluxation (42.8%) and pain control was not uniform. While

Table 2
Postoperative patient outcomes.

Patient	Final ASES	Δ ASES	Final SST	Δ SST	Final VAS Pain	Δ VAS Pain	Final Rowe	Δ Rowe	SANE (PostOp)	Oxford (PostOp)	Recurrent Subluxation	Repeat Surgery	Likert Satisfaction
1	90	50	10	4	0	−6	75	45	90	42	N	N	Much better
1	90	50	10	4	0	−6	75	45	90	43	N	N	Much better
2	60.1	43.1	7	5	4	−4	55	25	40	30	Y	N	Somewhat better
3	69.9	23.3	10	3	3	−3	75	35	55	33	N	N	Much better
4	62	–	9	4	7	3	50	35	68	24	Y	N	Somewhat better
4	87	34	9	4	2	−2	75	45	85	40	N	N	Much better
5	21.6	−11.4	2	−2	8	1	15	−15	30	2	Y	N	Somewhat better

ASES, American Shoulder and Elbow Surgeons; SST, Simple Shoulder Test; VAS, Visual Analog Scale; SANE, Single Assessment Numeric Evaluation.

one patient had complete resolution of discomfort in both shoulders treated and three shoulders reported improved pain, two patients reported higher levels of pain postoperatively compared to preop. In contrast to the prior study, our cohort did demonstrate improved postoperative ASES, SST, and ROWE scores. One major difference between our patient cohorts is that four (40%) of the patients in the prior study elected for revision to glenohumeral joint fusion for persistent pain. The reasons for this difference in rate of conversion to glenohumeral fusion are likely multifactorial and may also be reflective of differences in willingness of the treating surgeons to perform fusion procedures.

The isolated use of allograft tendon to augment capsular deficiencies has been described by other authors with varied success.[19] Iannotti et al. described the use of fascia lata graft to reconstruct the anterior capsule in 7 patients, highlighting the ability to selectively tighten the graft to recreate the variable length-tension relationship of the capsule as the shoulder is placed in different levels of abduction and external rotation. All 7 patients in their study had improvement in shoulder function without recurrence of instability at 2-year follow-up. Dewing et al. reported on a modified reconstructive technique with more sobering results.[20] In their study of 15 patients (20 shoulders), tendon graft was utilized to recreate an anterior labrum and then the graft tails were brought out laterally and tenodesed into the humeral head to recreate the middle glenohumeral ligament and anterior-inferior glenohumeral ligament. At an average of 3.2-years of follow-up, they observed a recurrent instability rate of 55%, highlighting the unpredictable nature of revision stabilization procedures.

In our approach to the patient with recalcitrant multidirectional instability, we feel that joint arthrodesis should be a last resort. Our surgical technique incorporates biceps suspensionplasty along with revision capsulorrhaphy and rotator interval imbrication. In cases of severe capsular deficiency, allograft tendon is utilized to reconstruct anterior or posterior capsule. With this technique joint stability was achieved in 4 of 7 shoulders; however, this often came at the expense of reduced glenohumeral motion. In particular, we noted statistically significant decreases in active forward elevation and active external rotation compared with preoperative levels. We believe it is crucial to discuss with patients the expected reduction in glenohumeral joint motion as a consequence of surgery at the time of their preoperative evaluation. Additionally, it is discussed with the patient that the anterior capsular tissue may be deficient and therefore may require augmentation with allograft tendon. Permanent lifting and activity restrictions are discussed with the patient. Despite these limitations and the objective decline in range of motion, many of our patients were satisfied with having the surgical procedure performed. We believe that this highlights the significant level of disability that patient with recalcitrant multidirectional instability face as well as their readiness to pursue further surgery in order to obtain joint stability and pain relief. The risks and restrictions should be reviewed with the patients and we believe this technique is worth consideration as an alternative treatment to arthrodesis in patients with recurrent shoulder instability.

Limitations of this study include the evolving technique from open to arthroscopic revision stabilization with biceps suspensionplasty, and the heterogenous use of allograft and posterior capsular plication. However, revision surgery for recurrent multidirectional shoulder instability must be individualized to the quality of tissue and capsule remaining, making a homogenous patient cohort difficult to obtain in this rare condition. This also makes it difficult to isolate the effect of biceps suspensionplasty on the clinical outcomes, however this study does provide additional evidence that suspensionplasty may be a useful adjunct in difficult revision cases. Another limitation is the lack of radiographic analysis at final follow up to confirm concentric joint reduction given that patients were contacted via phone interview. An additional concern in this cohort is their relatively young age and the unknown long-term durability of this procedure. Future research should identify patients who had identical procedures with and without a biceps suspensionplasty in order to better define the individual contribution of the suspensionplasty to shoulder stability.

Color print

The figures do not require publication in color.

Declarations of interest

The authors declare that they have no conflicts of interest related to the subject of this article.

5. Conclusion

Recurrent shoulder instability remains a challenging problem to treat with no ideal solution. Biceps suspensionplasty in combination with capsular shift and rotator interval imbrication is a salvage procedure that may improve pain and function for patients while avoiding arthrodesis in the short-term. Patients must be counselled preoperatively regarding expected postoperative motion and activity restrictions.

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