How Does External Rotation Bracing Influence Motion and Functional Scores After Arthroscopic Shoulder Stabilization?

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Abstract

Background After arthroscopic shoulder stabilization, the loss of motion or delayed recovery of motion remains a clinical problem and may lead to poor patient satisfaction. There remains no consensus regarding the optimal position for postoperative immobilization and it is not known

whether the position for shoulder immobilization has an effect on motion and functional recovery.

Questions/purposes We asked: (1) Do patients treated with external rotation (ER) bracing after arthroscopic anterior shoulder stabilization reliably regain ROM and shoulder function? And (2) what is the frequency of recurrent instability and brace-related complications associated with the use of ER bracing?

Methods Forty consecutive patients with a primary diagnosis of anterior shoulder instability underwent arthroscopic stabilization and received postoperative ER bracing; 33 patients (83%; mean age, 23 years; range, 13–44 years) were followed for at least 1 year postoperatively and seven patients were lost to followup. Shoulder ROM and functional scores were recorded preoperatively and at 2 weeks, 12 weeks, 6 months, and greater than 1 year (mean, 16 months) after surgery.

Results All patients recovered their preoperative ROM and most patients achieved normal ROM by 3 months after surgery. Significant improvements in American Shoulder and Elbow Surgeons (ASES) and Western Ontario Shoulder Instability (WOSI) scores were observed at each postoperative time point. The mean ($\pm$ SD) final scores were 95 ± 9 for the ASES and $87\% \pm 17\%$ for the WOSI ($p < 0.001$ compared to preoperative scores). One patient (3%) developed recurrent instability. No patients underwent reoperation for the injured shoulder for any reason during the followup period.

Conclusions ER bracing after arthroscopic shoulder stabilization is associated with a predictable recovery of ROM and functional score improvement. Future studies comparing ER bracing to traditional sling use should be conducted to determine the optimal method of postoperative immobilization.

Level of Evidence Level IV, therapeutic study. See Instructions for Authors for a complete description of levels of evidence.

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Introduction

While the use of arthroscopic shoulder stabilization has increased over the past decade in the United States and Great Britain, there does not exist a consensus regarding postoperative management [15, 19]. There is great variability among surgeons regarding the desired position of the shoulder during the postoperative recovery period and the duration of postoperative immobilization. Modifications in these parameters may affect the rate of recovery of shoulder ROM and influence the risk of developing postoperative stiffness. In recent years, several clinical studies have assessed the efficacy of external rotation (ER) bracing after traumatic anterior shoulder dislocation, with varying effects on the incidence of recurrent instability [2, 5, 6, 14]. However, there have been no reports in the literature about ER bracing after surgical treatment for anterior shoulder instability. Loss of ER after shoulder stabilization surgery is associated with decreased patient satisfaction so efforts should be made to safely recover range of ER during the early postoperative period [21].

In our clinical practice, we have observed that placing the shoulder in an internally rotated position with a traditional sling resulted in complaints of stiffness and increased pain during physical therapy, particularly during ER exercises. Impaired recovery of ROM is particularly

distressful to patients with shoulder instability, who tend to be young and active. When the shoulder was placed in an externally rotated position during the immediate postoperative period, we observed patients had a much easier time with physical therapy and less frequently complained about stiffness, thus causing us to evaluate alternatives to traditional slings in this patient population.

We therefore asked in the context of a prospective observational study: (1) Do patients treated with ER bracing after arthroscopic anterior shoulder stabilization reliably regain ROM and shoulder function? And (2) what is the frequency of recurrent instability and brace-related complications associated with the use of ER bracing?

Patients and Methods

Patient Enrollment and Study Design

This prospective observational study was approved by our institution's investigational review board. Over a 1-year enrollment period (November 19, 2010, to November 18, 2011), we prospectively screened all 139 patients who were scheduled to undergo first-time arthroscopic shoulder capsulorrhaphy and/or labral repair (Current Procedural Terminology code: 29806 and/or 29807) at our tertiary care

Fig. 1 A flowchart shows inclusion and exclusion criteria used to determine the 33 patients who were analyzed for this study. CPT = Current Procedural Terminology; SLAP = superior labral anterior-posterior; OA = osteoarthritis; MDI = multidirectional instability.

university-affiliated institution. Patients undergoing revision surgery and those with bone loss requiring a bone augmentation procedure were not considered. Of those screened, 66 patients were determined to be eligible for the study based on having surgery for the first time for a primary diagnosis of closed anterior glenohumeral dislocation or recurrent shoulder instability (ICD-9: 831.01 or 718.31, respectively). At the time of surgery, 26 patients were excluded because of the following criteria: (1) declined to participate or did not speak English ($n = 21$); (2) diagnostic arthroscopy revealed no anterior-inferior labral pathology ($n = 3$); (3) presence of Grade III to IV osteoarthritis ($n = 1$); or (4) presence of a greater than 270° labral tear with multidirectional instability based on intraoperative examination under anesthesia and arthroscopic findings ($n = 1$). This resulted in final enrollment of 40 patients. Enrolled patients who missed two or more followup time points were considered lost to followup and were excluded from the analysis ($n = 7$), resulting in 33 patients (83%) available for followup and analysis at least 1 year postoperatively (Fig. 1).

Patient Demographics

The mean age was 23.2 years (range, 13.2–44.7 years) and 28 of 33 patients (85%) were male (Table 1). The dominant arm was injured in 40% of patients. The injury resulted from athletic participation in 25 patients (76%), with nine patients involved in contact sports (27%). The most common mechanism of injury was football ($n = 6$), followed by chronic injury without distinct mechanism ($n = 4$) and baseball, skiing, and weight lifting (each with $n = 3$).

Operative Procedure and Findings

All patients underwent arthroscopic soft tissue repair of an anterior-inferior labral tear using bioabsorbable suture anchors, without the need for a bone augmentation procedure. An average of 4.6 suture anchors (range, 2–10) was used in the 33 patients in this study (Table 2). A majority of patients ($n = 21$, 64%) had a concomitant superior labral anterior-posterior tear that was repaired. Additionally, 16 patients (48%) also had capsular redundancy that was addressed with capsular plication using free sutures or suture anchors, which were secured with the shoulder in neutral rotation.

Immediately after surgery, all patients were placed by a trained orthotist in a shoulder orthosis in 10° to 20° of ER and approximately 30° of abduction according to the patient's comfort and body habitus (Rotation & Abduction

Table 1. Patient demographics ($n = 33$)

Variable	Number of patients
Sex	
Male	28 (85%)
Female	5 (15%)
Age group	
10–20 years	16 (48%)
21–30 years	12 (36%)
31–40 years	4 (12%)
> 41 years	1 (3%)
Injured extremity	
Dominant	13 (39%)
Nondominant	20 (61%)
Mechanism of injury	
Noncontact sports	16 (48%)
Baseball	3
Skiing	3
Weight lifting	3
Swimming	2
Gymnastics, javelin, rock climbing, rowing, sailing	1 each
Contact sports	9 (27%)
Football	6
Basketball	2
Rugby	1
Not sports-related	8 (24%)
No distinct mechanism of injury	5
Mechanical fall	2
Assault	1

Table 2. Operative findings ($n = 33$)

Variable	Number of patients
SLAP tear requiring repair	21 (64%)
Capsular redundancy requiring plication	16 (48%)
Number of suture anchors used	
2–3	12 (36%)
4–6	16 (48%)
7–10	5 (15%)
Mode	3 ($n = 8$)
Mean	4.6

SLAP = superior labrum anterior-posterior.

Device; Span Link International, Deer Park, NY, USA) (Fig. 2). They were instructed to wear the brace at all times except to maintain hygiene and during supervised physical therapy. Brace wear was discontinued at 4 to 6 weeks postoperatively. All patients participated in a standardized physical therapy protocol consisting of progressive passive

Fig. 2 Patients were placed in a shoulder orthosis in 10° to 20° of ER and approximately 30° of abduction according to the patient's comfort and body habitus.

and active-assisted forward elevation (FE) in the scapular plane to 140° during the first 2 weeks. Active ER using elastic tubing started at Week 2 and progressed to strengthening starting at Week 4, with dynamic weight-bearing starting at Week 8.

Outcomes

Preoperatively, we recorded the patient's shoulder ROM and baseline functional scores, including the American Shoulder and Elbow Surgeons (ASES) score, Western Ontario Shoulder Instability (WOSI) score, VAS pain score, and SF-12 health survey (physical component summary [PCS] and mental component summary [MCS] scores). ROM and functional scores were again recorded at 2 weeks, 6 weeks, 3 months, 6 months, and greater than 1 year postoperatively (mean, 65 weeks; range, 52–95 weeks). ROM was measured with a large-angle goniometer with the patient in an upright standing position. FE was measured in the scapular plane and ER was measured with the arm positioned at the patient's side in 0° of abduction and forward flexion.

We evaluated the safety of ER bracing by determining the rate of recurrent instability and brace-related complications or complaints. Patients were evaluated for signs or symptoms of recurrent instability by physical examination at all followup time points. At the 2- and 6-week followup appointments, 29 of the 33 patients (88%) completed a survey to assess their compliance and satisfaction with bracing. Overall self-reported compliance with bracing was rated on a 0- to 10-point Likert scale, with 0 signifying no

brace wear at all and 10 signifying brace wear at all times except for hygiene activities and physical therapy. The patients also rated their satisfaction with the brace in five domains (overall satisfaction, comfort, adjustability, convenience of use, and ability to support the shoulder) using a 5-point Likert-style scale, with 1 representing excellent, 2 very good, 3 good, 4 fair, and 5 poor.

Statistical Analysis

We analyzed the data using SPSS® Version 19 (IBM Corp, Armonk, NY, USA). Thirteen of the 33 patients (40%) had incomplete data collections secondary to missed appointments or incomplete surveys. Little's missing completely at random chi-square test was used to show that the missing values occurred completely at random, without being influenced by any of the outcome parameters (ROM, ASES, WOSI, VAS, or SF-12) or any other values in the data set. The generalized estimating equation (GEE) was used to complete each patient's data set based on existing values so that all patients available for 1-year or greater followup ($n = 33$) could be included in the analysis. The GEE is an established statistical method [1] used to deal with regression with correlated errors and nonnormal outcomes and has been used in recent orthopaedic studies [3, 17]. All results are reported as means with SDs.

Results

ROM and Functional Outcomes

The patients had a mean ER of $62^\circ \pm 15^\circ$ (range, 30° – 80°) preoperatively. As a group, they regained this motion by 3 months postoperatively and had a significantly improved mean range of ER at time of final followup ($72^\circ \pm 12^\circ$; range, 40° – 85°) (Fig. 3A). The mean FE in the scapular plane was 170° (range, 90° – 180°) preoperatively and 177° (range, 165° – 180°) at final followup, with the average patient also recovering preoperative ROM by the 3-month postoperative visit (Fig. 3B).

The mean preoperative ASES score was 65 ± 25 , which improved to 83 ± 15 by 3 months postoperatively and was 95 ± 9 at time of final followup ($p < 0.001$ compared to preoperatively) (Fig. 4A). Similarly, the mean WOSI score improved from $45\% \pm 23\%$ preoperatively to $54\% \pm 19\%$ at Week 6 ($p < 0.001$) and $87\% \pm 17\%$ at final followup ($p < 0.001$) (Fig. 4B). The VAS pain score showed a steady and significant decrease at each postoperative time point, going from a preoperative mean of 3.5 ± 3 to a final value of 0.7 ± 1.5 ($p < 0.001$) (Fig. 4C). The SF-12 PCS score showed significant improvement ($p < 0.001$) between

Fig. 3A–B Postoperative (A) ER and (B) FE returned to preoperative values by 3 months after surgery and were improved at final followup when compared to preoperative values. 1 = preoperative; 2 = 2 weeks; 3 = 6 weeks; 4 = 3 months; 5 = 6 months; 6 = more than 1 year.

all followup visits, from a low of 38 ± 13 at Week 2 to 55 ± 5 at final followup (Fig. 4D). The SF-12 MCS score in our group was higher than the national average at every point in the study and did not show any significant changes during the study period (Fig. 4E).

Recurrent Dislocation, Compliance, and Device-related Patient Satisfaction

One patient developed shoulder pain and recurrent apprehension on physical examination after a new injury (fall while mountain biking) and was being treated nonoperatively as of his last visit at 13 months after surgery. None of the remaining patients in the study reported any signs or symptoms of recurrent subluxation. This resulted in a 3% rate of recurrent instability in our group. No patients required reoperation for any reason, and there were no infections or surgery-related neurologic injuries in this group.

In the 29 patients who completed the survey, overall self-reported compliance with bracing was 8.8 at 2 weeks and 6.9 at 6 weeks postoperatively (Fig. 5A). The patients

rated the brace as good to very good in terms of overall satisfaction, comfort, adjustability, and convenience of use. A mean score of very good to excellent was given for its ability to support the shoulder (Fig. 5B).

Discussion

The loss of ROM, especially ER, after arthroscopic shoulder stabilization is a well-recognized clinical problem [7]. The rate of stiffness in the early postoperative period is not known because previous studies, both historic and recent, have focused on the incidence of recurrent instability, a relatively longer-term outcome that led to the reporting of data at greater than 2 years after surgery [4, 8, 9, 20]. To our knowledge, this is the first study to report ROM and functional scores over multiple time points during the first year after surgery to assess the short-term recovery of ROM and shoulder function in patients who used the ER brace. In the current observational study, we asked: Do patients treated with ER bracing after arthroscopic anterior shoulder stabilization reliably regain ROM and shoulder function during the first year after surgery? And what is the risk of recurrent instability and brace-related complications associated with the use of ER bracing?

The main shortcoming of our study is the lack of a control group using the traditional sling that keeps the humerus in an internally rotated position. Without a control group, we could not determine whether ER bracing is better than traditional sling immobilization. Additionally, we cannot conclude that using the sling has any detrimental effects on ROM or function. With the current limited study, we were only able to establish the safety of the ER brace during the first year after surgery, but we were unable to determine which intervention is better (sling or brace) and whether there is any reason to discontinue the use of slings in this clinical scenario. A future randomized trial comparing the two positions of immobilization should be pursued to more directly answer these relevant clinical questions. Our study also had a relatively short followup period (mean, 16 months; range, 12–24 months). Previous instability studies have shown that recurrent instability can occur many years after arthroscopic stabilization, so it is likely that the incidence of recurrent instability will rise if our patient cohort is followed over time [9, 12]. Additionally, compliance and patient satisfaction were assessed by patient survey, which may not have been entirely reliable, particularly insofar as 28% of patients did not complete the survey; it is possible that patients did not consistently wear the brace, which raises the question of whether some patients need bracing at all after these procedures. Finally, seven of the original 40 patients were lost to followup; it is therefore

Fig. 4A–E Postoperative improvements in **(A)** ASES, **(B)** WOSI, and **(C)** VAS pain scores were consistently observed at every time point. **(D)** The SF-12 PCS score steadily recovered and exceeded the US national average by time of final followup. **(E)** The SF-12 MCS did not vary significantly in the study group, who in general had better

than average MCS scores than the US national average throughout the study. The dotted line denotes the national average SF-12 PCS and MCS scores among the 25- to 34-year-old age group when surveyed in 2001 [4]. 1 = preoperative; 2 = 2 weeks; 3 = 6 weeks; 4 = 3 months; 5 = 6 months; 6 = more than 1 year.

possible that the risk of recurrent instability may be much higher than the 3% we observed among patients who followed up. Our study was also limited by our method for measuring ROM, which has not been formally validated by previous studies.

The functional outcomes observed in our series are similar to those previously reported in the literature. Kim et al. [10] reported that a series of 167 patients who

underwent arthroscopic Bankart repair had an average final ASES score of 91.9, with 78% of patients having an excellent Rowe score and a 4% rate of recurrent instability at 2- to 6-year followup. Another series by Law et al. [13] of 38 patients with an average age of 21 years at mean 28 months after arthroscopic Bankart repair for anterior shoulder instability recorded an average WOSI score of 83%, which is similar to our mean WOSI of 86.8%.

Fig. 5A–B (A) The mean self-reported brace compliance score was 8.8 on a 0- to 10-point Likert scale at 2 weeks and predictably fell at 6 weeks postoperatively as some patients had discontinued brace use

by that time point. (B) The mean scores for satisfaction with the brace across all domains of device properties were generally high when graded on a 1- to 5-point Likert scale with 1 being excellent.

In a series of 18 patients with a mean age of 26.8 years, Marquardt et al. [16] reported a mean ASES score of 92.1 at mean 8.7 years after surgery. The mean SF-12 PCS score at final followup of 54.7 ± 0.8 was higher than the national mean of 53.3 for the 25- to 34-year-old age group [23]. On average, our patients experienced full recovery of preoperative FE and ER at 3 months postoperatively. Interestingly, this time point was also when the patients first achieved a minimal important difference in their ASES and WOSI scores. Previous studies showed that the minimal important difference, which is defined as the minimum

amount of change on the scoring scale that is actually noticeable to the patient, is 16 for the ASES score and 10% for the WOSI [11, 18, 22]. The mean preoperative ASES score was 64.5 and the first time point for this to achieve a 16-point improvement was at 3 months after surgery (82.5). Similarly, the WOSI improved greater than 10% from 45.0% to 66.2% over the course of 3 months.

To our knowledge, no other studies have compared different approaches for postoperative immobilization after this kind of surgery. The frequency of recurrent instability in our study seems comparable to other published series of

arthroscopic instability procedures in which a simple sling was used [10, 13, 16], but without a head-to-head comparison in the setting of a single study, this inference should be interpreted cautiously.

Using ER bracing after arthroscopic shoulder stabilization surgery, we found reliable and relatively quick return of motion, high scores for pain and function, and an apparently low risk of recurrent instability during the first year after surgery. We observed a close correlation between ROM recovery and patient-reported functional outcomes, suggesting, at least preliminarily, some rationale for further investigation of the ER brace for this application. The current series and others have shown that immobilization in ER is well tolerated by the patient and is associated with high compliance and satisfaction without excessive brace-related complications or complaints [2, 5, 6]. Future comparative trials should compare the ER brace to other forms of immobilization after arthroscopic shoulder instability repairs and should focus on recurrent instability and on the correlation between restored ROM, functional scores, and patient satisfaction.

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