Changes in Shoulder Rotator Strength After Arthroscopic Capsulolabral Reconstruction in Patients With Anterior Shoulder Instability

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Background: The correlation between isokinetic internal and external rotation (IR and ER) strength and functional outcomes in patients with anterior shoulder instability treated by arthroscopic capsulolabral reconstruction (ACR) has not been studied.

Purpose: To analyze isokinetic IR and ER strength and their correlation with clinical outcomes in patients with anterior shoulder instability treated by ACR.

Study Design: Case series; Level of evidence, 4.

Methods: Between January 2004 and June 2015, a total of 104 patients who underwent ACR for anterior shoulder instability were analyzed. The mean peak torque (PT) in IR (IR_{PT}) and ER (ER_{PT}), PT deficit (PTD; %) relative to the opposite healthy shoulder, and PT ratio (PTR; ER_{PT}/IR_{PT}) were calculated before and 1 year after surgery. Functional scores were evaluated before surgery and at every follow-up visit. Recurrence and postoperative apprehension during ER at 90° of arm abduction were evaluated at 1 year and the final follow-up (76.6 ± 64.4 months).

Results: IR and ER strength were measured for 68 of 104 patients at 1 year after surgery. ER_{PT} and IR_{PT} were less on the involved side than on the uninvolved side before surgery (0.29 ± 0.10 vs 0.33 ± 0.10 N·m/kg, respectively, for ER_{PT} [$P = .002$]; 0.36 ± 0.14 vs 0.41 ± 0.16 N·m/kg, respectively; for IR_{PT} [$P = .01$]). At 1 year after surgery, IR_{PT} on the involved side recovered (0.40 ± 0.20 N·m/kg), whereas ER_{PT} remained weak (0.30 ± 0.13 N·m/kg) relative to the baseline value. PTD in IR (PTD_{IR}) improved to 2.2% ± 24.4% ($P = .012$), whereas PTD in ER (PTD_{ER}) showed no improvement (13.5% ± 13.8%; $P = .569$). PTR on the involved side improved from 1.07 ± 1.71 to 0.86 ± 0.23 at 1 year ($P < .001$). All functional scores improved significantly at the final follow-up. At 1 year, 9 of 68 (13.2%) patients showed positive apprehension. PTD_{IR} and PTD_{ER} on the involved side were worse in patients with positive apprehension than in those with negative apprehension ($P = .039$ and .014, respectively). PTD_{ER} was worse than PTD_{IR} in patients with positive apprehension at 1 year ($P = .022$).

Conclusion: For those with anterior shoulder instability, preoperative IR and ER strength of the involved shoulder were lower than those of the uninvolved shoulder. IR_{PT} recovered, whereas ER_{PT} remained weak after ACR. To prevent positive apprehension after surgery, IR and ER strengthening exercises are important, with more emphasis on exercises for ER.

Keywords: anterior shoulder instability; arthroscopic capsulolabral reconstruction; isokinetic rotator strength; rotator muscle balance; functional outcomes

Glenohumeral instability occurs because of deficiencies in static and/or dynamic stabilizers of the humeral head on the glenoid.[6] Shoulder muscles stabilize the glenohumeral joint by compressing the humeral head against the concave glenoid surface, allowing concentric rotation of the humeral head on the glenoid.[13] Capsulolabral reconstruction establishes the chock block effect of the labrum in an unstable shoulder, preventing abnormal anterior translation. This allows an effective concavity-compression mechanism by the shoulder muscles,[19] thereby protecting the reconstruction site and restoring full range of motion and arm strength to facilitate a return to normal working or sporting activities.[17]

An isokinetic muscle strength test is a tool that quantifies shoulder muscle strength.[21,28] The isokinetic torque of the rotator muscles as well as the side-to-side difference (isokinetic strength deficit) and the ratio between external and internal rotation (ER and IR) strength for the involved or uninvolved shoulder are often used to assess dynamic stabilizers of the shoulder joint.[3,4,8,27] There are contradictory reports regarding the imbalance of ER and IR muscles in patients with shoulder instability. According to Edouard et al,[7] recurrent anterior instability is associated with

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weakness and imbalance between the strength of internal and external rotators relative to the strength on the healthy side. However, in a prospective study of 102 patients with anterior shoulder instability, Jan et al[14] found no significant difference in the strength of internal and external rotators between the injured and uninjured sides for those patients suffering from shoulder instability, regardless of arm dominance, the number of dislocations, and the severity of bone damage.

Although Amako et al[2] showed that the mean peak torque (PT) in ER (ER_{PT}) and IR (IR_{PT}) was recovered after arthroscopic or open Bankart repair, there are few studies regarding the correlation of rotator muscle strength with shoulder function after surgery for instability. Moreover, rotator muscle strength of the shoulder after anterior arthroscopic capsulolabral reconstruction (ACR) is a debatable topic.[2,24] Furthermore, the correlation between isokinetic strength of the shoulder rotators and functional outcomes in patients with anterior shoulder instability treated by ACR has not been studied. Therefore, this study aimed to analyze isokinetic strength of the shoulder rotator muscles and its correlation with clinical outcomes in patients with anterior shoulder instability treated by ACR.

METHODS

In this institutional review board–approved study, a series of anterior ACR procedures performed by the senior author (J.H.O.) were retrospectively reviewed. Patients electing to undergo arthroscopic capsulolabral repair for unilateral anterior shoulder instability between January 2004 and June 2015 were recruited from an institutional database (n = 231). All of the patients had a true dislocation due to moderate to severe trauma, a minimally traumatic dislocation, or a subluxation with subjective feelings of having a dislocation. A minimal traumatic dislocation was defined as a dislocation during daily activities (reaching out hands to the back seat while driving, taking off clothes, etc) without trauma or dislocation due to light exercise. A subluxation with subjective feelings of having a dislocation was regarded as "instability without a true dislocation." Most patients were recreational sports players, and unless those were revision cases, at our facility, soft tissue procedures were preferred over bony procedures, including the Latarjet procedure. Patients with bilateral involvement (n = 21), those who underwent revision/multiple surgical procedures (n = 15), those requiring open surgery or additional procedures (remplissage, Latarjet, Bristow; n = 3), those with multidirectional instability (n = 6), and those lost to follow-up (n = 82) were excluded. Ultimately, 104 patients who had undergone the isokinetic muscle performance test (IMPT) before and at 1 year after surgery were included (Figure 1). Bone loss of the anteroinferior glenoid before surgery was measured for all patients using computed tomography. The level of shoulder activity during sports or work was graded using a 3-level scale (high, moderate, and low).[20] A high level was defined as participation in dynamic or contact sports (eg, boxing, rugby, basketball, tennis, and volleyball) or heavy manual labor (eg, construction and manufacturing), a moderate level was defined as participation in static sports (eg, golf, yoga, swimming, and skiing) or manual labor involving less physical activity (eg, housework), and a low level was defined as rarely engaging in sports or a sedentary lifestyle.

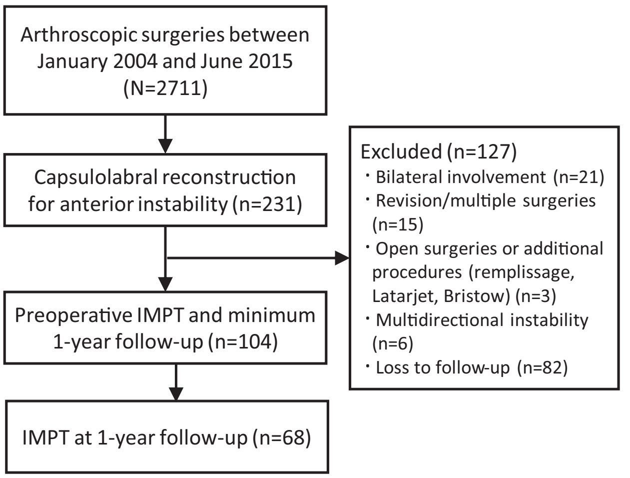

Figure 1. Flowchart of patient inclusion in the study. IMPT, isokinetic muscle performance test.

Surgical Procedure

All surgical procedures (Figure 2) were performed in the lateral decubitus position using a traction device (ACUFEX; Smith & Nephew) with approximately 4 kg (10 lb) of weight. For anterior capsulolabral reconstruction, an additional lateral traction device was applied to pull the arm laterally for easy access to the anterior compartment of the glenohumeral joint. Diagnostic arthroscopic surgery

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Ethical approval for this study was obtained from Seoul National University Bundang Hospital (No. B-1612/373/102).

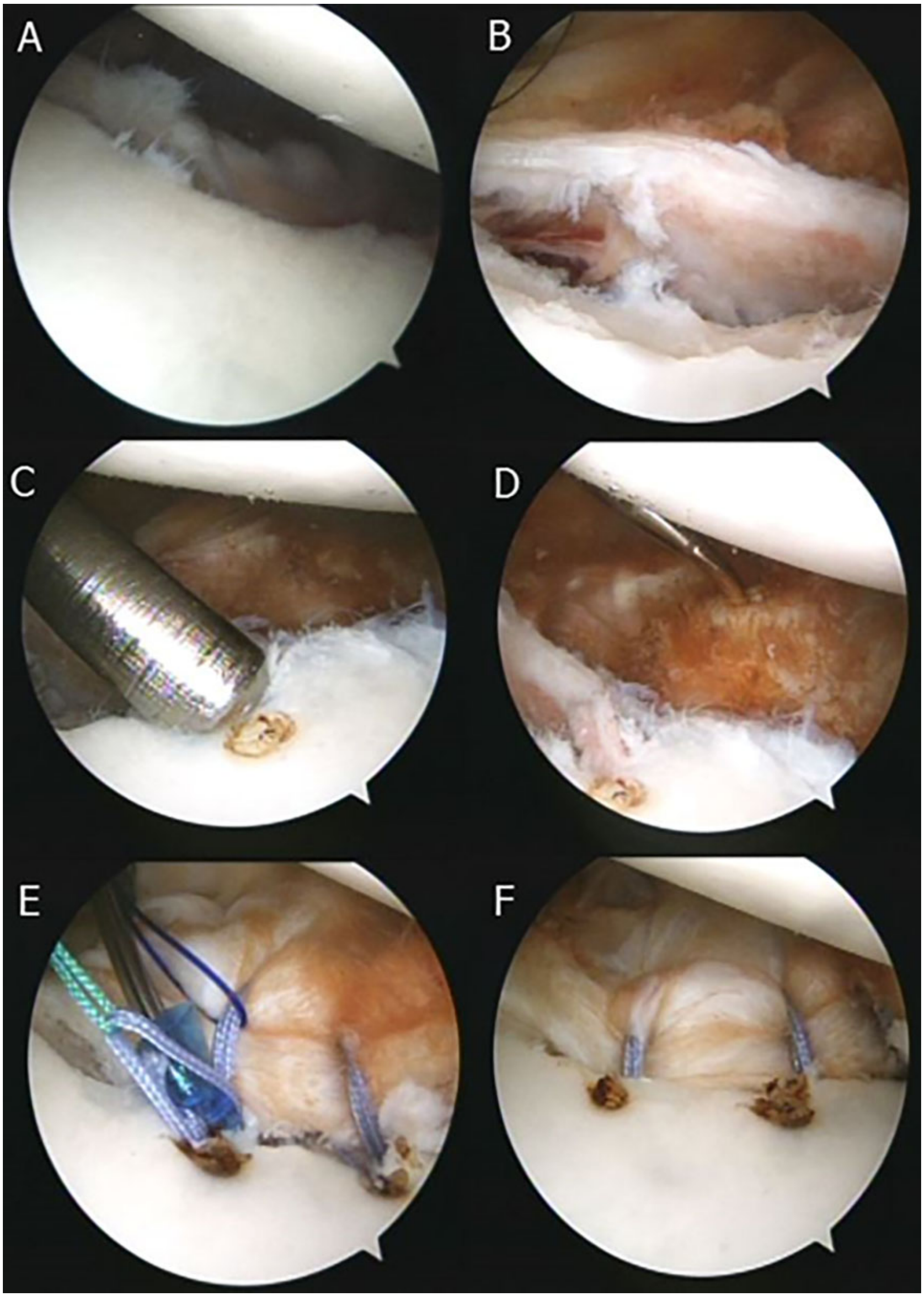

Figure 2. (A) A Bankart lesion is shown through a posterior portal. (B) The labrum is mobilized from the glenoid neck, and subchondral bone is exposed using a bur. (C) There are 3 to 4 drill holes made from the 2- to 6-o'clock positions. (D) A capsulolabral bite is created with the help of a suture passer at a point 1 cm distal and 1 to 2 cm lateral to the drill hole. (E) The same length and tension are achieved between the anterior tissue and posterior tissue limb of the anchor loop. (F) The final construct of capsulolabral repair is shown.

was performed with the standard posterior portal as the viewing portal and the anteroinferior portal as the primary working portal. When an overall examination of the glenohumeral joint was performed, an additional anterosuperior portal was used as the secondary working portal. The abnormally attached labrum or anteroinferior glenohumeral ligament was mobilized first from the glenoid neck. Then, a 2– to 3 mm–wide section of subchondral bone was exposed using a motorized bur for bleeding bone bed preparation. Overall, 3 or 4 drill holes were made from the 2- to 6-o'clock positions. The ideal path for suture passage was through the capsule, at least 1 cm distal and 1 to

2 cm lateral to the drill hole. With the anterior labrum when present, the capsule was sutured and tacked down using 3 or 4 evenly spaced suture anchors (Bioknotless; Mitek).

Postoperative Rehabilitation

After surgery, a home-based physical therapy protocol was prescribed for all patients, and the exercises were taught during follow-up visits. The shoulder was supported for 4 to 6 weeks in neutral rotation with a brace (Acro Assist 50A1; Ottobock). No passive motion was allowed during that period, and only active hand, wrist, and elbow exercises with shrugging were permitted. Active shoulder stretching exercises including active/active-assisted range of motion were started after brace removal. After the restoration of range of motion by stretching exercises, strengthening exercises with TheraBand (Hygenic) were started at 3 months. TheraBand was available in 4 progressive levels of resistance. Patients were instructed to start strengthening exercises involving forward flexion, ER, and IR with the lowest level of resistance. For forward flexion, patients were instructed to begin while standing upright. Then, they were asked to place TheraBand under the foot and push forward with arm extension. For ER and IR exercises, patients were instructed to begin in a standing upright position with their elbows bent at 90°. For ER, TheraBand was anchored into a doorjamb, and patients were asked to rotate slowly away from the opposite arm. For IR, patients were asked to assume the same position as that for ER and told to rotate slowly toward the opposite arm. If the patients experienced pain during the exercises, they were asked to rest or lower the resistance level. If the patients found the exercises too easy or felt no resistance, they were instructed to move to the next resistance level. These 3 exercise sets were performed 3 times a day, with 10 repetitions each time. The proper level of resistance was checked at the follow-up visit. Regular sports activities were usually permitted 6 months postsurgically.

Isokinetic Muscle Performance Test

The IMPT was performed using a Biodex 3 PRO System (Biodex) with patients in the sitting position (Figure 3). There were 2 bands strapped across the chest with the shoulder in a neutral position, 45° of abduction in the scapular plane, elbow in 90° of flexion, and forearm in neutral rotation. ER_{PT} and IR_{PT} were measured at 60 deg/s, which is considered representative of functional tasks.[12] PT was normalized to the body weight and reported in N·m/kg. The mean PT deficit (PTD) was calculated as the weight-normalized PT on the uninvolved (nonoperated/healthy) side minus that on the involved (operated) side. The percentage PTD was calculated as a percentage of the mean PTD divided by the weight-normalized PT on the uninvolved limb: (uninvolved side PT − involved side PT)/(uninvolved side PT × 100). The PT ratio (PTR) was the ratio between ER_{PT} and IR_{PT} on 1 side (ER_{PT}/IR_{PT}), which is indicative

Figure 3. The isokinetic muscle performance test is performed in the sitting position. There are 2 bands strapped across the chest with the shoulder in a neutral position and 45° of abduction in the scapular plane. External rotation and internal rotation are tested in a neutral forearm position with the elbow flexed to 90°.

of rotator muscle balance and stability of the shoulder joint.[5,8-10,27] The PTR ranges from 0.57 to 1.19 in different populations,[26] and a value of 2:3 to 3:4 (0.66-0.75) has been recommended for shoulder injury prevention.[8,10,18,27]

Outcome Assessment

IMPT findings were analyzed both preoperatively and at 1 year after surgery. Further, preoperative IMPT results of patients who had instability without a dislocation or had a minimal traumatic dislocation were compared with those of patients who had major trauma resulting in a dislocation. Preoperative pain was assessed on a scale of 0 to 10 (maximum pain = 10) using a visual analog scale (VAS). Patients were also asked to rate their postoperative pain and satisfaction with surgery by using the VAS at the annual follow-up visits. A single trained researcher, who was unaware of the study, collected data for the American Shoulder and Elbow Surgeons (ASES) score, Rowe score, and Western Ontario Shoulder Instability Index (WOSI) before surgery and at every follow-up visit (3 months, 6 months, and 1 year after surgery) and analyzed them. According to a previous study, the minimal clinically important differences (MCIDs) for the ASES score and Rowe score are 8.5 and 9.7, respectively.[23] The MCID for the WOSI is not available because of the lack of literature.[22] Any recurrence after surgery was recorded. For the apprehension test, the patient was placed in the supine position with the scapula supported by the edge of the examining table. Positive apprehension during ER at 90° of arm abduction with increasing ER was evaluated by a senior surgeon (J.H.O.) at 1 year and the final follow-up.

TABLE 1
Patient Demographic Characteristics (N = 104)[a]

	Value
Sex, male:female, n	89:15
Age, y	26.6 ± 10.7 (15-69)
Dominant arm involvement, n (%)	73 (70.2)
Overhead activity, n (%)	45 (43.3)
Level of sports or work, n	
High	20
Medium	52
Low	32
Time from dislocation to surgery, y	5.4 ± 6.7 (0-40)
Follow-up, mo	76.6 ± 64.4 (26-112)
Instability without dislocation, n (%)	11 (10.6)
Minimal traumatic dislocation, n (%)	15 (14.4)
Reaching out hands to the back seat while driving, n	5
Taking off clothes, n	4
Other, n	6
Amount of glenoid bone loss before surgery, %	14.1 ± 9.5 (0-32)
>15%, n (%)	39 (37.5)
≤15%, n (%)	65 (62.5)
Glenoid bone loss in patients with positive apprehension, %	
At 1 year after surgery	14.5 ± 9.5 (0-27)
At final follow-up	16.9 ± 9.8 (0-32)

[a]Data are presented as mean ± SD (range) unless otherwise indicated.

Statistical Analysis

Data regarding patient demographics, IMPT results, clinical assessment findings, and functional scores were obtained from the hospital database, tabulated, and analyzed using Stata/SE software (Version 14; StataCorp). The independent *t* test and paired *t* test were used for statistical analysis. Pearson correlation analysis was used to investigate correlations between IMPT findings and clinical outcomes, including VAS scores for pain and satisfaction and functional scores. $P < .05$ was considered statistically significant.

RESULTS

The demographic characteristics of the study patients are shown in Table 1. Of the 104 patients initially included, 68 completed the IMPT at 1 year after surgery. Most patients were male (n = 89; 85.6%), and the mean number of dislocations was 9.4 ± 9.4 before surgery. The mean age was 26.6 ± 10.7 years, and the mean follow-up period was 76.6 ± 64.4 months (range, 26-112 months).

PT of ER and IR

Preoperative ER_{PT} and IR_{PT} values for the involved side were significantly lower than those for the contralateral side (0.29 ± 0.10 vs 0.33 ± 0.10 N·m/kg, respectively, for ER_{PT} [$P = .002$]; 0.36 ± 0.14 vs 0.41 ± 0.16 N·m/kg, respectively, for IR_{PT} [$P = .01$]). At 1 year, IR_{PT} on the involved side recovered (0.40 ± 0.20 N·m/kg) to the level on the uninvolved side (0.44 ± 0.21 N·m/kg) ($P = .154$). However, ER_{PT} remained weaker than that on the contralateral side (0.30 ± 0.13 vs 0.35 ± 0.11 N·m/kg, respectively; $P < .001$) (Table 2).

TABLE 2
Peak Torque in External and Internal Rotation[a]

	Involved Side, N·m/kg	Uninvolved Side, N·m/kg	*P* Value
ER_{PT}			
Before surgery (N = 104)	0.29 ± 0.10	0.33 ± 0.10	**.002**
1 year after surgery (n = 68)	0.30 ± 0.13	0.35 ± 0.11	**<.001**
IR_{PT}			
Before surgery (N = 104)	0.36 ± 0.14	0.41 ± 0.16	**.01**
1 year after surgery (n = 68)	0.40 ± 0.20	0.44 ± 0.21	.154

[a]Data are presented as mean ± SD. Values are normalized to body weight. Bolded *P* values indicate statistically significant differences. ER_{PT}, peak torque in external rotation; IR_{PT}, peak torque in internal rotation.

TABLE 3
Peak Torque Deficit in External and Internal Rotation (n = 68)[a]

	Before Surgery, %	1 Year After Surgery, %	*P* Value
PTD_{ER}	11.2 ± 16.9	13.5 ± 13.8	.569
PTD_{IR}	10.6 ± 23.4	2.2 ± 24.4	**.012**

[a]Data are presented as mean ± SD. Bolded *P* value indicates statistically significant differences. PTD_{ER}, peak torque deficit in external rotation; PTD_{IR}, peak torque deficit in internal rotation.

PTD in IR and ER and PTR

On the involved side, PTD in ER (PTD_{ER}) and PTD in IR (PTD_{IR}) were 11.2% ± 16.9% and 10.6% ± 23.4%, respectively, before surgery. At 1 year after surgery, PTD_{IR} significantly improved to 2.2% ± 24.4% ($P = .012$), while PTD_{ER} showed no improvement (13.5% ± 13.8%) ($P = .569$) (Table 3).

Before surgery, PTR, the ratio between ER_{PT} and IR_{PT} (ER_{PT}/IR_{PT}) on the involved side (1.07 ± 1.71) was higher than that on the uninvolved side (0.74 ± 0.28), indicating the relative weakness of the internal rotators ($P < .001$). At 1 year, PTR on the involved side (0.86 ± 0.23) became closer to that on the uninvolved side (0.84 ± 0.21) ($P = .731$), indicating the recovery of IR strength.

Preoperative IMPT Findings of Patients Who Had Instability Without Dislocations or Had Minimal Traumatic Dislocations

Among the 104 patients, 11 (10.6%) showed instability without a true dislocation, and 15 (14.4%) showed a minimal traumatic dislocation. The preoperative variables of the IMPT were compared between the patients who had instability without a dislocation or had a minimal traumatic dislocation (minor trauma group) and the patients who had moderate to severe trauma (major trauma group) (Table 4). PTD_{ER} was significantly worse in the minor trauma group ($P = .038$).

Functional Outcomes

The pain VAS score improved from 4.3 ± 3.1 before surgery to 0.8 ± 1.4 at 1 year after surgery ($P = .001$), while the satisfaction VAS score was 8.7 ± 1.5 at 1 year. Similarly, all functional scores (that is, the ASES score, Rowe score, and WOSI) significantly improved at 1 year ($P < .001$, $P = .001$, and $P < .001$, respectively) relative to the baseline values. Functional scores were maintained at the final follow-up (Table 5). Both the ASES and Rowe scores achieved their respective MCIDs. There was no significant correlation between the IMPT results and functional scores (all $P > .05$).

TABLE 4
Isokinetic Muscle Performance Test Findings[a]

	Minor Trauma Group (n = 26)	Major Trauma Group (n = 78)	*P* Value
ER_{PT}			
Involved side	0.28 ± 0.10	0.30 ± 0.10	.442
Uninvolved side	0.33 ± 0.10	0.34 ± 0.10	.945
IR_{PT}			
Involved side	0.34 ± 0.20	0.37 ± 0.10	.338
Uninvolved side	0.41 ± 0.20	0.42 ± 0.20	.760
PTD_{ER}	15.4 ± 18.8	10.6 ± 17.8	**.038**
PTD_{IR}	14.4 ± 28.0	10.2 ± 19.1	.192
PTR			
Involved side	1.17 ± 1.99	0.83 ± 0.22	.089
Uninvolved side	0.88 ± 0.21	0.84 ± 0.22	.458

[a]Data are presented as mean ± SD. Values are normalized to body weight. Bolded *P* value indicates statistically significant differences. ER_{PT}, peak torque in external rotation; IR_{PT}, peak torque in internal rotation; PTD_{ER}, peak torque deficit in external rotation; PTD_{IR}, peak torque deficit in internal rotation; PTR, peak torque ratio.

Positive Apprehension After Surgery and Isokinetic IR and ER Strength

There were no true recurrent dislocations in this case series, but 14 patients (13.5%) showed positive apprehension at the final follow-up. At 1 year, 9 of 68 (13.2%) patients with isokinetic IR and ER strength showed positive apprehension. There was no significant difference in bone loss before surgery between patients with positive apprehension and those with negative apprehension at 1 year after surgery ($P = .877$) and the final follow-up ($P = .675$). With regard to PTD on the involved side in patients with positive apprehension, both PTD_{IR} (positive apprehension vs negative apprehension: 19.0% ± 30.2% vs –1.6% ± 25.4%, respectively; $P = .039$) and PTD_{ER} (positive apprehension vs negative apprehension: 28.7% ± 29.9% vs 12.3% ± 14.9%, respectively; $P = .014$) were worse than those in patients with negative apprehension. However, PTD_{ER} was worse than PTD_{IR} in patients with positive apprehension at 1 year ($P = .022$).

DISCUSSION

The current study demonstrated that most patients had satisfactory outcomes with the recovery of IR strength after surgery. Intrinsic rotator balance, which is essential for preventing instability, was shifted toward the weakened internal rotators to lie in the normal range 1 year postsurgically. However, ER strength on the involved side remained weak. Patients with positive apprehension at 1 year after surgery showed more deficiency in IR and ER strength than did those with negative apprehension, indicating the importance of rehabilitation to achieve better IR and ER strength and reduce apprehension.

PT values for the operated and nonoperated shoulders provide objective and quantitative data for examining the preoperative status of the external and internal rotators and have shown good to very good reliability for the assessment of progress after rehabilitation.[9,21] The patients in this study showed weakness in both IR_{PT} and ER_{PT} before surgery, and this could be either a cause or a consequence of instability. For a stable glenohumeral joint, the complex interaction of static and dynamic elements is essential. It is generally accepted that the joint capsule with its

TABLE 5
Functional Outcomes[a]

	Before Surgery	1 Year After Surgery	Final Follow-up	*P* Value[b]	*P* Value[c]
Pain VAS	4.3 ± 3.1	0.8 ± 1.4	0.7 ± 0.7	**.001**	.357
Satisfaction VAS	NE	8.7 ± 1.5	9.1 ± 0.9	NA	.311
ASES	64.0 ± 19.7	98.2 ± 4.6	92.1 ± 3.5	**<.001**	.562
Rowe	64.3 ± 17.8	91.3 ± 12.3	89.7 ± 8.9	**.001**	.711
WOSI	1077.6 ± 337.1	587.4 ± 390.0	572.7 ± 233.8	**<.001**	.425

[a]Data are presented as mean ± SD. Bolded *P* values indicate statistically significant differences. ASES, American Shoulder and Elbow Surgeons; NA, not applicable; NE, not examined; VAS, visual analog scale; WOSI, Western Ontario Shoulder Instability Index.
[b]Statistical significance of the difference between preoperative and 1-year postoperative values.
[c]Statistical significance of the difference between 1-year and final follow-up values.

ligamentous reinforcements and the labrum play a role in static stabilization of the glenohumeral joint.[15] For dynamic stability, the interaction of neuromuscular structures is essential to position the arm in space.[24] In this study, the patients who showed instability without true dislocations (10.6%) or minimal traumatic dislocations (14.4%) had a worse PTD_{ER} than that of patients who had moderate to severe trauma. As suggested by Codine et al,[4] with regard to the strength deficit as a cause of instability, this supports the idea that a strength deficit negatively affects dynamic stability.

With regard to PTD on the involved and uninvolved sides, PTD_{IR} showed a significant improvement at 1 year after surgery. Although the importance of IR and ER strength for dynamic stability remains debatable,[14] a significant improvement in PTD_{IR} without recurrence during a mean follow-up period of 76.6 months supports the protective role of IR strength in dynamic stability, as suggested by Warner et al.[27] However, in this study, only the internal rotators, not the external rotators, showed strength improvements at 1 year after surgery. The lack of improvement in ER strength indicated that a longer observation period would be needed to verify the improvement of the external rotators and support the need for rehabilitation, especially more focused rehabilitation on the external rotators, beyond 1 year.

In terms of PTR, ER_{PT}/IR_{PT} normalized at 1 year after surgery. Generally, the internal rotators are found to be significantly stronger than the external rotators, and a PTR of 0.66 to 0.75 has been recommended for shoulder-injury prevention.[8,10,18] Given that the latissimus dorsi and pectoralis major are larger and stronger internal rotators than are the infraspinatus and teres minor, the larger cross-sectional area of the former 2 muscles could be the reason for the greater strength of the internal rotators.[14] The longer lever arm of the internal rotators could be another reason for the greater strength.[14] However, patients with anterior instability in this study showed a preoperative PTR of 1.07 ± 1.71 on the involved side, indicating that the internal rotators were weaker than the external rotators. The weaker preoperative internal rotators and improved PTR and IR strength after surgery without recurrence indicate the restoration of balance in the internal and external rotators after shoulder stabilization with arthroscopic capsulolabral repair.

In the present study, pain VAS scores improved significantly after surgery, with high patient satisfaction. Moreover, all functional scores (that is, the ASES and Rowe scores and the WOSI) were improved after surgery. Surprisingly, no recurrent dislocation was found. Thus, arthroscopic capsulolabral repair seems to be a satisfactory procedure for anterior instability. Although there were no clinical failures in this case series, 14 patients (13.5%) experienced apprehension at the final follow-up. Therefore, although ACR for the correction of shoulder instability can prevent recurrent dislocations, some degree of instability remains. Hiemstra et al[12] reported that 11 of 34 patients (32.4%) felt apprehension at a mean follow-up of 22 years after open Bankart repair. The higher proportion of patients with apprehension in the previous study than in the present study could be attributed to subscapularis muscle insufficiency after open Bankart repair.[25] A recent study of 143 patients who underwent arthroscopic Bankart repair showed an overall recurrence rate of 18.8% after surgery, which is comparable to the findings of our study.[1]

Interestingly, patients with apprehension at the final follow-up displayed worse PTD_{IR} and PTD_{ER} on the involved side at 1 year after surgery. A higher PTD_{IR} might have negatively affected the protective effect of the internal rotators on stabilization of the shoulder and consequently induced apprehension.[27] With regard to the worse PTD_{ER} on the involved side at 1 year after surgery, it is generally known that the posterior rotator cuff muscles decrease strain on the anterior structures of the glenohumeral joint by pulling the humeral head posteriorly and increasing the compressive force during ER of the shoulder.[16] PTD_{ER} before surgery was significantly worse in patients who had dislocations due to minor trauma or without trauma than that of patients with major trauma, which indicates that instability may remain if patients have weak ER strength after surgery. On the other hand, minor instability after surgery could require more external rotator muscle activation to control laxity, which could result in fatigue and weakening of ER strength. Although the authors could not arrive at a conclusion on the cause or effect of PTD_{ER} on instability, Gates and Dingwell[11] addressed in their biomechanics study that muscle fatigue did not lead to increased instability of the upper extremity. Therefore, the results of this study suggest the need for rehabilitation of both the internal and external rotators to prevent apprehension after arthroscopic capsulolabral repair. Furthermore, considering that PTD_{ER} on the involved side was worse than PTD_{IR} in patients with positive apprehension at 1 year after surgery, surgeons should emphasize the importance of ER strength for better stabilization after surgery and encourage patients to strengthen their external rotator muscles.

The present study has several limitations, including the retrospective design and unavailability of data regarding return to sports or work. Although the mean follow-up period was >6 years, with at least 2 years of follow-up for every patient, the administration of the IMPT at only 1 year after surgery may have been responsible for the lack of improvement in ER strength. For the same reason, we could not evaluate the association between positive apprehension and rotation strength at the final follow-up. The results of the IMPT at the final follow-up may have been different. Additionally, the reliability of side-to-side differences (eg, right- and left-handedness and physical activity level) has always been controversial. A strength difference of 10% to 15% between the 2 sides has been found in healthy patients,[12] and an asymptomatic contralateral side with impingement or instability cannot be considered a referent side.[5,8,26] A comparison with a control group may have reduced the errors associated with the side-to-side analysis. Moreover, the number of patients with apprehension at 1 year after surgery or the final follow-up was small. Also, there was no recurrent dislocation after surgery, even for those who had a high number of dislocations before surgery or for those who had glenoid bone loss. There is the possibility of a selection bias, and further studies with a greater volume of patients are needed from the same facility to verify the true rate of recurrent dislocations. Last, return to sports was not reported in the hospital information system; thus, we could not address the return-to-sports rate.

CONCLUSION

For those with anterior shoulder instability, preoperative IR and ER strength of the involved shoulder were lower than those of the uninvolved shoulder. IR_{PT} recovered, whereas ER_{PT} remained weak after arthroscopic capsulolabral repair. To prevent positive apprehension after surgery, IR and ER strengthening exercises are important, with more emphasis on exercises for ER.

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