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Criteria-based return-to-sport testing is associated with lower recurrence rates following arthroscopic Bankart repair

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Hypothesis and background: This study aimed to analyze the impact of a criteria-based return-to-sport (CBRTS) testing protocol on recurrent instability following arthroscopic Bankart repair. We hypothesized that patients who underwent an objective CBRTS testing protocol to guide their clearance to return to sports would have less recurrent instability than those who did not undergo testing.

Methods: Thirty-six consecutive patients who underwent arthroscopic Bankart repair from 2016 to 2018, had a minimum of 1 year of follow-up, and completed functional and strength testing to evaluate readiness to return to sports were included in this retrospective case-control study. Patients with critical glenoid bone loss $> 13.5\%$, multidirectional instability, and off-track Hill-Sachs lesions necessitating a remplissage or bone augmentation procedure were excluded from the study. Recurrence was defined as dislocation or subluxation symptoms requiring revision surgery. Statistical analysis included analysis of variance and the independent *t* test.

Results: There was no difference between the study and control groups regarding age ($P = .15$), sex ($P = .11$), hand dominance ($P = .56$), or participation in contact sports ($P = .78$). Patients who underwent the CBRTS testing protocol had a reduced rate of recurrent shoulder instability (5% vs. 22%; odds ratio, 4.85; $P < .001$). There was no difference in the time from surgery to recurrence between the groups (12 months vs. 13.6 months, $P = .43$).

Conclusion: Athletes who underwent an objective CBRTS testing protocol to guide their clearance to return to sports had a lower rate of recurrent instability following arthroscopic Bankart repair than those cleared to return based on the time from surgery. Athletes who did not undergo CBRTS testing after arthroscopic shoulder stabilization had a 4.85 times increased likelihood of recurrent instability development after return to sports.

Level of evidence: Level III; Retrospective Case-Control Design; Prognostic Study

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Keywords: Return-to-sport testing; shoulder instability; recurrence rate; labral repair; rehabilitation; Bankart repair; isokinetic strength; functional testing

Traditionally, return to sports (RTS) following Bankart repair is based on subjective assessment of strength and range of motion (ROM), as well as the arbitrary passage of time, which is usually around 5-6 months. This includes both the physician's assessment of the physical examination and the physical therapist's more standardized measurements. The ultimate assessment of functional ability is sometimes left to coaches and trainers as an athlete returns to the team.

Recurrent shoulder instability after RTS following shoulder stabilization surgery is an undesirable

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complication, which often results in short-term disability, increased risk of post-traumatic glenohumeral arthritis,[7] and patient dissatisfaction.[13] Historically, recurrence rates after Bankart repair between 3% and 23% have been reported.[1,5] The current literature is focused on preoperative variables and surgical technique to identify modifiable factors, such as open vs. arthroscopic approaches,[9] the number and type of anchors used,[14] the amount of glenoid loss and the size of the Hill-Sachs defect,[4,12,15] and the type and level of sports participation.[9] However, nonsurgical factors such as rotator cuff weakness have been associated with recurrent shoulder instability in the preoperative setting.[10,11,16,18] Therefore, modifiable factors during the postoperative recovery period, such as muscle strength and shoulder function, may be just as important for recurrence rates and a successful RTS.

A criteria-based return-to-sport (CBRTS) test popularized following anterior cruciate ligament (ACL) reconstruction has been shown to substantially decrease the reinjury risk after RTS following ACL reconstruction.[8] Similarly, a recent study by Wilson et al[19] analyzing a CBRTS test at 6 months after arthroscopic shoulder stabilization surgery revealed residual strength and/or functional deficits in 88% of the consecutive athletes tested. This finding suggests that an objective assessment of strength and function may be more effective than clinical examination findings in identifying potential hidden deficits before RTS. The ability of CBRTS testing to reduce recurrent instability rates in the setting of shoulder stabilization surgery remains unknown.

The purpose of this study was to evaluate the impact of a CBRTS test on recurrence rates after arthroscopic Bankart repair. We hypothesized that athletes who underwent a CBRTS test to guide their clearance to return to play would have a lower recurrence rate than those who did not undergo testing.

Methods

We performed a retrospective case-control study with minimum 1-year follow-up to analyze 36 competitive high school and collegiate athletes who underwent primary arthroscopic anterior labral repair at our institution from 2016 to 2018. Surgical techniques were consistent during the collection period and involved capsulolabral plication and labral repair using standard portals, suture anchors (knotless PushLock; Arthrex, Naples, FL, USA) along the glenoid rim, and suture passage techniques. The subscapularis was not violated during anterior repairs. We excluded patients with glenoid bone loss $> 13.5\%$,[15] calculated by the best-fit circle method on magnetic resonance imaging; general joint hyperlaxity, defined as a score ≥ 4 according to the Beighton criteria; off-track Hill-Sachs lesions[4]; concomitant injury, such as rotator cuff tear requiring repair; or prior shoulder surgery.

All patients underwent a standardized postoperative rehabilitation protocol for anterior labral repair surgery (Table I). This included 3 main phases before RTS testing. Phase 1 (weeks 0-6) involved sling use for 4 weeks with generally no active ROM, with a focus on scapular posture and mobility. Rotator cuff isometric exercises began at 4 weeks postoperatively. Phase 2 was generally from week 6 to week 12. During the second phase, there was a gradual increase in ROM to the staged goal and submaximal tissue loading, with dynamic stabilization and posture being the focus of phase 2. Neuromuscular control was the goal for week 12. Phase 3 lasted from week 12 until week 24 or beyond, with a focus on the normalization of strength and neuromuscular control. Beyond 12 weeks, athletes were allowed to begin working on developing power for higher-level sport-specific activities, with the development of dynamic stability in the final phases.

Table I Phased rehabilitation protocol

Phased rehabilitation
Phase 1 (0-6 weeks)
Sling × 4 weeks (no AROM)
Scapular posture and mobility
Rotator cuff isometrics at 4 weeks
Phase 2 (6-12 weeks)
Gradual increase in ROM to goal
Submaximal tissue loading
Dynamic stabilization and posture
Neuromuscular control
Phase 3 (12-24 weeks)
Normalization of strength and neuromuscular control
Development of power for high-level activities (sport specific)
Achievement of dynamic stability
Return-to-sport testing at 6 mo

AROM, active range of motion; *ROM*, range of motion.

At 6 months postoperatively, patients underwent complete CBRTS testing, performed by a physical therapist, using a previously published protocol.[19] The battery of tests consisted of analysis of strength, which included isokinetic and isometric internal rotation and external rotation, as well as the external rotation endurance test. The goal of strength testing was to reach 90% of the values for the contralateral extremity.[8] Isokinetic internal and external rotation was measured on a Biodex System 4 isokinetic dynamometer (Biodex, Shirley, NY, USA) using peak torque at 60°/s and 180°/s (Fig. 1).

Isometric internal rotation and external rotation, as well as their ratio, were measured at 0° and 90°. The external rotation endurance test involved repetitions to failure with 5% of body weight at 0° of abduction (side lying) and at 90° of abduction (prone). Tests of function included the closed kinetic chain upper extremity stability (CKCUES) test (Fig. 2) and the unilateral seated shot put (USS) test (Fig. 3).

The CKCUES test involved an alternating touch and push-up position. Touches were measured across 3 rounds of 15 seconds with a 45-second break. The average of the 3 rounds was used to calculate the final score. Scores were tabulated as touches per 15 seconds. One touch was defined as moving one hand from the floor to the contralateral hand and back. The results of the CKCUES test were compared against reference values determined from healthy and active male and female individuals.[17] A passing score was $\geq$21 touches, which represented the 75th percentile for active female individuals and the 85th percentile for active male individuals. The USS test was performed using a 6-lb (2.72-kg)

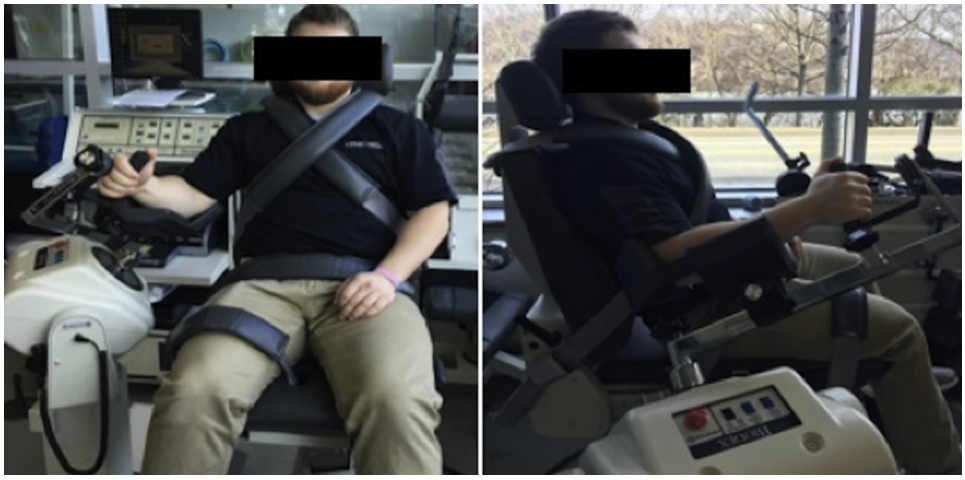

Figure 1 Isokinetic external and internal rotation test.

medicine ball and was scored for distance. The goal was to achieve 90% of the distance of the nonoperative extremity, with a 10% adjustment for hand dominance.[3] The test was performed with the back flat against the wall and knees flexed at 90° with the patient seated on the floor. The mean distance from 3 trials was measured, and there was a 30-second rest period between trials 1 and 2, as well as between trials 2 and 3. Patients who passed all components of the CBRTS test were cleared to RTS. Patients who failed multiple components of the test were not cleared to RTS, underwent additional formal rehabilitation to address deficits over a period of 4-6 weeks, and repeated the test before final clearance. Patients who completed the test but failed only 1 component continued specific physical therapy focused on their particular deficit for 4 weeks before RTS.

The testing cohort was then compared with an unmatched control group of 36 consecutive historical patients with arthroscopic Bankart repair from 2014 to 2015 who did not undergo a CBRTS test. All patients underwent the same rehabilitation protocol shown in Table I. Patients in the control group were cleared to RTS based on physical examination assessment of ROM and strength, as well as the passage of time, usually at 5-6 months after surgery. There were no differences between the groups regarding age, sex, dominant side, tear extension, number of anchors, and type of sport involved (Table II). Recurrent shoulder instability was defined as symptomatic instability requiring revision stabilization surgery.

Descriptive statistics were used to report continuous data. One-way analysis of variance and the independent t test were used to compare mean values between groups. We performed the χ^2 test for all categorical variables and calculated likelihood using the odds ratio. All statistics were performed using SPSS software (IBM SPSS Statistics for Macintosh, version 24.0 [released 2016]; IBM, Armonk, NY, USA). Two-tailed P values $< .05$ were considered statistically significant.

Results

There was no difference between the study and control groups regarding age (mean, 20 years [range, 17-29 years] vs. 19 years [range, 16-30 years]; $P = .15$), male sex (83% vs. 64%, $P = .11$), dominant-side involvement (52% vs. 60%, $P = .56$), or participation in contact sports ($P = .78$). Extension of the anterior labral tear to the posterior labrum was observed in 10 cases (28%), with no differences between groups. In all cases, at least 3 anchors were used, with no statistically significant difference in the number of anchors used between groups (Table II).

For all assessments performed unilaterally, a shoulder index score was calculated by dividing the value for the involved shoulder by the value for the uninvolved shoulder. Shoulder index scores reaching $\geq$0.90 were considered ''passing'' scores for the assessment.[1] This scoring system was used for isokinetic testing, isometric testing, repetition-to-failure testing, and the USS test. Passing of the CKCUES test was determined by averaging $\geq$22 repetitions over 3 trials of the test. The CBRTS testing results are presented in Table III. Patients in the control group were cleared to RTS based on physical examination assessment of ROM and strength, as well as the passage of time, which was around 5-6 months after surgery.

Only 6 patients fully passed the test at 6 months after surgery and were cleared to RTS at that time. Two patients completely failed the test, defined as failing $\geq$2 components of the test, and were not cleared to RTS at 6 months. They underwent additional formal rehabilitation with a specific focus on their deficits for 4-6 weeks and repeated the test after this period. Both passed the second test and were cleared to RTS at 8 months after surgery. The majority of athletes (83.8%) failed at least 1 component of the test and were not cleared to RTS at 6 months. They underwent additional rehabilitation specific to their weakness for 4 weeks and were cleared to RTS at 7 months after surgery.

Patients who underwent the CBRTS testing protocol showed a statistically significant difference in the rate of recurrent shoulder instability (5% [2 of 36 patients] vs. 22% [8 of 36 patients]; odds ratio, 4.85; $P = .04$). The time from surgery to recurrence was not different between groups (12 months vs. 13.6 months, $P = .43$) (Table IV).

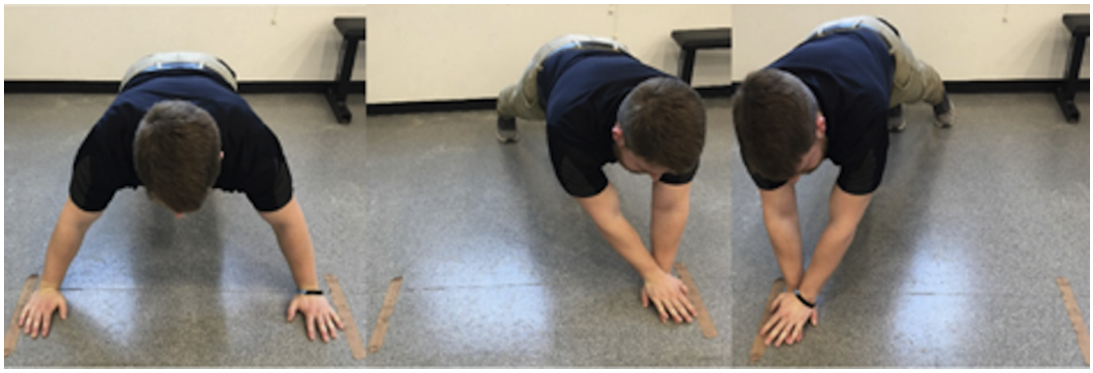

Figure 2 Closed kinetic chain upper extremity test.

Figure 3 Unilateral seated shot put test.

Table II Demographic characteristics

	CBRTS test group	Control group	*P* value
Age, yr	20 (14-29)	19 (15-36)	.15
Male sex, n (%)	30 of 36 (83)	23 of 36 (64)	.11
Dominant side involved, n (%)	19 of 36 (52)	18 of 30 (60)	.56
Isolated anterior labrum tear, n (%)	26 of 36 (72)	26 of 36 (72)	>.999
Anterior plus posterior labrum tear, n (%)	10 of 36 (28)	10 of 36 (28)	>.999
≥3 Anchors, n (%)	36 (100)	36 (100)	>.999
Sport			
Football	16	13	.78
Basketball	3	3	
Wrestling	2	4	
Soccer	2	3	
Hockey	2	3	
Lacrosse	2	1	
Other	9	9	

CBRTS, criteria-based return to sport.

Table III Criteria-based return-to-sport testing results

Component	Pass, n (%)
Strength	
Isokinetic	
ER at 60°/s	17 of 32 (45.9)
ER at 180°/s	17 of 32 (45.9)
ER at 60°/s + 180°/s	11 of 32 (29.7)
IR at 60°/s	21 of 32 (56.8)
IR at 180°/s	21 of 32 (56.8)
IR at 60°/s + 180°/s	16 of 32 (43.2)
All isokinetic tests	6 of 32 (16.2)
Isometric	
ER at 0°	22 of 32 (59.5)
ER at 90°	18 of 31 (48.6)
IR at 0°	23 of 32 (62.2)
IR at 90°	26 of 31 (70.3)
ER/IR at 0°	28 of 32 (75.7)
ER/IR at 90°	20 of 31 (54.1)
ERET at 0°	27 of 35 (73)
ERET at 90°	22 of 33 (59.5)
ERET while prone	30 of 35 (81.1)
Functional	
CKCUE	26 of 35 (70.3)
Shot put	32 of 34 (86.5)

ER, external rotation; *IR*, internal rotation; *ERET*, external rotation endurance test; *CKCUE*, closed kinetic chain upper extremity.

The study group had 2 cases of recurrent instability. Both athletes participated in football and underwent surgical revision with the open Latarjet procedure. The control group, on the other hand, had 8 cases of recurrence. The sports involved included football (5), wrestling (2), and basketball (1). These patients subsequently underwent a revision arthroscopic Bankart repair (6), revision open Bankart repair (1), or open Latarjet procedure (1).

Discussion

The major finding of our study is that patients who underwent a CBRTS test following arthroscopic Bankart repair to guide decision making for RTS had a >4 times lower rate of recurrence than those who did not undergo testing. To our knowledge, this is the first study analyzing the impact of a CBRTS test on recurrent shoulder instability rates after shoulder stabilization surgery. These findings are almost identical to the results of a previous study in an ACL reconstruction population that found that patients who did not meet clinical discharge criteria before RTS had a 4 times greater risk of rupture of the ACL graft.[10]

Successful RTS after shoulder stabilization surgery requires restoration of joint homeostasis. The static stabilizers must heal, and the dynamic stabilizers must be restored to preinjury function levels. RTS following Bankart repair has traditionally been based on subjective assessment of strength and ROM, as well as the arbitrary passage of time (6 months). However, a recent study found that a majority of athletes did not meet the expected goals for their operative shoulder at 6 months after arthroscopic shoulder stabilization when following an objective CBRTS testing protocol.[19] Similarly, in our cohort, the majority of athletes (83.8%) failed at least 1 component of the test. In this previous study, despite the strength deficits identified, some subjects were able to pass functional testing,[19] suggesting that athletes may be able to compensate functionally for focal and detectable strength deficits. These findings were also present in our study and call into question whether patients who appear well on physical examination in the clinic at 6 months postoperatively are truly ready to RTS. Objective measurements, on the other hand, may reveal hidden strength deficits and can guide specific rehabilitation and decision making for RTS. For athletes in our study who failed a component or multiple components of our testing protocol, specific and targeted physical therapy was initiated to focus on their deficits before RTS. The results of the previous study suggest that if our control group had undergone CBRTS testing, these patients likely would have had detectable deficits.[19] It is possible that these athletes may have been at increased risk of recurrence on RTS owing to uncorrected residual strength and/or functional deficits.

The current literature on recurrent shoulder instability is focused on preoperative variables and surgical technique. Recent investigations have highlighted nonmodifiable[14] as well as modifiable risk factors influencing recurrent instability, such as open vs. arthroscopic approaches,[9] the number and type of anchors,[1] concomitant procedures to address variable amounts of glenoid and humeral bone loss,[4,12,15] and the type and level of sports participation.[2] Our cohorts were demographically matched with strict exclusion criteria to minimize any preoperative and surgical confounding risk factors, as mentioned earlier, in an effort to isolate postoperative factors as the only variable studied. Loss of isokinetic muscle strength has been shown to be a risk factor for recurrent instability in the preoperative state.[6,16] Likewise, our study demonstrates that proper postoperative restoration of dynamic stabilizers may be just as important as other risk factors. Deficits found with CBRTS testing are modifiable factors in the episode of care that can guide specific rehabilitation to better restore dynamic stabilizers and aid in the decision-making process for a successful RTS.

Regarding level of activity, our athletes in both cohorts consisted of high school and collegiate competitive athletes, predominantly football players, who may be the highest demographic risk category for recurrent instability.[2] The generalizability of our findings is therefore strengthened by studying individuals in the highest-risk population.

The duration of follow-up did not influence our results. Whereas all subjects had ≥1 year of follow-up, the control group—by nature of being a historical cohort—had longer follow-up from the index operation. However, the time from surgery to recurrence was not statistically significantly

Table IV Results

	CBRTS test group	Control group	*P* value	Odds ratio
Recurrence rate, n (%)	2 of 36 (5)	8 of 36 (22)	.04*	4.85*
Time from surgery, mo	12	13.6	.43	
Return to sports, n (%)	6 mo: 6 of 36 (16.6) 7 mo: 28 of 36 (77.7) 8 mo: 2 of 36 (5.55)	6 mo: 36 of 36 (100)		
Sport				
Football	2	5		
Wrestling		2		
Basketball		1		
Treatment	Latarjet procedure: 2	Arthroscopic Bankart repair: 6 Open Bankart repair: 1 Latarjet procedure: 1		

CBRTS, criteria-based return to sport.
* Statistically significant ($P < .05$).

different between groups, with recurrences occurring around the 1-year mark in both groups. Whether the reason for the significant differences in recurrent shoulder instability was failure to heal or lack of fully restored dynamic stabilizers or whether this finding was simply related to the risk of injury associated with high-level competitive contact sports remains unknown. Studies in the ACL reconstruction population have found that RTS at $\geq$9 months after surgery and more symmetrical quadriceps strength prior to RTS substantially reduced the reinjury rate.[8] Whether an analogous strength or functional parameter could be translated effectively to the shoulder is a matter for future studies.

The strength of our study is the potentially new clinical application of an objective CBRTS protocol with a comparison group using a consecutive matched control group and strict exclusion criteria. The study is limited primarily by its retrospective design and reliance on historical controls. Rehabilitation compliance was not able to be determined. Despite fairly standardized rehabilitation protocols from the senior author, there is certainly variability in the quality and quantity of rehabilitation sessions that were attended. A prospective randomized control group was not readily available owing to the retrospective design. In addition, patient-reported outcomes or rates of return to play at preinjury levels were not available to report. These outcome measures are currently the focus of an ongoing multicenter trial with prospective collection of data including patient-reported outcomes, as well as return to preinjury levels of participation and randomization of cohorts (A. Lin, unpublished data, August 2020).

Conclusion

Athletes who undergo an objective CBRTS testing protocol have a lower rate of recurrent instability following arthroscopic Bankart repair than those cleared to return using the time from surgery. Athletes who did not undergo CBRTS testing after arthroscopic Bankart repair had a 4.85 times increased likelihood of recurrent instability development after RTS. On the basis of our findings, we strongly recommend the use of a CBRTS testing protocol for return to play following arthroscopic Bankart repair, particularly for sports that have known higher risks of recurrence.

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