Association of Traumatic and Atraumatic Posterior Shoulder Instability With Glenoid Retroversion and Outcomes After Arthroscopic Capsulolabral Repair

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Purpose: To compare glenoid retroversion and functional outcomes between patients with traumatic onset of posterior shoulder instability (PSI) and patients with atraumatic onset of PSI. **Methods:** Patients with PSI who underwent arthroscopic posterior capsulolabral anchor repair, were active in sports, and had undergone surgery a minimum of 2 years earlier were included. Traumatic onset was defined as PSI that occurred after a trauma with the shoulder in adduction, flexion, and internal rotation in patients with no history of instability. Subjective evaluations were obtained with the American Shoulder and Elbow Surgeons (ASES); Quick Disabilities of the Arm, Shoulder and Hand; Single Assessment Numeric Evaluation (SANE); and Short Form 12 Physical Component Summary scores preoperatively and after a minimum 2-year follow-up postoperatively. Additional questions assessed return to sport and shoulder stability. Glenoid version was measured with a 2-dimensional glenoid vault method on magnetic resonance imaging. **Results:** A total of 41 shoulders in 38 patients were eligible for inclusion (3 female and 35 male patients; mean age, 27.6 years; age range, 13 to 66 years). Three patients refused participation, and 2 patients required subsequent surgery for failure. Postoperative outcomes were available for 32 of the remaining 36 shoulders (89%) with a mean follow-up of 4.1 years (range, 2.0 to 7.8 years; 20 atraumatic and 12 traumatic). The ASES score improved significantly in both groups ($P < .03$), whereas the SANE; Quick Disabilities of the Arm, Shoulder and Hand; and Short Form 12 Physical Component Summary scores only significantly improved for patients with traumatic PSI ($P < .02$). Baseline score–adjusted comparison between groups showed that the postoperative median ASES scores (atraumatic, 95.8; traumatic, 99.9) and SANE scores (atraumatic, 86.5; traumatic, 98.0) were significantly more improved in patients with traumatic PSI ($P = .01$ and $P = .012$, respectively). Atraumatic PSI was associated with significantly higher glenoid retroversion ($-21.8° \pm 4.2°$ vs $-17.7° \pm 5.5°$, $P = .032$). There was no significant difference regarding return to sport ($P = .375$) or postoperative re-dislocations ($P = .99$) between the groups. **Conclusions:** Atraumatic onset of PSI was associated with higher degrees of glenoid retroversion and less favorable functional outcomes of arthroscopic posterior capsulolabral anchor repair than traumatic PSI. **Level of Evidence:** Level III, retrospective case-control study.

Posterior instability of the shoulder joint accounts for approximately 10% of surgically treated shoulder instabilities and is being seen with increasing frequency.[1,2] Posterior shoulder instability (PSI) can result from numerous causes.[3-7] In general, a traumatic cause can be distinguished from an atraumatic cause with various acknowledged trauma mechanisms having been described in the literature.[3,4,7] However, in clinical outcome studies, the definition of traumatic PSI is often vague and not necessarily linked to the acknowledged mechanisms described in the literature.

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Arthroscopic capsulolabral anchor stabilization is the current surgical gold standard for patients with PSI who do not have bone loss and in whom nonoperative treatment has failed.[4,8-14] Most studies reporting outcomes of arthroscopic capsulolabral repair have presented results of patient populations with mixed causes of PSI or focused on patients with either traumatic or atraumatic onset.[3,5,8-15] Apart from one study that found inferior outcomes for adolescent patients with atraumatic PSI, little is known about functional outcomes and return to sport after arthroscopic capsulolabral repair for traumatic and atraumatic PSI.[16]

In the past, some authors have described an association between atraumatic PSI and excessively increased glenoid retroversion (GR).[17-19] Furthermore, patients with traumatic PSI were shown to have significantly more GR than patients with anterior shoulder instability.[20] In addition, increased GR was recently identified as the most significant risk factor for PSI in young athletes.[21] However, it remains unclear if the degree of GR differs between patients with traumatic onset of PSI and patients with atraumatic onset of PSI.

Therefore, the aim of this study was to compare GR and functional outcomes between patients with traumatic onset of PSI and patients with atraumatic onset of PSI. It was hypothesized that there would be more GR and that functional outcome scores would be significantly lower in patients with PSI that had an atraumatic onset.

Methods

Institutional review board approval was obtained before the start of the study. The patient database of a single sports medicine fellowship–trained surgeon (P.J.M.) was screened for all patients who received surgical treatment for PSI, after a period of failed nonoperative treatment. Operations performed between January 2006 and November 2013 were included in this study. Only patients who underwent arthroscopic posterior capsulolabral repair with suture anchors were included. In addition, patients had to live in the United States and had to have undergone the index surgical procedure a minimum of 2 years earlier for inclusion in this study. Only patients with self-reported regular sports participation (independent of the type of sport and the level of sports participation) were included. Patients with bony lesions of the glenohumeral joint that required more extensive surgical treatment and patients with subsequent shoulder surgery not related to posterior instability were excluded.

The operated shoulders were kept immobilized for 2 weeks in a sling, which was worn for a total of 6 weeks. Patients started pendulum exercises and passive motion beginning after 2 weeks. Active and active-assisted motion was delayed for 6 weeks.

For the purpose of this study, PSI was defined as a clinical history of involuntary posterior instability (dislocation or subluxation) in patients without multidirectional instability or connective tissue disease. All patients underwent preoperative magnetic resonance imaging (MRI) evaluation, but the final diagnosis was made if the patient had glenohumeral posterior translation over the glenoid rim during intraoperative examination under anesthesia.

Patients were divided into 2 groups depending on whether they had traumatic or atraumatic onset of PSI. Traumatic onset was defined as PSI that occurred after high-energy contact (e.g., a motor vehicle accident or a fall while skiing or snowboarding) or a direct trauma with the shoulder in adduction, flexion, and internal rotation in patients with no history of dislocation, subluxation, or instability.[3,4,7] All other mechanisms of injury were classified as atraumatic onset.

Glenoid version was measured with a recently published 2-dimensional (2D) glenoid vault method on preoperative MRI scans (Fig 1).[20,22] The 2D glenoid vault method has been shown to have a high interobserver and intraobserver reliability and to be more accurate than the currently recognized method for 2D measurement of Friedman et al.[23] described in 1992.[22] It is important to note that the 2D glenoid vault method produces higher retroversion values than the conventional method of Friedman et al.[22,23] For the 2D glenoid vault measurement, a line is drawn from the medial corner of the endosteal vault, equally bisecting the isosceles triangle, which marks the glenoid vault. Another line is drawn perpendicular to this to define the line of neutral version. A line is then drawn parallel to the glenoid endosteal face, and the angle at which these 2 lines bisect is the angle of glenoid version (Fig 1).

Subjective evaluations were obtained by mailed questionnaires including assessment of the American Shoulder and Elbow Surgeons (ASES); Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH); Single Assessment Numeric Evaluation (SANE); and Short Form 12 Physical Component Summary (SF-12 PCS) scores preoperatively and after a minimum 2-year follow-up postoperatively. A question on return to sport was asked with answer choices all relative to preinjury level: (1) above or equal to, (2) slightly below, (3) moderately below, (4) significantly below, (5) cannot compete in usual sport, and (6) cannot compete in any sports. Answer choices 1 through 3 were judged to qualify as return to sport, whereas answer choices 4 through 6 were judged to not qualify as return to sport. Furthermore, shoulder dislocations or subluxations that occurred after the index surgery in the follow-up period were noted. Failure was defined as the need for surgical revision. All data were collected prospectively and retrospectively reviewed.

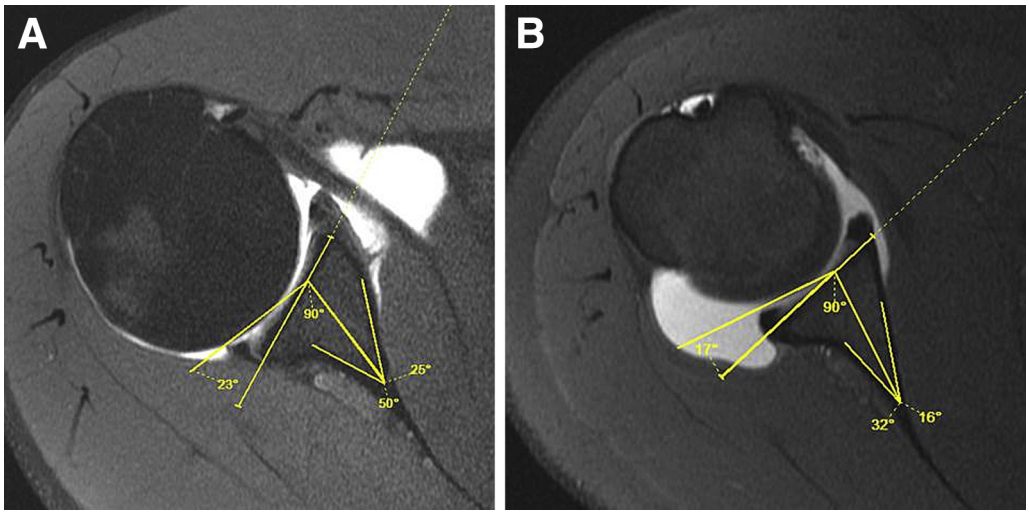

Fig 1. Measurement of glenoid retroversion on axial magnetic resonance images with the glenoid vault method.[20,22] (A) Right shoulder with atraumatic posterior instability and 23° of glenoid retroversion. (B) Right shoulder with traumatic posterior instability and 17° of glenoid retroversion. In the glenoid vault method, a line is drawn from the medial corner of the endosteal vault, equally bisecting the isosceles triangle, which marks the glenoid vault. Another line is drawn perpendicular to this to define the line of neutral version. A line is then drawn parallel to the glenoid endosteal face, and the angle at which these 2 lines bisect is the angle of glenoid version.

Glenoid version was normally distributed and was compared between the groups with use of the *t* test. All other data were not normally distributed. Preoperative and postoperative scores were compared with the paired Wilcoxon signed rank test. Postoperative outcomes were compared between the groups with baseline score–adjusted analysis of covariance. For nonparametric tests, the pseudo-median with corresponding 95% confidence interval (CI) (lower boundary [LB] and upper boundary [UB]) was reported. Return to sport and re-dislocations were compared between the groups with the Fisher exact test. The level of significance was set at $P < .05$.

Results

During the study period, the senior surgeon (P.J.M.) performed operations on 64 shoulders with PSI (54 patients). We had to exclude 23 shoulders for reasons mentioned in the Methods section, leaving 41 shoulders (38 patients) eligible for inclusion (3 female and 35 male patients; mean age, 27.6 years; age range, 13 to 66 years) (Fig 2). Three patients who refused participation (2 traumatic and 1 atraumatic) and 2 patients who required subsequent surgery for failure were excluded from the statistical outcome analysis.

Both failures (1 of 23 shoulders in atraumatic group [4.3%] and 1 of 18 in traumatic group [5.5%]) were related to recurrent posterior instability with glenoid deficiency in adolescent patients within the first postoperative year and were treated with open distal tibia allograft glenoid reconstruction. At final follow-up, the ASES score of the patient with atraumatic PSI was 63.3 (7 years after open revision surgery) whereas the ASES score of the patient with traumatic PSI was 100 (4.6 years after open revision surgery).

PSI was classified as traumatic in 15 of the remaining patients and as atraumatic in 21 (Table 1). Concomitant shoulder pathologies with the need for an additional arthroscopic procedure (biceps tenodesis, SLAP repair, and so on) were seen in 80% of patients with a traumatic cause of PSI and in 57% of patients with atraumatic onset (Table 2).

Minimum 2-year outcome data were available for 32 of the remaining 36 shoulders (89%; 20 of 21 in atraumatic group and 12 of 15 in traumatic group) (Fig 2). Overall, the mean follow-up was 4.3 years (range, 2.0 to 7.8 years). For both patients with atraumatic onset of PSI and patients with traumatic onset of PSI, ASES scores improved significantly from preoperatively to postoperatively (Table 3), resulting in excellent scores at final follow-up. The SANE, QuickDASH, and SF-12 PCS scores, however, significantly improved only in patients with traumatic onset of PSI and not in patients with atraumatic onset (Table 3).

Baseline score–adjusted comparison between groups showed that the postoperative ASES and SANE scores were significantly more improved in patients with traumatic PSI ($P = .01$ and $P = .012$, respectively). The difference in postoperative QuickDASH scores (pseudo-median, 2.3; 95% CI, 0.0 [LB] to 13.7 [UB]; $P = .057$) and SF-12 PCS scores (pseudo-median, −1.5; 95% CI, −5.9 [LB] to 0.0 [UB]; $P = .072$) did not reach statistical significance. Atraumatic PSI was associated with significantly higher GR ($-21.8° \pm 4.2°$, $P = .032$) than traumatic PSI ($-17.7° \pm 5.5°$). There was not a significant difference regarding return to sport

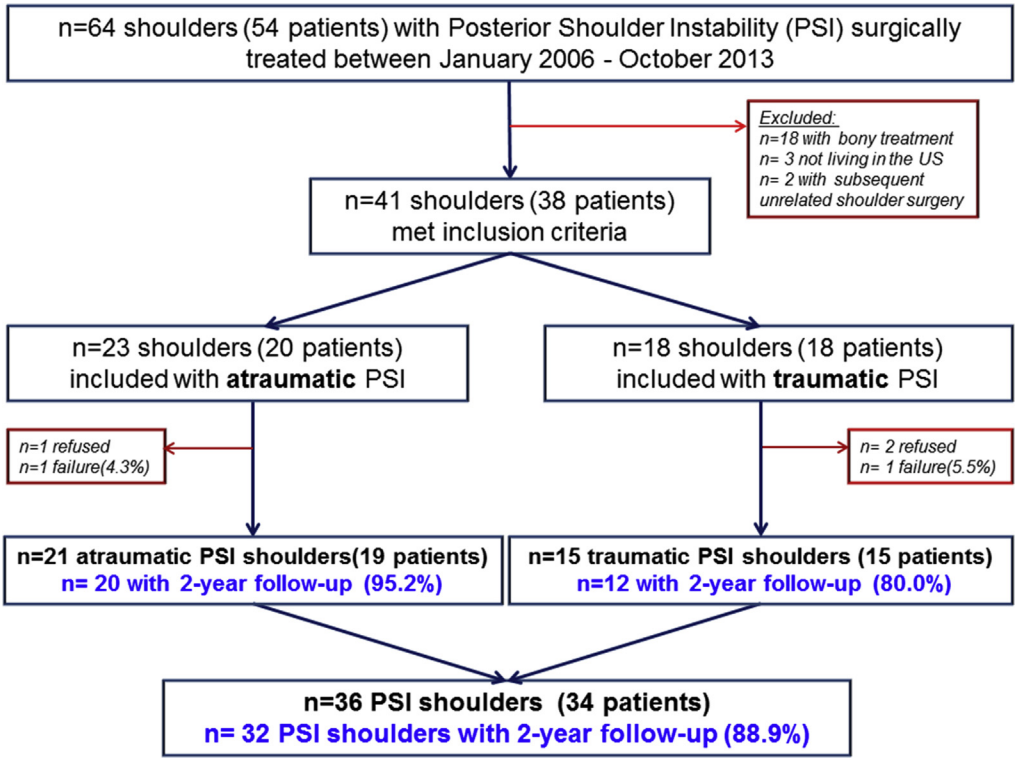

Fig 2. Patient flowchart showing entire patient group, excluded patients, and final groups. (PSI, posterior shoulder instability.)

($P = .375$) or postoperative self-reported re-dislocations or subluxations ($P = .99$) between the groups (Table 4).

Discussion

The most important findings of this study were that atraumatic onset of PSI was associated with increased GR and inferior clinical outcomes compared with traumatic PSI. Higher degrees of GR, inferior clinical outcomes, and a trend toward lower rates of return to sport suggest that the treatment of patients with atraumatic onset of PSI may be more challenging.

Several studies have shown that arthroscopic procedures are effective and reliable for treatment of unidirectional posterior glenohumeral instability with respect to outcome scores, satisfaction, and return to sport.[4,8-14] Arthroscopic treatment was found to be superior to open treatment, and anchor repair seems more favorable than suture repair or plication alone.[4,14] However, most studies in the literature either reported outcomes for treatment of traumatic PSI in athletes or failed to distinguish between traumatic and atraumatic onset.[8-10,13-15,24]

In one study by Bradley et al.,[9] the authors differentiate a traumatic onset (defined as a discrete traumatic event) from an atraumatic onset of PSI. However, functional outcomes between these groups were not explicitly compared because the authors focused on a subgroup of contact athletes. To our knowledge, there is

Table 1. Group Characteristics of Patients With Atraumatic Versus Traumatic Onset of Posterior Shoulder Instability

	Atraumatic Group (21 Shoulders)	Traumatic Group (15 Shoulders)
Gender, n	19 M and 2 F	14 M and 1 F
Age at surgery, mean ± SD, yr	28 ± 11.3	30.3 ± 15.6
Follow-up, mean ± SD, yr	4.2 ± 1.9	4.5 ± 1.8

F, female; M, male; SD, standard deviation.

Table 2. Concomitant Pathologies of Ipsilateral Shoulders Treated With Additional Arthroscopic Procedures

Concomitant Pathology	Atraumatic	Traumatic
Type II SLAP lesion, n	4	5
Chondral damage of humeral head and/or glenoid grade III and IV, n	2	4
Biceps pathology (hourglass biceps, pulley lesion), n	3	3
AC joint separation, n	1	0
Partial-thickness supraspinatus tear, n	1	0
Posterior HAGL lesion, n	0	3
Total no. of glenohumeral pathologies with additional arthroscopic procedure	11	15
Anterior labrum tear, n	2	1
No. of patients affected	12 of 21 (57%)	12 of 15 (80%)

AC, acromioclavicular; HAGL, humeral avulsion of glenohumeral ligament.

Table 3. Comparison of Preoperative and Postoperative Outcome Parameters in Patients With Atraumatic and Traumatic Posterior Shoulder Instability

	Atraumatic			Traumatic		
Outcome Score	Preoperative	Postoperative	Significance *P* (Pseudo-Median; 95% CI)	Preoperative	Postoperative	Significance *P* (Pseudo-Median; 95% CI)
ASES	69.9 (21.6-91.6)	95.8 (38.3-99.9)	.029* (−16.6; −22.5 to −5.0)	61.6 (18.3-68.3)	99.9 (74.9-99.9)	.009* (−38.3; −56.6 to 21.6)
QuickDASH	29.5 (20.4-31.8)	5.7 (0-34)	.188 (10.2; −6.8 to 27.3)	42 (18.1-53.9)	1.1 (0.0-15.9)	.004* (35.2; 22.7 to 51.1)
SANE	67.0 (40.0-85.0)	86.5 (8-100)	.844 (−3.5; −24 to 31)	52.0 (22.0-90.0)	98.0 (84.0-99.0)	.014* (−34.5; −57.7 to −16.5)
SF-12 PCS	48.7 (32.8-54.2)	54.5 (30.8-56.6)	.142 (−2.7; −8.6 to 1.1)	44.3 (36.3-50.5)	56.8 (44.6-57.8)	.013* (−10.1; −14.9 to −5.3)

NOTE. Outcome data are presented as median (range).
ASES, American Shoulder and Elbow Surgeons; CI, confidence interval (lower boundary to upper boundary); QuickDASH, Quick Disabilities of the Arm, Shoulder and Hand; SANE, Single Assessment Numeric Evaluation; SF-12 PCS, Short Form 12 Physical Component Summary.
*Significant difference.

only one study in the literature with assessment of outcomes between traumatic and atraumatic PSI, in an adolescent population.[16] Patients with traumatic onset had a significantly higher mean postoperative ASES score (77.7 points) than patients with an atraumatic onset (mean ASES score, 48.4 points). These results of adolescent patients are inferior compared with the results found in our study. Nonetheless, the findings of our study are in accordance with the results from the adolescent population because patients with traumatic onset of PSI had significantly higher baseline-adjusted ASES and SANE scores compared with patients with atraumatic onset.[16] Apart from the evaluation of an adolescent population, there seems to be a lack of information in the literature concerning the comparison of outcomes of arthroscopic capsulolabral anchor repair between adult patients with atraumatic PSI and those with traumatic PSI.

Functional outcomes of the entire group of patients, as well as the subgroups of atraumatic and traumatic onset, are comparable with results of arthroscopic stabilization procedures described in the literature, with ASES scores ranging between 85 and 96 points.[8-11,13-15] The rate of return to sport was higher for patients with traumatic onset and concurs with what has been described in the literature.[10,14,15]

GR was recently identified as a risk factor for PSI.[20,21] In this study, atraumatic onset of PSI was associated with significantly higher GR than traumatic onset of PSI. This finding might suggest that shoulders with a higher degree of GR tend to need weaker force mechanisms of injury to result in posterior instability. The theory that the 4° difference between the mean GR of both groups is clinically relevant is supported by the fact that the same amount of difference of GR is existent between patients with posterior instability and healthy controls with stable shoulders.[9,18] The idea of more GR causing posterior displacement more easily is furthermore supported by the results of an experimental study on the effects of glenoid component version on humeral head displacement and joint reaction forces in total shoulder arthroplasties.[25] In this experimental study, each 4° increase of retroversion of the glenoid component was associated with significant posterior displacement.[25] Overall, patients with PSI seem to have an increase in GR compared with the general population without PSI, with the largest degree of GR among patients with an atraumatic onset.[17-21]

Although bony treatments (e.g., McLaughlin procedure for reverse Hill-Sachs lesion) were excluded, more than 50% of patients had one or more concomitant pathologies of the ipsilateral shoulder that required an additional arthroscopic procedure. Additional concomitant procedures have been described in 11 of 29 patients and 13 of 32 patients in 2 other outcome studies of arthroscopic posterior

Table 4. Comparison of Outcome Parameters Between Patients With Atraumatic PSI and Patients With Traumatic PSI

Postoperative Evaluation	Atraumatic Group (n = 20)	Traumatic Group (n = 12)	OR (95% CI)	Significance *P*
Return to previous level of sports (equal to, slightly below, or moderately below preinjury level)	13 of 18 (72%)	9 of 10 (90%)	0.30 (0.01-3.39)	.375
Postoperative self-reported re-dislocation or subluxation	2 of 20 (10%)	1 of 12 (8.3%)	0.69 (0.01-14.4)	.99

CI, confidence interval (lower boundary to upper boundary); OR, odds ratio; PSI, posterior shoulder instability.

stabilization.[8,13] It has been stated before that no essential lesion is present in PSI but that it rather consists of multiple and varied pathologies.[26] Because concomitant pathologies are common in the context of PSI and should be expected in 40% to 80% of patients, the group of patients included in this study was similar to previously described collectives.[8,13] Posterior humeral avulsion of the glenohumeral ligament, which was present in 3 patients with traumatic onset of PSI, should be especially recognized and addressed adequately.[27] In 3 shoulders, there were anterior labral tears with some degree of anterior instability, although patients with multidirectional instability (positive sulcus sign >1 cm) had been excluded. However, combined anterior and posterior instability types have been recognized in up to 19% of patients with PSI.[2,24] Similar to posterior humeral avulsion of the glenohumeral ligament, these conditions need to be identified and treated accordingly.

Higher degrees of GR, inferior clinical outcomes, and a trend toward lower rates of return to sport suggest that the treatment of patients with atraumatic onset of PSI may be more challenging. Further investigation is needed to determine whether arthroscopic capsulolabral anchor stabilization is the best treatment for patients with atraumatic PSI.

Limitations

Despite the fact that results of "only" 32 patients are presented, this patient group is among the larger collectives presented on PSI with the inclusion criteria creating a group of patients with a consistent surgical technique. Furthermore, the mean follow-up period of 4.3 years is among the longest described in this context. However, this study has several limitations. First, the patient groups (traumatic and atraumatic) that were compared in this study are unequal in size. Second, there are many gray zones regarding the discrimination between traumatic and atraumatic onset of PSI. Similar to other shoulder pathologies, there may be some overlap between a traumatic onset and an atraumatic onset, and differentiation is difficult for some individuals. However, the inclusion criteria for traumatic onset were derived from the literature and are generally acknowledged. Third, measurements of GR were performed with MRI rather than computed tomography scans as originally published.[22] However, this method using MRI has been published in the context of PSI previously.[20] Furthermore, results of GR measurements were not corrected for racial differences because racial information was not collected for the purpose of this study.[28] Although the racial distribution among patients with traumatic onset and atraumatic onset of PSI was not assessed in this study, we believe that the racial impact on GR measurements can be neglected. The outcomes of patients who had failure and underwent open revision posterior stabilization surgery were reported separately from the remainder of the group. This way of reporting outcomes may have the potential to positively affect the outcomes of patients without failure. However, the final ASES score of the patient with failed surgery for traumatic PSI was higher than the ASES score of the patient with failed surgery for atraumatic PSI, which is in accordance with the results of patients without failure. Reporting the outcomes of patients with failed treatment separately from the outcomes of patients with successful treatment helps future patient counseling. Information regarding return to sport was available for only 28 shoulders of the final group of 36 shoulders (78%), which must be considered a limitation. Lastly, the fact that the baseline score—adjusted comparison of the QuickDASH and SF-12 PCS scores did not reach statistically significant differences is likely related to a type II error.

Conclusions

Atraumatic onset of PSI was associated with higher degrees of GR and less favorable mid-term functional outcomes of arthroscopic posterior capsulolabral anchor repair than traumatic PSI.

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