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Epidemiology of Posterior Glenohumeral Instability in a Young Athletic Population

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Background: While several studies have observed the incidence of posterior glenohumeral instability in selected populations, there are no data from large-scale population-based studies with corresponding athletic exposure data to calculate incidence rates (IRs) and associated risk factors.

Purpose: To determine risk factors for posterior glenohumeral instability within the physically active population at the United States Military Academy.

Study Design: Descriptive epidemiology study.

Methods: A longitudinal cohort study was performed over a 6-year period from 2006 to 2012 at the United States Military Academy utilizing the Cadet Illness and Injury Tracking System. Exposure data were collected from daily attendance data documented for every practice and game at the intramural, club, or varsity sport level. The primary outcomes calculated were the IRs of posterior glenohumeral joint instability per 1000 person-years at risk and per 1000 athlete-exposures. IR ratios and confidence intervals were calculated between male and female cadets and between intercollegiate and intramural athletes.

Results: Between 2006 and 2012, there were 1348 shoulder injuries in total, with 633 instability events. During the study period, 113 posterior shoulder instability injuries (17.9% of instability events) and 26,408 person-years at risk were documented, for an overall IR of 4.28 per 1000 person-years. The overall IR of posterior instability was 0.08 per 1000 athlete exposures. In male athletes, 105 sustained a posterior shoulder instability event, for an IR of 4.67 per 1000 person-years. Female athletes were less likely to sustain a posterior instability event, accounting for only 8 events, for an IR of 2.04 per 1000 person-years. A total of 6670 athletes were at risk for posterior shoulder instability injury during the study period. A total of 55 injuries were documented, for an IR of 8.25 per 1000 person-years. Intercollegiate wrestlers had the highest IR: 34.15 per 1000 person-years. The sport with the highest injury rate among intramural sports was football, at 2.79 per 1000 person-years. Three athletes had a history of a posterior shoulder dislocation, while no significant difference was found for subluxation versus pain as the presenting symptom. Of the 113 posterior shoulder instability injuries, 77.0% required surgical stabilization. All injuries associated with weight lifting required surgical stabilization.

Conclusion: Among athletes, intercollegiate athletes are at an increased risk of posterior glenohumeral instability when compared with intramural athletes. Intercollegiate athletes and weight lifters demonstrate a high likelihood of requiring surgical treatment as compared with intramural athletes.

Keywords: shoulder instability; posterior instability; instability; athlete; labrum; epidemiology; injury prevention

Posterior glenohumeral instability is less common than anterior instability. It represents approximately 2% to 10.3% of all shoulder instability cases.[1,14] Posterior shoulder instability is caused by an abnormal posterior translation of the humeral head relative to the glenoid. Recurrent posterior subluxation is the most common type of posterior instability, while acute dislocation is infrequent.[19] Posterior shoulder instability may occur in isolation, but it is also commonly associated with multidirectional instability.[6]

Patients with posterior shoulder instability primarily have pain and weakness rather than frank instability.[12] Given this atypical presentation by the patient, elucidating the true underlying issue of instability can create a problem for physicians, especially if only subtle differences are present, and may lead to a delay in diagnosis.[13] Regardless

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of the presenting symptoms, symptomatic posterior shoulder instability has the potential to sideline young athletes for an extended period.

Several studies have observed the incidence of posterior glenohumeral instability in selected populations, the most recent evaluating strength and anatomy as predictors for injury.[9,13,14] No study has categorized the risk of posterior instability in relation to type of sport, level of play, and demographic information. The purpose of this study was to determine the epidemiology of posterior glenohumeral instability within the physically active population at the United States Military Academy (USMA), West Point, NY, USA. The focus of this study is to evaluate the correlation among sex, type of sport, level of competition, and incidence of posterior glenohumeral instability in a homogeneous cohort. We hypothesized that male sex and participation in collision and intercollegiate sports would be associated with higher rates of posterior glenohumeral instability.

METHODS

Study Design and Setting

A retrospective longitudinal cohort study was performed to examine the epidemiology of posterior glenohumeral joint instability over a 6-year period (2006-2012) within the population at the USMA by utilizing the Cadet Illness and Injury Tracking System (CIITS). This study was approved by the Institutional Review Board at Keller Army Community Hospital. The population for this study included all cadets in attendance during the study period. All students entering the USMA undergo a comprehensive medical evaluation and are required to meet the US Army's physical induction standards when joining the military. During their 4 years at the USMA, cadets are required to participate in the intramural, club, or intercollegiate sports in at least 6 semesters of their attendance. Cadets also participate in the Department of Physical Education courses and activities, some of which may be sex specific, as well as a biannual Army Physical Fitness Test. Mandatory military training occurs throughout the cadets' attendance at the military academy. Cadets participate in intensive physical training programs and field-training exercises in addition to mandatory participation in either intramural or intercollegiate athletics. Because of the USMA's requirements, documented attendance is required for cadets at all places of duty, to include athletics. Attendance is taken and reported for all sporting events, games, and practices.

Exposure data are based on daily attendance data documented for most activities (practice and game) at the intramural, club, or varsity sport level. The data are reported online through the USMA's student information system, which then provides athletic exposure data for the CIITS. All cadets receive medical care through the closed health care system at the Keller Army Community Hospital, and all injuries are evaluated through its associated sports medicine and orthopaedic clinics. All injuries resulting in time lost to sports or activity and requiring presentation at a receiving clinic are documented in the CIITS.

Injury Surveillance

Patients identified as having shoulder instability were seen and evaluated by 1 of the fellowship-trained orthopaedic sports medicine surgeons at the institution. Plain radiographs and magnetic resonance imaging (MRI) were obtained on all patients with posterior instability. Radiographs included standard shoulder anteroposterior and axillary views. MRI was performed on a single 1.5-T machine and included T1 and T2 images with 2-dimensional reconstructions in the coronal and sagittal plane.

Primary direction of instability was determined from a combination of history (to include mechanism of injury and arm position at time of injury), examination (in clinic and under anesthesia), and MRI findings. In the case of pathology present on MRI consistent with injury to anterior and posterior labrum, initial injury mechanism and patient history/complaints were used to make determination of instability direction. Those with questionable patterns of injury/history and vague complaints were not classified as posterior instability but multidirectional or anterior. Individuals with a history of increased shoulder laxity or volitional instability without traumatic labral tears were also classified as having multidirectional instability. Isolated superior labral injuries were diagnosed from a combination of examination findings without anterior or posterior laxity and having MRI and/or operative findings of isolated superior labral injuries.

Data Collection

Injury data were extracted from the CIITS database, and all posterior glenohumeral instability injuries were identified. Electronic medical records and radiographic images were reviewed, and only new posterior glenohumeral instability cases were included in incidence rate (IR) calculations. New posterior glenohumeral joint instability cases were defined as primary injury resulting in time lost to sport and activity that occurred within the study period. Injuries sustained before the study period were not included as new posterior glenohumeral joint injuries. The primary outcomes of interest were the IR of posterior glenohumeral joint instability per 1000 person-years at risk and per 1000 athlete-exposures. Person-years were calculated from the beginning of the study period until (1) the patient sustained an incidence of posterior glenohumeral joint injury, (2) the patient graduated or left the USMA, or (3) the study period ended (December 31, 2012). Athlete-exposures were defined as 1 activity session (ie, game or practice). Recurrent posterior glenohumeral joint injuries were not included in IR calculations. IRs are calculated by dividing the total number of injuries observed in a population by a measure of person-time at risk to injury. While athlete-exposure to injury has commonly been used as a measure of person-time at risk in sports injury research, person-year at risk is a more widely used measure of exposure in population-based epidemiologic studies. In our population, athlete-exposure is a more precise measure of person-time in the calculation of IRs for

TABLE 1
IRs of Posterior Shoulder Instability at the United States Military Academy, 2006-2012[a]

	Posterior Instability, No.	Total Person-Years					Athlete-Exposures				
		No.	IR per 1000	IRR	95% CI	P Value	No.	IR per 1000	IRR	95% CI	P Value
Sample											
Males	105	22,492	4.67	2.29	1.11-4.69	**.02**					
Females	8	3916	2.04	Ref							
Overall	113	26,408	4.28				1,437,164	0.08			
IC athletes											
Male	48	4995	9.61	2.3	1.04-5.08	**.04**	567,443	0.08	2.14	0.97-4.74	.06
Female	7	1675	4.18	Ref			177,344	0.04			
Overall	55	6670	8.25	8.14	4.88-13.58	**<.0001**	744,787	0.07	2.56	1.53-4.26	**.0003**
IM athletes	20	19,738	1.01	Ref			692,377	0.03			
DPE athletes	23										
Military training	6										
Weight lifting	9										

[a]Blank cells indicate "no data." Bold indicates significance ($P < .05$). DPE, department of physical education; IC, intercollegiate; IM, intramural; IR, incidence rate; IRR, incidence rate ratio; ref, referent group.

posterior glenohumeral joint instability, and Knowles et al[11] recommended collecting data for person-time at risk to injury as precisely as possible.

Data Analysis

Using data extracted from the CIITS database, IRs with 95% confidence intervals were calculated per 1000 person-years at risk by sex, sport, and level of competition for the entire population. IRs with 95% confidence intervals were also calculated per 1000 athlete-exposures by sex, sport, and level of competition (intercollegiate or intramural). Intercollegiate sport categories include sports with men's and women's athletic teams (basketball, rugby, lacrosse, tennis, soccer, track sports) as well as single-sex athletic teams (men's baseball, football, combat grappling, orienteering, pass-n-go, Sandhurst, team handball, ultimate Frisbee, and wrestling). Pass-n-go is similar to ultimate Frisbee but uses a football. Sandhurst is a team adventure racing competition involving running in full combat gear and obstacle maneuvering. IR ratios (IRRs) and confidence intervals were calculated between male and female cadets, intercollegiate and intramural athletes, and men's and women's intercollegiate rugby. Chi-square and Poisson regression analyses were used to examine the relationship between the variables of interest and the incidence of posterior glenohumeral instability injury. All analyses were carried out with SAS (v 9.4; SAS Institute Inc), with statistical significance set at $P < .05$ for all comparisons.

RESULTS

Between 2006 and 2012, there were 1348 shoulder injuries in total, with 633 instability events. Anterior instability was the most common injury noted, with 457 events accounting for 72.1% of injuries; multidirectional instability and isolated superior labral injuries accounted for 63 events (10% of instability events). During the study period, 113 posterior shoulder instability injuries (17.9% of instability events) and 26,408 person-years at risk were documented. All subjects with suspected posterior instability were evaluated by an orthopaedic sports medicine surgeon for formal evaluation. Radiographs and MRI were obtained on all patients for review. The overall IR was 4.28 per 1000 person-years for posterior instability in our population, with 0.08 per 1000 athlete exposures; 29 individuals were excluded from exposure data analysis secondary to lack of exposure data for their activities (Table 1).

During the study period, 105 male athletes sustained a posterior shoulder instability event, for an IR of 4.67 per 1000 person-years. Female athletes were less likely to sustain a posterior instability event, accounting for only 8 events (0.2% of female cadets), for an IR of 2.04 per 1000 person-years. When compared with females, male cadets were twice as likely to sustain a posterior shoulder instability event, with an IRR of 2.29 (95% CI, 1.11-4.69). When intercollegiate athletes were compared, males were at significantly greater risk than female athletes according to population-based data, with an IRR of 2.3 (95% CI, 1.04-5.08) (P = .04), and approached significance with respect to exposure-based data, with an IRR of 2.14 (95% CI, 0.97-4.74) (P = .06).

A total of 6670 intercollegiate athletes were at risk for posterior shoulder instability injury during the study period. A total of 55 injuries were documented, for an IR of 8.25 per 1000 person-years and 0.07 per 1000 athlete exposures. Intercollegiate athletes were at significantly higher risk of injury than intramural athletes with an IRR of 8.38 (95% CI, 4.90-14.35) per 1000 person-years and 2.63 (95% CI, 1.54-4.51) per 1000 athlete exposures ($P < .0001$) (Table 2).

Intercollegiate wrestlers had the highest injury rate, with 0.32 per 1000 athlete exposures and 34.15 per 1000 person-years. Wrestling (IR, 0.32), women's rugby (IR, 0.22), and men's rugby (IR, 0.20) represent the 3 highest IRs among intercollegiate athletics per 1000 athlete exposures. The

TABLE 2
IRs of Posterior Instability in Intercollegiate/Intramural Sports, 2006-2012[a]

		Person-Years					Athlete-Exposures				
	Injury, No.	No.	IR per 1000	IRR	95% CI	*P* Value	No.	IR per 1000	IRR	95% CI	*P* Value
Intercollegiate sports[b]	55	6670	8.25	8.38	4.90-14.35	**<.0001**	744,787	0.07	2.63	1.54-4.51	**.0004**
Male athletes[c]	48	4995	9.01	2.16	0.97-4.78	.06	567,443	0.08	2.01	0.91-4.46	.09
Rugby[d]	3	291	10.31	0.72	0.14-3.56	.69	15,351	0.20	0.91	0.18-4.49	.90
Wrestling[e]	7	205	34.15	16.27	5.17-51.28	**<.0001**	21,709	0.32	2.2	0.70-6.92	.18
Track	1	411	2.43				36,458	0.03			
Judo	1										
Swimming	2	340	5.88				32,057	0.06			
Gymnastics	1	83	12.05				11,079	0.09			
Football[f]	27	1515	17.82	6.39	2.90-14.07	**<.0001**	224,450	0.12	0.56	0.26-1.24	.15
Ski Nordic	1										
Baseball	3	301	9.97				30,845	0.10			
Handball	1										
Lacrosse	1	392	2.55				46,937	0.02			
Female athletes[g]	7	1675	4.18	4.58	1.91-10.97	**.0006**	177,344	0.04	1.52	0.63-3.64	.35
Rugby	3	209	14.35				13,908	0.22			
Basketball	3	96	31.25				21,440	0.14			
Fencing	1										
Intramural sports	20	19,738	0.91				692,377	0.03			
Grapplinge[h]	2	2221	0.90	3.87	0.35-4.26	.27	71,414	0.03	1.60	0.14-17.59	.70
Football[h]	8	2869	2.79	11.97	1.50-95.73	**.02**	37,352	0.21	12.20	1.53-97.55	**.018**
Wrestling[h]	5	2383	2.10	9.01	1.05-77.12	**.04**	34,052	0.15	8.36	0.98-71.60	**.053**
Rugby[h]	1	1692	0.59	2.54	0.16-40.57	.51	21,718	0.05	2.62	0.16-41.88	.50
Basketball	1	4294	0.23				56,968	0.02			
Soccer[h]	1	2511	0.40	1.71	0.11-27.34	.70	37,137	0.03	1.53	0.10-24.52	.76
Paintball	1										
Cheerleading	1										

[a]Blank cells indicate "no data." Bold indicates significance ($P < .05$). IR, incidence rate; IRR, incidence rate ratio.
[b]Intramural sports as referent group.
[c]Female intercollegiate athletes as referent group.
[d]Female rugby intercollegiate athletes as referent group.
[e]Wrestling intramural sports as referent group.
[f]Football intramural sports as referent group.
[g]Intramural sports as referent group.
[h]Basketball intramural sports as referent group.

sport with the highest injury rate among intramural sports was football, with 0.21 per 1000 athlete exposures; the only intramural sport with an IR >0.20 per 1000 athlete exposures (Figure 1).

Athletes participating in contact sports sustained injuries at a rate of 0.11 per 1000 athlete exposures, as compared with those participating in noncontact activities, who sustained injuries at a rate of 0.06 (IRR, 1.76; 95% CI, 0.76-4.07); however, this was not statistically significant (P = .19) (Table 3).

Review of the patient record on initial presentation revealed that 61 of 113 patients with posterior instability (54%) reported subluxation/instability as the primary/chief complaint; pain was the primary complaint in 48 patients (42.5%). Only 3 patients (0.03%) reported a history of dislocation.

Intercollegiate athletes and injuries sustained while weight lifting were far more likely to require surgery as compared with intramural athletes with posterior instability (Table 4). While all patients in our cohort had a primary complaint of posterior instability, there were a substantial number of patients (47%) who required inclusion of an anterior and/or superior labral repair at the time of surgical treatment. Overall, 42% of patients with posterior instability had MRI findings that appeared to involve the anterior and/or superior labrum in addition to the posterior labrum.

DISCUSSION

The data from this cohort support our hypothesis that males and intercollegiate athletes are at increased risk of posterior instability. This is the largest known study to evaluate risk of posterior shoulder instability in relation to athlete exposure. The overall incidence of posterior instability in the population was 0.08 per 1000 athlete exposures, with males having a twice as likely incidence of posterior glenohumeral instability than females. Posterior shoulder

TABLE 3
Contact/Collision Versus Noncontact Athletics

	Contact/Collision	Noncontact	Incidence Rate Ratio (95% CI)	*P* Value
Injuries	60	6		
Participants	16,167	1052		
Athlete exposures	565,299	99,360		
Incidence per 1000 person-years	3.71	5.7	0.65 (0.28-1.51)	.3156
Incidence per 1000 athlete exposures	0.11	0.06	1.76 (0.76-4.07)	.1878

TABLE 4
Surgical Procedures for Posterior Instability[a]

	Posterior Instability, No.	Surgery		Injury Pattern During Arthroscopy, No.			
		No.	%	Panlabral	Anterior Posterior	SLAP Posterior	Posterior Only
Sample							
Overall	113	87	77.0	8	21	12	46
Male	105	81	77.1	8	17	12	44
Female	8	6	75.0	0	4	0	2
IC athletes							
Overall	55	45	81.8	4	11	9	21
Male	48	40	83.3	4	7	9	20
Female	7	5	71.4	0	4	0	1
IM athletes	20	9	45.0	1	3	1	4
DPE athletes	23	19	82.6	1	2	2	14
Military training	6	5	83.3	1	2	0	2
Weight lifting	9	9	100.0	1	3	0	5

[a]DPE, department of physical education; IC, intercollegiate; IM, intramural; SLAP, superior labral anterior-posterior.

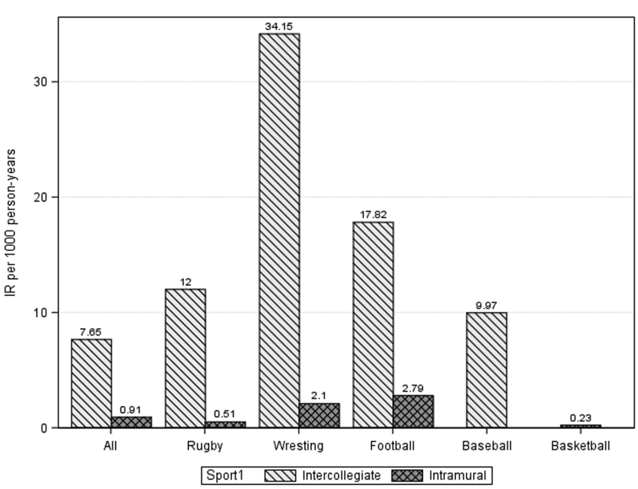

Figure 1. Incidence rate (IR) per 1000 person-years by sport.

instability appears to be more common in young athletes and accounts for 34% of shoulder injuries to professional rugby players.[9] We found that the most at-risk activities include wrestling, rugby, and football regardless of the level of competition or sex.

The level of competition in which athletes participated was also a factor for increasing the risk for posterior shoulder instability. Intercollegiate and collision sports participation were found to increase the incidence for posterior shoulder instability. Posterior shoulder instability has commonly been associated with falling on an outstretched hand, football, and weight lifting; however, other activities have demonstrated substantially increased rates of injury.[2,9,15,17,21] We noted that intercollegiate athletes were at 8 times higher risk of posterior instability when compared with the remainder of the population.

Additionally, these athletes were more likely to require surgical treatment: 82% of intercollegiate athletes versus 45% of intramural athletes. Studies have demonstrated success rates of 70% to 89% for nonoperative treatment of posterior shoulder instability with atraumatic ligamentous laxity and repetitive microtrauma causes but only 19% success with a history of a traumatic event.[3,7] Historically, it has been thought that weight lifting, especially bench press, causes repetitive microtrauma to the shoulder resulting in posterior shoulder subluxation and labral damage.[17,18] A trial of physical therapy of 6 to 8 weeks was performed on 91.2% of the patients in our cohort. Only 10 patients deferred a trial of therapy owing to severity of symptoms and their preference. Given that the majority of subsets within our cohort had >70% of individuals requiring surgical stabilization, it appears that therapy did not diminish pain and improve stabilization to permit the required activity level and shoulder function of our cohort despite injury mechanism. All individuals sustaining posterior shoulder injuries secondary to weight lifting activity required surgical treatment to return desired functional level.

Individuals who underwent surgical stabilization were frequently found to have injury patterns that extended to additional areas of the labrum aside from the posterior aspect (47%). Dickens et al[4,5] demonstrated the propensity for combined lesions in this population group from a single event. This potentially creates a conflict for some surgeons and therapists in postoperative care and restrictions: which side of the repair to protect (both or 1 side) or clinically based rehabilitation for the primary direction of symptomatology? Further studies examining functional outcomes and failure rates may help to answer this question, although they cannot be determined in our study.

Owens et al[13] prospectively followed a cohort of 714 military cadets and demonstrated that only 1% of participants sustained a posterior glenohumeral instability event, with 15% sustaining acute glenohumeral instability events. Posterior shoulder instability presentation has routinely been taught as a primary and initial complaint of increased pain with diminished performance or weakness, whether on the field or the gym.[2,8,10,12,16-18,20] Our analysis demonstrated a slightly higher number of athletes presenting with complaints of a sensation of instability within the shoulder as compared with pain (61 vs 48); however, this was not statistically significant. When evaluating young active patients with shoulder injuries, clinicians must keep in mind that only slightly more than half will have symptoms of instability.

When comparing contact/collision athletes versus noncontact athletes, we expected to find a significant difference in injury rates; however, this difference was not found in our data. This could be due to the lack of exposure data, which were typically not available for our noncontact activities and were the basis for this calculation.

The limitations of our study include its retrospective nature and having to rely on the accuracy of documentation with the cadet injury tracking system. Exposure data for all documented activities were also not available, leaving 29 patients with posterior shoulder instability excluded from calculation for exposure data in the subgroup analysis section. These events include injuries that did not occur during organized activity (weight lifting, self-guided physical training activity, skiing, etc). Inclusion of these individuals without the exposure data would significantly alter the IR and IRR of the subgroups and be grossly incorrect. By excluding these from analysis, we minimized the effect of failing to have these data available. While not accounting for all aspects, the slight increase or decrease in the IR and IRR that would result from having the correct numbers would be minimal based on our projections. The CIITS does rely on athletes' missing participation time or evaluation for injury to capture the events; if no time is missed from play or no care/evaluation for pain is sought, then the events are not captured. It does, however, capture all of the athletes who do seek evaluation or miss time. Given the length of the study and the rigorous athletic and military requirements of the cohort, we are confident that all individuals with activity-limiting shoulder pain were captured by the cadet injury tracking system.

Another potential weakness or confounder is the diagnostic accuracy of determining primary direction of instability. In our population, almost half of individuals treated with surgery had injury to other areas of the labrum in addition to the posterior labrum. While this potentially confounds the accuracy of labeling injuries as posterior, anterior, or multidirectional, our methods of diagnosing primary direction were consistent with all individuals, according to history and examination with the addition of MRI and operative findings. A large number of individuals demonstrated extension of tearing into these other areas and did not demonstrate substantial instability on examination under anesthesia in the anterior direction, despite having extension into this area. However, the slight increase in laxity as compared with the contralateral side indicated them for fixation of the extension with additional fixation. Surgeons have different methods (based on training) for determining the primary direction of instability. Perhaps the best way to eliminate this variability in the future is to create a standardized method for determining the primary instability direction that has evidence-based validity. The strengths of our study include the size of the study and the high-risk young athletic population. Future work may include a prospective study with formalized screening tools with preselected criteria to evaluate and complete exposure tracking for exposure time for all activities.

Our analysis found risk factors for posterior glenohumeral instability in our population; this study was not designed or used to determine ways to potentially mitigate the risk of injury. Our analysis has helped to identify the groups at risk for injury, which could assist providers in more rapid diagnosis and treatment that will ideally allow for reduced time missed from activity.

In conclusion, posterior shoulder instability represents nearly 18% of all shoulder instability events. Males participating in intercollegiate sports are at increased risk for posterior shoulder instability. Wrestling, rugby, and football are the activities that present the greatest risk of injury per exposure. Only slightly more than half of athletes with posterior shoulder instability report symptoms of instability on initial presentation, thereby increasing the difficulty of making an appropriate diagnosis on initial evaluation. There is a very high probability of surgical treatment being necessary for young active individuals to return to a functional level of activity.

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