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## Risk factors associated with atraumatic posterolateral rotatory instability

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**Background:** Traumatic posterolateral rotatory instability after elbow dislocation or fracture dislocation has been well described. However, few reports cover atraumatic posterolateral rotatory instability as a cause of lateral-sided elbow pain. We assessed the risk factors and epidemiology of atraumatic posterolateral rotatory instability in a case-control study.

**Methods:** A retrospective review of all patients treated operatively for atraumatic posterolateral rotatory instability during a 6-year period was compared with a group of patients with extensor carpi radialis brevis tendinopathy without instability treated during the same time period. Bivariate and multiple logistic regression statistical analyses were used to investigate the following risk factors: gender, age, hand dominance, diabetes, smoking, body mass index, corticosteroid injection history, and duration of symptoms. Disabilities of the Arm, Shoulder, and Hand and pain scores were obtained preoperatively and postoperatively.

**Results:** Thirteen patients with atraumatic posterolateral rotatory instability were compared with 12 patients with extensor carpi radialis brevis tendinopathy. Multivariate analysis revealed patients with atraumatic posterolateral rotatory instability were more likely to have multiple corticosteroid injections ( $P = .05$ ) and present with a longer duration of symptoms ( $P = .03$ ). Postoperative pain scores improved in both groups.

**Conclusions:** Atraumatic posterolateral rotatory instability should be considered in the differential diagnosis of lateral elbow when patients present with a protracted clinical course. Statistically, posterolateral rotatory instability patients more often present with a history of multiple corticosteroid injections.

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Lateral-sided elbow pain is a common presentation to both orthopedic and primary care practitioners. The most common diagnosis for atraumatic lateral elbow pain is extensor carpi radialis brevis (ECRB) tendinopathy or “tennis elbow” with a prevalence of 3%.<sup>30</sup> Successful treatment of ECRB is usually accomplished through nonoperative approaches, including rest, nonsteroidal anti-inflammatory drugs, and physiotherapy.<sup>15</sup> Outcomes with non-surgical treatment are largely successful with 85% or more of patients noting complete relief of symptoms.<sup>18</sup> However, in refractory cases, pathologic tissue from the extensor tendon origin can be

repaired, excised, or released using open, percutaneous, or arthroscopic approaches.<sup>6</sup> The failure rate of surgical treatment, depending on the surgical technique, ranges from 8% to 11%.<sup>13</sup> Surgical failure to alleviate symptoms is multifactorial and related to intrinsic patient-related factors, technique, and possibly failure to diagnose and address the appropriate pathology.

In addition to ECRB, the differential diagnosis of lateral-sided elbow pain includes atraumatic posterolateral rotatory instability (PLRI), radial tunnel syndrome, radiocapitellar arthrosis, and plica syndrome. Traumatic PLRI after elbow dislocation is well described, but case reports have only discussed atraumatic PLRI.<sup>6</sup> The risk factors that help distinguish atraumatic PLRI from ECRB are unknown.

The aim of this study is to identify which factors are associated with PLRI in the absence of traumatic elbow instability. We hypothesized that patients undergoing surgical management of atraumatic PLRI are more likely to be women, present with an

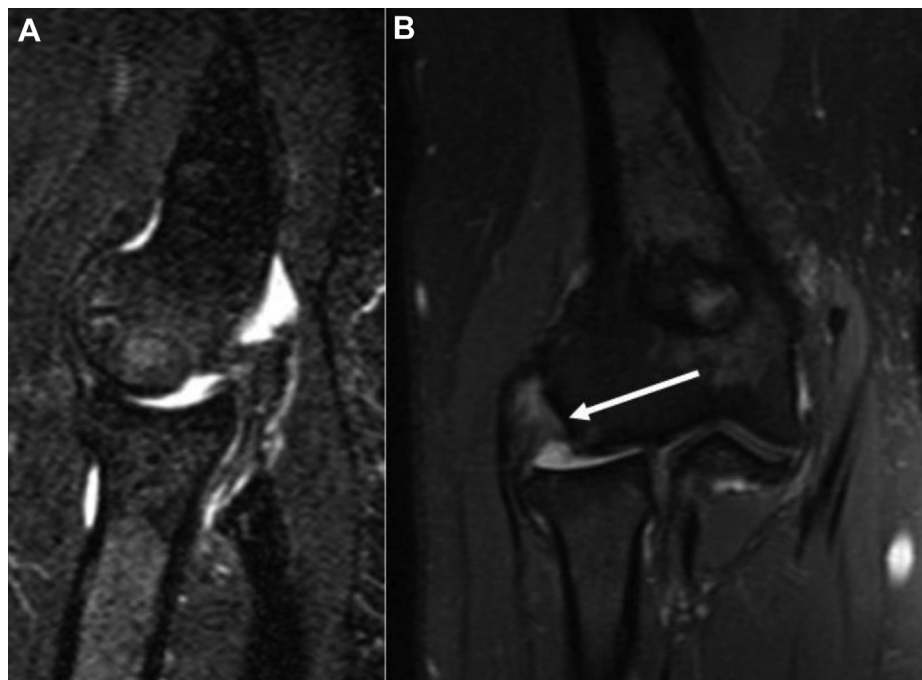
Approval for this study was obtained from the University of Pennsylvania Institutional Review Board (Protocol # 817227).

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**Figure 1** (A) Sagittal oblique MRI image of a 28-year-old with 6 months of lateral elbow pain without a history of trauma, but with repetitive loading on her arm during cleaning and housework. Evidence of PLRI is present with elbow extension and supination. (B) Coronal MRI image of a 45-year-old with 2 years of lateral elbow pain treated with multiple corticosteroid injections. Attenuation and detachment of the LUCL origin is evident (arrow). LUCL, lateral ulnar collateral ligament; MRI, magnetic resonance imaging; PLRI, posterolateral rotary instability.

increased number of steroid injections, and present with a longer duration of symptoms compared with patients surgically treated for ECRB.

### Materials and methods

We completed a retrospective review of all patients treated operatively for atraumatic PLRI from January 2009 to April 2015 from a single surgeon's database. A cohort of patients with ECRB treated operatively in the same time period was reviewed for comparison in a case-control design. Data were collected and compiled via clinical chart review, and patients completed Disabilities of the Arm, Shoulder, and Hand (DASH) forms at the time of clinical follow-up. In instances where direct patient follow-up was not possible, patients were contacted via telephone for DASH scores.

Patients with a history of a previous surgery, traumatic elbow dislocation, or fracture were excluded from the study. During the study period, 14 traumatic cases of PLRI treated surgically with ligament reconstruction were excluded. All patients underwent preoperative magnetic resonance imaging (MRI) of their effected elbow.

Patients with ECRB complained of pain distal to the lateral epicondyle that was reproduced with resisted wrist and long finger extension had no restrictions in motion and had no pain in the radiocapitellar or posterolateral portion of the elbow upon palpation. MRI, while exhibiting tendinopathy of the common extensor origin, did not show lateral ulnar collateral ligament (LUCL) disruption or radial head posterior subluxation in any of the study cases. Absence of posterolateral drawer test, varus instability, and pivot shift were confirmed in the office and under anesthesia. All patients with ECRB failed conservative management before surgery including nonsteroidal anti-inflammatory drugs, occupational therapy, and a counterforce elbow strap. No additional injections were administered.

The diagnosis of PLRI was based initially on history and physical examination with signs and symptoms atypical for ECRB. Pain at the radiocapitellar joint, especially with supination and extension associated with a lack of terminal elbow extension in supination, raised suspicion for PLRI.<sup>34</sup> Disruption of the LUCL on MRI was noted in all cases, and posterior subluxation of the radial head was noted on MRI in some cases (Fig. 1).<sup>33</sup> Examination under anesthesia at the time of surgery confirmed the diagnosis with positive tests for PLRI including varus instability, a positive pivot shift, and posterolateral drawer tests.<sup>4,20,21</sup> All patients with PLRI also failed conservative management prior to surgery including nonsteroidal anti-inflammatory drugs when appropriate and occupational therapy. No additional injections were administered.

Patients with ECRB were treated with either an open or arthroscopic débridement based on surgeon preference. If present, a plica was resected in all cases either arthroscopically or through a small arthrotomy in open cases. Patients with atraumatic PLRI underwent LUCL reconstruction with palmaris autograft or non-radiated gracilis allograft using a modification of Jobe's technique for ulnar collateral ligament reconstruction.<sup>24</sup> Patients were immobilized in a splint for 1 week and started active-assisted motion after that time. Supination with terminal extension was avoided for 6 weeks. Lifting any object or pushing with the operative arm was avoided for 2 months. Progressive resumption of unrestricted activity was permitted at 3 months.

Patient-specific factors assessed for statistical analysis included the following: gender, age, hand dominance, diabetes, smoking, and body mass index. The preoperative and postoperative pain and DASH scores, number of corticosteroid injections, and duration of symptoms before presentation were also assessed. Age, body mass index, duration of symptoms, preoperative and postoperative pain, and DASH scores were analyzed as continuous variables. Duration of symptoms was defined as the number of months the patient recalled having pain up until the time of diagnosis. Categorical

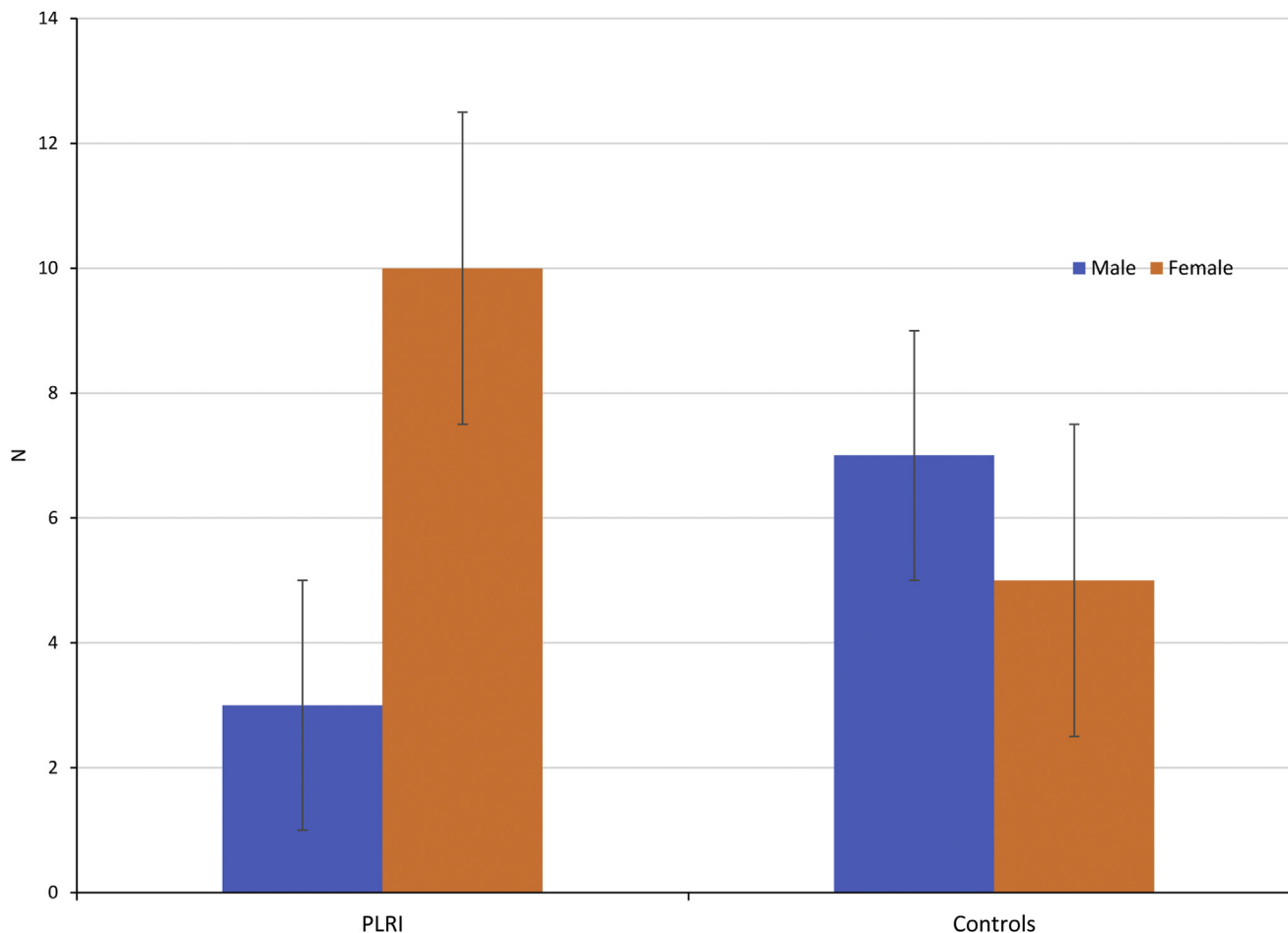


Figure 2 Gender differences of posterolateral rotary instability (PLRI).

variables were gender, hand dominance, diabetes, smoking, and number of corticosteroid injections. Smoking was coded as a binary variable grouping former smokers who quit within 1 year of surgery with current smokers. The number of corticosteroid injections was defined as the number of corticosteroid injections received before clinic presentation and was dichotomized as none or 1 compared with 2 or more injections.

Categorical variables were summarized as counts and percentages and were compared based on study group using chi-square with Fisher’s exact post hoc tests. Continuous variables were normally distributed, described as mean values and standard deviation, and were compared based on study group using Student’s t-test. Potential risk factors for PLRI (independent variables) were assessed for a statistical association with PLRI (the dependent variable) using univariate analysis. The alpha level was set at 0.05. Logistic regression was used to determine unadjusted and adjusted odds ratios (OR) for PLRI with relevant covariates. A final reduced model obtained by backward stepwise elimination based on a minimum Akaike information criterion was selected. Paired t-tests were used in assessing treatment response: pain and DASH scores. All statistical analyses were performed using JMP Pro, version 14 (SAS Institute, Cary, NC, USA).

**Results**

A total of 14 cases (12 patients) of surgically treated ECRB and 15 cases (13 patients) of atraumatic PLRI were reviewed. Patients with a bilateral diagnosis were included as 1 case referring to the first

treated elbow at the time of presentation (Table 1). The average length of postoperative follow-up for patients with ECRB was 14.3 months (range, 1-47 months) and 15.9 months (range, 2-40 months) for patients with atraumatic PLRI.

No significant differences were observed in the demographic characteristics between patients with PLRI and ECRB. Although a trend toward more women (10 of 13, 77%) diagnosed with PLRI compared with ECRB was demonstrated, the gender difference between groups did not reach statistical significance ( $P = .07$ ) (Fig. 2). Patients with PLRI were more likely to present with a history of more than 1 corticosteroid injection. Eight of 13 (62%) patients with PLRI presented with multiple corticosteroid injections. Conversely, 2 of 12 (17%) patients with ECRB ( $P = .02$ ) presented with more than 1 corticosteroid injection (Fig. 3). Patients with PLRI had lateral elbow symptoms for a longer period of time than patients with ECRB. At the time of diagnosis, patients with ECRB complained of symptoms for an average of 5.8 months (95% CI, 3.0-8.5 months) vs. 19.6 months (95% CI, 10.0-29.3 months) for patients with PLRI ( $P = .01$ ) (Fig. 4).

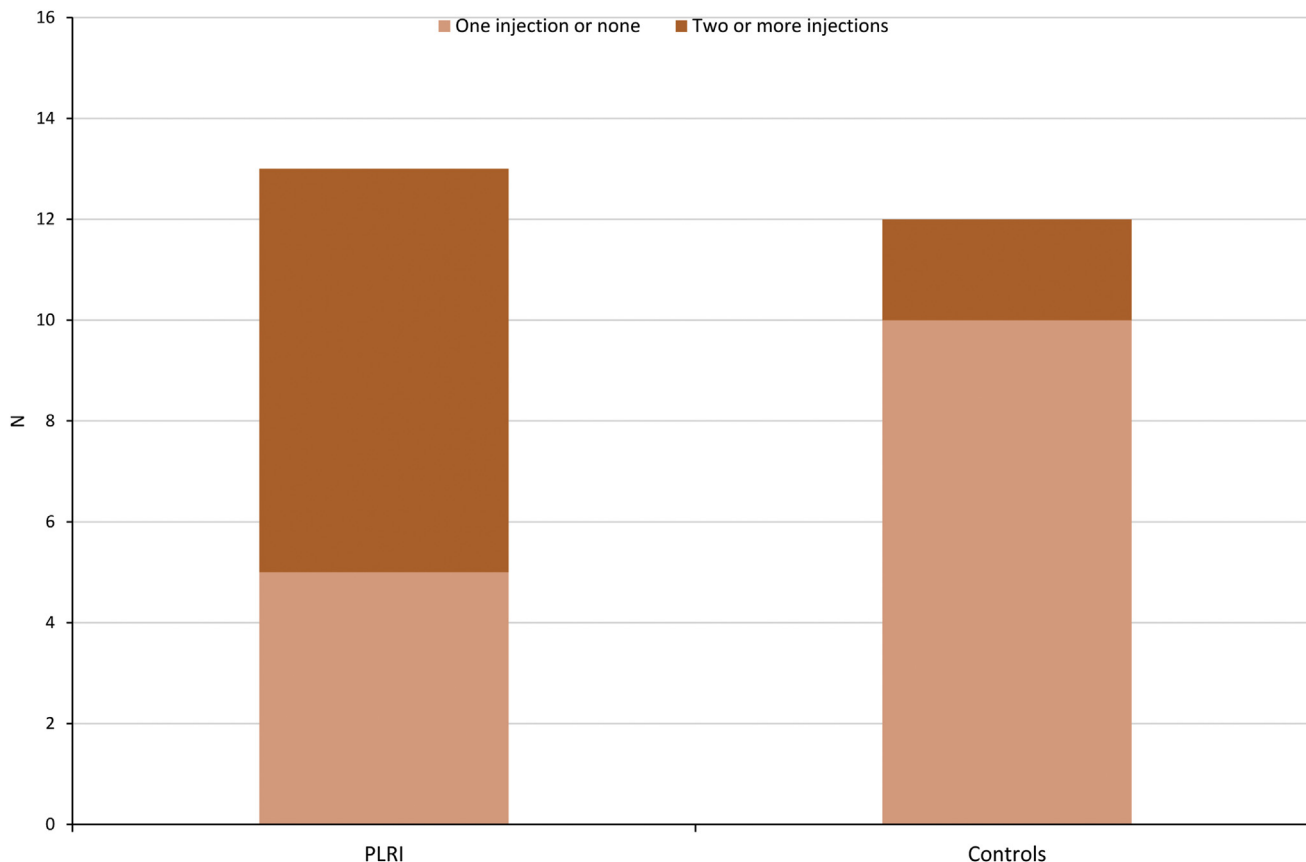
Based on our multivariable regression analyses, patients are 52% more likely to have PLRI with each additional month of symptoms (OR, 1.52; 95% CI, 1.04-2.23;  $P = .03$ ) (Table II). The model identified a marginal association between multiple corticosteroid injections and PLRI. Patients who had received more than 1 corticosteroid injection before presentation were 21 times more likely to have PLRI (OR, 20.83; 95% CI, 0.94-462.22;  $P = .05$ ).

In the univariate analyses, women were nearly 5 times more likely to have PLRI compared with men (OR, 4.7; 95% CI, 0.83-26.24;

**Table 1**  
Characteristics of the study population (N = 25).

Variable	All (n = 25)	Cases (n = 13)	Controls (n = 12)	P value
Age, y, mean (SD)	47.4 (9.0)	47.1 (10.3)	47.9 (7.9)	.42
Sex, female, n (%)	15 (60)	10 (77)	5 (42)	.07
BMI (kg/m <sup>2</sup> ), mean (SD)	30.3 (8.5)	30.7 (9.5)	29.9 (7.8)	.59
Dominant hand affected, n (%)	12 (48)	8 (62)	4 (33)	.16
Smoking history, n (%)	13 (52)	7 (54)	6 (50)	.85
History of diabetes, n (%)	5 (20)	1 (8)	4 (33)	.11
Months of symptoms, mean (SD)	13.0 (13.6)	19.6 (16.0)	5.8 (4.3)	.01
Two or more injections, n (%)	10 (40)	8 (62)	2 (17)	.02

BMI, body mass index.



**Figure 3** Multiple corticosteroid injections in posterolateral rotary instability (PLRI).

$P = .08$ ). This statistically marginal gender difference and other predictor variables including age, body mass index, hand dominance, smoking, and history of diabetes were eliminated in the final model.

Both groups showed a marked decrease in DASH and pain scores from preoperative survey to a postoperative survey. Preoperatively, the ECRB group scored on average a 56.7 DASH score and 6.0 pain score. Postoperatively, the ECRB group scored 27.5 on the DASH score ( $P = .07$ ) and an average of 3.0 pain score ( $P = .01$ ). At presentation, the PLRI group scored an average 46.4 DASH score and 6.8 pain score. After treatment, the PLRI cohort had an average 33.1 DASH score ( $P = .17$ ) and 3.5 pain score ( $P < .0001$ ) with restoration of stability based on clinical examination. The postoperative DASH and pain scores were not significantly different between the 2 groups ( $P > .05$ ).

**Discussion**

PLRI is a well-established sequela after simple elbow dislocation.<sup>2,16,20,21,26,28</sup> PLRI has also been described iatrogenically, as a complication after arthroscopic or open release of the ECRB when the dissection is carried too far posteriorly.<sup>19,25</sup> In contrast, few case series of atraumatic PLRI are described in the literature. A case series by Cohen and Kalainov<sup>12</sup> examined PLRI in association with ECRB. In this series, 3 women presented with atraumatic PLRI after an extended period of symptoms and a history of multiple corticosteroid injections. The patients’ instability was thought to be related to the ECRB and possibly exacerbated by repeated corticosteroid injections.<sup>8</sup> Our review of 13 cases with atraumatic PLRI mirrored the demographic findings of these authors. In our cases, patients with PLRI tended to be women, who presented to our

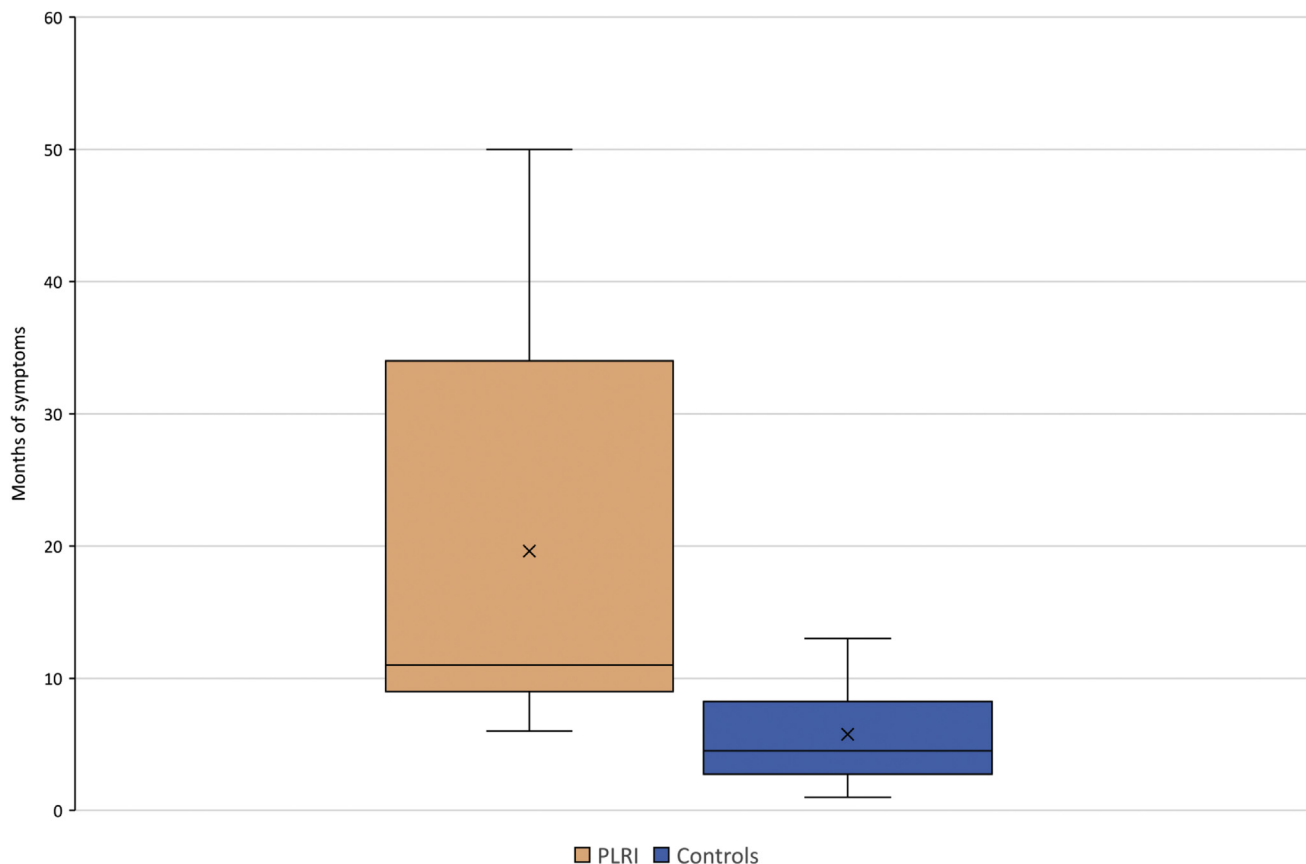


Figure 4 PLRI and duration of symptoms prior to presentation. PLRI, posterolateral rotary instability.

Table II  
Predictor variables of PLRI.

Predictors of PLRI	Unadjusted	P value	Adjusted*	P value
	Or (95% CI)		Or (95% CI)	
Months of symptoms	1.34 (1.02-1.74)	.03	1.52 (1.04-2.23)	.03
Two or more injections	8.0 (1.39-68.33)	.03	20.83 (0.94-462.22)	.05

CI, confidence interval; OR, odds ratio; PLRI, posterolateral rotary instability.  
\* Adjusted model includes months of symptoms and two or more injections.

subspecialty practice with more than a 12-month duration of symptoms. Many of the cases had received multiple cortisone injections before presentation.

Patients presenting without a clear history of dislocation but diagnosed with PLRI were discussed in a study by Sanchez-Sotelo et al<sup>24</sup> where results after LUCL reconstruction were compared with LUCL repair. In this retrospective review of PLRI, post-dislocation was the most common PLRI etiology. However, 8 of the 44 patients did not have a clear history of instability or dislocation. Other risk factors for atraumatic PLRI were not assessed in this subgroup of patients; however, patients did well with a ligament reconstruction.<sup>10,14,22,24</sup>

A short-term benefit of corticosteroid injections in the treatment of ECRB has been demonstrated.<sup>27</sup> Nonetheless, harmful consequences of multiple corticosteroid injections have been identified in the basic science and clinical literature. Initially, Unverferth and Olix<sup>29</sup> demonstrated that local steroid injections both mask the symptoms of tenosynovitis and decrease the tensile strength of the tendon. The latter predisposes the tendon to the possibility of a complete rupture.<sup>29</sup> At a cellular level,

glucocorticoid injections are associated with suppression of tenocyte cellular activity and a reduction in collagen production.<sup>32</sup> Intratendinous injections result in tissue death followed by a loss of collagen fiber strength.<sup>12</sup>

Moreover, steroid injections into a compromised ligament might impede healing and have detrimental effects on the tissue. In a cohort of 51 patients presenting with plantar fasciitis, whose plantar fascia ruptured, 44 ruptures were associated with corticosteroid injection.<sup>1</sup> More recently, a case series suggested a correlation between patellar tendon rupture and local steroid injections. All individuals in that study had a history of multiple corticosteroid injections and no systemic predisposing factors for tendon rupture.<sup>5</sup>

Causality is related to a temporal association, a dose-response relationship and biologic plausibility.<sup>9,11</sup> The clinical association between steroid injections observed in this study further support a potential causal relationship but cannot be proven. Cohen et al<sup>6</sup> proposed that steroid injections into the region of maximum point tenderness might cause degenerative changes in the extensor tendon origin and the lateral collateral ligament, which is adjacent

and deep to the tendon. Similar to Cohen et al, we think our data support that repeated injections in our cohort promoted both tendon and ultimately ligament degeneration leading to joint instability. Degenerative changes coupled with recurrent instability have been shown to be predictive of poor outcomes in these patients.<sup>7</sup>

We acknowledge that an increased number of injections might reflect that patients afflicted by more recalcitrant epicondylitis are more likely to have multiple injections. In that case, an association between injections and disease severity would serve as a confounding variable. Baker et al<sup>3</sup> described the most severe presentation of epicondylitis as a complete rupture and retraction of the capsule in addition to fraying of the ECRB tendon observed at the time of arthroscopy. In the study by Baker et al,<sup>3</sup> 28% of patients reached this stage of capsular injury. In our center, patients with atraumatic PLRI presented at an average of approximately 20 months after their initial symptoms and had failed nonoperative treatment elsewhere. In this interval of time, epicondylitis disease progression might be independent of steroid injection.

Women presented with PLRI more often than men, although this was not statistically significant. Ligament failure is multifactorial, but hormonal causes have been implicated in the knee. Lui et al<sup>17</sup> first demonstrated the effect of female steroid hormones, estrogen and progesterone, on the structure of the anterior cruciate ligament (ACL). Variations in estrogen concentration can alter blood supply to the ACL<sup>17</sup> and these fluctuations could alter the ACL stiffness in women.<sup>23</sup> Hormonal presence could be a factor in the elevated rates of ACL injuries in women.<sup>31</sup> Considering the data in our retrospective study, it is possible these same effects could be present in the elbow but has not yet been substantiated.

In a case-control study, the limitations of a retrospective analysis must be considered. We are unable to prove a causal relation of direct ligament damage with steroid injection. Injections were mostly performed by outside physicians and institutions so the indication, exact location, and dosage of corticosteroid are unknown. Second, we only compared operative cases of ECRB and atraumatic PLRI. These patients tend to have the most severe disease especially by the time of presentation or referral for consideration of surgical management. If atraumatic PLRI is truly a disease progression of ECRB, then our comparison involves the most severe cases of tennis elbow, which required surgical intervention. Finally, this study involves a relatively small sample size with less than 2-year follow-up. The goal of this study, though, was to determine the preoperative risk factors. Although ECRB is common, atraumatic PLRI represents a small subset in the differential diagnosis of lateral sided elbow pain and the vast majority of patients with tennis elbow at our center are treated nonoperatively.

## Conclusion

When compared with cases of tennis elbow, patients with atraumatic PLRI tend to have a longer interval of symptoms and have a history of multiple corticosteroid injections. This information is helpful for the clinician discerning these 2 diagnoses. Although the association of increased steroid injections and atraumatic PLRI remains unclear, there is some concern that multiple injections might weaken the lateral collateral ligament structures. Future prospective studies are necessary to develop any causal relationships.

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