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High incidence of posterior glenoid dysplasia of the shoulder in young baseball players

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Background: Rounding of the posterior glenoid rim is observed in young throwing athletes with internal shoulder impingement and is considered developmental dysplasia of the glenoid. The aim of our study was to determine the incidence rate of dysplastic changes of the glenoid within a group of 92 young baseball players.

Methods: The study group included 92 male baseball players, with a mean age of 14.63 years. Of these patients, 30 were diagnosed with Little Leaguer's shoulder and 62 with a painful baseball-throwing shoulder with no abnormal findings on x-ray. The posterior glenoid rim of the affected shoulder was compared with the contralateral nonpainful shoulder, with the 2 following outcomes measured on radiographs obtained using the modified Bernageau imaging method: the distance between the anterior and posterior glenoid rims and the presence or absence of dysplasia of the posterior glenoid rim.

Results: The mean distance between the anterior and posterior glenoid rims was significantly shorter in the painful shoulders (mean, 26 mm) than in the nonpainful shoulders (mean, 29 mm; $P < .0001$). Dysplasia of the posterior glenoid rim was identified in 89 painful shoulders (96.7%), with 9 cases (9.7%) identified on the unaffected contralateral side ($P < .001$). The presence of dysplasia was not correlated with the age at which baseball playing began.

Conclusion: The incidence of dysplasia of the posterior glenoid rim is high (96.7%) among young baseball players with a painful shoulder. The identified dysplasia may be related to impaired development of the inferior peripheral secondary glenoid ossification center due to repetitive throwing.

Level of evidence: Level IV; Case Series; Epidemiology Study

Keywords: Level IV; Modified Bernageau method; young athletes with painful throwing; glenoid dysplasia; baseball; posterior tightness; secondary glenoid ossification centers

The shoulder joint has the largest range of motion of any joint in the body. This range of motion is afforded by the anatomic structure of the shoulder, with a small radius of curvature of the cartilage of the humeral head compared with that of the scapular glenoid, which renders the shoulder inherently unstable.[21] Repeated throwing produces various stresses on the glenoid cavity, resulting in dysplastic changes

Approval of the study was obtained from the Internal Review Board of Hamamatsu City Rehabilitation Hospital (No. 16-63) and the relevant institutional Medical Research Ethics Review Committee.

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that can increase the instability of the shoulder joint.[20] Specifically, the overhead throwing motion applies stress to the anterior and posterior rims of the glenoid cavity,[12,14,16] leading to a rounding (dysplasia) of the rim. This activity-dependent remodeling of the glenoid rim has been associated with internal shoulder impingement syndrome and immature development of the glenoid cavity.[7] Moreover, calcific changes of the posterior-inferior glenoid, known as Bennett lesions, are likely to result from repeated traction on the posterior capsule and the posterior inferior glenohumeral ligament with excessive overhead throwing.[3,7] This study was aimed at determining the incidence rate of dysplasia of the posterior glenoid rim in young baseball players, aged 19 years or younger, presenting with a painful baseball shoulder. We evaluated differences in the width of the articular surface of the glenoid in these patients by use of the modified Bernageau method for shoulder radiographic imaging.[17,18]

Materials and methods

We conducted a retrospective analysis of 143 patients who were evaluated at our hospital for shoulder pain related to throwing between September 2014 and December 2017. Among these patients, 92 male baseball pitchers, aged 9-19 years (mean, 14.63 years), with an average height of 166.0 cm (range, 136-181 cm), were enrolled in our study and evaluated by the modified Bernageau radiographic imaging method. Patients with severe shoulder pain, in whom the standardized imaging protocol could not be performed, and those who had undergone radiographic assessment at another hospital were excluded. To achieve a study power of 80% to detect a relative risk of shoulder dysplasia at a significance level of 5%, a sample size of 90 participants was needed.

Of the 92 patients enrolled, 32 were diagnosed with Little Leaguer's shoulder and 60 with a painful baseball-throwing shoulder with no abnormal findings on x-ray. A painful baseball-throwing shoulder with no abnormal findings on x-ray was clinically described as pain in the shoulder joint that is related to overhead throwing but with no abnormal findings on radiographic imaging. On average, participants in our study group had started playing baseball at 8.2 years of age (range, 3-13 years), with 87 of our patients (94.6%) having begun baseball before the age of 10 years. The average duration of baseball experience at the time of assessment was 6.4 years (range, 1-13 years).

We used the modified Bernageau method of shoulder imaging for radiographic assessment,[17,18] which provides an improved method to evaluate the shape of the glenoid cavity in patients with traumatic anterior shoulder instability.[1,4,8] Specifically, patients were placed in the side-lying position on the x-ray table, with the shoulder in abduction and the palm of the hand placed behind the head, with the scapula oriented at 95° to the cassette (Fig. 1, *a*) and the x-ray tube at an angle of incidence of 15°-20° caudally (Fig. 1, *b*).[17,18]

The morphologic measurements were performed by an orthopedic surgeon with more than 20 years of experience performing shoulder surgery and by a radiologist with 19 years of experience. The agreement in measurement between the orthopedic surgeon and radiologist was high, at 96.74% ($\kappa = 0.56$, $P > .05$). As the radiologist was blinded to participants' information, we used the data analyzed by the radiologist in our analysis to minimize observer bias.

Posterior glenoid dysplasia was defined by the presence of a mild rounding of the posterior rim (Fig. 2, *a*), with a normal posterior rim presenting with a sharp triangular shape, similar to the anterior rim (Fig. 2, *b*). The distance between the anterior and posterior glenoid rims was measured to obtain the width of the articular surface of the glenoid. In the presence of posterior glenoid dysplasia, the width of the articular surface was measured only over its flat section, from the anterior rim to the start of the rounding, excluding the rounded regions (Fig. 3).

Posterior shoulder tightness, which is a known risk factor for overhead throwing injuries of the shoulder, was evaluated using the modified supine assessment of posterior shoulder tightness test.[7,13] For this test, the patient lies in a supine position with the shoulder placed in adduction and internal rotation. The test is positive if the position of the olecranon, with the shoulder in this position, is not above the nose (Fig. 4).

Figure 1 (**a**) The modified Bernageau imaging method is shown, with the patient placed in a side-lying position, with the affected shoulder in abduction and the palm of the hand placed behind the head, with the scapula oriented at 95° to the cassette. (**b**) The cassette is placed at a distance of 100 cm from the x-ray tube, with the tube placed at an angle of incidence of 15°-20° caudally. The *arrow* indicates the direction of the x-ray beam.

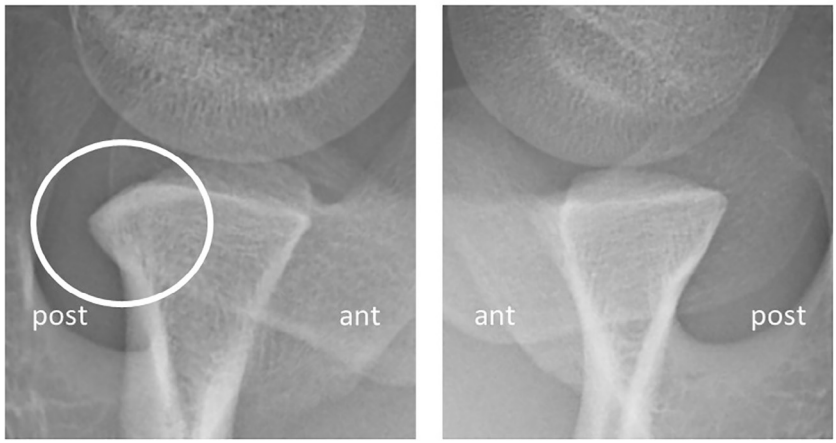

Figure 2 Representative images obtained using the modified Bernageau method in a patient with (**a**) and without (**b**) posterior glenoid dysplasia (*circle*). *post*, posterior; *ant*, anterior.

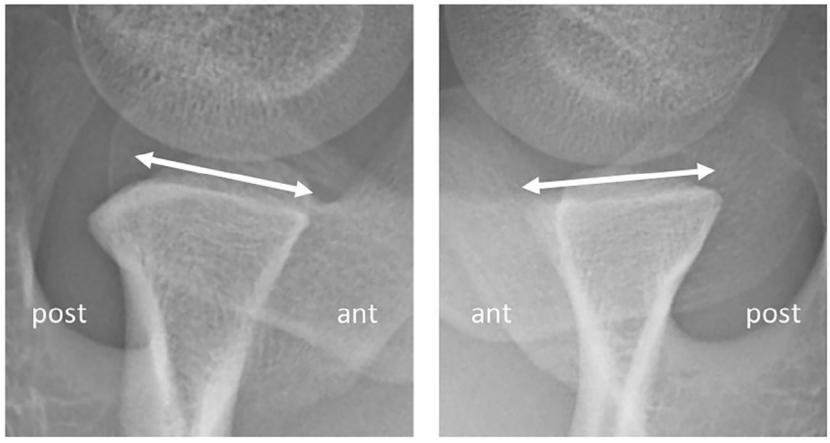

Figure 3 Measurement of width of articular surface. (**a**) In the presence of posterior glenoid dysplasia, the width of the articular surface (*arrow*) is measured only as the flat section from the anterior rim of the glenoid cavity to the start of the rounding, excluding rounded regions. The start of the rounding is defined as the boundary between the flat section and the posterior rounding shape at the glenoid surface. (**b**) The distance between the anterior and posterior glenoid rims (*arrow*) is measured to determine the width of the articular surface. *post*, posterior; *ant*, anterior.

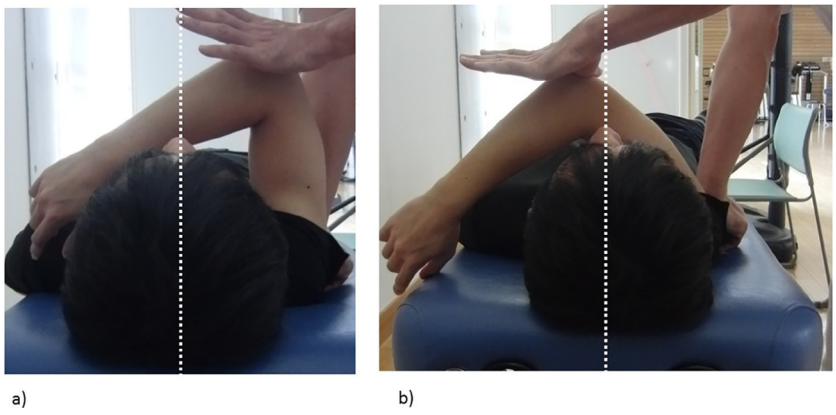

Figure 4 Modified supine assessment of posterior shoulder tightness test. (**a**) A positive result is indicated by an inability to raise the arm sufficiently for the olecranon of the affected arm to pass the height of the nose. (**b**) A negative result is indicated by the ability to raise the arm sufficiently for the olecranon to pass the height of the nose.

Measured outcomes were compared with the contralateral nonpainful shoulder using a paired *t* test to evaluate between-side differences in the width of the glenoid articular surface and the Fisher exact test for morphologic changes and tightness. Logistic regression analysis was performed to identify the risk factors associated with the development of posterior glenoid dysplasia according to the age at which baseball was started and the years of experience. In the multivariate logistic analysis, age (continuous variable) and type of shoulder pain (Little Leaguer's or painful baseball-throwing shoulder, binomial) were classified as independent variables, and odds ratios (ORs), with 95% confidence intervals (CIs), were calculated for each identified independent risk factor. The significance level was set at 5%. All images were obtained using a NEOVISTA I-PACS SX system (Konica Minolta, Tokyo, Japan), with an NEC MultiSync MD212MC display (resolution of 1200 × 1600 pixels; NEC Display Solutions, Itasca, IL, USA) used for measurements.

Results

All the players included in our study group were year-round baseball players. Posterior glenoid dysplasia of the throwing shoulder was identified in 89 of 92 shoulders (96.7%), with an incidence rate of 9.7% (9 cases) in the contralateral nonthrowing shoulder ($P < .001$). The average width of the glenoid articular surface in the throwing shoulder was 26 mm (95% CI, 20-33 mm) compared with 29 mm (95% CI, 18-35 mm) in the nonthrowing shoulder ($P < .001$). Posterior shoulder tightness was identified in 87 of the 92 painful affected shoulders (94.6%) compared with an incidence rate of 31.5% (29 of 92 cases) for nonpainful contralateral affected shoulders ($P < .001$, Table I). Among the 92 painful affected shoulders, 91.3% (84 of 92 shoulders) had both glenoid dysplasia and posterior tightness. On both univariate and multivariate regression analyses, controlling for age and type of shoulder pain, the risk of posterior glenoid dysplasia increased as a function of the years of baseball experience but without reaching a level of significance (crude OR = 1.36, $P = .22$; adjusted OR = 1.47, $P = .14$). Similarly, starting baseball at a younger age was associated with a nonsignificant increased risk of posterior glenoid dysplasia (crude OR = 1.42, $P = .34$; adjusted OR = 1.42, $P = .33$). The risk of posterior glenoid dysplasia did not differ between patients with Little Leaguer's shoulder and those with a painful baseball-throwing shoulder with no abnormal findings on x-ray (crude OR = 0.97, $P = .98$; adjusted OR = 2.65, $P = .48$) (Table II).

Discussion

Our study confirmed a high incidence (96.7%) of posterior glenoid dysplasia among young baseball players, aged 19 years or younger, presenting with painful baseball-throwing and Little Leaguer's shoulder pain. As posterior glenoid dysplasia is usually considered a congenital condition that usually occurs bilaterally,[19] we consider the high incidence of a unilateral presentation in young baseball players to be acquired, owing to the following mechanism: The scapula is almost completely ossified at birth, with the subcoracoid secondary ossification center (SOC) appearing at approximately 8-10 years of age. The SOC ultimately forms the superior one-third of the glenoid articular surface (Fig. 5, *a*). The horseshoe-shaped, lower glenoid SOC, which will form the rim, emerges

Table I Comparison of throwing shoulder and nonpainful contralateral side

	Orthopedic surgeon		Radiologist		
	Throwing side	Nonthrowing side	Throwing side	Nonthrowing side	*P* value
Glenoid dysplasia, n					
Yes	88	7	89	9	.001*
No	4	85	3	83	
Mean glenoid length (95% CI), mm	26 (19-34)	29 (18-35)	26 (20-33)	29 (18-35)	.001*
Posterior tightness, n					
Yes	87	29	—	—	.001*
No	5	63	—	—	

CI, confidence interval.
* Statistically significant.

Table II Univariate and multivariate logistic regression analysis of risk estimation

	Crude OR (95% CI)	Crude OR *P* value	Adjusted OR (95% CI)	Adjusted OR *P* value
Years of experience	1.36 (0.84-2.24)	.22	1.47 (0.88-2.47)	.14
Starting age	1.42 (0.70-2.88)	.34	1.42 (0.70-2.90)	.33
Disease	0.97 (0.84-11.10)	.98	2.65 (0.29-9.36)	.48

OR, odds ratio; *CI*, confidence interval.

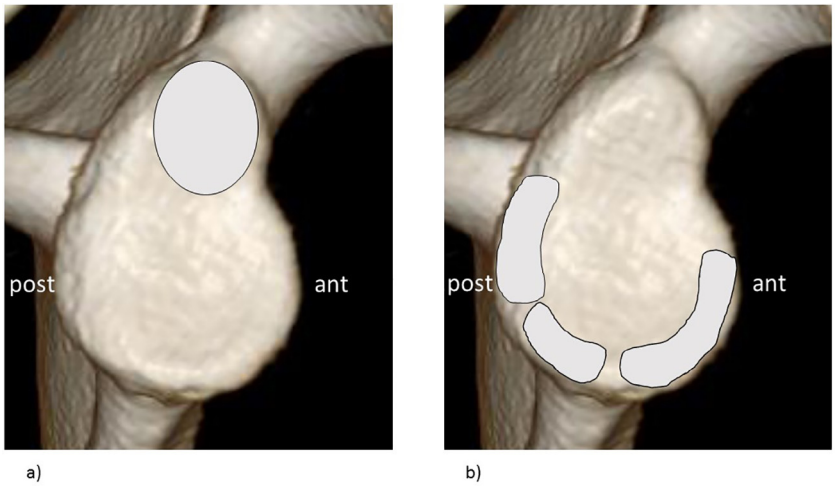

Figure 5 Secondary ossification centers of glenoid (right shoulder). (**a**) Subcoracoid secondary ossification center. (**b**) Horseshoe-shaped, lower glenoid ossification center. *post*, posterior; *ant*, anterior.

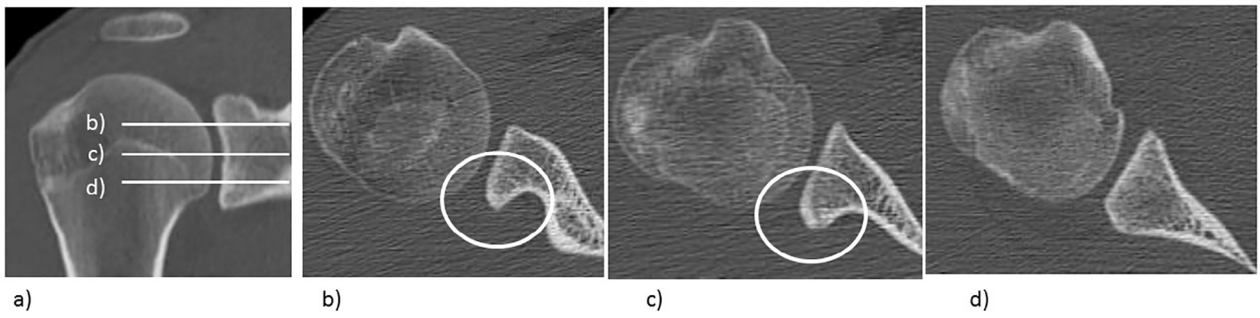

Figure 6 Coronal view and cross-sectional views of shoulder joint showing the posterior glenoid protruding like a "balcony" (*circles*) (**a**), the superior glenoid (**b**), the midglenoid (**c**), and the inferior glenoid (**d**).

in the inferior two-thirds of the glenoid at approximately 10-14 years of age and is completely ossified by 17-18 years of age (Fig. 5, *b*).[11] In our study, 95.6% of athletes began throwing when they were younger than 10 years, which is before the appearance of the SOC in the inferior two-thirds of the glenoid. Although it is possible that repetitive overhead throwing at a young age causes damage to the ossification centers, which could have a subsequent effect on bone maturation, we did not identify a significant association between the age at which a patient started playing baseball and the incidence of posterior glenoid dysplasia. Therefore, the mechanism of glenoid rim dysplasia in young baseball pitchers remains to be fully elucidated.

Of note, 94.5% of the players with a painful shoulder in our study group were identified as having tightness of the posterior shoulder capsule. The repetitive stress on the posterior shoulder during the deceleration phase of throwing results in muscle fatigue, involving the infraspinatus and posterior deltoid muscles, which ultimately can result in tightness of the posterior soft-tissue structures of the shoulder.[10] As the positional relationship between the humeral head and glenoid surface varies depending on the status of the tightness of the glenoid capsule, posterior tightness might lead to a loss of alignment of the humeral head on the glenoid cavity during overhead throwing, especially when the shoulder is in a position of abduction and external rotation during the late cocking phase.[2,5] On the basis of this reasoning, we propose 2 potential mechanisms by which posterior shoulder tightness could lead to posterior glenoid dysplasia: First, posterior shoulder tightness could induce a superior-to-posterior displacement of the humeral head on the glenoid cavity,[5] causing an impingement between the humeral head and the articular surface of the rotator cuff, which increases the force applied to the posterior-superior glenoid by the humeral head.[2,3,5] Second, the anterior glenoid is strongly supported by the triangular linear cortex, whereas the posterior rim is a balcony-like structure without a strong supporting structure[15]; the computed tomography images in Figure 6 show this balcony-like structure. Repetitive stress on the posterior glenoid rim may lead, over time, to posterior dysplasia. Our hypothesis is supported by previous reports of a disordered development of the posterior SOC on the inferior two-thirds of the glenoid that might possibly be related to a tightness of the posterior shoulder capsule during the immature stage of ossification of the glenoid.[6,15] A previously reported cadaveric study concluded that posterior tightness of the shoulder capsule restricts

the movement of the humeral head in the late cocking phase, forcing it in a posterosuperior direction.[5]

The limitations of this study were as follows: First, we only included young baseball players with symptomatic shoulders, and therefore, we do not know whether the incidence of posterior glenoid dysplasia is equally high in nonsymptomatic shoulders. However, we demonstrated that the incidence rate of glenoid dysplasia was higher in symptomatic shoulders compared with nonpainful contralateral shoulders. Second, we did not evaluate soft-tissue changes and, therefore, cannot determine whether compensatory growth of the glenoid labrum is present in the posterior glenoid defect, which has been previously reported.[9] Last, as we used a cross-sectional design, a causative effect of repetitive overhead throwing on the incidence of posterior rim dysplasia could not be evaluated. However, because we did compare our findings with the contralateral side, we are confident that the dysplastic changes were contributed by developmental effects of repetitive overhead throwing on the ossification of the glenoid. To confirm this point, we look forward to furthering our research.

Conclusion

In this study, we identified a high prevalence of posterior glenoid dysplasia using the modified Bernageau radiographic imaging method in young athletes presenting with painful baseball shoulders. These dysplastic changes appear to be associated with repetitive overhead throwing, and therefore, future research is needed to better understand the underlying mechanisms and possible strategies to lower the risk of posterior glenoid dysplasia in baseball pitchers.

Disclaimer

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