Bipolar Bone Loss in Patients With Anterior Shoulder Dislocation: A Comparison of Adolescents Versus Adult Patients

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Purpose: To compare bipolar bone loss by evaluating the degree of glenoid bone loss, Hill-Sachs lesion size, and glenoid track in adolescents and adults with shoulder dislocations. **Methods:** We performed a retrospective review between 2012 and 2016 of surgical and nonsurgical patients with a history of anterior shoulder dislocations (primary or recurrent) who underwent magnetic resonance imaging of the affected shoulder. The exclusion criteria included multidirectional instability, prior surgery, and posterior dislocation. Patients were grouped into 2 groups: adolescents (aged 10-19 years) and adults (aged ≥20 years). The groups were compared regarding measures of glenoid bone loss (best-fit circle technique) and Hill-Sachs lesion size (medial margin of rotator cuff footprint to medial margin of Hill-Sachs lesion). If the medial margin of a Hill-Sachs lesion was within the glenoid track, it was defined as on track; if it was more medial than the glenoid track, it was defined as off track. **Results:** We identified 45 adolescents (mean age, 16.1 years) and 30 adults (mean age, 28.9 years) with anterior shoulder dislocations. There was no significant difference in percentage of bone loss between adolescents (mean, 8.4%) and adults (mean, 9.9%; $P = .23$). There was no significant difference in Hill-Sachs lesion size between adolescents (mean, 12.7 mm) and adults (mean, 9.9 mm; $P = .12$). There were 12 patients with off-track lesions. Off-track lesions were present in 11 of 45 adolescents (24.4%) and 1 of 30 adults (3.3%). Adolescents had an increased risk of having an off-track lesion (odds ratio, 9.38; 95% confidence interval, 1.14-77.1). A subgroup analysis identified multiple dislocations as an independent risk factor for an off-track lesion (odds ratio, 4.15; 95% confidence interval, 0.85-20.23). **Conclusions:** This study shows that adolescence and a history of multiple dislocations are independent risk factors for a greater likelihood of glenoid off-track lesions. The findings support the use of bipolar assessment of shoulder dislocators, especially in adolescents and multiple dislocators. **Level of Evidence:** Level III, retrospective comparative study.

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Adolescence has been identified as the most significant risk factor for recurrent anterior shoulder dislocations despite comprehensive nonoperative treatment.[1,2] Similar to the situation in adults, shoulder dislocations account for 90% of shoulder instability cases and usually occur after a fall during a sporting activity.[3] In adolescent patients, however, there is a 75% to 80% rate of recurrent dislocations with nonoperative treatment.[4-6]

Outcomes of arthroscopic treatment of shoulder instability in the adolescent population have shown a much higher rate of failure than in the adult population.[7,8] Shymon et al.[8] reported a failure rate of 21% in the adolescent population within 2 years and a 5-year survival rate of only 49% after shoulder stabilization. This is compared with a failure rate of 8% to 11% in adults after 11 years.[7] The reasons for this are not completely known. It may be because of the engagement of these athletes in high-demand collision sports that stress the repair unlike their adult counterparts.

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Other risk factors for the increased rate of recurrent instability in this population may include the amount of glenoid bone loss after initial dislocation. A degree of glenoid bone loss occurs in up to 40% of traumatic anterior shoulder dislocations.[9] Another risk factor may be the degree of humeral head injury. The incidence of a humeral head injury (Hill-Sachs lesion) in shoulder instability ranges from 38% to 88%.[10,11] In contrast, several studies did not find that larger Hill-Sachs lesion size was a potential cause of recurrence.[10-13] These studies, however, did not assess the relation of the Hill-Sachs lesion with glenoid bone loss. More recently, Yamamoto et al.[14] identified a model to account for both glenoid and humeral head (bipolar) bone loss: the glenoid track. In this concept, 2 terms were defined to simultaneously characterize the relation of glenoid bone loss and its relation to Hill-Sachs lesions: on track and off track.[14]

Metzger et al.[15] modified the glenoid track model to allow for clinical application and found, through a regression analysis, that younger age and multiple dislocations were predictive of off-track lesions. To date, however, there has not been a direct comparison of the glenoid track concept between adolescent and adult patients with shoulder instability.

The purpose of this study was to compare bipolar bone loss by evaluating the degree of glenoid bone loss, Hill-Sachs lesion size, and glenoid track lesions in adolescents and adults with shoulder dislocations. We hypothesized that adolescent patients would have similar glenoid bone loss but greater likelihood of off-track lesions because of the relation with the Hill-Sachs lesion.

Methods

After obtaining institutional review board approval (No. 16-19,515), we performed a retrospective review of surgical and nonsurgical patients with a history of primary and recurrent anterior shoulder dislocations over a 4-year period (2012-2016) who underwent magnetic resonance imaging (MRI) with arthrograms of the affected shoulder. Dislocation was defined by an episode requiring a reduction. The exclusion criteria included prior surgery on the affected shoulder, multidirectional instability, and posterior dislocation. Demographic data, sports played, and number of dislocations were collected. The patients were grouped into 2 groups: adolescents (aged 10-19 years) and adults (aged $\geq$20 years). We used 20 years of age as a cutoff on the basis of prior studies that have established age, in particular less than 20 years, as a risk factor for recurrent instability.[2,16-19]

The groups were compared regarding bipolar bone loss by measuring glenoid bone loss and Hill-Sachs injury size as determined on MRI. All patients were evaluated for any glenoid bone loss and Hill-Sachs defects. On the basis of the extent of the bipolar lesion, the glenoid track was defined as outside and engaging the glenoid on the humeral head (off track) or as inside and non-engaging (on track).

MRI Assessment

As described by Yamamoto et al.,[14] the size of the glenoid track was determined by the amount of glenoid bone loss. When there is no glenoid defect, the width of the glenoid track is 84% of the glenoid width. Yamamoto et al. showed in a cadaveric study that this is the contact point of the glenoid with the arm in 60° of abduction to the medial margin of the rotator cuff footprint on the humerus.

When there is a bony defect at the anterior rim of the glenoid, the defect width should be subtracted from the value representing 84% of the length to obtain the true width of the glenoid track.[14] If the medial margin of the Hill-Sachs lesion was more medial than the glenoid track, it was defined as off track and more likely to engage and have a higher risk of recurrent instability. Conversely, if the medial margin of the Hill-Sachs lesions was within the glenoid track, it was defined as on track and less likely to engage[14] (Fig 1).

Our study used the modified glenoid track method as defined by Metzger et al.[15] on the basis of clinical magnetic resonance (MR) images performed by a single evaluator. By use of the sagittal-oblique image, the bare spot was identified and the glenoid width was measured using this as the central reference point as described by Huysmans et al.[20,21] To determine the expected glenoid width, a best-fit circle was placed on the inferior third of the glenoid centered on the bare spot and the diameter of the circle was measured to calculate the expected width prior to bone loss (Fig 2).[20] The glenoid bone loss percentage and glenoid track were both determined from these measurements. The glenoid track was calculated as 84% of the actual glenoid width. In the setting of bone loss, the amount of bone loss was subtracted from 84% of the actual glenoid width to calculate the glenoid track.[14]

The size of the Hill-Sachs lesion was determined by the method reported by Saito et al.[22] It was calculated based on the distance from the medial margin of the rotator cuff footprint to the medial margin of the Hill-Sachs lesions, in millimeters, by use of the largest distance on a coronal image (Fig 2). If this value was greater than the previously determined glenoid track (84% of actual glenoid width minus any bone loss), then the humeral lesion was determined to be off track. If the value was less than the glenoid track (84% of actual glenoid width minus any bone loss), then the humeral lesion was determined to be on track. The described method of combined glenoid bone loss, Hill-Sachs assessment, and glenoid tracking has been shown to have good intraobserver and interobserver reliability and high correlation (>0.89).[23]