Original Research

Unperceived First-Time Anterior Shoulder Subluxation

The Role of MRI in Detection and Characterization of Pathoanatomy

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Background: First-time anterior shoulder subluxation is typically diagnosed based on subjective instability or positive physical examination findings. However, some patients present without any perceived instability yet demonstrate definitive magnetic resonance imaging (MRI) findings such as Bankart or Hill-Sachs (HS) lesions.

Purpose: To study the pathoanatomy of unrecognized subluxation with first-time dislocation and typical subluxation.

Study Design: Cross-sectional study; Level of evidence, 3.

Methods: This study investigated patients diagnosed with first-time shoulder instability who underwent MRI at an army hospital between September 2023 and March 2025. Only patients with no previous history of dislocation, subluxation, or surgery were included. Patients were categorized as having dislocation, typical subluxation, or unrecognized subluxation based on clinical history and examination. Unrecognized subluxation was defined as the absence of perceived instability and negative physical examination findings despite MRI-confirmed Bankart-equivalent lesions. Radiologic assessments included glenoid bone loss and HS lesion characteristics (interval, width, depth, and distance to dislocation [DTD]). The time interval from trauma to MRI acquisition was recorded for all patients, as it may reflect the time to clinical recognition.

Results: Of the 75 male soldiers with first-time shoulder instability and MRI-confirmed Bankart lesions, 18 had dislocations, 30 had typical subluxations, and 27 had unrecognized subluxations. Glenoid bone loss was minimal in all groups (mean, $<5\%$) and did not differ significantly among the 3 groups ($P = .806$). The dislocation group had significantly greater HS interval, width, depth, and lower DTD than the other groups (all $P < .001$), while no significant differences were found between typical and unrecognized subluxation. MRI was obtained significantly later in the unrecognized subluxation group (median, 35 days), followed by the typical subluxation (19.5 days) and dislocation groups (1 day) ($P < .001$).

Conclusion: Anterior shoulder instability is not always recognized by patients, and initial physical examination may be limited in the acute setting. MRI findings of unrecognized first-time subluxations were similar to those of typical subluxations and showed less severe HS morphology than in dislocations. Clinicians should maintain a high index of suspicion in young patients presenting with traumatic shoulder pain, even in the absence of perceived instability.

Keywords: Bankart lesion; first-time dislocation; first-time subluxation; shoulder instability; unrecognized subluxation

Anterior shoulder instability is the most common type of shoulder instability.[11] It typically presents as either a dislocation or subluxation after trauma. In recent decades, the distinction between these 2 types has relied on whether the shoulder required manual reduction by medical staff or spontaneously returned to its position.[6,10,12,13] Although shoulder subluxation is known to occur more frequently than dislocation, both in primary and recurrent

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episodes,[1,11] first-time subluxation has received less attention than first-time dislocation.[12] This may be attributed to the difficulty of the exact determination of the occurrence of a subluxation event, as they can be subtle and lack the obvious evidence provided by manual reduction.[4,12,14] Furthermore, some subluxation cases may present primarily with shoulder pain after trauma rather than subjective instability, making them easy to overlook unless clinicians maintain a high degree of suspicion.[4,14]

In our experience at an army hospital, we encountered several patients who presented with shoulder pain after trauma but had no subjective perception of instability, even after thorough history-taking. Interestingly, despite the absence of any perceived instability, these patients exhibited pathologic findings associated with subluxation, such as Bankart lesions and Hill-Sachs (HS) lesions, on magnetic resonance imaging (MRI). For those patients, physical examination, such as anterior apprehension or relocation tests, was often unreliable in the acute phase because muscle guarding and pain often obscured the findings.[4,15] These observations raised the possibility that a subgroup of patients may experience a first-time subluxation without recognizing an instability event, which may lead to delayed diagnosis and inappropriate treatment.

To our knowledge, no previous study has specifically characterized the MRI findings in these patients who experience a subluxation event without perceiving instability. These patients were defined as having unrecognized first-time subluxation. This study aimed to compare their MRI findings with those of patients presenting with first-time dislocation and perceived subluxation. The hypothesis was that the pathoanatomic features on MRI would differ significantly among these groups.

METHODS

Our institutional review board waived the requirement for informed consent for this study. This retrospective study included patients who underwent shoulder MRI at an army hospital between September 2023 and March 2025 (Figure 1). The inclusion criteria were as follows: (1) a definite traumatic event; (2) the presence of a Bankart lesion or a Bankart-equivalent lesion, with or without an HS lesion on MRI; and (3) no history of previous shoulder surgery. Bankart-equivalent lesions were defined as glenolabral articular disruption, anterior labroligamentous periosteal sleeve avulsion, humeral avulsion of the glenohumeral ligament (HAGL), or bony Bankart lesions. The exclusion criteria included a history of previous shoulder instability or the absence of documented medical records regarding the traumatic event. Since the initial inclusion was based on MRI findings of Bankart or Bankart-equivalent lesions, patients who reported subjective instability but lacked these MRI findings were considered outside the scope of this study.

Patients were allocated to the dislocation group based on the classic definition requiring manual reduction by medical personnel.[12,14] For the remaining patients, classification was based on history taking and physical examination performed by fellowship-trained orthopaedic surgeons. At the start of the study period, 3 had completed fellowship training 1 year earlier, 2 had completed it 2 years earlier, and 5 had completed it $\geq$4 years prior. These surgeons had received fellowship training in the following subspecialties: shoulder (W.-S.D.; n = 1), sports medicine and knee (n = 4), upper extremity/wrist (n = 1), foot and ankle (n = 1), trauma (n = 1), spine (n = 1), and general arthroscopy (n = 1). Any patient-reported descriptions suggestive of instability—such as a sensation of the shoulder going in and out, clunking, or feeling like it had dislocated—as well as any positive physical examination findings indicating instability, such as a positive apprehension or relocation test, were classified into the perceived subluxation group. The positive apprehension test was defined as fear of imminent instability when placing the arm in abduction and external rotation, distinct from mere pain. When neither the patient nor the physician identified any clues of an instability event at the initial visit and before MRI acquisition, those patients were classified into the unrecognized subluxation group. These patients typically presented with severe pain, inability to raise the arm, or a tearing sensation during the traumatic event, which led clinicians to order an MRI for further evaluation despite the absence of perceived instability.

The type of activity at the time of injury and the laterality of the affected shoulder were recorded. The interval between the traumatic event and the MRI was also investigated, as this interval may partially reflect the severity and recognition of the injury within the military medical system in this country. Two main factors typically influence the timing of MRI acquisition: (1) clinical prioritization based on the clinician's assessment of injury severity, and (2) the timing of hospital presentation, which is influenced by the judgment of the patient's commanding officer.

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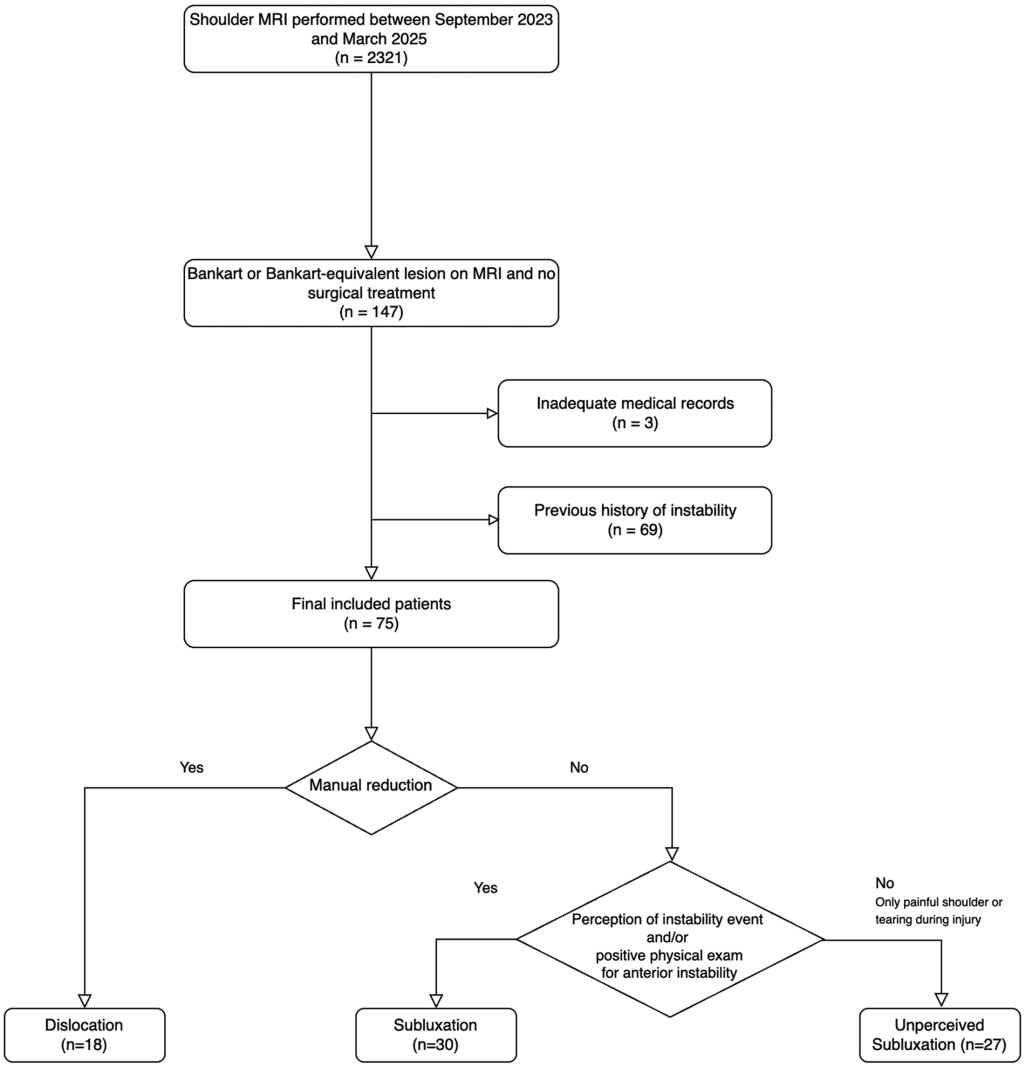

Figure 1. STROBE diagram of study enrollment and allocation. MRI, magnetic resonance imaging; STROBE, Strengthening the Reporting of Observational Studies in Epidemiology.

Radiologic Assessments

MR images were acquired using a 1.5-T scanner (GE Medical Systems). Three independent radiologists assessed the presence of Bankart and Bankart-equivalent lesions. All images and reports were subsequently reviewed by a shoulder fellowship–trained orthopaedic surgeon (W.-S.D.) who has published on the reliability of imaging assessments related to shoulder instability.

For comparison of each group's pathoanatomy, glenoid bone loss and HS lesions were quantitatively measured, and the presence of off-track lesions was evaluated. Glenoid bone loss was assessed using the Sugaya method, which is based on linear measurement of the injured side using a best-fit circle representing the estimated glenoid diameter.[5,17] A best-fit circle was placed along the inferior glenoid rim in the en face view on a parasagittal slice. Because this technique may lead to overestimation or measurement error, the number of patients with glenoid bone loss >5% was also analyzed.[2]

Regarding the HS lesion, its presence was defined as a bony bruise or indentation of the posterolateral humeral head.[12] The lesion was further assessed in terms of width, depth, and interval (Figure 2). The HS interval was measured on the axial image demonstrating the lesion's greatest medial extent.[5] The width and depth were measured on the respective axial images that demonstrated the maximal width and depth of the HS lesion. The width was defined as the distance between the most medial and lateral edges of the lesion.[16] The depth is measured from the deepest point of the lesion perpendicular to a line connecting the most medial and the most lateral edges of the lesion.[16]

To determine whether the lesion was an off-track lesion, the glenoid track and the distance to dislocation (DTD) were calculated.[8] The glenoid track was calculated using the following formula: glenoid track = (0.83 $\times$ glenoid diameter)

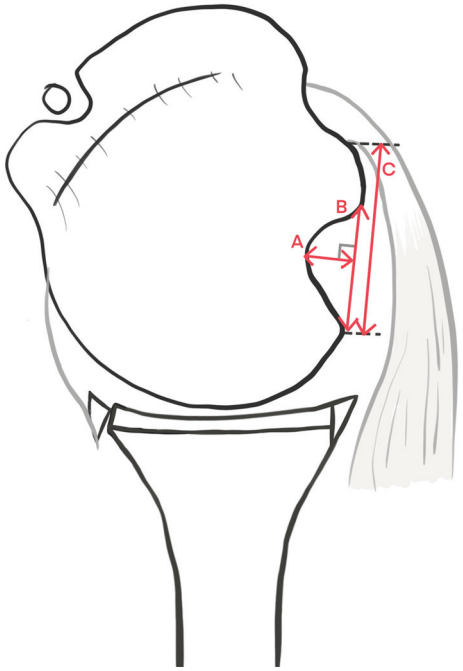

Figure 2. Measurement of Hill-Sachs lesion morphology. A, depth, measured from the deepest point of the lesion to a line connecting its medial and lateral edges; B, width, measured between the medial and lateral margins of the lesion; C, interval, measured from the infraspinatus footprint to the medial margin of the lesion at its most medial extent.

− anterior glenoid bone loss width. The DTD was then calculated as DTD = glenoid track − HS interval. If the DTD was <0, the lesion was classified as an off-track lesion.

Statistical Analysis

For comparisons among the 3 groups, continuous variables that met the assumptions for parametric testing were analyzed using 1-way analysis of variance, followed by the Tukey Honestly Significant Difference test for post hoc comparisons (age, HS measurements, and glenoid defect size). When the normality assumption was not met, the Kruskal-Wallis test was used, followed by the Dunn test with Bonferroni correction for post hoc analysis (duration event to MRI). For categorical variables, the chi-square test (laterality, operation rate, frequency of glenoid defect >5%) or the Fisher–Freeman–Halton (presence of an HS lesion) test was applied. All statistical analyses were performed using R software (Version 4.5.0; R Foundation for Statistical Computing).

RESULTS

A total of 75 patients with 75 affected shoulders were included. Among them, 27 patients were classified as having unrecognized subluxation, defined as the absence of subjective perception of instability even after clinical evaluation by a physician (Table 1). Eighteen patients experienced dislocation that required manual reduction by medical personnel, and 30 experienced subluxation that spontaneously reduced. All patients were Asian male soldiers. The mean age was 21.5 ± 3.2 years. A total of 44 traumatic injuries involved the right shoulder, and 31 involved the left. Nineteen patients experienced a traumatic event during military training—9 during combat training, 6 during guerrilla training, and 4 during crawling. Twelve injuries occurred during soccer or futsal, and 11 during weightlifting. Among the weightlifting-related injuries, the most common activities were shoulder press (n = 6) and bench press (n = 3).

The median duration from the traumatic event to hospital presentation was 3 days. The median duration from the traumatic event to MRI was 15 days. Dislocation cases underwent MRI earliest, followed by subluxation and then unrecognized subluxation (overall, $P < .001$; dislocation vs unrecognized subluxation, $P < .001$; dislocation vs typical subluxation, $P = .032$; typical subluxation vs unrecognized subluxation, $P = .193$).

TABLE 1
Clinical Characteristics[a]

Type	Dislocation n = 18	Subluxation n = 30	Unrecognized Subluxation n = 27	*P*
Age, years	22.1 ± 3.3	21.4 ± 3.6	21.4 ± 2.5	.595
Laterality				.317
Left	5 (27.8)	15 (50)	11 (40.7)	
Right	13 (72.2)	15 (50)	16 (59.3)	
Operation[b]	9/18 (50)	8/30 (26.7)	5/27 (18.5)	.069
Duration of the event to MRI,[c] days	1 [0-7]	19.5 [3-33]	35 [13-84]	<.001[d]

[a]IQR, interquartile range; MRI, magnetic resonance imaging.
[b]Percentage of patients who underwent surgical treatment during the study period.
[c]Median duration [IQR] from the traumatic event to MRI acquisition.
[d]Post hoc comparisons: dislocation versus unrecognized subluxation ($P < .001$), dislocation versus typical subluxation ($P = .032$), typical subluxation versus unrecognized subluxation ($P = .193$).

TABLE 2
Radiologic Results[a]

Type	Dislocation n = 18	Subluxation n = 30	Unrecognized Subluxation n = 27	P
Glenoid defect size, %	1.1 ± 3.9	1.5 ± 3.5	1.5 ± 3.4	.806
Glenoid defect >5%	1/18 (5.6)	5/30 (16.7)	5/27 (18.5)	.447
HS lesion, existence	18/18 (100)	29/30 (96.7)	24/27 (88.9)	.352
HS interval, mm[b]	15.2 ± 3.1	7.5 ± 6.7	7 ± 6.5	<.001
HS width, mm[b]	13.5 ± 3.1	6.5 ± 5.9	6.4 ± 5.8	<.001
HS depth, mm[b]	4 ± 1.8	1.2 ± 1.2	1 ± 1.2	<.001
Off track	0	0	0	
DTD, mm[b]	6.8 ± 2.8	14.5 ± 6.8	14.8 ± 6.5	<.001

[a]Data are presented as mean ± SD or n/N (%), unless otherwise indicated. Dislocation versus unrecognized subluxation or versus typical subluxation ($P < .001$) (HS interval, HS width, HS depth, DTD). Unrecognized subluxation versus typical subluxation ($P \geq .999$) (HS interval, HS width, HS depth, DTD. DTD, distance to dislocation; HS, Hill-Sachs.
[b]Post hoc comparisons.

Among the patients, 22 underwent surgery. Although not statistically significant ($P = .069$), the dislocation group showed a trend toward a higher rate of surgical intervention. However, these procedures were performed by various surgeons, including both military and nonmilitary surgeons, and thus the surgical indications may have varied depending on each surgeon's clinical judgment.

Radiologic Assessment

Overall, the mean glenoid bone loss among the 75 patients was 1.3% ± 3.5 %. Eleven patients had a glenoid bone defect of >5%. The extent of bone defect did not differ between the groups (Table 2).

Four bony Bankart lesions were observed, with 1 in the dislocation group and 3 in the unrecognized subluxation group. In addition to Bankart lesions, 6 superior labrum anterior to posterior lesions were observed—including 3 in the dislocation group, 2 in the subluxation group, and 1 in the unrecognized subluxation group. One HAGL lesion was observed in the unrecognized subluxation group. One biceps dislocation was observed in the dislocation group.

An HS defect was observed in 71 out of 75 patients overall. Notably, all 18 patients in the dislocation group exhibited an HS lesion. The prevalence of HS lesions did not differ significantly between the groups (Table 2). However, the morphology of the lesions differed significantly between the dislocation group and the subluxation or unrecognized subluxation groups. Specifically, the interval, width, depth of the HS lesions, and DTD were all significantly different. Compared with the subluxation and unrecognized subluxation groups, the HS lesions in the dislocation group were more medially positioned, deeper, and wider at the time of the first event. In contrast, the HS morphology—specifically width, interval, and depth—was similar between the subluxation and unrecognized subluxation groups, with no statistically significant differences observed. None of the patients had an off-track HS lesion.

During the study period, 1 patient from the unrecognized subluxation group and 2 patients from the typical subluxation group underwent repeat MRI due to recurrent subluxation events. Although the first case was originally classified as unrecognized subluxation, the recurrent event was clearly recognized by the patient. In this patient, the initial glenoid bone loss was minimal, but it progressed to 16.2% on follow-up MRI. The HS lesion remained relatively unchanged from the first-time event. In contrast, the 2 patients with typical subluxation showed increases in the width of the HS lesions after recurrence (from 8 to 12 mm and from 16 to 20 mm, respectively), while glenoid bone loss remained unchanged. However, all 3 lesions remained on track.

DISCUSSION

The primary finding of this study is the identification of the unrecognized subluxation in patients with no perceived instability event at the initial visit. Despite its unrecognized characteristics, the pathoanatomy closely resembled that of a typical first-time subluxation rather than a first-time dislocation in terms of HS morphology. These findings suggest that clinicians should consider the possibility of a primary subluxation event in young patients when a traumatic event is accompanied by severe shoulder pain or consequent inability to raise the arm, even in the absence of perceived instability.

Regarding the investigation into first-time subluxation, army cohort studies have made substantial contributions.[1,11,12] In 2007, Owens et al[11] prospectively studied the incidence of primary and recurrent instability events, including first-time subluxation, within a closed population of United States military academy students. Subsequently, in 2010, Owens et al[12] conducted an in-depth MRI-based investigation of the pathoanatomy of first-time subluxation, reporting a high prevalence (25/27) of HS lesions. This prevalence was similar to that observed

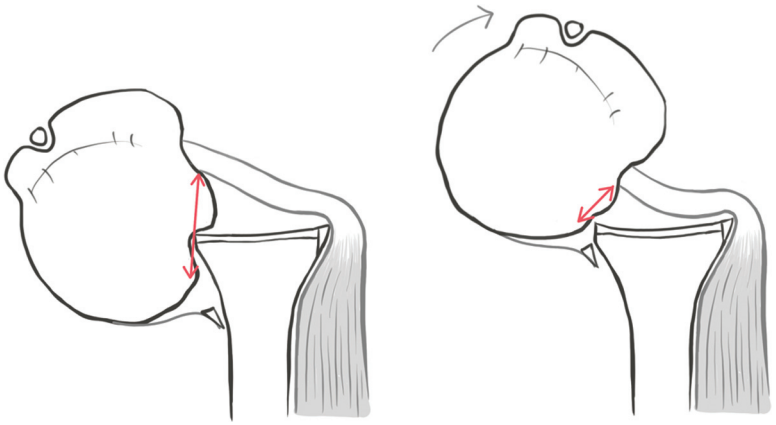

Figure 3. Summary of Hill-Sachs depth, width, and interval.

in the present study, both for typical first-time subluxation and for unrecognized subluxation cases. In addition to characterizing the HS lesion profile, this study provides quantitative information on glenoid bone loss in first-time instability. Across all 3 groups, glenoid bone loss showed no significant differences and was minor, with the vast majority of cases demonstrating <5% bone loss. Owens et al[11] specifically targeted patients who perceived subjective transient instability and exhibited anterior apprehension, relief upon relocation, or pathologic anterior translation during load-shift testing, making it difficult to include patients without perceived instability or those in whom physical examinations could not be adequately performed due to pain.[7,15] Conversely, this study's retrospective design enabled the study to be initiated from a cohort of patients with MRI-confirmed Bankart lesions, thereby including unrecognized subluxation cases. Therefore, although the results include unrecognized subluxations, this study does not provide an accurate incidence profile for each event type. Nevertheless, during the study period, the number of unrecognized subluxations identified was greater than that of dislocations and was similar to that of typical subluxations. Given the specific context of an army hospital—where MRI is more commonly recommended for instability events than for posttraumatic pain alone (due to medical necessity and the Army Physical Fitness System influencing military duty)—the number of unrecognized subluxation cases identified may be an underestimate rather than an overestimate.

In this study, the unrecognized subluxation group exhibited HS lesion characteristics very similar to those observed in typical subluxation cases. With the evolving understanding of the pathoanatomy of instability, quantifications such as glenoid bone loss and HS lesions using bipolar defects have facilitated more precise comparisons between first-time dislocations and subluxations. As demonstrated by Ozaki et al[13] and Nakagawa et al,[9] primary dislocations featured larger HS lesions in terms of depth, width, and interval compared to primary subluxations. This tendency persisted in the unrecognized group as well. As illustrated in Figure 3, we interpret this finding as resulting from the anatomic requirements necessary for dislocation.

In dislocated cases (left), the HS lesion is typically deeper and located farther from the infraspinatus footprint (red double-headed arrow). In contrast, in unrecognized or subluxated cases (right), the lesion tends to be shallower and situated closer to the footprint of infraspinatus. For true dislocation to occur, the anterior glenoid rim must engage with the HS lesion, functioning as a mechanical hook. When the lesion is too shallow or narrow, engagement may not occur, making dislocation less likely. This schematic suggests that subluxation may be associated with differences in humeral positioning or rotation during the injury event. In dislocation, the humeral head approaches the anterior glenoid rim at a steeper and more perpendicular angle relative to the curvature of the posterior humeral head, enabling it to engage and form a deep indentation. In contrast, subluxation involves a shallower or glancing contact, resulting in a shallow contusion.

While an HS lesion is considered an imprint of the injury mechanism, it also serves as a prognostic factor for recurrence. Dyrna et al[3] reported that off-track HS lesions in first-time dislocations were a negative prognostic factor for conservative treatment. However, in the present study, no off-track lesions were identified in first-time events. In addition, the mean glenoid bone loss was minor across all groups. In dislocation cases, where the mean HS interval was the greatest among the groups (15.2 mm), even assuming a small glenoid diameter of 26 mm and applying the critical bone loss threshold of 13.5%, the DTD remained 3 mm, indicating an on-track lesion. Therefore, in this cohort, the on-track/off-track concept and glenoid bone loss may have limited utility in predicting prognosis for first-time subluxation and dislocation. However, the 8 mm cutoff value for DTD, which was proposed as a prognostic threshold after arthroscopic Bankart repair, lies between the mean DTD values observed in the subluxation and dislocation groups (Figure 4). Based on this study, first-time subluxation may theoretically have a better prognosis than first-time dislocation after arthroscopic Bankart repair.[10]

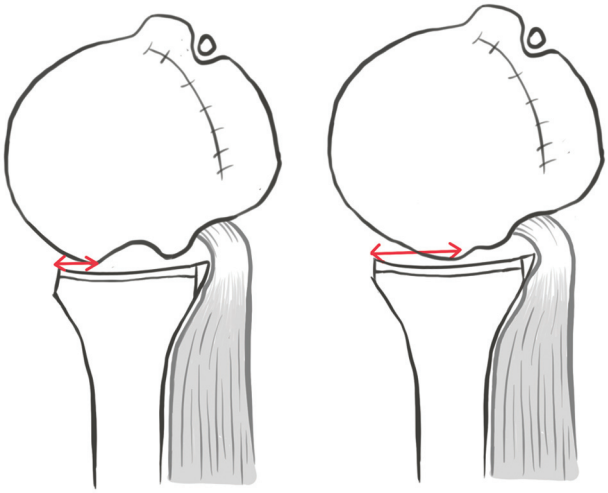

Figure 4. Figure summary for distance to dislocation.

Both images depict the humeral head in full external rotation as assumed in the glenoid track concept. In the dislocated cases (left), the HS lesion is positioned more medially, resulting in a shorter remaining distance before engaging with the anterior glenoid rim. In contrast, the unrecognized or subluxated cases (right) show an HS lesion located more laterally, allowing a greater distance before potential engagement.

The term *unrecognized* might suggest that the lesion is mild or associated with a favorable prognosis compared with typical subluxation. However, the only clear difference identified in this study is the occult nature at the initial presentation, not differences in the underlying pathoanatomy. Anatomic prognostic factors, such as glenoid bone loss, HS defect, and DTD, did not differ significantly between unrecognized and typical presentations. If the absence of perception is due to impaired proprioception, there is no reason to interpret the occult nature as a positive prognostic indicator or a milder form of instability.

The absence of initial perception complicated early diagnosis and delayed MRI in these patients. In most cases, the primary indication for MRI was severe pain after trauma. Specifically, many patients underwent MRI due to severe pain associated with a tearing sensation during the event or an inability to raise the arm after the event. Several factors may also contribute to delayed imaging. Military men may intentionally downplay their symptoms. In addition, pain and guarding can limit the accuracy of physical examinations, and several initial visits were conducted by non-shoulder or non-sports specialists under these challenging conditions. To avoid overlooking this patient group, clinicians should suspect unrecognized subluxation, reassess clinical symptoms and physical examination findings after the acute injury resolves, and then consider MRI to confirm the diagnosis when instability remains suspected. Ultimately, shoulder instability should not be judged solely by the patient's subjective perception, particularly at the initial visit, when pain and guarding may limit accurate assessment.

Several limitations should be acknowledged. First, all included patients were men, as mandatory military service in this country applies exclusively to men; thus, caution is warranted when generalizing these findings to female patients. Second, because of its retrospective nature, this study does not provide incidence rates. Since the analysis began with an MRI-confirmed Bankart lesion cohort, the sensitivity and specificity of physical examinations or clinical assessments could not be accurately determined. Third, although all patients were treated by 1 of 10 fellowship-trained orthopaedic surgeons, intersurgeon variability in clinical practice may have existed, particularly compared with previous prospective studies. Due to the retrospective nature of the study, standardized physical examination protocols were not implemented, introducing the risk of variability in clinical diagnosis and potential misclassification, which may have influenced group allocation. Fourth, this study relied on MRI, which inherently has limitations in accurately depicting bony morphology compared with 3-dimensional computed tomography reconstruction. Fifth, due to the study's retrospective design, standardized documentation of the exact injury mechanism at the time of trauma was not available. Lastly, information on whether physical examinations were limited by pain or guarding was not consistently recorded, and no outcome data were available.

CONCLUSION

Patients do not always recognize anterior shoulder instability, and initial physical examination may be limited in the acute setting. MRI findings of unrecognized first-time subluxations were similar to those of recognized subluxations and showed less severe HS morphology than in dislocations. Clinicians should maintain a high index of suspicion in young patients presenting with traumatic shoulder pain, even in the absence of perceived instability.

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