HAGL and Reverse HAGL Lesions

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Introduction

Tearing of the anteroinferior glenoid labrum (Bankart lesion) and of the posteroinferior glenoid labrum (reverse Bankart lesion) are well-documented, common injuries following traumatic shoulder subluxation or dislocation. The labral injury, as well as the loss of tension of the attached capsuloligamentous structures, is known to lead to recurrent instability [1].

Injuries to the capsuloligamentous attachments to the humerus are much less common but have recently gained attention due to advancements in arthroscopic experience and imaging techniques. In 1942, Nicola [2] first described an acute shoulder dislocation with avulsion of the anterior band of the inferior glenohumeral ligament (IGHL). In 1988, Bach et al. [3] described a humeral avulsion of the lateral capsule as a cause for recurrent shoulder dislocation. The term "humeral avulsion of glenohumeral ligaments (HAGL)," which is now commonly used for this pathology, was introduced by Wolf et al. [4] in 1995. Although the typical anterior HAGL lesion is more common, posterior injuries do occur. These are referred to as reverse or posterior HAGL (PHAGL) lesions and involve an avulsion of the posterior band of the IGHL from the humeral neck. While rare, these lesions have been shown to contribute to recurrent instability [5, 6].

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Epidemiology

HAGL and PHAGL lesions typically occur in patients with shoulder instability and are often seen in combination with other pathologies such as Bankart and posterior Bankart lesions, respectively [5, 7–9]. The patient's history typically involves high-energy trauma [10, 11]; however, repetitive microtrauma in overhead or throwing athletes has also been reported as a potential cause for this pathology [13, 14]. The incidence of HAGL lesions has been reported to approach 10 % [4, 14] in patients with shoulder instability, rising to nearly18% in patients needing revision procedures [14]. Bokor et al. [14] reported an incidence of nearly 40 % in patients with anterior instability that did not have a distinct Bankart lesion. Therefore, in the absence of a Bankart lesion in an individual with recurrent instability, suspicion for a HAGL lesion should be elevated.

The PHAGL lesion has been reported in patients with posterior instability [5, 15, 16]. Although not well quantified by the scientific literature to date, the incidence of PHAGL lesions is presumed to be much less common than that of HAGL lesions.

Pathophysiology

Stabilization of the humerus is achieved through the concomitant actions of various static and dynamic structures surrounding the joint which ultimately serve to maximize surface contact of the humeral head on the glenoid surface and to prevent anteroposterior translation. Static components include the labrum, tendons, and capsular ligaments, while dynamic components represent muscle contraction, scapulothoracic motion, and, potentially, proprioception [17].

The capsuloligamentous complex includes the coracohumeral ligament (CHL), superior glenohumeral ligament (SGHL), the middle glenohumeral ligament (MGHL), and the inferior glenohumeral ligament (IGHL) complex (Fig. 33.1). The primary static stabilizer preventing

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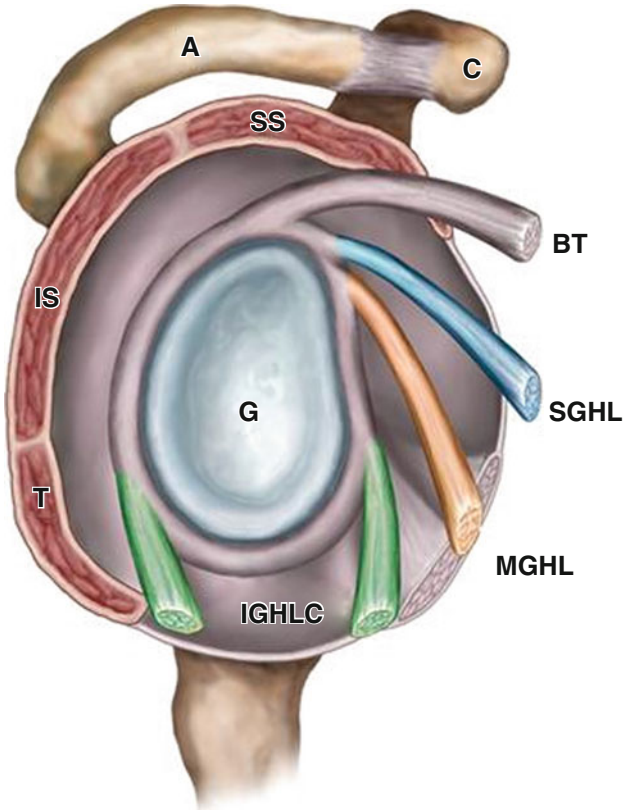

Fig. 33.1 Glenohumeral ligament anatomy. Note the anterior and posterior bands of the IGHL complex with interconnected axillary pouch. *A* acromion; *C* coracoid process; *BT* biceps tendon; *SS* supraspinatus; *IS* infraspinatus; *T* teres minor; *G* glenoid cavity. (Reprinted with permission from American Roentgen Ray Society: Modarresi et al. [33])

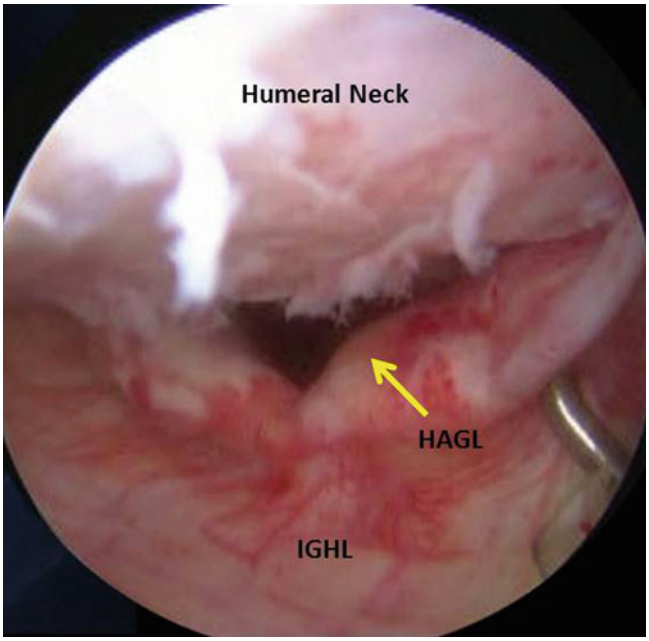

Fig. 33.2 Arthroscopic visualization of HAGL lesion. Note bleeding and fraying of avulsed IGHL

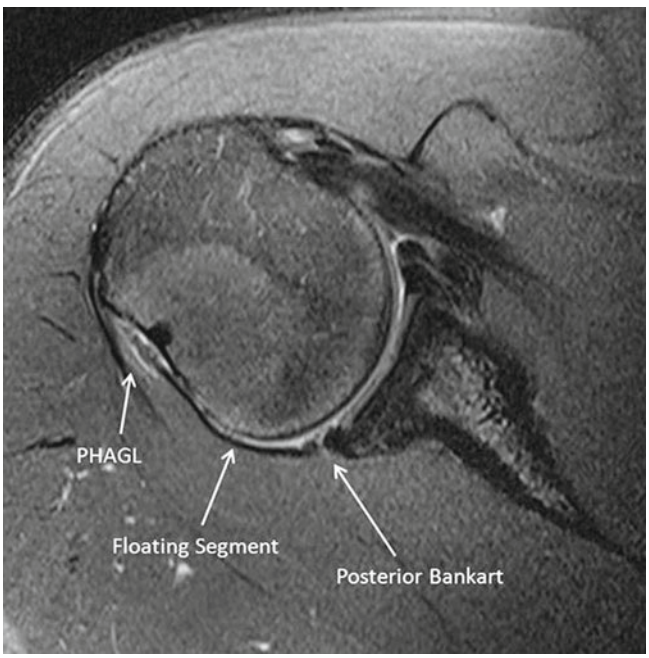

Fig. 33.3 Floating posterior IGHL (*PIGHL*) lesion in a 19-year-old rugby player after a forceful hyperabduction and hyperextension injury. The posterior Bankart lesion propagated superiorly, resulting in a concomitant mild superior labral anterior to posterior (SLAP) lesion

anteroposterior motion is the IGHL complex, which is known to change shape with different arm positions. This plasticity allows for static stabilization of the humeral head in multiple positions, preventing anterior or posterior translation [18, 19, 21].

The IGHL complex consists of an anterior and posterior band along with an interconnecting axillary pouch, which together create a "hammock-like" structure [18–20]. The humeral insertion of the IGHL has been described as "collar-like," with its attachment close to the articular margin, or "V-shaped," with its apex near the cartilaginous rim of the humerus and its base further distal on the humeral metaphysis [6, 18, 20–22]. Assuming a right shoulder, the anterior band originates between 2 and 4 o'clock and the posterior band between 7 and 9 o'clock, both arising primarily from the labrum [22]. Ticker at al. reported the humeral insertion of the IGHL to be distal to the lesser tuberosity anteriorly and distal to the greater tuberosity posteriorly [23].

Traumatic anterior dislocation or subluxation of the humeral head can result in avulsion of the IGHL from either the anteroinferior glenoid (i.e., Bankart lesion) or at its humeral insertion (HAGL lesion) (Fig. 33.2). Although both injuries are the result of arm hyperabduction, it has been noted that HAGL often has an external rotation component [19]. Unidirectional posterior instability can result in reverse lesions such as a posterior Bankart lesion, PHAGL lesion, or a combination of each (floating PIGHL) (Figs. 33.3, 33.4, and 33.5) [5].

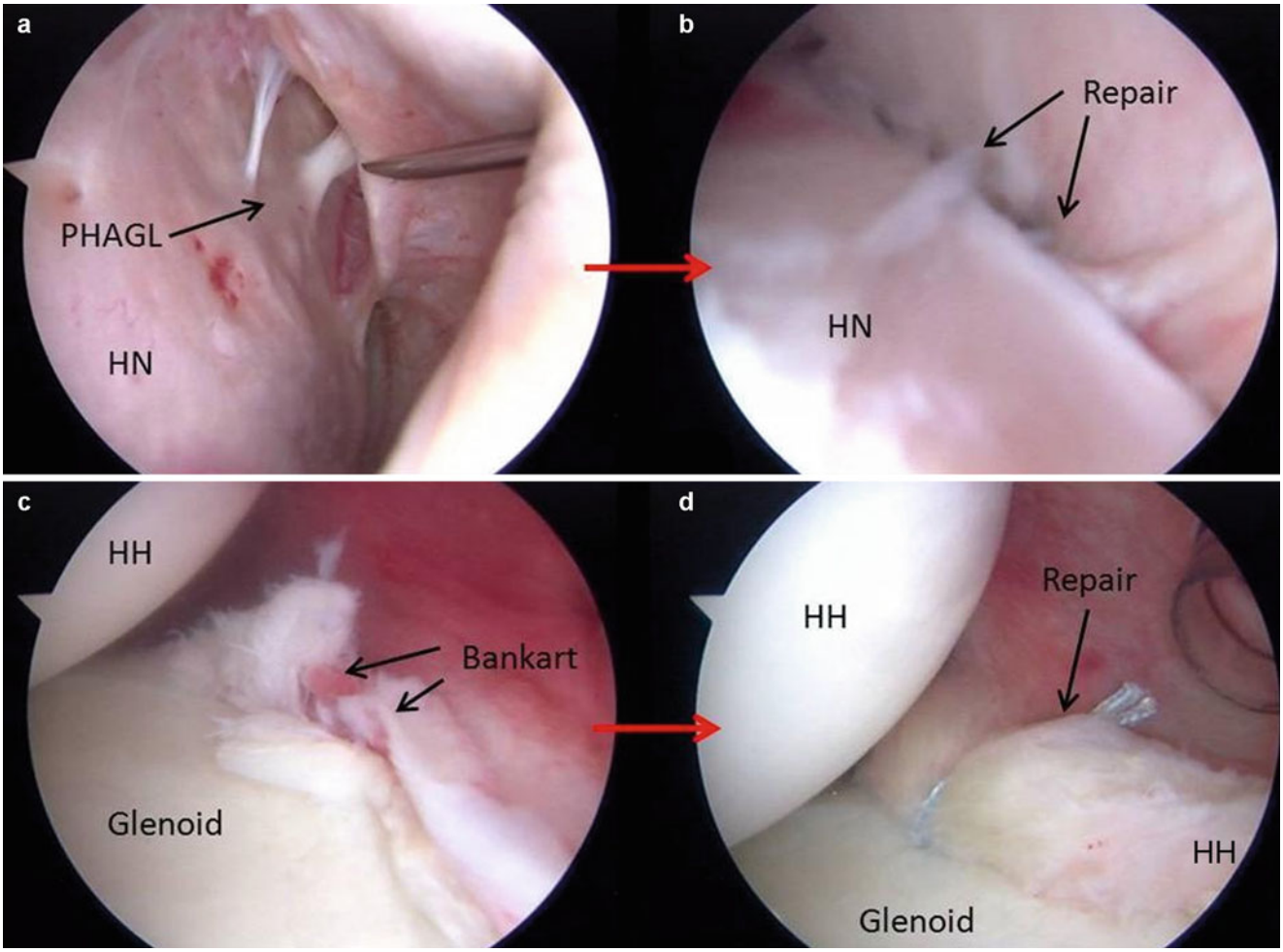

Fig. 33.4 Visualization and repair of a floating PIGHL lesion in a 19-year-old rugby player. Avulsion of the IGHL complex from the humeral neck (*HN*) (**a**) followed by repair (**b**). An associated posterior Bankart lesion (**c**) was also present in this patient and was repaired (**d**), *HH* humeral head

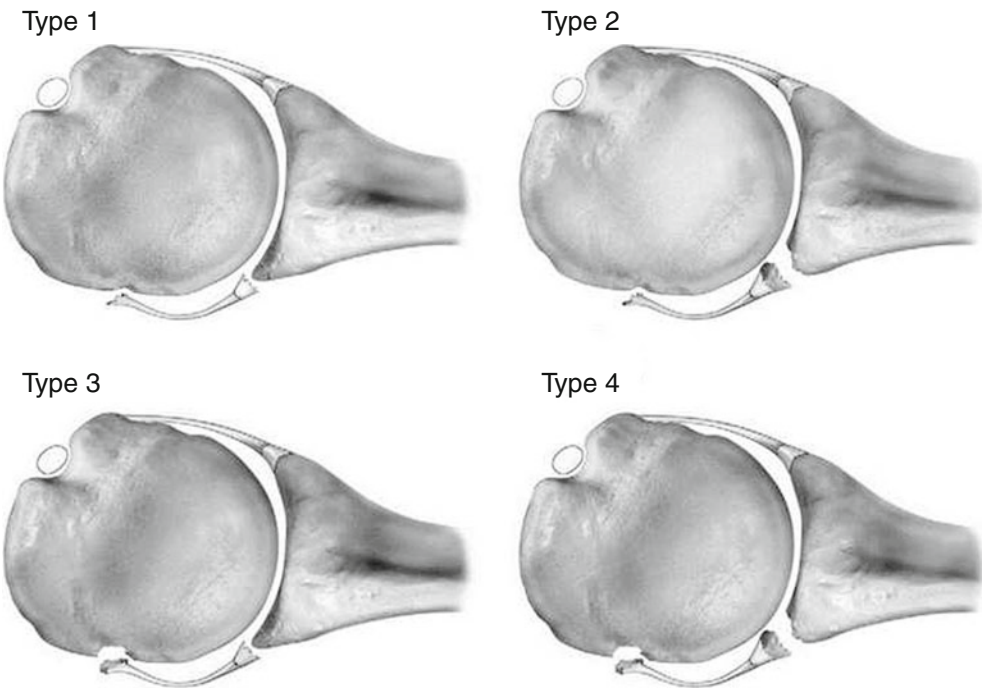

Fig. 33.5 Floating PIGHL subtypes as described by Ames and Millett [5]. Type 1 represents a PHAGL with a concomitant posterior Bankart lesion. Type 2 is a PHAGL with a posterior bony Bankart lesion. Type 3 is a bony PHAGL with a posterior Bankart lesion. Type 4 is a bony PHAGL with a posterior bony Bankart lesion (Reprinted with permission from the *Journal of Bone and Joint Surgery* [5])

Table 33.1 Classification of HAGL lesions according to Bui-Mansfield et al. [6]

Anterior	Posterior
Anterior humeral avulsion of the glenohumeral ligament (AHAGL)	Reverse humeral avulsion of the glenohumeral ligament (PHAGL)
Anterior bony humeral avulsion of the glenohumeral ligament (ABHAGL)	Posterior bony humeral avulsion of the glenohumeral ligament (PBHAGL)
Floating AHAGL	Floating PHAGL

Bui-Mansfield et al. [6] created the West Point classification system for describing anterior and posterior injuries to the IGHL in 2007. In this classification, there are six types of lesions broken into two separate categories depending on the direction of instability (Table 33.1).

History

Careful, detailed history taking is critical to making the diagnosis of HAGL. Patients typically have nonspecific shoulder complaints with a typical history of previous dislocation or subluxation, although this is not always present. Position of the arm at the time of injury is important in that hyperabduction with external rotation is often the mechanism in HAGL lesions while external rotation is not always necessary for a simple Bankart lesion. Furthermore, the direction of instability and history of recurrent instability are important questions to be evaluated. Recurrent instability in a patient with a previous Bankart repair may be a clue that a missed HAGL lesion is present. Also, a patient with recurrent instability in the absence of a Bankart lesion should raise suspicion of an injury to the IGHL complex at its humeral attachment (HAGL or PHAGL).

Clinical Examination

Nonspecific findings in the clinical exam are typical, but it is important to rule out other sources of shoulder pathology before considering the diagnosis of HAGL or PHAGL. Therefore, a complete and thorough examination of active and passive range of motion and strength in forward flexion, abduction, adduction, external rotation, and internal rotation should be determined, beginning with the asymptomatic shoulder. It is especially important to evaluate subscapularis function and strength since a tear of this tendon is often associated with a HAGL lesion.

Since HAGL and PHAGL lesions are associated with shoulder instability, the following provocative maneuvers are performed bilaterally: the load and shift test, the jerk test, the anterior and posterior apprehension test, and the relocation test. Hyperlaxity together with multidirectional instability is also assessed bilaterally and the rotator interval is checked for a sulcus sign. Although these tests are indicative of instability, none are sensitive or specific for the detection of HAGL or PHAGL lesions.

Imaging

Diagnostic imaging for the detection of HAGL and PHAGL lesions has improved in recent years, principally due to better recognition and also treatment of HAGL and PHAGL pathologies. True AP films should be obtained in neutral and internal rotation to identify possible fractures of the greater and lesser tuberosities. Scapular Y films are obtained to evaluate glenohumeral alignment. Axillary views are also obtained to identify lesions of the humeral head (such as a Hill-Sachs lesion) and any corresponding glenoid pathology. An interruption of the subchondral sclerosis line on AP films or abnormal glenoid anatomy or version on axial films may be indicative of chronic instability. A Garth view may reveal "scalloping" of the medial aspect of the surgical neck in cases of HAGL [24] or as a fleck of bone inferior to the anatomic neck of the humerus in bony HAGL lesions [22, 25].

Magnetic resonance imaging (MRI) with or without intra-articular contrast is the imaging modality of choice in cases of suspected HAGL or PHAGL lesions. Coronal oblique or sagittal oblique, T-2, fat-suppressed images are most likely to reveal the diagnosis; however, axial images are also useful (Fig. 33.3) [22]. It is important to note that the axillary pouch contains fluid which typically creates a characteristic U shape on the coronal or sagittal oblique MRIs. Loss of this shape due to contrast or fluid extravasation indicates the presence of a lesion in the IGHL complex [22, 24]. In the acute post-traumatic setting, blood in the joint provides excellent contrast and obviates the need for gadolinium enhancement. Chronic HAGL lesions are difficult to visualize because the IGHL has typically scarred back to its attachment on the surgical neck of the humerus and may or may not result in clinical instability or findings on MRI [17].

Treatment: Indications and Contraindications

Nonsurgical management is typically advocated when the injury to the IGHL complex is intra-substance and does not result in detachment from the humerus. In these cases, care

must be taken to identify any concomitant injuries [6]. Strengthening of the rotator cuff and surrounding musculature is helpful to prevent recurrent instability. Detached lesions are initially managed nonsurgically with physical therapy and range of motion exercises. The incidence of recurrent instability in patients with a HAGL lesion is unknown; however, preliminary evidence suggests that it may be an indication for operative repair. Surgical management of HAGL lesions is most often reserved for high-functioning individuals who desire a return to work or sports or those with recurrent instability. Although outcome data is limited to small case series and reports, some data suggests that arthroscopic repair and open repair result in similar, satisfactory outcomes [7, 12, 14, 26]. The contraindications for surgical repair are similar to those of any open or arthroscopic shoulder surgery.

Decision-Making Algorithm

As mentioned, history, physical examination, and imaging studies are used appropriately to establish the correct diagnosis. Typically, patients with HAGL lesions are initially treated nonsurgically since the rate of recurrent instability resulting from HAGL lesions is unknown. In cases of failed nonsurgical treatment with recurrent instability, ongoing pain, or impairment of shoulder function, surgical repair is indicated [17]. If a HAGL lesion is diagnosed as a concomitant injury during arthroscopy, a repair of the IGHL complex to the humeral insertion site should be performed to minimize the risk of failure and recurrent instability leading to revision surgery.

Clinical Case/Example

A 19-year-old collegiate rugby player suffered a traumatic subluxation of his right shoulder during a rugby match after attempting to tackle an opposing player. The arm was forcefully abducted and extended immediately prior to the injury. Although he denied the incidence of frank dislocation, he did describe subluxation with spontaneous reduction. The patient also reported that he had shoulder discomfort earlier in the match for which he did not seek medical treatment. Prior to the match, the patient was completely asymptomatic without a history of injury or trauma.

Upon presentation, the patient reported feelings of instability, weakness, and vague pain. His pain was 8/10 at its worst and was exacerbated by overhead activities and relieved with rest. He denied neck pain, elbow pain, paresthesias, or any other injuries.

Initial physical examination of the shoulder revealed tenderness to palpation at the posterior shoulder and lateral brachium, while the coracoid, AC, and SC joints were nontender. Active and passive range of motion was adequate. Neurovascular examination was within normal limits. Global rotator cuff function and strength was normal. He did have mildly positive Neer and Hawkins signs with a positive O'Brien's test. Apprehension, relocation, and sulcus signs (in neutral and external rotation) were also negative.

Radiographs of the affected shoulder revealed no bony lesions, while MRI indicated an avulsion of the posterior IGHL complex off the humeral neck (PHAGL) along with a posterior labral lesion extending superiorly near the insertion of the biceps tendon. This combination of injuries resulted on a floating posterior IGHL (Fig. 33.3).

Discussion of the risks, benefits, and alternatives of each therapy modality was undertaken, and largely due to the nature of his sport, the patient decided to undergo PHAGL and posterior Bankart repair.

Exam under anesthesia revealed grade 2 posterior translation, grade 1 anterior translation, and a mild sulcus sign (<1 cm). Diagnostic arthroscopy revealed a mild SLAP lesion and a floating PIGHL (combined posterior Bankart and PHAGL) which was subsequently repaired as described below (Fig. 33.4).

Postoperatively, the shoulder was immobilized in abduction for the first 4 weeks at which point pendulum and passive motion exercises were begun. Active and assisted motion began 6 weeks postoperatively with an avoidance of posterior loading for approximately 12 weeks. Sixteen weeks postoperatively, the patient was cleared to return to sporting activities with encouragement to continue his strengthening regimen. No further problems have been reported by the patient to date.

Arthroscopic Treatment: Surgical Technique

Although reverse HAGL lesions often require an accessory posteroinferior portal for suture passage, the arthroscopic surgical technique for both lesions is similar. The step-by-step technique for repair of HAGL is given below, followed by a description of repair of PHAGL lesions.

Patient Positioning

In the operating suite, the patient is positioned in either a lateral decubitus or beach-chair position. The lateral decubitus position affords improved visualization of the inferior capsule, while the beach-chair position has mainly been adopted for surgeon comfort. Positioning of the patient is ultimately determined by the surgeon as there is no specific data indicating a difference in outcome between the two positions in the repair of HAGL or PHAGL.

The affected arm is placed in a traction device or pneumatic arm holder with 20° of forward flexion and 50° of

abduction. This positioning modifies tension on the inferior capsule such that accurate reattachment of the IGHL to the humeral neck can be achieved.

A bump, made of two of three small towels, is placed under the axilla, inferior and posterior to the inferior angle of the scapula. This configuration allows adequate access to the axillary pouch of the IGHL complex.

Portals

Although a two- or three-portal technique can be undertaken depending on surgeon experience, the three-portal technique is described here.

An axillary pouch portal of Bhatia [27] is first established 2–3 cm inferior to the inferior border of the posterolateral acromial angle and 2 cm lateral to the position of a standard posterior portal. After marking, an incision is made such that the portal is angled 30° medial in the axial plane and slightly inferior to the sagittal plane. Using an 18-guage spinal needle, an outside-in technique is used in order to prevent injury to the axillary nerve and the posterior capsule during cannula insertion.

An anteroinferior portal at 5-o'clock is also established using an outside-in technique with the shoulder in neutral position. The incision is made 1 cm inferior to the superior border of the subscapularis tendon at the 5-o'clock position relative to the leading edge of the glenoid [17].

A posteroinferior portal is then established at the 7-o'clock position, as described by Davidson and Rivenburgh [28]. The incision is made 2–3 cm inferior to a standard posterior viewing portal using outside-in needle localization technique. The function of this portal is for viewing during instrumentation.

Another portal may be established in the rotator interval for suture management. The use of this fourth portal is at the choice of the surgeon.

Diagnostic Arthroscopy: Understanding and Recognizing the Pathology

After the appropriate portals have been established, the entire humeral head, glenoid surface, and IGHL complex must be examined for concurrent lesions. It is critical to view the entire attachment of the IGHL to the humeral neck. The literature describes several cases of missed HAGL lesions due to a lack of visualization of the entire IGHL attachment. Missed HAGL lesions, as described above, can result in recurrent instability, further surgery, and patient dissatisfaction. It is also pertinent to visualize the muscular striations of the subscapularis through the IGHL defect such that damage is to be avoided.

Step-by-Step Procedure (Box 33.1)

At this point, it is important to keep the shoulder in a neutral position such that the capsuloligamentous structures of the joint are sufficiently lax to afford accurate and precise relocation of the anterior band to the humeral neck. An arthroscopic burr is used to abrade the surface of the humeral neck at the precise location of desired reattachment of the anterior band. Suture anchors are then placed at this location and the resulting loose suture is retrieved using the designated 5-o'clock suture management cannula. The suture is advanced from the 5-o'clock portal through the IGHL using a desired suture-passing device. Horizontal mattress sutures are then used to reattach the capsular tissue back to the surgical neck of the humerus. After tying, the performance of anterior and posterior arthroscopic drawer tests is essential to confirm appropriate tension of the joint capsule and subsequent stability.

Box 33.1: Tips and Tricks

The arthroscopic HAGL repair can be challenging even for the experienced arthroscopist. The following tips can help facilitate the procedure and avoid severe complications:

- Make sure you are familiar with the instruments and implants needed for this procedure.
- Use spinal needles to assure correct portal placement and proper working angles.
- Allow enough time for a thorough diagnostic arthroscopy to prevent missing an important lesion.
- Avoid overtightening the capsular complex as this may lead to impaired shoulder motion.
- If using the beach-chair position, use your assistant to help distract the humerus anterolaterally to improve visualization.

Reverse HAGL

This procedure is largely similar to the repair of the anterior HAGL with a few exceptions. The same 5-o'clock, 7-o'clock, and axillary portals are established. An additional posteroinferior portal for suture passage is often necessary in posterior lesions. It is vitally important to avoid damage to the posterior capsule with the arthroscopic cannula. The posterior humeral neck is prepared with an arthroscopic burr at the desired location of reinsertion of the posterior band. Suture anchors are placed at the reinsertion site and horizontal mattress sutures are advanced through the posterior band. The IGHL is then reduced to the humeral neck. It is extremely important to avoid overtightening of the posterior capsule as this can lead to dramatic limitations of internal

rotation postoperatively, potentially decreasing patient satisfaction and function.

Postoperative Care

The postoperative course for patients with HAGL and PHAGL is similar. The patient is placed in a shoulder immobilizer with an abduction pillow for approximately 6 weeks. Physical therapy is initiated at a point 3 weeks after surgery, focusing on progressive passive range of motion. It is important to avoid anterior loading of the IGHL complex in HAGL and posterior loading in PHAGL so as not to compromise the surgical repair. Active range of motion exercise is begun at 6 weeks after surgery followed by rotator cuff, deltoid, trapezius, and biceps strengthening at 8 weeks.

Literature Review

The work of Nicola [2] in 1942 first described anterior shoulder dislocation with avulsion of the anterior band of the IGHL. Wolf et al. [4] followed by referring to the lesion as humeral avulsion of the glenohumeral ligament (HAGL) in 1995. They described an open repair through a deltopectoral approach with detachment of the subscapularis tendon in two patients and an arthroscopic repair in four patients. Excellent clinical results with a follow-up of at least 36 months were reported in all six patients with free shoulder motion and return to sports.

A review of the literature indicates that anterior HAGL lesions can be treated successfully with an open arthroscopic surgery [3, 4, 14, 29–31]. Arciero and Mazzocca [26] proposed a mini-open technique for the repair of HAGL lesions since the all-arthroscopic repair was considered extremely difficult due to limited exposure along the anteroinferior pouch of the humeral neck. For this technique, the lower third of the subscapularis is incised and the tendon is then lifted up exposing the humeral ligament avulsion. Excellent initial results have been reported in 8 patients without recurrent instability or subscapularis weakness. The advantages of the all-arthroscopic repair of a HAGL lesion include direct identification of the lesion itself as well as concomitant injuries, minimization of soft tissue trauma, avoidance of subscapularis detachment, and less postoperative pain [24].

In 2007, Castagna et al. [32] reported on 9 cases with PHAGL lesions treated arthroscopically. In all patients, the diagnosis was not made preoperatively, exemplifying the difficulty in clinical diagnosis of these lesions. After a mean follow-up of 34 months, all patients were free of pain and symptoms and were able to perform all activities of daily living and resume the same sports activities with same frequency. Recently, the pathoanatomic variants of floating PHAGL lesions were described by Ames and Millett [5]. Arthroscopic treatment of a PHAGL with a concurrent posterior osseous Bankart lesion was described along with a new, four-part subclassification system for floating PHAGL lesions (Fig. 33.5).

Summary

HAGL lesions are relatively uncommon and most reports on this pathology are limited to small case series. However, its incidence may approach up to 10 % in instability cases [4] and an undiagnosed HAGL lesion can lead to recurrent instability and failure of surgical treatment [7, 14]. Therefore, a thorough history and clinical examination along with the appropriate imaging studies are necessary for correct diagnosis. While an MRI can make the diagnosis of a HAGL lesion, in many cases the diagnosis is made during arthroscopy and direct visualization [32]. Arthroscopic treatment of HAGL and PHAGL has shown to yield good clinical outcomes [4, 5, 31, 32]; however, the literature is lacking any prospective comparative reports on specific treatment strategies for these lesions. Given the decreased morbidity of the arthroscopic approach, it is the author's recommendation that, when technical skill is available, these lesions be treated arthroscopically.

References

1. Bankart AS. Recurrent or habitual dislocation of the shoulder-joint. Br Med J. 1923;3285:1132–3.
2. Nicola T. Anterior dislocation of the shoulder: the role of the articular capsule. J Bone Joint Surg. 1942;25A:614–6.
3. Bach BR, Warren RF, Fronek J. Disruption of the lateral capsule of the shoulder. A cause of recurrent dislocation. J Bone Joint Surg. 1988;70B:274–6.
4. Wolf EM, Cheng JC, Dickson K. Humeral avulsion of glenohumeral ligaments as a cause of anterior shoulder instability. Arthroscopy. 1995;11:600–7.
5. Ames JB, Millett PJ. Combined posterior osseous bankart lesion and posterior humeral avulsion of the glenohumeral ligaments: a case report and pathoanatomic subtyping of "floating" posterior inferior glenohumeral ligament lesions. J Bone Joint Surg. 2011;93A:e1181–4.
6. Bui-Mansfield LT, Banks KP, Taylor DC. Humeral avulsion of the glenohumeral ligaments: the HAGL lesion. Am J Sports Med. 2007;35:1960–6.
7. Field LD, Bokor DJ, Savoie 3rd FH. Humeral and glenoid detachment of the anterior inferior glenohumeral ligament: a cause of anterior shoulder instability. J Shoulder Elbow Surg. 1997;6:6–10.
8. Schippinger G, Vasiu PS, Fankhauser F, Clement HG. HAGL lesion occurring after successful arthroscopic Bankart repair. Arthroscopy. 2001;17:206–8.
9. Warner JJ, Beim GM. Combined Bankart and HAGL lesion associated with anterior shoulder instability. Arthroscopy. 1997;13:749–52.
10. Rowe CR, Zarins B, Ciullo JV. Recurrent anterior dislocation of the shoulder after surgical repair. Apparent causes of failure and treatment. J Bone Joint Surg. 1984;66A:159–68.

11. Coates MH, Breidahl W. Humeral avulsion of the anterior band of the inferior glenohumeral ligament with associated subscapularis bony avulsion in skeletally immature patients. Skeletal Radiol. 2001;30:661–6.
12. Gehrmann RM, DeLuca PF, Bartolozzi AR. Humeral avulsion of the glenohumeral ligament caused by microtrauma to the anterior capsule in an overhand throwing athlete: a case report. Am J Sports Med. 2003;31:617–9.
13. Taljanovic MS, Nisbet JK, Hunter TB, Cohen RP, Rogers LF. Humeral avulsion of the inferior glenohumeral ligament in college female volleyball players caused by repetitive microtrauma. Am J Sports Med. 2011;39:1067–76.
14. Bokor DJ, Conboy VB, Olson C. Anterior instability of the glenohumeral joint with humeral avulsion of the glenohumeral ligament. A review of 41 cases. J Bone Joint Surg. 1999;81B:93–6.
15. Bokor DJ, Fritsch BA. Posterior shoulder instability secondary to reverse humeral avulsion of the glenohumeral ligament. J Shoulder Elbow Surg. 2010;19:853–8.
16. Hill JD, Lovejoy Jr JF, Kelly RA. Combined posterior Bankart lesion and posterior humeral avulsion of the glenohumeral ligaments associated with recurrent posterior shoulder instability. Arthroscopy. 2007;23:327e1–3.
17. George MS, Khazzam M, Kuhn JE. Humeral avulsion of glenohumeral ligaments. J Am Acad Orthop Surg. 2011;19:127–33.
18. O'Brien SJ, Neves MC, Arnoczky SP, Rozbruck SR, Dicarlo EF, Warren RF, et al. The anatomy and histology of the inferior glenohumeral ligament complex of the shoulder. Am J Sports Med. 1990;18:449–56.
19. Turkel SJ, Panio MW, Marshall JL, Girgis FG. Stabilizing mechanisms preventing anterior dislocation of the glenohumeral joint. J Bone Joint Surg. 1981;63A:1208–17.
20. Burkart AC, Debski RE. Anatomy and function of the glenohumeral ligaments in anterior shoulder instability. Clin Orthop Relat Res. 2002;400:32–9.
21. Pouliart N, Gagey O. Reconciling arthroscopic and anatomic morphology of the humeral insertion of the inferior glenohumeral ligament. Arthroscopy. 2005;21:979–84.
22. Bui-Mansfield LT, Taylor DC, Uhorchak JM, Tenuta JJ. Humeral avulsions of the glenohumeral ligament: imaging features and a review of the literature. AJR Am J Roentgenol. 2002; 179:649–55.
23. Ticker JB, Bigliani LU, Soslowsky LJ, Pawluk RJ, Flatow EL, Mow VC. Inferior glenohumeral ligament: geometric and strain-rate dependent properties. J Shoulder Elbow Surg. 1996; 5:269–79.
24. Parameswaran AD, Provencher MT, Bach Jr BR, Verma N, Romeo AA. Humeral avulsion of the glenohumeral ligament: injury pattern and arthroscopic repair techniques. Orthopedics. 2008; 31:773–9.
25. Oberlander MA, Morgan BE, Visotsky JL. The BHAGL lesion: a new variant of anterior shoulder instability. Arthroscopy. 1996; 12:627–33.
26. Arciero RA, Mazzocca AD. Mini-open repair technique of HAGL (humeral avulsion of the glenohumeral ligament) lesion. Arthroscopy. 2005;21:1152.
27. Bhatia DN, de Beer JF. The axillary pouch portal: a new posterior portal for visualization and instrumentation in the inferior glenohumeral recess. Arthroscopy. 2007;23:1241.e1–5.
28. Davidson PA, Rivenburgh DW. The 7-o'clock posteroinferior portal for shoulder arthroscopy. Am J Sports Med. 2002;30:693–6.
29. Richards DP, Burkhart SS. Arthroscopic humeral avulsion of the glenohumeral ligaments (HAGL) repair. Arthroscopy. 2004;20:134–41.
30. Spang JT, Karas SG. The HAGL lesion: an arthroscopic technique for repair of humeral avulsion of the glenohumeral ligaments. Arthroscopy. 2005;21:498–502.
31. Kon Y, Shiozaki H, Sugaya H. Arthroscopic repair of a humeral avulsion of the glenohumeral ligament lesion. Arthroscopy. 2005;21:632.
32. Castagna A, Snyder SJ, Conti M, Borroni M, Massazza G, Garofalo R. Posterior humeral avulsion of the glenohumeral ligament: a clinical review of 9 cases. Arthroscopy. 2007;23:809–15.
33. Modarresi S, Motamedi D, Jude CM. Superior labral anteroposterior lesions of the shoulder: Part 1, anatomy and anatomic variants. AJR Am J Roentgenol. 2011;197:596–603.