

## Bony Instability of the Shoulder

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**Abstract:** Instability of the shoulder is a common problem treated by many orthopaedists. Instability can result from baseline intrinsic ligamentous laxity or a traumatic event—often a dislocation that injures the stabilizing structures of the glenohumeral joint. Many cases involve soft-tissue injury only and can be treated successfully with repair of the labrum and ligamentous tissues. Both open and arthroscopic approaches have been well described, with recent studies of arthroscopic soft-tissue techniques reporting results equal to those of the more traditional open techniques. Over the last decade, attention has focused on the concept of instability of the shoulder mediated by bony pathology such as a large bony Bankart lesion or an engaging Hill-Sachs lesion. Recent literature has identified unrecognized large bony lesions as a primary cause of failure of arthroscopic reconstruction for instability, a major cause of recurrent instability, and a difficult diagnosis to make. Thus, although such bony lesions may be relatively rare compared with soft-tissue pathology, they constitute a critically important entity in the management of shoulder instability. Smaller bony lesions may be amenable to arthroscopic treatment, but larger lesions often require open surgery to prevent recurrent instability. This article reviews recent developments in the diagnosis and treatment of bony instability. **Key Words:** Instability—Shoulder—Glenoid—Bankart—Hill-Sachs—Insufficiency.

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The shoulder is, by design, one of the most mobile and least constrained joints in the body.<sup>1</sup> This lack of anatomic constraint enables the shoulder to have a significant range of motion in multiple planes, but it also sets the stage for pathologic instability. The stabilizing forces of the shoulder can be divided into static constraints and dynamic constraints.<sup>2</sup> Static constraints include the glenoid labrum, the joint capsule, the coracohumeral arch, and the glenohumeral ligaments.<sup>2,3</sup> Dynamic stabilizers include the rotator cuff with its “compression concavity” mechanism, the del-

toid, the biceps, and other periscapular muscles.<sup>1,2,4</sup> The specific contributors to the stability of the shoulder at any given moment vary widely by the exact position of the arm and constitute a complex interaction of forces that is beyond the scope of this article. In any case, however, the foundation of stability begins with the bony structure of the glenoid and the humerus, and compromise of this foundation can lead to significant problems.

### DIAGNOSIS

#### History and Physical Examination

In a patient with bony instability, several features of the history and physical examination often set them apart from other cases of instability. The first key feature of the history is the ease and frequency of dislocation of the shoulder. Patients may describe dislocation events associated with various activities of daily living or even during sleep and often with the arm in a position of much lower degrees of abduction and external rotation than the well-described “position

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*0749-8063/08/2409-8137\$34.00/0*

*doi:10.1016/j.arthro.2008.05.015*

**TABLE 1.** Description of Special Tests for Diagnosis of Shoulder Instability<sup>1,9,11-16,79-81</sup>

Test	Description
Anterior apprehension test	The arm is placed into a position of 90° of abduction, 90° of external rotation, and slight extension. The test is positive if the patient reports a feeling of impending dislocation or subluxation of the shoulder. This test can be performed in a upright or supine position.
Relocation test	After a positive apprehension test, a posteriorly directed force is applied to the humeral head to relocate it into the glenoid fossa. The relocation test is positive if the posteriorly directed force relieves the pain or sense of instability.
Anterior release (“surprise”) test	After a positive anterior relocation test, the posteriorly directed force is suddenly released. The release test is positive if the pain or apprehension returns.
Anterior drawer test	With the patient supine, the arm is placed into a position of 60° to 80° of abduction and 0° of rotation. The examiner stabilizes the scapula, applies a slight axial load, controls the arm, and attempts to translate the humeral head over the glenoid rim with an anteriorly directed force. Subluxation beyond the glenoid rim that re-creates symptoms is considered a positive test.
Posterior drawer test	With the patient supine, the elbow is flexed to 120° and the arm is placed into 20° to 30° of forward flexion. Various degrees of abduction have been described in different modifications of this test. The examiner then stabilizes the scapula, flexes the arm, slightly internally rotates the arm, and applies a posteriorly directed pressure to the humeral head in an attempt to translate it over the posterior glenoid rim. Subluxation beyond the glenoid rim that re-creates symptoms is considered a positive test.
Load-and-shift test	With the patient upright, the arm is placed into a position of slight abduction and forward flexion and neutral rotation. The examiner then grasps the proximal humerus and applies a slight axial load, followed by anterior and posterior translational forces. Significant translation can indicate possible instability.
Bony apprehension test	The arm is placed into a position of 45° of abduction and 45° of external rotation—notably lower than the “standard” apprehension test. The test is positive if the patient reports a feeling of impending dislocation or subluxation of the shoulder. This test can be performed in an upright or supine position.

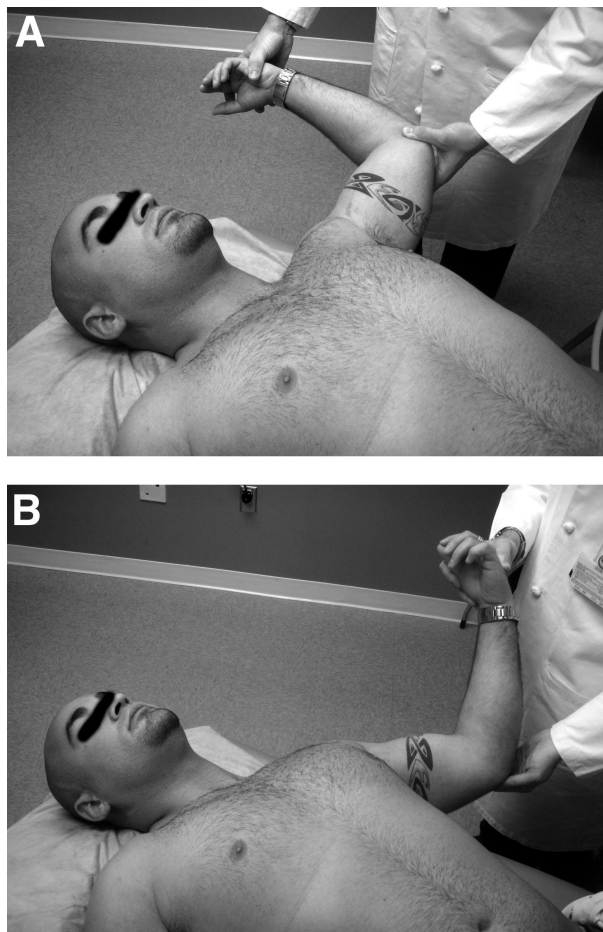
of athletic function” at 90° of abduction and 90° of external rotation.<sup>5,6</sup> Multiple dislocation events are often reported, with some patients even describing “hundreds” of episodes in a short period of time. The second key feature is a past traumatic event involving the shoulder, often higher energy and usually requiring medical treatment for reduction. The third key feature is one of a prior surgical intervention. Bony instability has been identified as the primary cause of failed arthroscopic reconstruction,<sup>7,8</sup> and thus it should sit atop the differential in cases of symptomatic instability after surgery. Obviously, not all patients with bony instability will have had prior surgery, and thus surgeons should keep bony instability in mind in primary cases as well. Despite these “warning signs” in the history, bony instability may also be deceptively similar to ligamentous instability, with complaints such as a “dead arm,” decreased strength or athletic performance, or nonspecific pain dominating the history.

The physical examination begins with inspection for prior scars, atrophy, or deformity. Then, a comparative analysis of range of motion, strength, and neurovascular status of both upper extremities is completed. Asymmetric active or passive motion could indicate an imbalance of the anterior and posterior capsule or prior shortening or imbrication of the subscapularis from a previous procedure. Particular atten-

tion should be paid to the status of the rotator cuff—especially the subscapularis—as well as the biceps tendon, both of which may be injured in an anterior dislocation event.

Multiple testing maneuvers may then be used to isolate instability as the primary problem (Table 1).<sup>9-12</sup> In particular, the bony apprehension test has been described as a specific means of screening for osseous-mediated instability.<sup>13,14</sup> It involves testing for apprehension at the lower position of 45° of abduction and 45° of external rotation, rather than the standard apprehension position of 90°/90° (Fig 1). With all of these tests, the patient’s sense of apprehension—rather than pain—should be used as a positive result to increase the reliability of the examination.<sup>9,15</sup>

In every case involving surgery, the operative procedure should always include a physical examination under anesthesia.<sup>4</sup> This is a comprehensive analysis of the shoulder in which the patient’s pain, volitional control, and dynamic stabilizers are removed as variables in the assessment of instability. The physician can perform a comparative evaluation of motion, which provides further information about the amount of laxity, subscapularis contracture, and the presence of bony crepitation or “clunks” that may indicate bony lesions. The position of engagement, subluxation/locking, and relocation can be repeatedly analyzed and precisely documented without



**FIGURE 1.** Bony apprehension test. (A) The standard apprehension test is performed with the arm at a position of 90° of abduction and 90° of external rotation. (B) The bony apprehension test, which screens for instability mediated by a bony lesion, is performed with the arm at a position of 45° of abduction and 45° of external rotation.<sup>13,14</sup>

any discomfort for the patient. The examination under anesthesia also represents the final opportunity to make or change a diagnosis before beginning an actual surgical procedure.

### Radiographic Workup

Every patient should receive a radiographic “instability series” consisting of a true anteroposterior (Grashey) view, internal and external rotation views, a scapular Y view, an axillary lateral view, and an apical oblique (Garth) view.<sup>16,17</sup> The West Point and Stryker notch views can also provide detail about bony deformity and may be obtained if desired.<sup>18</sup> Sometimes, plain radiography alone is sufficient to identify a bony lesion and permit adequate planning of treatment. In

many cases, however, plain radiographs will not lead to an accurate diagnosis. A recent study identified that almost 60% of operative bony lesions were missed by plain radiographs alone.<sup>13</sup>

Cases with a negative instability series but a history and physical examination concerning for possible bony instability should therefore undergo cross-sectional imaging with either computed tomography or magnetic resonance imaging (or both) to identify and quantify bone loss.<sup>19,20</sup> Unless a contraindication to joint injection exists, these modalities should be used along with arthrography to increase the sensitivity of the study.<sup>21-23</sup> Cross-sectional imaging should include coronal, axial, and oblique sagittal cuts to evaluate the glenoid and the humerus appropriately. Even if the plain radiographs are positive for a bony lesion, the surgeon may elect to order advanced imaging to better characterize the size, location, and extent of the lesion and to rule out additional pathology such as rotator cuff tears, labral tears, biceps tendon injury, ligamentous disruption, and other problems. Dynamic imaging (i.e., with the arm in a symptomatic position) may be considered, but it has not been established as superior to standard positioning.

A recent study described the use of the radiographic glenoid index in determining the need for bone graft in shoulder instability. By use of 3-dimensional computed tomography scans of both shoulders, the glenoid index is calculated as the maximum inferior diameter of the injured glenoid relative to the maximum inferior diameter of the uninjured glenoid. A glenoid index of 0.75 was found to be predictive of the need for a bone grafting procedure.<sup>24</sup>

### Arthroscopic Diagnosis

Although the diagnosis of bony instability should hopefully be made before any surgical intervention, it has been well established as an entity that is quite easy to miss.<sup>7,8</sup> In every case of shoulder arthroscopy for diagnostic purposes and for treatment of instability, the surgeon should thus specifically seek to rule out a bony lesion as a possible cause of the problem. If open surgery is already planned, the surgeon should still consider a diagnostic arthroscopy before proceeding with open surgery,<sup>25</sup> because certain areas of the shoulder (especially posteriorly) may be better visualized with arthroscopy than with certain open approaches—and the arthroscopic findings may alter the choice of open approach. The surgeon may also encounter unexpected additional pathology (such as

loose bodies, SLAP tears, cuff tendon injuries, and chondromalacia) requiring arthroscopic treatment.<sup>25,26</sup>

Posterior bone loss from the glenoid and a standard Hill-Sachs lesion of the humerus can be seen with the arthroscope in the standard posterior viewing portal.<sup>27,28</sup> Anterior bone loss from the glenoid (bony Bankart lesion) and a reverse Hill-Sachs lesion are better seen by use of an anterior viewing portal through the rotator interval.<sup>16</sup> The glenoid bare spot has been described as a reference marker to assess the percentage of bone loss from the glenoid,<sup>29,30</sup> and its use has been validated in several subsequent studies.<sup>28,31,32</sup> If a Hill-Sachs lesion is identified, a dynamic examination should be performed in which the shoulder is brought through a full range of motion to screen for “engagement” of the defect with the rim of the glenoid and the exact position of engagement noted.<sup>7</sup>

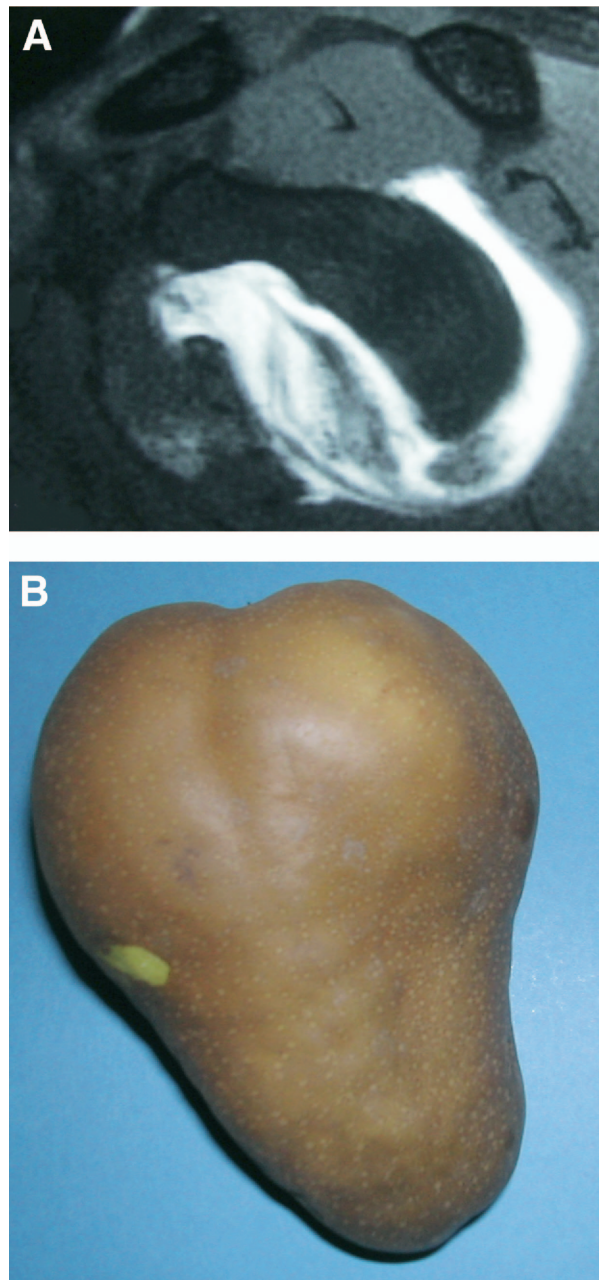
### TYPES OF BONY LESIONS

Bony instability lesions can be generally grouped according to the direction of bone loss (anterior or posterior) and the involved bone (glenoid or humerus). In several cases both bones may be involved—usually on opposite sides (i.e., anterior glenoid with posterior humerus and vice versa).

#### Glenoid

Lesions of the anterior glenoid are the most common reason for bony instability of the shoulder.<sup>33</sup> In 1923 Bankart<sup>34</sup> described an avulsion of the capsulolabral complex of the anteroinferior glenoid rim.<sup>35</sup> The lesion, which now bears his name, usually occurs as a result of an anterior shoulder dislocation. When an osseous fragment is also involved in this avulsion, it is commonly called a *bony Bankart lesion*. Cases of large bony Bankart lesions have been referred to as an *inverted-pear glenoid* because the affected glenoid in the en face oblique plane is wider superiorly than inferiorly (Fig 2).<sup>7</sup> Like a golf ball attempting to rest on a broken tee, the resistance to excessive anterior translation of the humeral head is obviously compromised when a significant amount of bone is destabilized or missing from the glenoid. Some controversy does exist about just how much bone loss is required to deem a lesion “significant” (Table 2), but most sources fall between 20% and 30%. The balance stability angle has also been described to help quantify this loss of stability secondary to bone loss.<sup>36</sup>

Because of differences in treatment options for each entity, a distinction should be made between attri-



**FIGURE 2.** Inverted-pear glenoid concept. In this oblique sagittal computed tomography image, the superior portion of the glenoid is wider than the inferior portion of the glenoid (A), giving it an appearance like an actual inverted pear (B).<sup>85</sup>

tional bone loss of the glenoid, a bony Bankart lesion or rim avulsion, and a frank glenoid fracture. Attritional bone loss may represent a prior bony Bankart lesion with subsequent resorption of the bony fragment.<sup>8,37</sup> Congenital glenoid dysplasia or hypoplasia may also be present in cases of bony instability and

**TABLE 2.** Significant Sizes

Author	Year	Size	Study Details
<b>Glenoid defects</b>			
Bigliani et al. <sup>82</sup>	1998	25%	Clinical
Burkhardt and De Beer <sup>7</sup>	2000	25%/6 mm	Clinical
Itoi et al. <sup>83</sup>	2000	21%	Biomechanical
Burkhardt et al. <sup>30</sup>	2002	25%	Biomechanical
Greis et al. <sup>84</sup>	2002	30%	Biomechanical
Porcellini et al. <sup>57</sup>	2002	25%	Clinical
Lo et al. <sup>85</sup>	2004	25%	Clinical/ biomechanical
Tauber et al. <sup>8</sup>	2004	5 mm	Clinical
Chen et al. <sup>33</sup>	2005	20%	Review
Sugaya et al. <sup>47</sup>	2005	25%	Clinical
Bahk et al. <sup>1</sup>	2007	20%	Review
Burkhardt <sup>29</sup>	2007	25%	Clinical
Mologne et al. <sup>46</sup>	2007	20%	Clinical
Auffarth et al. <sup>62</sup>	2008	25%	Clinical
<b>Humeral head defects</b>			
Gerber and Lambert <sup>70</sup>	1996	40%	Clinical
Miniaci and Gish <sup>6</sup>	2004	25%	Clinical
Chen et al. <sup>33</sup>	2005	20%	Review
Millett et al. <sup>86</sup>	2005	20%-30%	Review
Bock et al. <sup>65</sup>	2007	30%	Clinical
Raiss et al. <sup>78</sup>	2008	21%	Clinical

NOTE. Selected articles and their recommendations about what size defect constitutes one “significant” enough to indicate treatment with bony reconstruction surgery are listed.

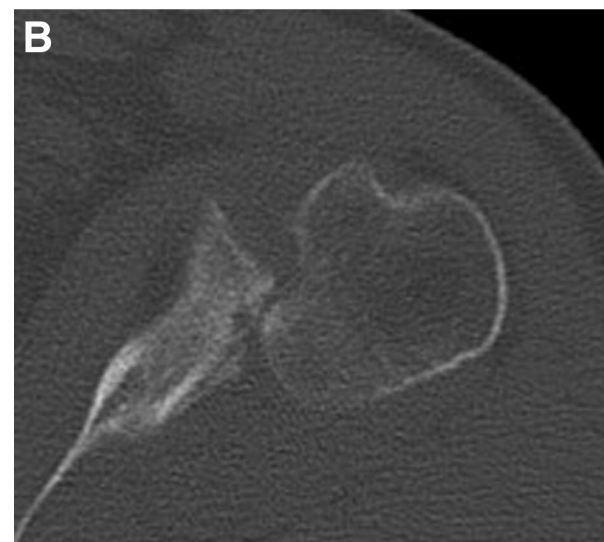
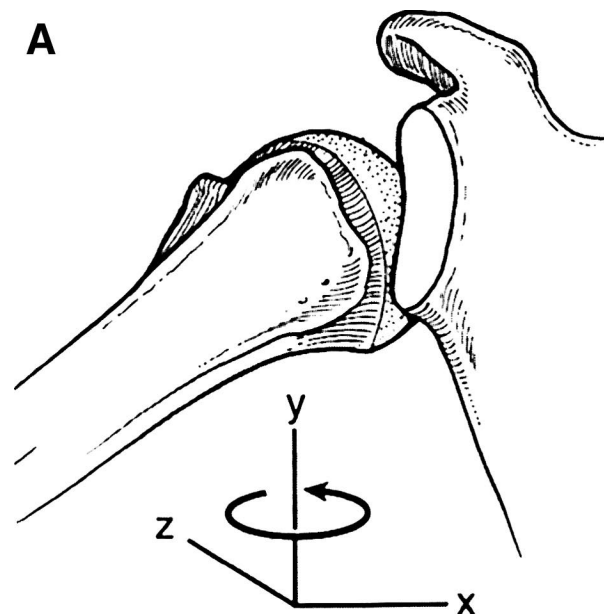
has been described as a loss of depth or an atrophic posterior and inferior wall—making it more likely a contributor in situations of posterior instability.<sup>1,38-40</sup>

Lesions of the posterior glenoid are less common than lesions of the anterior glenoid and are usually associated with a history of a distinct traumatic event with a posterior dislocation.<sup>27</sup> Nevertheless, the same principles of bony stability apply in that the humeral head lacks bony resistance to posterior translation. The amount of osseous insufficiency needed for instability has not been studied as much as that for the anterior glenoid, but some reports in the literature have cited various guidelines for “significant” bone loss (Table 2). These lesions can prove more difficult to treat if not recognized before surgery, because they often require a posterior approach for access.

**Humerus**

A Hill-Sachs lesion is an impression fracture of the posterosuperolateral humeral head, named for Hill and Sachs,<sup>41</sup> who described it in 1940. This entity can occur with any dislocation event wherein the soft bone of the humeral head impacts against the harder,

sharper edge of the glenoid (Fig 3). Its incidence has been estimated at 47% to 80% in anterior shoulder dislocation cases and up to 100% in cases of recurrent instability.<sup>33,42-44</sup> A reverse Hill-Sachs lesion is an impression fracture of the humeral head that occurs on the anterior aspect of the bone, usually in cases of posterior shoulder dislocation.<sup>27</sup>



**FIGURE 3.** Etiology of Hill-Sachs lesions. (A) A Hill-Sachs lesion is created when a dislocation event causes the soft bone of the posterosuperolateral humeral head to impinge against the hard edge of the anterior glenoid rim. A reverse Hill-Sachs lesion occurs via the same mechanism but with a posterior dislocation event. (Adapted with permission.<sup>7</sup>) (B) An axial computed tomography image shows both a reverse Hill-Sachs lesion of the humeral head and significant posterior glenoid bone loss.

Although a Hill-Sachs or reverse Hill-Sachs lesion may be present in many cases of instability, it is critical to determine whether the lesion is actually contributing to the instability. First, the size of the lesion should be determined by both radiographic and arthroscopic measurements. As with glenoid bone loss, controversy exists about the range of “significance” of size (Table 2). Second is the concept of *engagement*, described by Burkhart and De Beer<sup>7</sup> as a lesion “that presents the long axis of its defect parallel to the anterior glenoid with the shoulder in a functional position of abduction and external rotation, so that the Hill-Sachs lesion engages the corner of the glenoid” (Fig 4). Identification of an “engaging” lesion is a dynamic process that requires physical examination and often diagnostic arthroscopy to fully evaluate the contribution of the humeral lesion to the instability of the shoulder.

### TREATMENT OPTIONS

Nonoperative treatment of bony instability is not recommended. Bony lesions associated with instability represent a significant compromise of the foundational structure of the shoulder and generally will not improve without surgical intervention. Maquieira et al.<sup>45</sup> have reported successful nonoperative treatment of large anterior glenoid fractures, but these cases did not involve symptomatic instability. Although some all-arthroscopic procedures addressing bony lesions have been described,<sup>46-53</sup> most situations of bony instability require full open reconstruction or “hybrid” techniques combining arthroscopic and open portions.<sup>16,50</sup> Balg and Boileau<sup>54</sup> have described an instability severity index score to help the surgeon decide between arthroscopic and open approaches by screening for patients with a high probability for failure of arthroscopic surgery (Table 3). The heart of any treatment plan centers on adequate recognition of the involved bony lesions and stable reconstruction of the bony architecture supporting the joint.

### Approaches

The standard anterior deltopectoral interval can be used to address pathology in the anterior portion of the shoulder, such as bony Bankart lesions, glenoid fractures, and reverse Hill-Sachs lesions. This interval can also be used to address a standard Hill-Sachs lesion, but it requires extensive takedown of multiple structures (including the subscapularis, biceps, rotator interval, and sometimes even part of the deltoid), forces

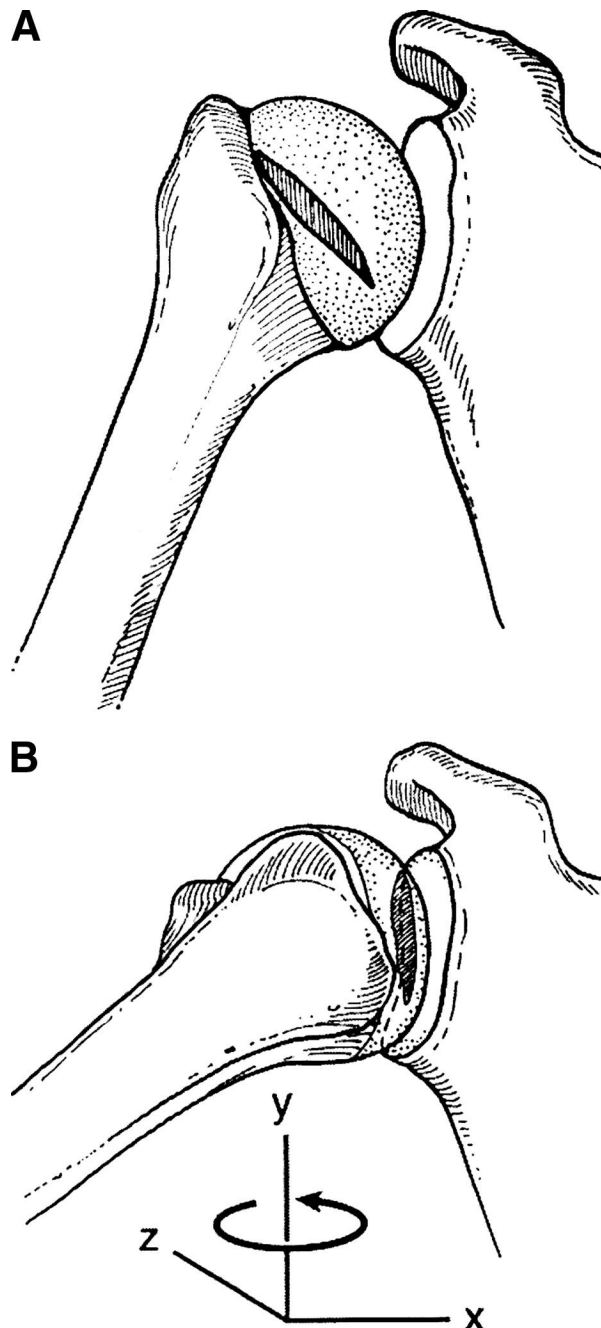


FIGURE 4. Engaging Hill-Sachs lesion. A Hill-Sachs lesion (A) “engages” the glenoid rim in a functional position of abduction and external rotation (B), thereby contributing to the instability of the shoulder. (Adapted with permission.<sup>7</sup>)

excessive rotation of the humerus, and does not provide the best visualization or access.<sup>16</sup> In addition, significant fatty atrophy of the subscapularis has been noted in cases in which the subscapularis was taken

**TABLE 3.** *Instability Severity Index Score*

Prognostic Factor	Points
Age at surgery	
≤20 yrs	2
>20 yrs	0
Degree of sport participation (preoperative)	
Competitive	2
Recreational or none	0
Type of sport (preoperative)	
Contact or forced overhead	1
Other	0
Shoulder hyperlaxity	
Anterior or inferior hyperlaxity	1
Normal laxity	0
Hill-Sachs on anteroposterior radiograph	
Visible in external rotation	2
Not visible in external rotation	0
Glenoid loss of contour on anteroposterior radiograph	
Loss of contour	2
No lesion	0
Total (points)	10

NOTE. A score of greater than 6 had at least a 70% risk of recurrence after arthroscopic Bankart repair. The instability severity index score is based on a preoperative questionnaire, clinical examination, and radiographs. (Reproduced with permission and copyright © of the British Editorial Society of Bone and Joint Surgery.<sup>54</sup>)

down again for revision surgery.<sup>55</sup> A posterior approach can therefore be used to address posterior pathology, including Hill-Sachs lesions and posterior glenoid insufficiency or fracture. Various posterior approach techniques have been described, including minimally invasive approaches that involve splitting the deltoid and the infraspinatus muscles.<sup>16,56</sup> Finally, a hybrid approach combining arthroscopy for 1 lesion and an open approach for another, such as a soft-tissue Bankart lesion in conjunction with an engaging Hill-Sachs lesion, may also be used.<sup>16</sup>

## Glenoid

Fractures of the glenoid may be treated with open reduction and internal fixation if identified early and if surgery is indicated for the fracture pattern (Table 4). Acute bony Bankart lesions with a small fragment and glenoid loss not meeting the size parameters for “significant” may be addressed with arthroscopic or open repair, with recent arthroscopic series reporting results similar to open techniques.<sup>57</sup> Cases of delayed diagnosis, “significant” bone loss, and/or attritional loss of bone, however, usually require a bony reconstruction technique from 1 of 2 major categories: coracoid transfer and iliac crest grafting.

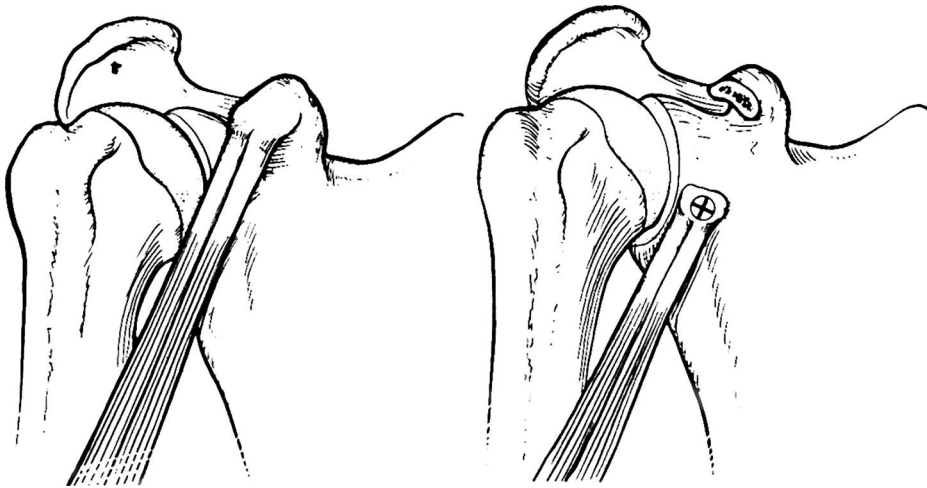
Several procedures have been described to provide bony stability to the deficient glenoid via a local transfer of part of the coracoid process to the anterior glenoid rim. The Bristow procedure involves transfer of the tip of the coracoid to the glenoid and functions as a bone block to stabilize anterior translation (Fig 5). Multiple studies have reported successful results with its use in recurrent instability.<sup>58</sup> The Latarjet procedure is similar to the Bristow procedure, but it involves a larger portion of the coracoid process and seeks to re-create more of the bony arc of the glenoid (Fig 6).<sup>59</sup> Proponents of this procedure believe that the lengthened glenoid arc and the additional slinglike support of the conjoined tendon help stabilize the shoulder even more effectively.<sup>59</sup> In addition, minimal morbidity to the biceps is involved.<sup>60</sup>

Other authors advocate reconstruction of the anterior glenoid using iliac crest autograft—especially with very large lesions in which the coracoid process may not provide adequate bone for complete stability.<sup>36,61</sup> Although multiple variations of this technique have been described, 2 essential themes exist: use as an extra-articular bone block to translation and use as an intra-articular extension of the glenoid arc (Fig 7).<sup>36</sup> Proponents of the latter method believe that it can provide better union rates and improved rotation of the shoulder.<sup>62,63</sup>

Although the current gold standard for addressing bony instability of the anterior glenoid is an open reconstructive procedure, some authors have reported successful results with arthroscopic repair of bony lesions. Mologne et al.<sup>46</sup> had only a 14% failure rate in a series of 21 patients with at least a 20% loss of bone from the anterior glenoid. All of the failures, however,

**TABLE 4.** *Indications for Open Reduction–Internal Fixation of Glenoid<sup>87-93</sup>*

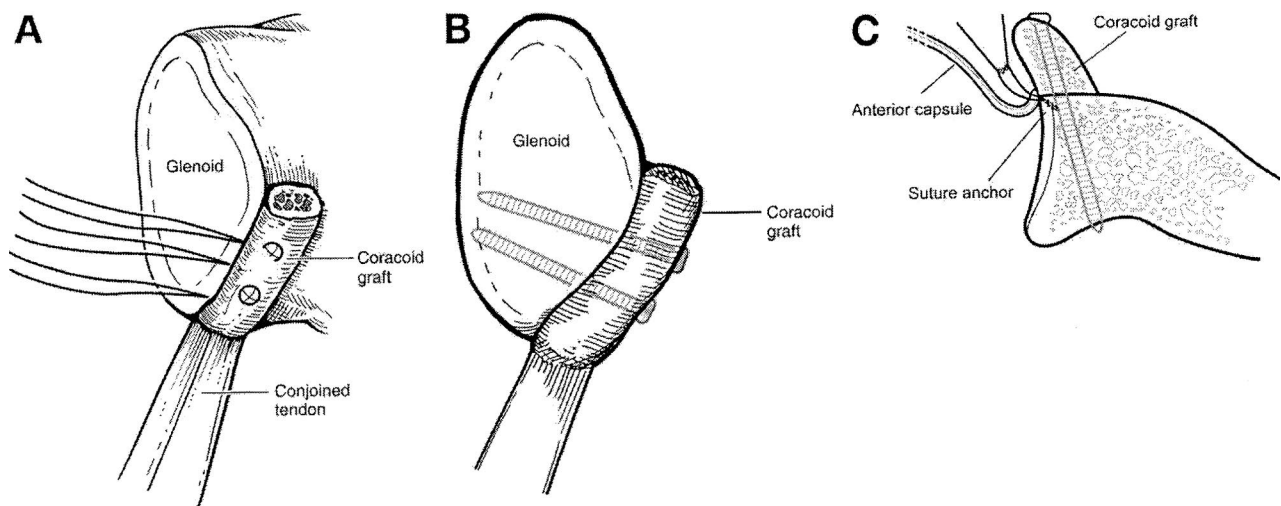
Significantly displaced fractures of glenoid cavity (rim and fossa)
At least 10 mm of displacement of fragments
At least 5 mm of articular incongruity (step-off)
At least 25% of anterior aspect of glenoid cavity
At least 33% of posterior aspect of glenoid cavity
Failure to maintain concentric radiographic reduction of humeral head
Significantly displaced fractures of glenoid neck
At least 10 mm of translational displacement
At least 40° of angular displacement (transverse or coronal plane)
Concomitant disruption of superior shoulder suspensory complex in which one or more elements of scapula are significantly displaced



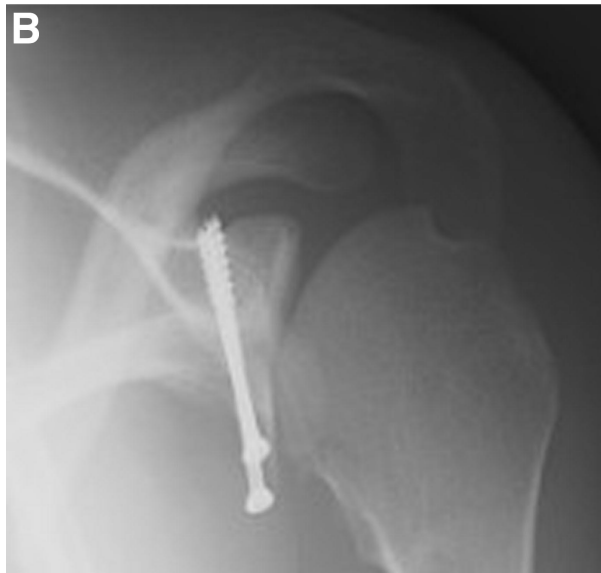
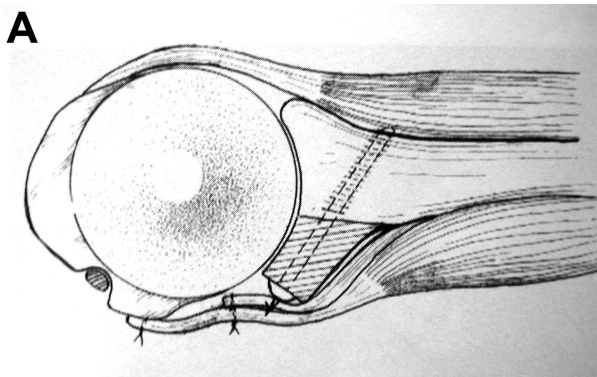
**FIGURE 5.** Bristow procedure. The Bristow procedure involves transfer of the tip of the coracoid process along with the conjoint tendon to the anteroinferior glenoid rim (Adapted with permission from *The Journal of Bone and Joint Surgery, Inc.*<sup>94</sup>)

involved attritional bone loss with no identifiable bony fragment. In cases with an identifiable fragment, it was incorporated into the repair, resulting in significantly improved stability and outcome scores. Sugaya et al.<sup>47</sup> reported only a 5% failure rate in a series of 39 patients with mean bone loss of 25%. In all cases a bony lesion was identified and incorporated into the repair. These authors highlighted the importance of searching for the bony fragment, which they often found hidden within the capsulolabral soft-tissue complex. Although these studies report some success with arthroscopic repair instead of open reconstruction, the common theme to their success was adequate recognition of the bony lesion and incorporation of the bony fragment into the repair when possible.

In addition to the success of these procedures for known bony instability, several authors have also developed arthroscopic versions of various existing reconstructive procedures. Nourissat et al.<sup>53</sup> performed a successful cadaveric pilot study of a mini-open arthroscopically assisted Bristow-Latarjet procedure. Boileau et al.<sup>48</sup> have reported good results at 19 months' follow-up for an arthroscopic Bankart repair supplemented by an arthroscopic Bristow transfer of the conjoint tendon with a coracoid fragment for patients with a stretched or deficient capsule. Lafosse et al.<sup>51</sup> subsequently described an arthroscopic version of the Latarjet technique using a larger coracoid graft fragment to re-create the glenoid arc. Mochizuki et al.<sup>52</sup> have reported on all-arthroscopic bone grafting



**FIGURE 6.** Latarjet procedure. The Latarjet procedure involves fixation of a longer arc of coracoid graft to the glenoid by use of 2 bicortical screws (A) to re-create the pear shape of the glenoid (B). (C) The graft is placed outside of the anterior capsule. (Adapted with permission.<sup>59</sup>)



**FIGURE 7.** Intra-articular (arc extension) iliac crest graft to glenoid. (A) An appropriately sized and contoured iliac crest autograft can be fixed to the glenoid with screws as an intra-articular extension of the glenoid arc beneath the capsule and subscapularis muscle. (Reprinted with permission of SAGE Publications, Inc.<sup>63</sup>) (B) A postoperative Garth view shows the completed reconstruction.

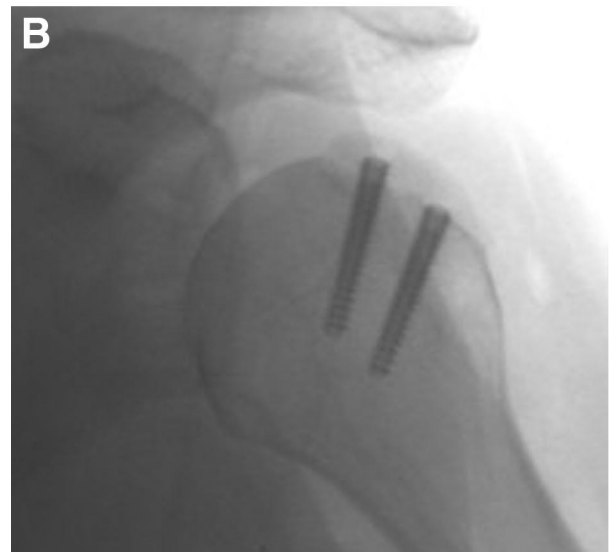
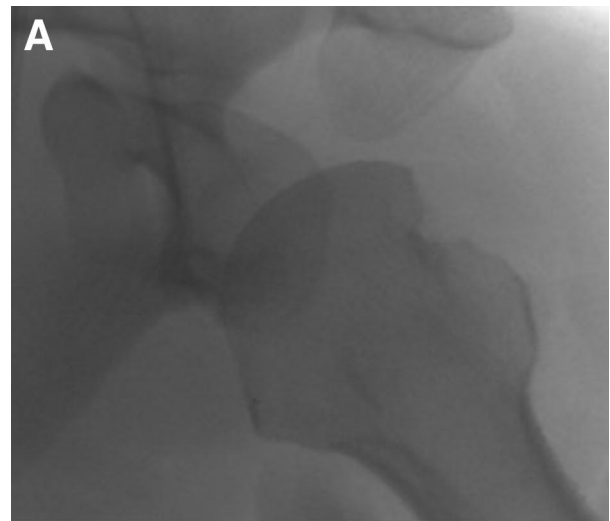
of the glenoid using a lateral acromion donor site for the graft, and Scheibel et al.<sup>64</sup> have described arthroscopic bone grafting of the glenoid using autologous tricortical iliac crest.

### Humeral Head

Several authors have described various forms of bone grafting for humeral head lesions, including iliac crest autograft,<sup>16,65</sup> coracoid process autograft,<sup>66</sup> local graft, fresh-frozen osteochondral allograft,<sup>67</sup> cancellous allograft,<sup>65</sup> humeral head allograft (Fig 8),<sup>6,16,68</sup> and femoral head allograft.<sup>69,70</sup> Reverse Hill-Sachs lesions may also be treated with a transfer of the

subscapularis tendon or the lesser tuberosity into the defect.<sup>66,70</sup>

Rotational osteotomy represents another option for treatment of humeral head lesions. In this technique the humeral head is rotated such that the area of pathology no longer contributes biomechanically to the instability.<sup>71,72</sup> Variations of a humeroplasty technique, in which the impression fracture of the humeral head is reduced by use of a bone tamp, may also be used. Kazel et al.<sup>73</sup> described a percutaneous humeroplasty in a cadaveric study, and Re et al.<sup>74</sup> described



**FIGURE 8.** Humeral head allograft for Hill-Sachs lesion. Preoperative (A) and postoperative (B) radiographs from a large Hill-Sachs lesion treated with fixation of a humeral head allograft via a posterior approach and 2 screws.<sup>16</sup>

an open humeroplasty in a small clinical series. Wolf et al.<sup>75</sup> have also described an arthroscopic “remplissage” procedure for treatment of engaging Hill-Sachs lesions, and Kelly and Ogunro<sup>76</sup> have described arthroscopic “filling” of Hill-Sachs lesions.

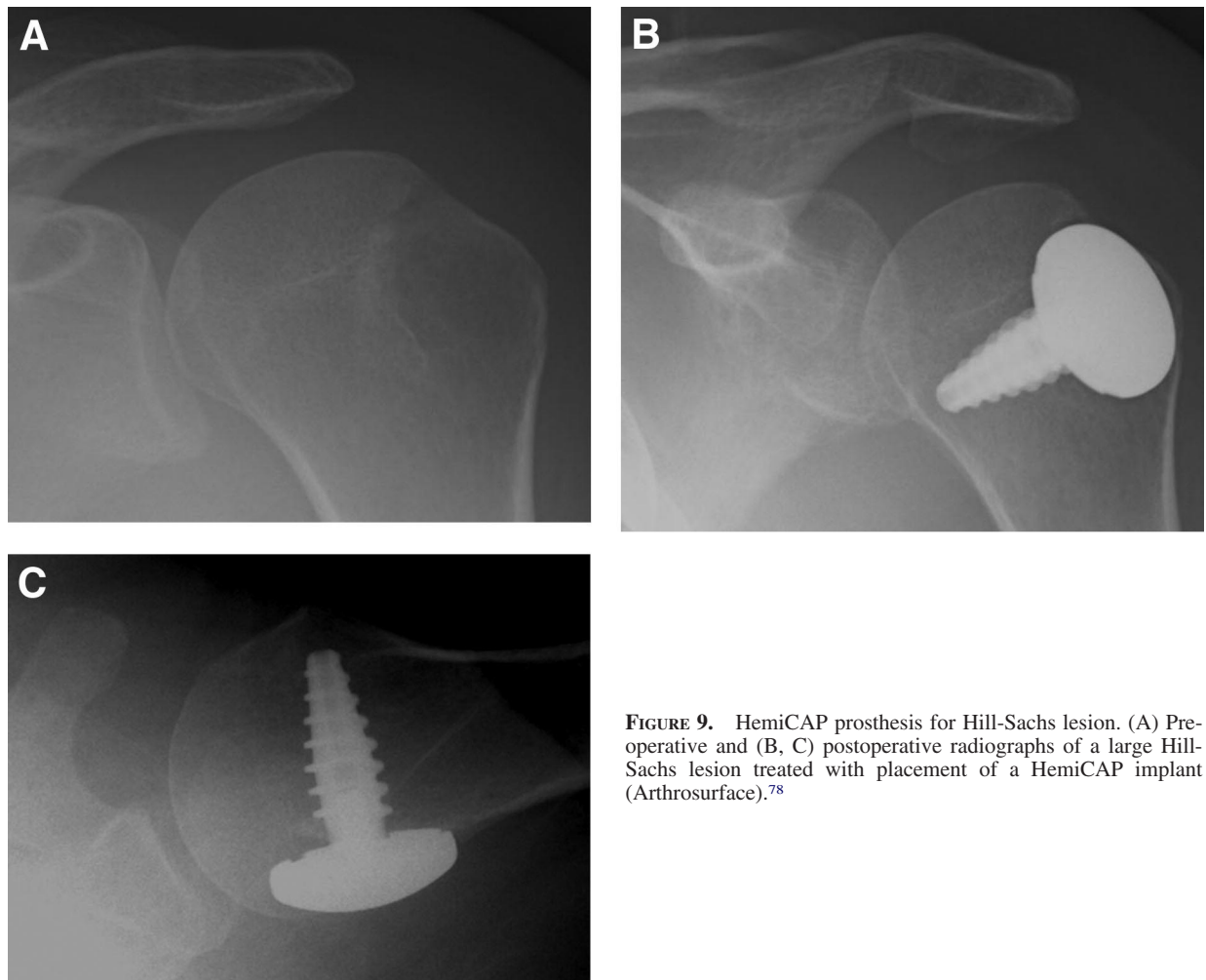
Prosthetic resurfacing arthroplasty has also gained popularity recently as a means of addressing large Hill-Sachs lesions and other focal deficits of the humeral head (Fig 9). Scalise et al.<sup>77</sup> have described their limited experience with the HemiCAP prosthesis (Arthrosurface, Franklin, MA) in targeted replacement of limited areas of insufficiency. Raiss et al.<sup>78</sup> have reported the use of the Copeland Shoulder prosthesis (Biomet Europe, Dordrecht, Netherlands) and the Epoca RH Cup (Argomedical, Cham, Switzerland) in reconstructing significant humeral head bone defects.

### Postoperative Rehabilitation

Rehabilitation after surgical intervention depends on the particular surgery involved, demands and expectations of the patient, medical comorbidities, other problems with the same shoulder (e.g., concomitant rotator cuff tear requiring repair), injuries or problems elsewhere in the body, available resources, and preferences of the treating surgeon. Ultimately, an individualized rehabilitation program should be specifically tailored for each patient, taking into consideration all of these factors.

### Complications

As with any invasive procedure, the surgeon must warn the patient about possible complications such as bleeding, infection, anesthetic risks, and worsening of



**FIGURE 9.** HemiCAP prosthesis for Hill-Sachs lesion. (A) Pre-operative and (B, C) postoperative radiographs of a large Hill-Sachs lesion treated with placement of a HemiCAP implant (Arthrosurface).<sup>78</sup>

medical comorbidities. Bony stabilization procedures also have their own unique possible complications as well. Harvesting graft from the iliac crest can lead to donor-site problems such as lateral femoral cutaneous nerve hypoesthesia, pain, or infection.<sup>8</sup> Open procedures requiring takedown of the subscapularis tendon have had high rates of subscapularis insufficiency, especially in revision cases.<sup>55</sup> Given the small, thin areas of bone involved in bony reconstruction of the glenoid or humerus, hardware-related problems may also occur, such as screw pullout, partial graft resorption, and excessive length with irritation of nearby structures (Fig 10). Arthritis is also a significant problem, especially in cases with greater bone loss, and may appear late even in cases of successful surgical treatment of instability.

In conclusion, most cases of instability of the shoulder usually do not involve a significant osseous lesion. When a contributory bony lesion is involved, however, it can be easily missed and result in failure of attempted surgical repair—usually because the surgeon has unknowingly addressed a bony problem with a soft-tissue solution. If the surgeon always considers bony instability in the differential diagnosis and follows an appropriate protocol for workup, however, the



**FIGURE 10.** Hardware complications. In this case a large Hill-Sachs lesion was treated with an allograft fixed with 2 headless screws. At 9 months postoperatively, the radiograph showed a symptomatic prominent screw and some resorption of the graft. The patient's symptoms resolved after removal of the screws, and stability was still maintained because the graft was well fixed.

symptomatic lesion can usually be effectively identified. The best choice of treatment options, on the other hand, still remains unclear. Multiple authors have reported successful outcomes in treating bony instability using a variety of procedures, but the literature has not yet provided definitive answers about which procedures may be better than others through direct comparisons in randomized controlled trials. The relative infrequency of bony instability makes such studies a challenging undertaking, and surgeons thus must rely on the existing literature for guidance. Open reconstructive procedures currently represent the best-studied options for treating bony instability, but arthroscopic versions of these techniques are quickly gaining popularity.

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