Level V Evidence With Video Illustration

Evolving Concept of Bipolar Bone Loss and the Hill-Sachs Lesion: From "Engaging/Non-Engaging" Lesion to "On-Track/Off-Track" Lesion

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Abstract: For anterior instability with glenoid bone loss comprising 25% or more of the inferior glenoid diameter (inverted-pear glenoid), the consensus of recent authors is that glenoid bone grafting should be performed. Although the engaging Hill-Sachs lesion has been recognized as a risk factor for recurrent anterior instability, there has been no generally accepted method for quantifying the Hill-Sachs lesion and then integrating that quantification into treatment recommendations, taking into account the geometric interplay of various sizes and various orientations of bipolar (humeral-sided plus glenoid-sided) bone loss. We have developed a method (both radiographic and arthroscopic) that uses the concept of the glenoid track to determine whether a Hill-Sachs lesion will engage the anterior glenoid rim, whether or not there is concomitant anterior glenoid bone loss. If the Hill-Sachs lesion engages, it is called an "off-track" Hill-Sachs lesion; if it does not engage, it is an "on-track" lesion. On the basis of our quantitative method, we have developed a treatment paradigm with specific surgical criteria for all patients with anterior instability, both with and without bipolar bone loss.

It is generally accepted that anteroinferior glenoid bone loss comprising 25% or more of the inferior glenoid diameter must be addressed by glenoid bone grafting, using either a coracoid graft (Latarjet procedure), iliac graft, or allograft.[1,2] However, there are no clear guidelines on how to address patients with bipolar lesions who have varying degrees of bone loss of the glenoid as well as the proximal humerus (Hill-Sachs defects). The geometric interplay of these bipolar lesions can be subtle, yet it is critical to understand the pathologic importance of this interplay in developing logical criteria for their surgical treatment.

Biomechanical and Anatomic Considerations

It is essential to define the role that the anteroinferior labrum and the bone play in distributing forces across the glenolabral complex during compressive loads, thus guaranteeing an adequate amount of intrinsic stability.

Greis et al.[3] showed the effect of progressive labral and bone loss on the articular contact area and pressure across the glenohumeral joint under compressive loads. Loss of the anteroinferior labrum decreased the contact area by 7% to 15% compared with the intact specimens, and the mean contact pressure increased by 8% to 20%. With bone loss in the anteroinferior quadrant corresponding to a defect measuring 30% of the diameter of the inferior glenoid, the contact area across the entire glenoid decreased by a mean of 41%, whereas the mean contact pressure for the entire glenoid increased by nearly 100% and mean contact pressures in the anteroinferior quadrant increased by 300% to 400%. Because progressive bone loss in the anteroinferior quadrant has the effect of causing further increases in mean contact pressure and peak pressure, as well as a decrease in contact area, an isolated soft-tissue (Bankart) repair without bone graft in a patient with significant glenoid bone loss would have to resist this overload at the bone—soft tissue repair interface. This overload at the repair site would increase the likelihood of failure of the repair. In recent years efforts have been made to identify the morphology, extent, location, and interaction of the bone losses that, if not restored, may potentially compromise surgical outcome expectations.

Burkhart and De Beer[4] recognized that one of the risk factors for failure of arthroscopic stabilization was based

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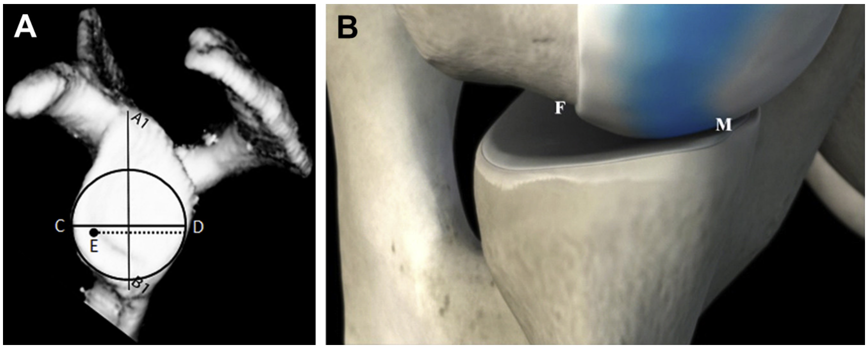

Fig 1. (A) Three-dimensional CT scan with en face view of a normal glenoid, with subtraction of the humeral head. The width of the glenoid track without a glenoid defect is 83% of the glenoid width. Line A1-B1 is the long axis of the glenoid; line C-D, which is perpendicular to A1-B1, is the glenoid width; and line E-D, which is 83% of the glenoid width, is equal to the width of the glenoid track. (B) Relation of glenohumeral joint in abduction and external rotation. The distance from the medial margin of the contact area (M) to the medial margin of the cuff footprint (F) is 83% ± 14% of the glenoid width: F − M = 83% of glenoid width = glenoid track.

on the anatomic relation of the bone loss affecting the humeral head and the glenoid in critical positions. In fact, they introduced the concept of "significant bone loss." They defined a significant glenoid bone defect as 1 in which the arthroscopic appearance of the glenoid, when viewed from a superior-to-inferior perspective, was an inverted pear. On the humeral side, they defined a significant bone defect to be an engaging Hill-Sachs lesion, oriented in such a way that it engaged the anterior glenoid in a position of athletic function (90° of abduction combined with external rotation of approximately 90°). They found that the instabilities associated with "engaging-type" Hill-Sachs lesions were at high risk of recurrence if treated with the classic arthroscopic capsuloligamentous repair, confirming that the restoration of the soft tissues alone would not be sufficient to contain the humeral head under stress.

Burkhart and De Beer[4] emphasized the role of arthroscopy as a dynamic diagnostic tool that was essential in identifying the bone lesions "at risk" so that the surgeon could restore both the anatomy and the biomechanical function of the damaged structures. They reported that most arthroscopic repair failures have resulted from traumatic bone defects on either the glenoid or humeral side and that the underlying cause of failure was not inadequate soft-tissue fixation but, rather, traumatic bone deficiency. They initiated a paradigm shift in the surgical approach to treatment of instabilities, and their ideas prompted orthopaedic surgeons to reconsider the merits of certain more classic surgical techniques.[2,5-10]

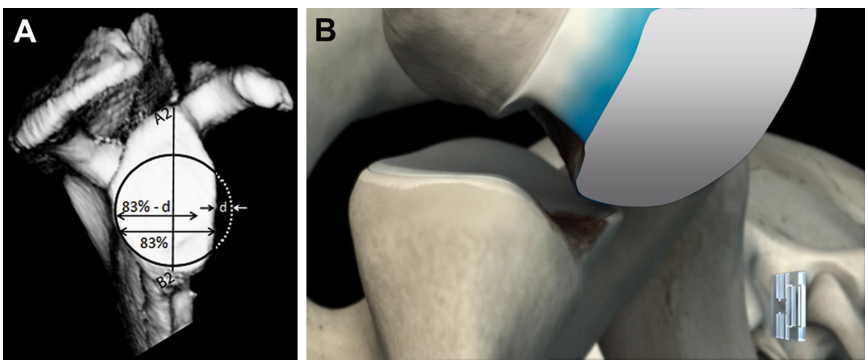

Fig 2. (A) Three-dimensional CT scan with en face view of a glenoid with bone loss of width d. In such a case with glenoid bone loss, the glenoid track will be 83% of the normal glenoid width minus d. A2-B2 is the long axis of the glenoid. (B) Relation of glenohumeral joint in abduction and external rotation. One should note the loss of contact of the intact humeral articular surface with the articular surface of the glenoid due to anteroinferior glenoid bone loss. In this case the large Hill-Sachs interval (i.e., distance from posterior rotator cuff attachments to medial margin of Hill-Sachs lesion) is wider than the glenoid track, whose width has been reduced because of the glenoid bone loss.

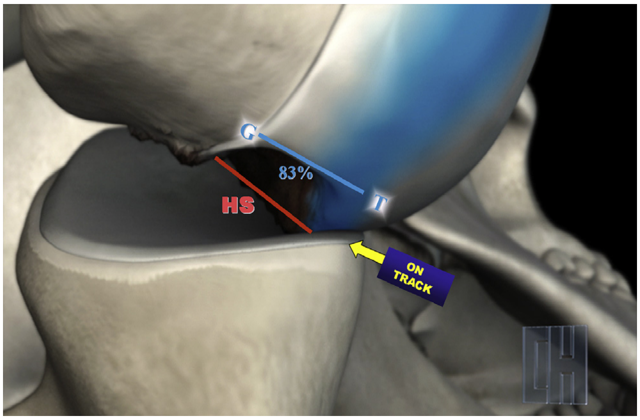

Fig 3. Glenohumeral joint in abduction and external rotation. If the Hill-Sachs lesion (HS) is within the medial margin of the glenoid track (G-T), there is still glenoid track support for bone stability (on-track Hill-Sachs lesion). This implies that intrinsic stability can be shared between the Bankart repair and bone support.

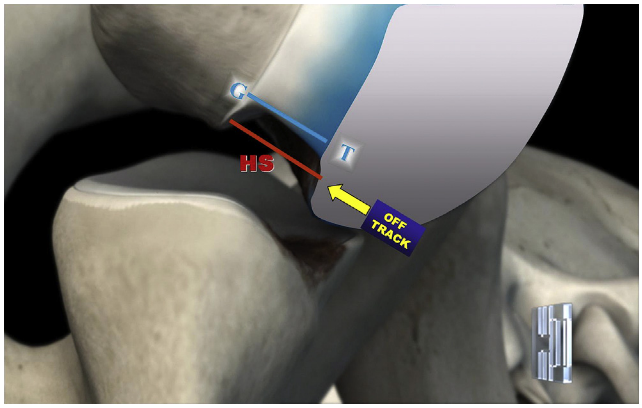

Fig 4. Glenohumeral joint in abduction and external rotation in shoulder with glenoid defect and Hill-Sachs lesion (HS) (bipolar bone loss). The Hill-Sachs lesion extends medial to the medial margin of the glenoid track (G-T), with loss of bone support at the anterior glenoid rim (off-track Hill-Sachs lesion).

Subsequently, this work was in part confirmed by an "instability severity index score" that viewed humeral and glenoid bone loss as a clear contraindication to arthroscopic treatment.[11] In addressing the instability severity index, Balg and Boileau[11] stated that there is no simple method available to identify patients in whom recurrent instability will develop after an arthroscopic Bankart procedure and who would be better served by an open operation. However, in their prospective case-control study, they identified the following risk factors: patient aged younger than 20 years at the time of surgery, involvement in competitive or contact sports or in sports involving vigorous overhead activity, shoulder hyperlaxity, and radiographically identifiable bone defects (a Hill-Sachs lesion on the anteroposterior radiograph of the shoulder in external rotation and/or loss of the sclerotic inferior glenoid border).

Itoi and associates[12-14] examined the exact anatomic relation between the humeral head and the glenoid in various critical positions, when all the anterior soft-tissue structures were preserved. This investigation was a prelude to the critically important concept of the "glenoid track."

The Glenoid Track: Its Relation to Engaging and Non-Engaging Hill-Sachs Lesions

Itoi and associates[15] introduced the concept of the glenoid track. Using 3-dimensional (3D) computed tomography (CT) scans, they identified bipolar bone losses that, interacting in different dynamic ways in abduction and external rotation, may require treatment with bone graft. They clarified the contact area of the humeral head and the glenoid from the standpoint of shoulder dislocation. They showed that, as the arm was raised, the glenoid contact area shifted from the inferomedial to the superolateral portion of the posterior articular surface of the humeral head, creating a zone of contact between the glenoid and the humeral head. They defined this contact zone as the glenoid track. An intact glenoid track, without significant bone loss, guarantees bone stability. The distance from the medial margin of the contact area to the medial margin of the rotator cuff attachment onto the humerus was 18.4 ± 2.5 mm, or $84\% \pm 14\%$ of the glenoid width with the arm at 60° of abduction to the scapula or 90° of abduction to the trunk.[15] Omori et al.[16] measured the width of the glenoid track in live shoulders. In this preliminary study using a semi-dynamic method, they reported that the glenoid track width with the arm at 90° of abduction was $85\% \pm 12\%$ of the glenoid width. More recently, they compiled the data of 30 volunteers and concluded that the glenoid track width was $83\% \pm 12\%$ (unpublished data, Omori Y, August 2013). In this article we use this most recent value of 83% obtained in live shoulders (Fig 1). The integrity of the glenoid track and the location of the Hill-Sachs lesion with respect to the medial margin of the glenoid track become essential in identifying those bipolar bone lesions at risk when standard stabilization procedures such as Bankart repair are being considered. We believe that the definition of engaging versus non-engaging Hill-Sachs lesions, though still very important in distinguishing significant loss, is in need of clarification in terms of how these lesions relate to the glenoid track.

The concept of engaging versus non-engaging lesions of Burkhart and De Beer[4] is completely consistent with the concept of the glenoid track of Itoi and associates.[15] They are complementary concepts in that they both evaluate the interaction of bipolar bone loss during dynamic shoulder function. The presence of an engaging Hill-Sachs lesion can be detected at arthroscopy with the

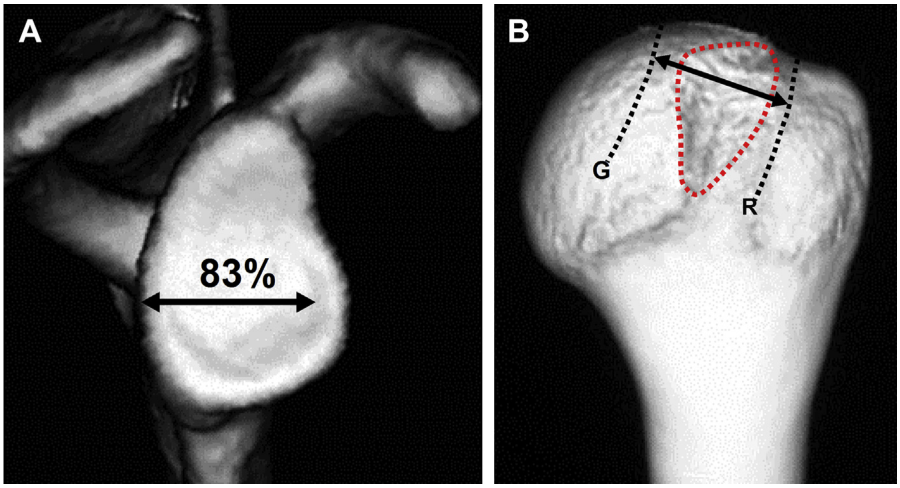

Fig 5. Case with no bony defect of glenoid (A) and medium-sized Hill-Sachs lesion (B). By use of the contralateral glenoid as a reference (100%), 83% width is determined, which is the distance from the medial margin of the footprint of the rotator cuff to the medial margin of the glenoid track. Dotted line G indicates the location of the medial margin of the glenoid track. Dotted line R represents the medial margin of the rotator cuff attachments. This Hill-Sachs lesion is on track because it lies totally within the glenoid track.

arm in abduction—external rotation, whereas the glenoid track can be evaluated by either arthroscopy or CT scan. Itoi and colleagues[17] and Boileau and associates[18] have stated that all bipolar bone lesions are engaging because engagement was required for formation of the Hill-Sachs lesion. In fact, if the exact mechanism and sufficient energy were to be reproduced, all bipolar lesions would engage. This concept was reinforced by Kurokawa et al.,[19] who recommended that the glenoid track rather than dynamic intraoperative assessment be used to assess engaging Hill-Sachs lesions. Dynamic intraoperative assessment is almost always performed before repairing the Bankart lesion. However, this diagnostic technique could potentially cause an over-diagnosis of engaging Hill-Sachs lesions because ligament insufficiency might permit the humeral head to excessively translate anteriorly, thus facilitating engagement of the humeral defect with the glenoid rim. Such anterior translation of the humeral head during motion in the horizontal plane has been shown experimentally.[20] Kurokawa et al. defined the "true engaging Hill-Sachs lesion" as either a lesion that engages after Bankart repair or a lesion that extends over the glenoid track. On the basis of the latter definition, they reported that in their series of 100 shoulders with recurrent anterior dislocation, 94 shoulders had a Hill-Sachs lesion, and 7 of these (7.4%) were defined as having a true engaging Hill-Sachs lesion. On the other hand, Parke et al.[21] reported the prevalence of engaging Hill-Sachs lesions using the former definition. They arthroscopically looked for engagement after Bankart repair in 983 shoulders and found that 70 shoulders (7.1%) showed engagement. It should be emphasized that

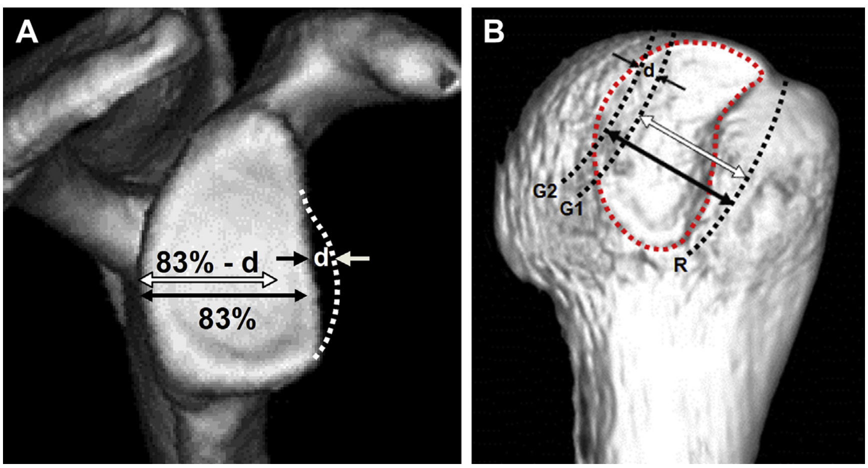

Fig 6. Case with bony defect of glenoid (A) and large Hill-Sachs lesion (B). By use of the contralateral glenoid as a reference (100%), 83% width is determined (black double-headed arrow). Then, the defect width (d) is subtracted from this 83% length to obtain the glenoid track width for this case (white double-headed arrow). Dotted line R represents the medial margin of the rotator cuff attachments. It should be noted that there is normally an intact "bone bridge" between the cuff attachments and the lateral border of the Hill-Sachs lesion. Dotted line G1 indicates the location of the medial margin of the glenoid track. If there had been no glenoid bony defect, the medial margin of the glenoid track would have been dotted line G2.In this case the Hill-Sachs lesion extends medially beyond the medial margin of the glenoid track (dotted line G1), so this is an off-track lesion.

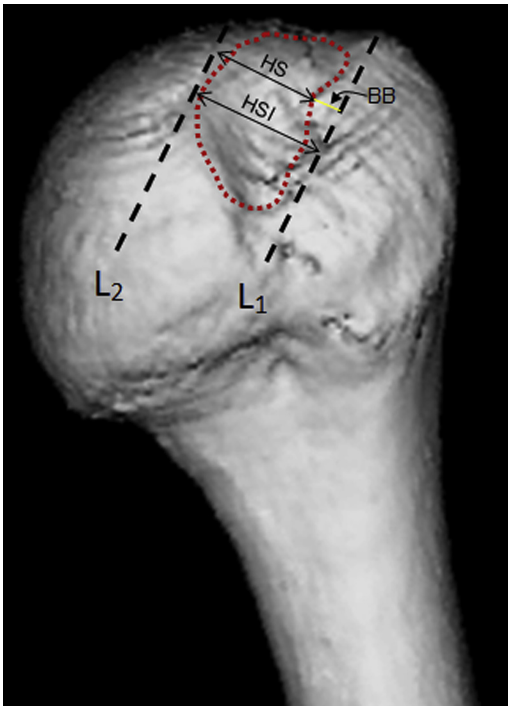

Fig 7. The HSI in this right shoulder is defined as the width of the Hill-Sachs (HS) lesion plus the width of the intact bone bridge (BB) that lies between the Hill-Sachs lesion and the posterior rotator cuff attachments. Dotted line L1 represents the medial margin of the rotator cuff attachments, and dotted line L2 represents the medial margin of the glenoid track in this particular case.

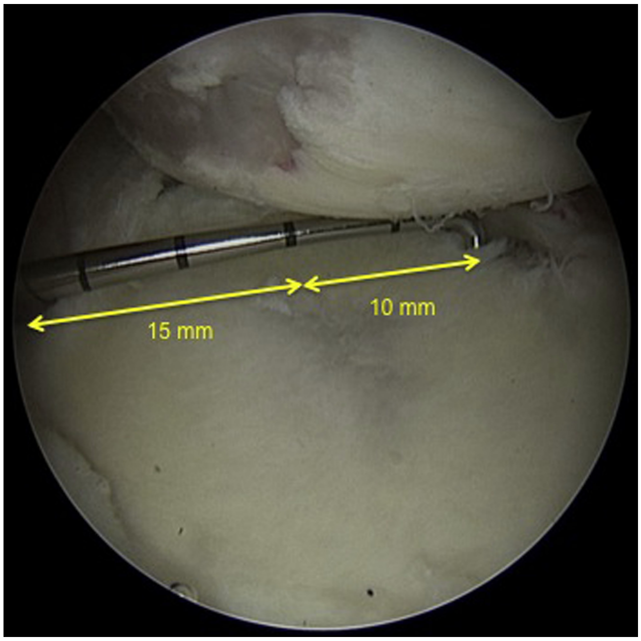

Fig 8. Left shoulder, anterosuperolateral viewing portal. The calibrated probe, with 5-mm hash marks, has been introduced through a posterior portal. The radius of the glenoid is the distance from the bare spot of the glenoid to the posterior glenoid rim, or 15 mm (3 hash marks). There has been some anterior bone loss, and the distance from the bare spot to the anterior glenoid rim is only 10 mm, indicating that there has been a 5-mm anterior glenoid bone loss.

the prevalence of true engaging Hill-Sachs lesions using dynamic arthroscopic assessment after Bankart repair is the same as that assessed by use of the glenoid track concept. It is noteworthy that the prevalence of true engaging Hill-Sachs lesions (7%) is not as common as previously reported with the use of only dynamic arthroscopic assessment before Bankart repair (34% to 46%).[22-24]

Bipolar Bone Loss: On-Track Hill-Sachs Lesions Versus Off-Track Hill-Sachs Lesions

The importance of adequate bone as an element of stability has been confirmed; thus its interpretation

Table 1. How to Determine Whether Hill-Sachs Lesion Is "On Track" or "Off Track"

1. Measure the diameter (D) of the inferior glenoid, either by arthroscopy or from 3D CT scan.
2. Determine the width of the anterior glenoid bone loss (d).
3. Calculate the width of the glenoid track (GT) by the following formula: $GT = 0.83\ D - d$.
4. Calculate the width of the HSI, which is the width of the Hill-Sachs lesion (HS) plus the width of the bone bridge (BB) between the rotator cuff attachments and the lateral aspect of the Hill-Sachs lesion: $HSI = HS + BB$.
5. If $HSI > GT$, the HS is off track, or engaging. If $HSI < GT$, the HS is on track, or non-engaging.

and evaluation become essential. As mentioned previously, the dynamic interaction of bipolar bone loss assessed at arthroscopy, before Bankart repair, risks reproducing a situation that is only partially reliable because it does not correspond to the anatomic and biomechanical context of a shoulder with an intact capsuloligamentous complex. On the other hand, evaluating the engagement arthroscopically after completion of an arthroscopic Bankart repair, albeit more correct from the anatomo-functional standpoint, can put the repair at risk by overstressing the newly repaired capsulolabral complex in abduction and external rotation, thus compromising the repair itself. In essence, these arthroscopic techniques provide qualitative information about Hill-Sachs engagement. However, we now believe that engagement must be quantified to be rigorously demonstrated.

It is precisely on this point that Itoi et al.[12] emphasized quantification of bipolar bone damage. The diagnostic arthroscopic evaluation that is performed before Bankart repair to evaluate engaging versus non-engaging Hill-Sachs lesions should thus be reconsidered in favor of a new concept that comprises an evaluation of the glenoid track, including the influence of associated glenoid bone loss, and the role of the location of the Hill-Sachs lesion with respect to the glenoid track itself (Fig 1).

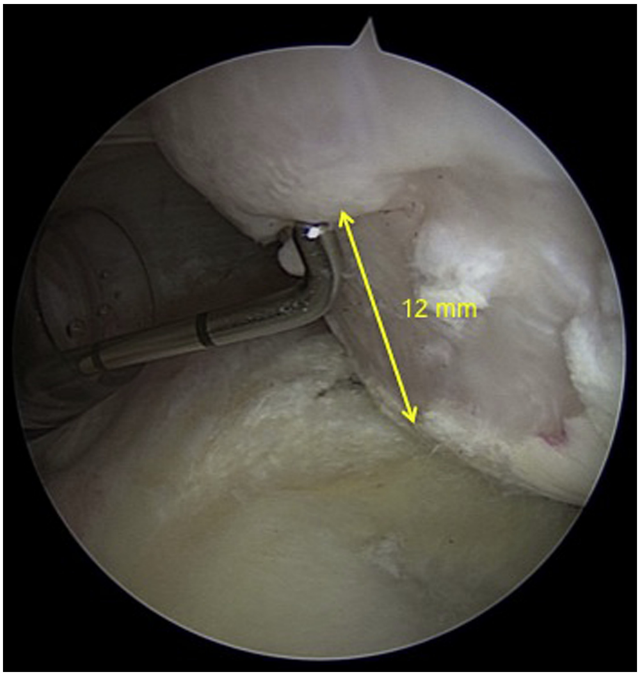

Fig 9. The width of the Hill-Sachs lesion is measured sequentially by the 4-mm tip of the probe. The Hill-Sachs lesion has a width equal to 3 probe tips: 3 × 4 mm = 12 mm.

The width of the glenoid track decreases if there is a glenoid bone defect. To calculate the width of the glenoid track in a patient with glenoid bone loss, the width of the defect should be subtracted from 83% of the glenoid width, which is the width of the glenoid

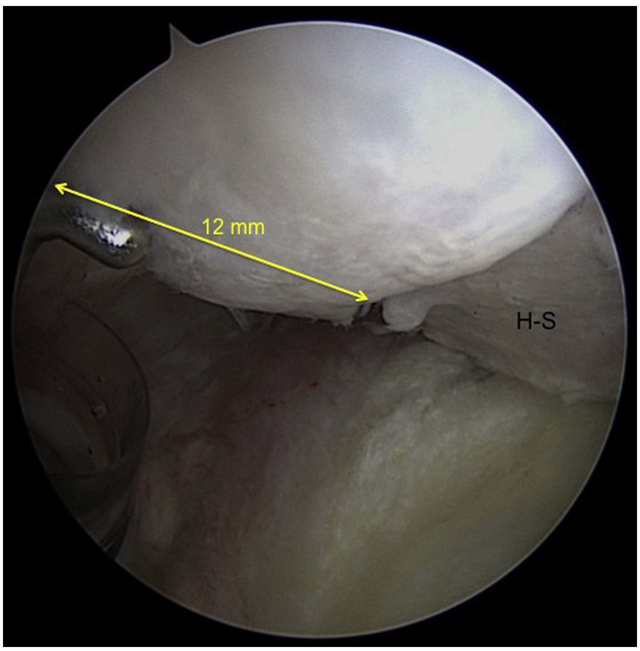

Fig 10. The width of the bone bridge between the posterior cuff attachments and the Hill-Sachs lesion (H-S) is found to span 3 probe tips: 3 × 4 mm = 12 mm.

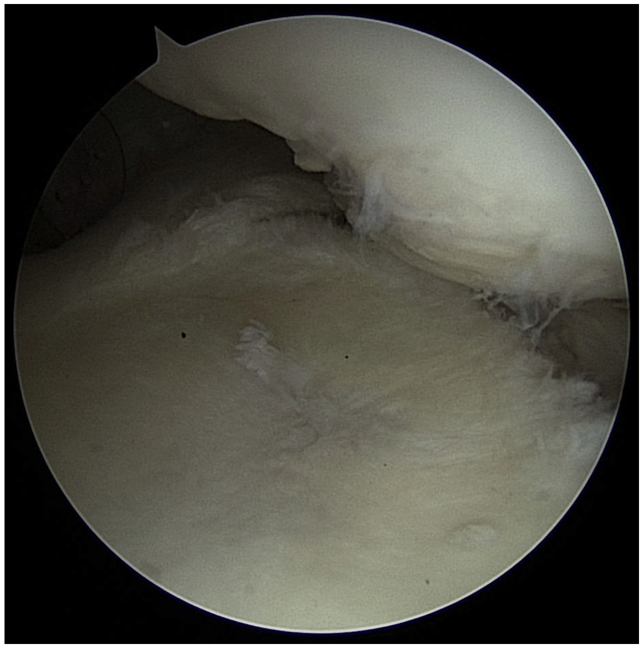

Fig 11. The off-track Hill-Sachs lesion engages the anterior glenoid rim.

track when there is not a glenoid defect (Fig 2). In this way, the bone defects of the glenoid and humeral head can be assessed with regard to each other. If the medial margin of a Hill-Sachs lesion is within the glenoid track, there is bone support adjacent to the Hill-Sachs lesion and the Hill-Sachs lesion is "on track" (Fig 3); if the medial margin of the Hill-Sachs lesion is more medial than the glenoid track, there is no bone support and the Hill-Sachs lesion is "off track" (Fig 4).

How to Assess an On-Track/Off-Track Hill-Sachs Lesion by Means of a CT Scan: The Importance of the Hill-Sachs Interval

As previously mentioned, the location of the medial margin of the glenoid track is equivalent to 84% of the glenoid width in cadaveric shoulders[15] and 83% in live shoulders (unpublished data, Omori Y, August 2013). For the measurements in live shoulders, a semi-dynamic magnetic resonance imaging (MRI) analysis was used, but the software for this technique is not yet commercially available. We are hopeful that in the near future we can transition from CT scan to MRI scan to obtain our quantitative evaluation of bone defects, thereby avoiding additional radiation.

Using the 83% value as the mean glenoid track width, we will demonstrate how to assess whether a Hill-Sachs lesion is on track or off track. First, we visualize the glenoid and the humeral head using 3D CT (Figs 5 and 6). When we order a unilateral shoulder scan, the patient is placed in the CT gantry and both shoulders are always placed in the scanning field. With a single scan, the data of both shoulders are recorded regardless

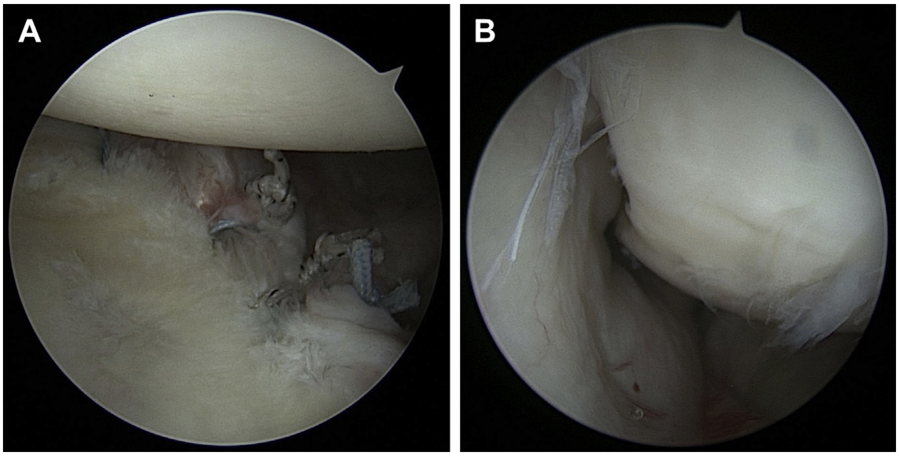

Fig 12. Left shoulder, anterosuperolateral viewing portal. (A) Arthroscopic Bankart repair. (B) Arthroscopic remplissage.

of our order for single shoulder scanning. Thus we can use the data of both shoulders whenever we order a single shoulder CT scan. First, we create an en face view of the glenoid. There are various methods to assess the size of the glenoid bony defect: defect length,[1] width-to-length ratio,[25,26] glenoid index (i.e., defect width/circle diameter),[25,27] and Pico method (i.e., defect area/circle area).[28,29] We prefer to use the contralateral shoulder as a reference because the difference between the right and left sides is extremely small.[28-31] According to Jeske et al.,[30] the average area difference between the left and right sides was only 1.8%. We can reliably use the contralateral glenoid as a reference.

We measure the greatest horizontal distance of the glenoid (width) on both shoulders. Using the intact glenoid width as a reference, we calculate the defect size (d) as follows: d = Intact glenoid width − Injured glenoid width (Fig 6A).

Next, using the posterior view of the humeral head, we identify the medial margin of the footprint of the rotator cuff and the Hill-Sachs lesion (Figs 5B and 6B). Then, we set a line located at a distance equivalent to 83% of the glenoid width from the medial margin of the rotator cuff footprint. If there is no bony defect of the glenoid, this line represents the medial margin of the glenoid track (line G in Fig 5B). If there is a bony defect of the glenoid (d), we subtract the distance d from the 83% line to obtain the medial margin of the true glenoid track (line G1 in Fig 6B). If the Hill-Sachs lesion is located within the glenoid track, we call it an on-track Hill-Sachs lesion (Fig 5B). If it extends more medially over the medial margin of the glenoid track, we call it an off-track Hill-Sachs lesion (Fig 6B). It is important to note that there is typically an intact bone bridge between the rotator cuff attachments and the lateral margin of the Hill-Sachs lesion (Fig 7). This bone bridge width plus the width of the Hill-Sachs lesion equals what we call the HSI, whose medial margin is the critical point in determining whether a Hill-Sachs lesion is on track or off track.

Table 2. Anterior Instability Categories

Group	Glenoid Defect	Hill-Sachs Lesion
1	<25%	On track
2	<25%	Off track
3	≥25%	On track
4	≥25%	Off track

Arthroscopic Assessment of On-Track/Off-Track Status of Hill-Sachs Lesion

With the foregoing principles in mind, one can systematically evaluate bipolar bone loss arthroscopically to determine whether a Hill-Sachs lesion is on track or off track (Table 1; Video 1, available at www.arthroscopyjournal.org). First, while viewing from an anterosuperolateral portal, one measures the radius of the inferior glenoid by measuring the distance from the bare spot of the glenoid to the posterior glenoid rim (Fig 8). Then, one doubles the radius to obtain the inferior glenoid diameter (D). In the example shown in Fig 8, the diameter (D) is as follows: 2 × 15 mm = 30 mm. One then measures the distance from the anterior glenoid rim to the bare spot of the glenoid. If there is no glenoid bone loss, this measurement should be the same as the posterior glenoid radius (15 mm). However, in this case the anterior measurement is only 10 mm (Fig 8), implying an anterior bone loss of 5 mm.

Table 3. Treatment Paradigm

Group	Recommended Treatment
1	Arthroscopic Bankart repair
2	Arthroscopic Bankart repair plus remplissage
3	Latarjet procedure
4	Latarjet procedure with or without humeral-sided procedure (humeral bone graft or remplissage), depending on engagement of Hill-Sachs lesion after Latarjet procedure

According to our formula, the glenoid track in the face of bone loss (d) is equal to 0.83 D − d. In this case we calculate the width of the glenoid track as follows: $0.83 \times 30 - 5 = 19.9$ mm (Fig 6A).

Next, we turn our attention to the Hill-Sachs lesion to determine what we have termed the Hill-Sachs interval (HSI). The HSI is the distance from the rotator cuff attachments to the medial rim of the Hill-Sachs lesion, and it is equal to the width of the Hill-Sachs lesion plus the width of the intact bone bridge between the rotator cuff and the Hill-Sachs lesion (HSI = Width of Hill-Sachs lesion + Width of bone bridge) (Fig 7). In this case the width of the Hill-Sachs lesion is 12 mm (Fig 9) and the width of the bone bridge is 12 mm (Fig 10): HSI = 12 mm + 12 mm = 24 mm. In this example, HSI equals 24 mm and the glenoid track is 19.9 mm wide. Therefore the medial rim of the Hill-Sachs lesion extends beyond the glenoid rim (because the HSI is greater than the glenoid track), so the Hill-Sachs is an off-track engaging lesion (Fig 11) as defined in Fig 6B. As our paradigm will show later in this article, our recommendation for treatment of an unstable shoulder with an off-track Hill-Sachs lesion in association with glenoid bone loss of less than 25% is a combination of arthroscopic Bankart repair plus arthroscopic remplissage (Fig 12).

The Next Step: A New Paradigm for Addressing Bone Loss in Instability

We believe that anterior instability patients with glenoid bone loss comprising 25% or more of the inferior glenoid diameter, regardless of the size of the Hill-Sachs defect, must be treated with a bone graft to the glenoid. The bone graft will widen the glenoid track to such an extent that in virtually all cases, the Hill-Sachs lesion cannot go off track. If, after grafting of the glenoid, the Hill-Sachs lesion still goes off track when the arm is brought into abduction and external rotation, the surgeon would need to consider either concomitant bone grafting of the Hill-Sachs defect or else remplissage of the Hill-Sachs lesion. However, this is hardly ever necessary. We prefer to address significant bipolar bone loss with a Latarjet procedure, in which the coracoid bone graft provides additional stability from the sling effect of the conjoined tendon. With this combination of glenoid track enlargement and the sling effect, the Latarjet procedure is able to effectively address even large degrees of bipolar bone loss without having to resort to additional humeral-sided procedures (humeral bone graft or remplissage).

In cases with glenoid bone loss of less than 25% of the inferior glenoid diameter, the Hill-Sachs lesion is usually small or nonexistent. In such cases an arthroscopic Bankart repair should be performed. However, one may see a large Hill-Sachs lesion in association with a glenoid that has little or no bone loss. In such a case, we recommend that the surgeon obtain a preoperative 3D CT scan to measure the width of the HSI (HSI = Hill-Sachs lesion + Bone bridge) (Fig 8). If the HSI width is greater than 83% of the inferior glenoid diameter, we recommend that arthroscopic remplissage be added to the arthroscopic Bankart repair. Obviously, the surgeon must consider sports-specific and activity-specific demands in each individual patient. For example, in an overhead athlete, the surgeon may wish to avoid remplissage because of the loss of motion that accompanies this procedure, particularly with the arm in abduction and external rotation. Conversely, in certain high-risk collision athletes, the surgeon might choose to perform a Latarjet procedure, even with lesser degrees of bone loss, to reduce the chance of recurrent instability. It should be noted that MRI measurement techniques are in development and should soon obviate the need for the CT scan, thereby eliminating the concerns about excessive radiation to the patient.

Conclusions

On the basis of the foregoing discussion, we prefer to categorize all of our anterior instability patients, regardless of the degree of bipolar bone loss, into 1 of 4 categories (Table 2): group 1, glenoid defect of less than 25% plus on-track Hill-Sachs lesion; group 2, glenoid defect of less than 25% plus off-track Hill-Sachs lesion; group 3, glenoid defect of 25% or more plus on-track Hill-Sachs lesion; and group 4, glenoid defect of 25% or more plus off-track Hill-Sachs lesion. By use of these categories, our recommended surgical treatment paradigm is as follows (Table 3): group 1, arthroscopic Bankart repair; group 2, arthroscopic Bankart repair plus remplissage; group 3, Latarjet procedure; and group 4, Latarjet procedure plus humeral-sided procedure (humeral bone graft or remplissage) if the Hill-Sachs lesion is engageable by surgeon on operating room table after Latarjet procedure or only Latarjet procedure if Hill-Sachs lesion is not engageable by surgeon after Latarjet procedure.

We believe that conversion of an off-track Hill-Sachs lesion to an on-track Hill-Sachs lesion is essential in stabilizing the shoulder with anterior instability. Our paradigm consistently achieves this goal.

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