Editorial Commentary: It Is Not the Size, But the Location of Hill-Sachs Lesion That Matters

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Abstract: The risk of a Hill-Sachs lesion (HSL) to engage the anterior glenoid rim depends on the location of the medial margin of the HSL relative to the anterior rim of the glenoid. The same-sized HSL can be engaging or nonengaging depending upon the size of the glenoid. In order to assess these bony lesions (bipolar lesion) together, the glenoid track concept has been introduced: an on-track lesion (stable) and an off-track lesion (unstable). Three-dimensional computed tomography (3D-CT) confirms that more medialized HSLs have larger volume, greater width, more surface area loss, and higher lesion angles (HS angle), and are more inferior in the humeral head. We know that medialization of the HSL is a definitive risk factor to make it off track, whereas the volume, surface area, and width are all subordinate risk factors dependent on the medialization. On the other hand, while we know very little about the orientation of the HSL, recent research shows a significant association between the medialization and orientation of the HSL. However, we do not know whether the orientation is an independent risk factor or dependent on the medialization. There are two things I emphasize when I look at a HSL: 1) do not look at the HSL alone, but look at the glenoid as well, and 2) the risk of the HSL depends on the location of the medial margin of the HSL relative to the glenoid, not on the volume, depth, or length.

See related article on page 3255

A Hill-Sachs lesion (HSL) is a compression fracture of the posterolateral portion of the humeral head created by the anterior rim of the glenoid when the humeral head comes out of the glenoid socket (anterior shoulder dislocation).[1] An anterior dislocation of the shoulder occurs either 1) at the end-range of motion, such as hyperflexion or abduction + horizontal extension, or 2) in the mid-range of motion.[2-6] However, a HSL and the anterior glenoid rim almost always fit in the mid-range of motion.[6,7] This means that the arm position at the time of dislocation and the one in which a HSL is created are not usually the same. This was confirmed in a cadaveric study, which revealed that HSLs were created not at the time of dislocation, but when the arm came to an equilibrium position under the muscle force.[1] After the reduction of dislocation, a HSL may engage the anterior glenoid, leading to another dislocation. This is the risk of HSL, which needs to be assessed in the clinical setting.

The risk of HSL to cause another dislocation has been reported in the literature by various investigators using various measurements such as the size,[8-10] percentage to the humeral head surface,[11,12] depth,[13,14] or volume[14] of the HSL. The present study "Advanced 3-Dimensional Characterization of Hill-Sachs Lesions in 100 Anterior Shoulder Instability Patients" by Golijianin, Peebles, Arner, Peebles, Douglass, Rider, Ninkovic, Midtgaard, and Provencher.[15] is also related to the measurements of various parameters of HSL. Using 3D-CT reconstruction, the authors measured the volume, surface area, width, and depth, as well as location and orientation of HSL. They found that the more medialized HSL had larger volume, greater width, more surface area loss, higher HS angles, and more inferior in the humeral head. They did not show any instability data related to these parameters. Thus, this is basically an anatomic study showing various parameters of HSL measured on 3D-CT images. I would like to point out that all of these studies in the literature, including the present study, are looking only at one side (HSL) of bipolar lesion, not the other (glenoid). There is no question that the risk of HSL cannot be determined by

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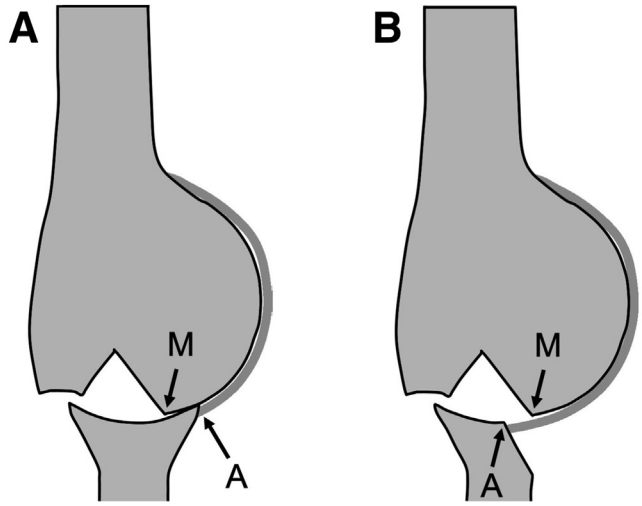

Fig 1. Hill-Sachs lesion (HSL) and the glenoid. (A) This HSL is entirely covered by the glenoid at the end range of motion. The medial margin of the HSL (M) is located lateral to the anterior rim of the glenoid (A with arrow), which means that this HSL is an on-track lesion. This shoulder is stable once the Bankart lesion is repaired. (B) The same HSL can be an off-track lesion if there is a bone loss of the glenoid. The medial margin of the HSL (M) extends more medially over the anterior rim of the glenoid (A with arrow). This shoulder is unstable even after the Bankart repair. These illustrations clearly show that the risk of HSL cannot be determined by the HSL alone. The size of the glenoid should also be taken into consideration. Reproduced with modification from Itoi E. 'On-track' and 'off-track' shoulder lesions. *EFORT Open Rev.* 2017; 2:343-351.[16]

the HSL alone. The same-sized HSL can be stable (Fig 1A) or unstable (Fig 1B) depending upon the size of the glenoid.[16] Therefore, the risk of HSL must be assessed together with the glenoid.

How can we assess the risk of bipolar lesion? One method is to use a dynamic examination during surgery. The problem is that many doctors perform this examination at the very beginning of the surgery, before the Bankart repair. Originally, Burkhart and Danaceau reported a case of failed Bankart repair, in which they performed a dynamic examination.[17] With the arm in abduction and external rotation, a large HSL engaged the anterior glenoid rim although the Bankart lesion had been well healed and stable on probing. As shown in their report, this examination should be performed without a Bankart lesion or after the Bankart repair. Otherwise, we may overestimate the existence of engagement. Another problem with using dynamic examination is that if you find the existence of engagement after the Bankart repair, an additional procedure such as remplissage to the HSL is technically demanding because the humeral head is already stabilized in the glenoid socket. From the clinical viewpoint, we would like to know whether an additional procedure is necessary or not before the Bankart repair. For this purpose, another method has been introduced: the glenoid track concept.[18] The glenoid track is defined as the zone of contact of the glenoid on the articular surface of the humeral head when the arm is moved along the posterior end-range of motion, such as maximum external rotation and maximum horizontal extension at various angles of abduction. If a HSL stays within the glenoid track (on-track lesion), there is no risk of engagement or no risk of recurrent dislocation because the anterior glenoid (medial margin of the glenoid track) is more medial than the HSL; it is completely on the articular surface of the humeral head. If a HSL extends more medially than the glenoid track (off-track lesion), there is a risk of engagement, and another dislocation may occur (Fig 2).

The point is that it is a location of the medial margin of the HSL relative to the anterior glenoid rim (medial margin of the glenoid track) that matters. The length, volume, or depth of the HSL does not matter. It is similar to a risk of falling into a pitfall when you are walking in a wide, open field. The risk of fall entirely depends on where you walk (glenoid track). It has nothing to do with the depth, volume, or length of the pitfall (HSL).

On the basis of the glenoid track concept, it is quite understandable that medialization of the HSL is a definitive risk factor (Fig 2).[19,20] Recently, we reported that the HSL with its medial margin located in the medial 1/4 of the glenoid track was related not to a higher recurrence rate but to a less satisfactory WOSI score. We called it a "peripheral-track lesion", which needs to be carefully considered for treatment

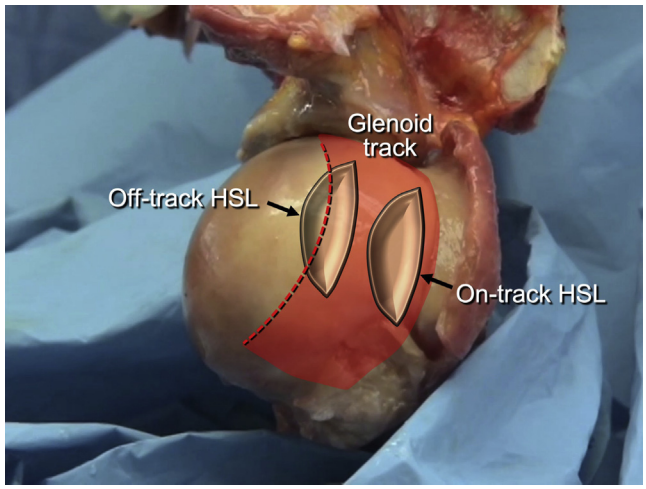

Fig 2. On-track HSL and off-track HSL. Posterior view of the cadaveric shoulder simulating a position of full-abduction, maximum external rotation, and maximum horizontal extension. The glenoid is on top of the humeral head. The orange zone along the posterior margin of the humeral head indicates the glenoid track. The HSL, which is completely inside the glenoid track, is called an "on-track" HSL, whereas the one which extends more medially than the medial margin of the glenoid track is called an "off-track" HSL.

selection.[21] A similar finding was reported by other investigators, who called it a "near-track lesion".[22] Other factors, such as volume, depth, and width seem to be subordinate to medialization because an increase in any of these factors would cause medialization of the HSL, considering the shape of the lesion.

Another parameter of HSL that we have to consider is the orientation of HSL.[2,17,23] Burkhart and De Beer were the first to pay attention to the orientation of the HSL.[2] They reported that a HSL created at a position of athletic function (90° of abduction and 0°-135° of external rotation) could engage with the arm in a functional position because the long axis of the HSL became parallel to the anterior glenoid rim in this position, whereas a HSL created at a nonfunctional position (adduction) presented the long axis of the HSL closer to the axis of the humerus, diagonal and nonparallel to the glenoid, and accordingly no engagement in a functional position. They defined the former an "engaging HSL" and the latter a "nonengaging HSL". The orientation of the HSL is determined solely by the position of the humeral head relative to the glenoid when it becomes indented by the glenoid.[2] It is closer to the axis of the humerus with the arm in adduction and more angled with the arm in abduction. Cho et al. measured the orientation of HSL (HS angle) and compared it between the engaging and nonengaging HSLs.[23] They found that the engaging HSLs were with greater HS angle, wider and deeper in size, but not medialized. These data are somewhat difficult to understand because a wide HSL should be medialized. In general, a HSL is located at the posterolateral corner of the humeral head, and when it becomes wider, it needs to extend medially, as it cannot extend laterally because of the rotator cuff. Di Giacomo et al. looked at the relationship between the HS angle and the position of dislocation. They divided the patients into two groups: ABD group (dislocation occurred in abduction $\geq 60°$) and ADD group (dislocation occurred in adduction $<60°$).[6] They found that the mean HS angle was much greater in the ABD group (32.4°) than in the ADD group (16.1°). In this study, they did not show any data regarding engagement or postsurgical recurrent instability. They just speculated that a large HS angle would increase the risk of recurrent instability because the axis of a HSL with a large HS angle would be almost parallel to the glenoid in a functional position of abduction and external rotation. Interestingly, the present study demonstrated that the larger the HS angle, the more medialized the HSL. This is a novel finding of this study. Since the medialization is a definitive risk factor of recurrent instability, a greater HS angle may be related to recurrence via medialization. In future studies, we need to clarify whether the orientation of the HSL is an independent risk factor or just dependent on the medialization of the HSL.

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