Anatomical Reconstruction of Reverse Hill-Sachs Lesions Using the Underpinning Technique

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abstract

Full article available online at Healio.com/Orthopedics. Search: 20120426-35

Posterior glenohumeral joint dislocation is an uncommon injury and is associated with bony and ligamentous disruption. It requires prompt diagnosis and early treatment to prevent acute or recurrent instability and subsequent dysfunction. Reverse Hill-Sachs lesions associated with this injury are challenging to treat, and optimal treatment is controversial. Treatment methods can be divided into those that achieve stability through muscle transfers, osteotomies, or posterior bone-block procedures (glenoid augmentation) and those that restore the sphericity of the humeral head. Joint replacement is often suggested for large head lesions (>50%) considered beyond reconstruction. Restoration of stability, preservation of the proximal humeral anatomy, and salvage of the humeral head sphericity should be the treatment goals in the younger population.

This article describes the surgical technique of elevation of the impressed osteochondral fragment followed by filling the lesion with Allomatrix bone graft putty (Wright Medical Technology, Arlington, Tennessee) in 2 patients. The size of the head lesion was <35%. Underpinning raft screws were used to provide subchondral support and prevent the collapse of the elevated fragment. Postoperatively, the sphericity of the humeral head and glenohumeral stability were restored. No evidence of collapse, osteonecrosis, or osteoarthritis progression was seen at latest follow-up. Functional results were excellent, with a minimum follow-up of 2 years.

This technique is an alternative method of restoring humeral head sphericity in patients with acute posterior glenohumeral joint dislocations with medium (20%-40%) reverse Hill-Sachs lesions.

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Drs Banerjee, Singh, Das, and Patel have no relevant financial relationships to disclose.

The authors thank Dr Shubhasree Dutta Choudhary for helping with the illustration of the surgical technique.

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doi: 10.3928/01477447-20120426-35
Posterior shoulder dislocation is a rare injury and is associated with bony or ligamentous disruption. Posterior dislocations occur following high-velocity trauma, epileptic seizures, and electrocution. The reverse Hill-Sachs lesion of the humeral head, which can accompany posterior glenohumeral joint dislocations, may contribute to recurrent posterior instability. Treatment is usually based on the size of the articular lesion. Open and arthroscopic surgical procedures have been described for the correction of instability secondary to humeral head lesions ranging from 0% to 50% of the articular circumference. Stability restoration, preservation of the proximal humeral anatomy, and salvage of the humeral head sphericity should be the goals of treatment in the younger population. The extent of the humeral head lesion that can be treated with elevation and bone grafting is debatable. Hemiarthroplasty or total shoulder arthroplasty have been suggested for major articular lesions beyond reconstruction (>50% articular circumference). This article describes the underpinning raft screw technique following elevation of the impressed cartilage for the reconstruction of medium (20%-40%) reverse Hill-Sachs lesions.

CASE REPORT

Patient 1

A 40-year-old man sustained a bilateral posterior shoulder dislocation following an electrocution accident when he fell from a ladder 6 feet in height. He underwent emergent closed reduction at another hospital and was referred to our shoulder unit 2 weeks following the initial injury because he reported persistent right shoulder stiffness, pain, instability, and clicking. On physical examination, the contour of the shoulder girdle was maintained bilaterally. The active range of motion (ROM) in the left shoulder was forward flexion to 170°, external rotation to 50°, and internal rotation to the T12 spinous process. The active ROM of the right shoulder was forward flexion to 120°, external rotation to 50°, and internal rotation to the L1 spinous process. The patient reported significant pain on passive forward flexion beyond 120° in the right shoulder. On clinical examination, the rotator cuff was intact on both sides. The posterior drawer or relocation test was Grade 2+ (translation of the humeral head onto the glenolabral rim with clunking but no locking) on the right side but was negative on the left side.

Initial plain radiographs revealed bilateral anterior humeral head lesions (Figures 1, 2). Magnetic resonance imaging (MRI) and computed tomography (CT) of the shoulders revealed an anterior humeral head lesions on the right side measuring approximately 34% of the humeral head arc and 20% on the left side (Figure 3; Table 1). The left shoulder was treated nonoperatively due to the small size of the lesion, absence of instability after closed reduction, and the lack of signs or symptoms on clinical assessment. The right shoulder was treated operatively to restore stability and humeral head articular congruity.

Patient 2

A 42-year-old man was riding a motorcycle at 20 miles per hour when he collided with a car that turned sharply in front of him. He went over the handle bars and landed on his outstretched right hand and then directly on his right shoulder. After initial assessment and resuscitation, radiographs revealed a posterior dislocation of the right shoulder. He underwent emergent closed reduction using the modified lever principle under general anesthesia.

Intraoperatively, the shoulder was significantly unstable, with redislocation and palpable locking of the humeral head beyond 10° of internal rotation in 70° of forward flexion and neutral adduction/abduction. The shoulder was unstable beyond 25° of internal rotation with the elbow by the side of the body. This led to clinical suspicion of a reverse Hill-Sachs lesion, and CT scan with 3-dimensional reconstruction revealed an anterior humeral head lesion involving 35% of the head circumference and an associated undisplaced fracture through the surgical neck of humerus (Neer Type 1 injury) (Table 1; Figures 4-7). The patient’s young age and instability linked with the
humeral head lesion necessitated urgent operative intervention to restore the humeral head anatomy.

**SURGICAL TECHNIQUE**

The patient was placed in a beach-chair position with a gel pad under the ipsilateral scapulae. The shoulder was exposed through an anterior deltopectoral approach. The cephalic vein was identified in the deltopectoral groove and preserved throughout the procedure. The subscapularis muscle was identified after retraction of the conjoined tendon. The subscapularis tendon was tenotomised 1 cm from its insertion for ease of repair during closure. The anterior glenohumeral capsule was incised longitudinally to expose the humeral head lesion and the fracture site. Anterior circumflex vessels and the axillary nerve were identified and preserved intraoperatively.

The interface between the depressed articular fragment and the cortical bone was developed with a one-quarter-inch osteotome, and the intact anteromedial periosteal hinge was preserved. The depressed fragment was then elevated by using the one-quarter-inch osteotome as a lever, and the void created after elevation of the articular fragment was filled with Allomatrix bone graft putty (Wright Medical Technology, Arlington, Tennessee). The articular fragment was then reduced and impacted into its bed, ensuring appropriate alignment.

Two 0.9-mm K-wires were inserted in the provisional direction of the underpinning screws from the lesser tuberosity directed anteroposteriorly into the head, passing through the fragment in a subarticular location. The position of the K-wires was checked to avoid intra-articular placement under the image intensifier in multiple projections. The lengths of the K-wires were measured to ascertain the screw size. A cannulated 2.7-mm drill bit (Synthes, Solothurn, Switzerland) was used to drill over the K-wire under image guidance to avoid displacement of the elevated fragment and intra-articular penetration. The K-wires were then replaced sequentially with two 3.5-mm full, threaded non-cannulated cortical screws (underpinning screws) in a raft configuration in the subchondral bone to provide subarticular support to the elevated fragment (Figure 8).

In patient 2, the proximal humeral fracture was initially stabilized with a 3-hole PHILOS plate (Synthes) (Figures 9, 10). Following stabilization of the surgical neck fracture with the PHILOS plate, the depressed fragment was elevated, and the void was filled with Allomatrix bone putty. The underpinning raft screw was then placed in the subchondral region directed from the lesser tuberosity using the underpinning technique. The subscapularis tendon was repaired with No. 2 FiberWire (Arthrex, Naples, Florida) at the end of the procedure using a Mason-Allen configuration, and the wound was closed in layers.

Postoperatively, both patients were advised to use a brace restricting internal rotation beyond neutral for 4 weeks. Active forward flexion up to 90° and external rotation up to 20° were allowed. After 4 weeks, full active ROM was allowed. Sporting activities were prohibited for 6 months.

At final follow-up, neither patient had radiographic evidence of graft

### Table: Patient Demographics and Results

<table>
<thead>
<tr>
<th>Case</th>
<th>Age, y/Sex/Handedness</th>
<th>Mechanism of Injury</th>
<th>Operation Interval</th>
<th>Profession</th>
<th>Complication/Further Procedure</th>
<th>Quick DASH Score</th>
<th>Oxford Shoulder Score</th>
<th>ROM Forward Flexion</th>
<th>ROM Abduction</th>
<th>ROM External Rotation</th>
<th>ROM Internal Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40/M/R</td>
<td>Electroconvulsion/bilateral</td>
<td>3 weeks</td>
<td>Plumber</td>
<td>None</td>
<td>34 mo</td>
<td>35</td>
<td>160</td>
<td>150</td>
<td>40</td>
<td>T12 spinous process</td>
</tr>
<tr>
<td>2</td>
<td>42/M/R</td>
<td>MVA/Right</td>
<td>5 days</td>
<td>Motor Vehicle Instructor</td>
<td>Adhesive capsulitis/arthroscopic capsular release at 14 months</td>
<td>24 mo</td>
<td>35</td>
<td>160</td>
<td>150</td>
<td>40</td>
<td>T12 spinous process</td>
</tr>
</tbody>
</table>
collapse, humeral head avascular necrosis, or osteoarthritis progression (Figures 11, 12). The proximal humeral fracture healed in anatomic alignment in patient 2. Neither patient reported clicking, catching, or recurrent instability in the shoulder. At 14 months postoperatively, patient 2 underwent an arthroscopic capsular release and subacromial decompression to improve the ROM in the right shoulder. Range of motion prior to the arthroscopic release was abduction of 140°, forward flexion of 140°, external rotation of 15°, and internal rotation to the L1 spinous process. Intraoperatively, the articular cartilage was normal on the glenoid side and Grade 1 arthritic on the humeral head. The reverse Hill-Sachs lesion had healed, with no evidence of overlying arthritic change (Figure 13). At final follow-up, both patients had regained almost full ROM (Table 1).

Patient 1’s Oxford shoulder score and Quick Disabilities of the Arm, Shoulder, and Hand score at final follow-up (24 months postoperatively) were 0. Patient 2’s Oxford shoulder score and Quick DASH score 34 months after injury were 10 and 35, respectively. Both patients had returned to work by final follow-up (Table 1). Clinical assessment of subscapularis strength revealed a Medical Research Council grade of 5/5 bilaterally in both patients.

**DISCUSSION**

Initial nonoperative management with immobilization in neutral or external rotation for 4 weeks after satisfactory stable, closed reduction of acute posterior dislocations with anterior humeral head lesions <20% is usually recommended. Instability, acute or recurrent, following closed reduction of acute posterior shoulder dislocation with anterior humeral head lesions necessitates surgical stabilization. Treatment methods can be divided into those that achieve stability through muscle transfers, osteotomies, or posterior bone-block procedures (glenoid augmentation) and those that restore the sphericity of the humeral head. Hemiarthroplasty or total shoulder arthroplasty are often suggested for large head lesions (>50%) considered beyond reconstruction. Although the results of transfer of the subscapularis tendon (Neer’s modification) or the lesser tuberosity with the attached subscapularis tendon (McLaughlin procedure) into the anteromedial lesion has been satisfactory for small impression fractures, they are less successful for lesions between 20% and 40%. Neer’s procedure, besides altering the anatomy of the proximal humerus, may lead to subscapularis dysfunction secondary to muscle contracture or from loss of strength. This produces a challenge if prosthetic reconstruction is required at a later date. Rotational osteotomy has also been described but has not been used widely due to the technical difficulty and the risk of devascularization of the humeral head.

**Figure 4:** Anteroposterior radiograph showing the humeral head lesion.

**Figure 5:** Axillary lateral radiograph showing the reverse Hill-Sachs lesion with the undisplaced fracture of the surgical neck.

**Figure 6:** Axial computed tomography scans showing the extent of the reverse Hill-Sachs lesion.

**Figure 7:** Coronal computed tomography scan showing the undisplaced fracture of the surgical neck.

**Figure 8:** Diagram showing the underpinning technique.
rior bone-block procedures produce good short-term results, they can lead to the progression of glenohumeral arthritis and poor clinical outcomes.\textsuperscript{15,16} Preservation of humeral head sphericity is achieved through structural osteochondral allograft/autograft or elevation of the impressed cartilage and bone grafting of the lesion. The extent of the anterior humeral head lesion that can be treated with elevation of the depressed osteochondral fragment and bone grafting of the void created is debatable.

Bock et al\textsuperscript{14} reported good to excellent results in a series of 6 patients, of which 5 had acute posterior dislocations of the glenohumeral joint following elevation of the impressed cartilage and filling the lesion with autograft, allograft, or composite graft with Mitek suture anchors (DePuy Mitek, Raynham, Massachusetts) holding the impacted graft. All patients in this series had humeral head lesions between 30\% and 45\%. Complications occurred in 2 patients. One patient had a recurrent dislocation postoperatively, which required revision surgery. The second patient had progression of osteoarthritis at follow-up.

Engel et al\textsuperscript{17} described an arthroscopic retrograde technique of elevation of the depressed osteochondral fragment. They used a bioabsorbable screw through the window created for elevation of the lesion to provide support and prevent collapse of the osteochondral fragment. The size of the lesion was not reported, although they performed preoperative axial CT scans to assess the reverse Hill-Sachs lesion. The void created after elevation of the lesion was buttressed with a bioabsorbable screw, without the need for bone grafting. Performing this technique requires arthroscopic skills.

Assom et al\textsuperscript{18} described an open retrograde technique through a cortical window that uses a bioabsorbable screw after elevation of the depressed articular cartilage through the rotator interval without jeopardizing the subscapularis in his series of 2 patients. However, the techniques described by Assom et al\textsuperscript{18} and Engel et al\textsuperscript{17} become redundant if an associated proximal humeral fracture occurs that prevents the use of a cortical window for the elevation of the lesion. It is also technically challenging to approach the entire extent of the humeral head lesion through the rotator interval without jeopardizing the subscapularis, especially for lesions >30\%.

In a series of 26 patients with posterior shoulder fracture dislocation by Robinson et al\textsuperscript{19}, 6 required elevation of the depressed osteochondral fragment and morsellized allografting. Five patients required a frozen structural osteoarticular allograft to fill the anterior humeral lesion. However, the exact technique used was not reported.

In the 2 patients in the current study, the underpinning screws provided subarticular support to prevent collapse of the elevated osteochondral fragment. AlloMatrix bone putty filled the void created after elevation of the impressed cartilage. This technique is similar in concept to the treatment of depressed tibial plateau fractures using raft screws for subchondral support. However, this has not been elaborately described in the literature for the treatment of reverse Hill-Sachs lesions. The use of bone graft substitute avoids donor site morbidity of the autograft harvest and is available off the shelf. In contrast, frozen allografts need to be specially procured. This technique can be used for dislocations and fracture dislocations provided the impressed cartilage is not fragmented. The underpinning raft screws provide stable subchondral support, which prevents articular cartilage collapse. The maintenance of humeral head sphericity was ratified arthroscopically at 14-month follow-up (patient 2). This technique can be used as an alternative treatment for anterior humeral head lesions <40\% following acute posterior glenohumeral joint dislocation.

The limitations of the current article include the short-term follow-up and the lack of an MRI to assess the viability of the humeral head. The sphericity of the humeral head on a plain radiograph was considered a sign of a well perfused and viable humeral head. Larger series are required to assess the results of this treat-
allows for restoration of humeral head sphericity and glenohumeral stability without the donor site morbidity of autograft harvest or compromising the proximal humeral anatomy through the tendon transfer operations. This technique is an alternative method of restoring humeral head sphericity in patients with acute posterior glenohumeral joint dislocations with medium (20%-40%) reverse Hill-Sachs lesions.

**REFERENCES**