Chondral and Osteochondral Lesions of the Humerus: Diagnosis and Management

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Chondral and osteochondral injuries to the humeral head are common in the setting of shoulder instability and often contribute to recurrent instability. Such lesions also may result from high-energy trauma, avascular necrosis, infection, and iatrogenic causes. Although small lesions may be successfully managed nonoperatively, there are expanding indications for the surgical management of symptomatic chondral and osteochondral lesions of the humeral head. We will review the etiologies of such lesions and the most current and effective diagnostic and treatment strategies. This work also provides concise, but detailed, guidelines and technical pearls for the most common surgical techniques for managing focal and extensive chondral and osteochondral lesions of the humeral head, including microfracture, allograft and autograft osteoarticular transplant grafts, autologous chondrocyte implantation, transhumeral disimpaction with bone grafting, structural allograft reconstruction, and soft-tissue transfers, such as remplissage and lesser tuberosity transfers. We also include pertinent evidenced-based literature in the support of each of these approaches. This review is intended to serve as a helpful resource to orthopedic surgeons managing the challenges of symptomatic chondral and osteochondral lesions of the humeral head.
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Chondral and osteochondral injuries to the humeral head may be attributed to previous surgery, trauma, acute or recurrent dislocation, avascular necrosis, infection, chondrolysis, osteochondritis dissecans, inflammatory arthritides, or osteoarthritis. The incidence of symptomatic Outerbridge grade II-IV lesions of the shoulder is reported to range from 5% to 17%, although asymptomatic cartilage lesions frequently are seen as incidental findings during arthroscopy.[1] The most common traumatic chondral lesion of the glenohumeral joint is the osteochondral fracture of the humeral head (Hill Sachs lesion), with an incidence of 30% to 71% after initial anterior dislocation,[2-5] and almost 100% in the setting of recurrent dislocations.[6,7] Burkhart and De Beer coined the term "engaging" Hill Sachs lesions to describe humeral head defects that drop over the glenoid rim and become partially or completely stuck when the arm is externally rotated.[8,9]

The geometry of these lesions is such that they are aligned parallel to the glenoid when the arm is abducted and externally rotated. In their series, "engaging" Hill Sachs defects were present in all patients with recurrent shoulder instability.[9]

The location and extent of osteochondral damage of the humeral head depends on the pattern and chronicity of glenohumeral dislocations. Both anterior and posterior shoulder dislocations associated with epileptic seizures have been shown to create large to massive bony defects of the humeral head (Hill Sachs lesions in anterior dislocations, reversed Hill Sachs lesions in posterior dislocations).[10] For large defects, structural grafts or other more extensive reconstructive techniques often are necessary to obtain clinical stability.[10] Although symptomatic, diffuse cartilage loss of the humeral head, as is seen in osteoarthritis, can be successfully treated by prosthetic arthroplasty,[11] focal cartilage lesions in the younger, active patient population demand alternative treatment strategies that preserve the joint. This article will focus on surgical techniques to treat focal chondral and osteochondral defects of the humeral head in younger, more-active individuals.

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Etiology

Chondral and osteochondral lesions may be caused by previous surgery, trauma, acute or recurrent dislocation, osteonecrosis, infection, chondrolysis, osteochondritis dissecans, inflammatory arthritides, rotator cuff arthropathy, and osteoarthritis.

Focal Chondral and Osteochondral Defects

There are limited reports on the surgical treatment of focal chondral and osteochondral defects of the humeral head. Isolated blows to the shoulder or high-impact trauma have resulted in focal cartilage lesions, which can be associated with extensive subchondral bone injury.[12,13] Active people and athletes are at greater risk for traumatic cartilage lesions than the general population.[12,13] Damage is attributed to high compressive and/or shear forces. Focal osteochondral defects of the humeral head are most commonly attributed to trauma and are frequently located along the superior surface of the posterior humeral head, more medial to the typical location of a Hill-Sachs lesion.[12]

Hill Sachs Lesions

Hill Sachs lesions are caused by impaction of the soft bone of the humeral head into the harder bone at the edge of the glenoid during dislocation. In anterior glenohumeral dislocations, defects are commonly found on the posterolateral aspect of the humeral head, with the specific location varying depending on the amount of abduction and external rotation at the time of dislocation. The extent and depth of these osteochondral injuries has been correlated to the number and frequency of recurrent dislocations.[6]

Osteochondritis Dissecans

Osteochondritis dissecans (OCD) is an uncommon finding in the glenohumeral joint. There have been a few cases reported involving the humerus or the glenoid. As such, there is no data on their true incidence. Most cases of OCD of the humeral head have been reported in the anterosuperior aspect of the articular surface, in young and middle-aged, active men.[14] The exact etiology of OCD is still not clear, but many patients have a history of repetitive microtrauma or one major trauma, suggesting that damage to the subchondral plate must play a significant role.[14-16]

Diagnosis

Clinical Evaluation

Glenohumeral cartilage lesions are mostly well tolerated and frequently are incidental findings during the arthroscopic treatment of more common glenohumeral conditions. Patients often describe vague symptoms and are unable to localize the source of their shoulder pain. Glenohumeral cartilage loss has been shown to reproduce the clinical presentation of impingement syndrome, perhaps the most common shoulder condition.[17] Not surprisingly, a precise and detailed history and physical examination are often the most important factors in establishing the proper diagnosis.

Particular points in the clinical history that may suggest cartilage lesions include:

- high-impact trauma, especially traumatic dislocation;
- previous shoulder surgery, especially with anchor placement;
- recurrent shoulder subluxations or dislocations;
- mechanical symptoms (clicking, catching, clunking); and
- increasing stiffness

In addition to the standard elements of the shoulder examination, the compression-rotation test[17] has been shown to be very helpful in differentiating between subacromial impingement and focal, chondral lesions. During this test, the patient is asked to internally and externally rotate the arm while axial compression of the glenohumeral joint is maintained by the examiner. Pain, especially in the midranges of motion, may indicate focal chondral damage in the glenohumeral joint. Subacromial injection with local anesthetics makes this test more specific by eliminating symptoms associated with subacromial impingement. As the result of the greater prevalence of chondral lesions in the setting of shoulder instability and rotator cuff tears, surgeons must focus their efforts at detecting possible concomitant chondral injuries.

Patients who suffer from osteochondral lesions may present with loss of external rotation, mechanical clunking, instability symptoms especially in midrange, or recurrent instability and dislocation. In those with pain and loss of external rotation, one should always consider the possibility of a locked posterior dislocation as the cause.

Imaging

Traditionally, imaging should begin with a standard shoulder series to include anterior-posterior (AP), trans-scapular-Y, and axillary views. The axillary view is particularly useful for visualizing Hill Sachs lesions, glenoid lip fractures, and joint space narrowing. Subchondral cyst formation, associated with high −Rade focal chondral lesions may also be detected on the axillary view. The West Point axillary view is best for evaluating glenoid rim fractures, and the Stryker notch view is best for Hill Sachs lesions. If chondral or osteochondral defects are suspected, magnetic resonance imaging (MRI) is strongly recommended. MRI remains the gold standard for detecting focal chondral lesions (Fig. 1), although the limited cartilage thickness of only 1.0 to 1.3 mm in the humeral head[12,18] leads to diminished sensitivity with standard MRI. Studies have described chondral lesions along the superior surface of the posterior humeral head, medial to the expected location of a Hill-Sachs lesion.[12] The addition of arthrography to MRI has been shown to yield greater sensitivity in detecting focal chondral lesions.[19] Early work with new, high-field MRI at 3.0-T shows promising results in more accurate detection of cartilage lesions in the shoulder-joint.

Although MRI and even ultrasound have high accuracies to detect Hill Sachs lesions (91-97% MRI, 96-100% ultra-

Figure 1 Chondral defect of the humeral head (arrows).

sound), computed tomography (CT), with accuracy near 100% and the possibility of 3D reconstruction, remains the study of choice for evaluating patients with suspected osseous injury. Three-dimensional CT provides the most accurate measures of bone loss and focal defects in the shoulder, facilitating preoperative decision making with detailed measures of glenoid dysplasia or deficiency, as well as the size, depth and location of Hill-Sachs lesions.

Surgical Options

It is widely accepted that articular cartilage defects rarely heal spontaneously, regardless of their acute, chronic, or degenerative etiology.[20] Defining the appropriate treatment of chondral and osteochondral lesions of the glenohumeral joint in young, active patients remains a challenge for surgeons, and surgical techniques continue to evolve. Shoulder replacement has been shown to yield predictably good results in the older, more sedentary population, but it remains a far less reliable option in active patients as replacement surgery demands significant activity restrictions and is further complicated by limited implant life span.[21]

Management of Chondral Defects of the Humeral Head

Microfracture
The success of isolated microfracture in treating focal chondral lesions of the knee is well documented.[22,23] Millett and coworkers[24] reported significant pain reduction and improved shoulder function in patients with glenohumeral chondral lesions treated by arthroscopic microfracture, in a series of 25 shoulders in 24 patients. They used a meticulous

surgical technique for the shoulder that was adapted from the technique Steadman popularized in the knee. Key points in the procedure include adequate debridement of the calcified chondral layer until punctate bleeding is observed and proper placement of the awl holes perpendicular to the subchondral plate and at 2- to 3-mm interval. After an average follow-up of 47 months, the mean pain scores decreased from 3.8 to 1.6 postoperatively (0 = no pain, 10 = worst pain). Patients' ability to work, activities of daily living, and sports activity significantly improved postoperatively ($P <$ 0.05). The average American Shoulder and Elbow Surgeons score also improved significantly from 60 (range, 22-80) preoperatively to 80 (range, 45-100) postoperatively ($P < 0.05$). In this study, the greatest improvements were seen in patients who had microfracture of isolated lesions of the humerus.

Others have reported good results with a combined technique of microfracture and periosteal flap in treating focal chondral lesions in the glenohumeral joint of 5 patients.[25] The authors used an additional periosteal flap to cover the area of microfracture to theoretically protect the regenerate tissue and enhance hyaline cartilage formation. At a mean follow-up of 25.8 months, the Constant score significantly improved from 43.4% preoperatively to 81.8% postoperatively. The pain level was also reduced significantly.

Microfracture remains an attractive option for the treatment of focal, well-marginated, full-thickness cartilage defects. It is inexpensive, technically feasible, and can be accomplished at the index procedure without the need for additional staged procedures. There remains a need for well-designed, prospective outcome studies on isolated microfracture procedures to further our understanding of how and when microfracture may best be used in the treatment of focal, high-grade cartilage lesions of the glenohumeral joint.

Technique. Microfracture may be performed arthroscopically or by open approach to the glenohumeral joint. We prefer the arthroscopic technique in the vast majority of cases. The chondral defect is identified and the edges are probed to assess for unstable cartilage flaps. The unstable edges must be debrided, with the use of a motorized shaver or sharp curette to create a well-shouldered lesion with perpendicular articular margins to entrap the marrow clot to allow for a better healing environment. Subsequently, it is essential to completely remove the calcified cartilage layer with a sharp curette or shaver, while maintaining the integrity of the subchondral bone. This subchondral layer is very thin in the humerus, and care must be taken to avoid excessive bone resection. Removal of the calcified cartilage layer is confirmed by punctate bleeding across the base of the lesion. It may be necessary to reduce arthroscopic pump pressure to confirm the completion of the debridement.

A sharp, metal awl is impacted with a mallet to penetrate the subchondral bone as orthogonally as possible to a depth of 3-4 mm (Fig. 2). The distance between the perforation holes should be approximately 2-3 mm. Additional accessory portals (posteromedial and anteromedial) and a pneumatic arm holder to position the arm can help to insure that the proper angle for microfracture is achieved. Confluence and
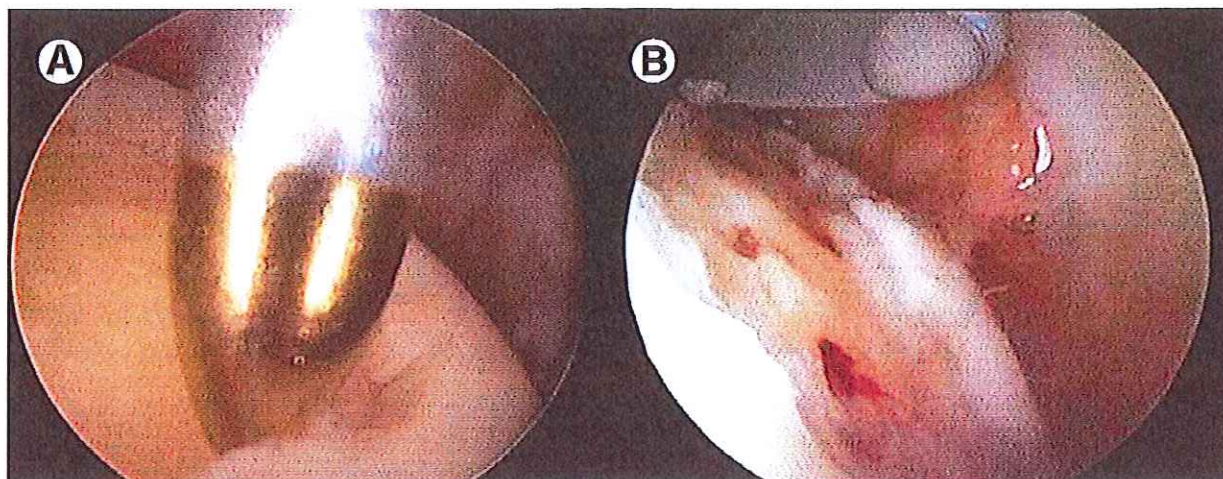
Figure 2 Focal chondral defect of the humeral head, penetration of the subchondral bone with a metal awl (A), and marrow elements extruding from the microfracture holes of the humeral head (B).

obliquity of the microfracture holes should be avoided to avoid subchondral fracture and collapse of a segment of the humeral head. Upon completion of the microfracture, the pressure is reduced in the joint to confirm marrow elements extruding from the holes (Fig. 2).

Rehabilitation. Because protected loading conditions and motion are important for healing after microfracture,[26] the authors recommend early motion with continuous passive range of motion for 6 to 8 hours a day in the early postoperative period. Gentle active assisted and active range of motion can be allowed after 1 to 2 weeks. Because the shoulder experiences lower loading conditions than the knee, active motion does not have to be as carefully restricted, although

patients should be encouraged to avoid heavy lifting and other activities which would increase the loading on the joint.

Autologous Chondrocyte Implantation

There are limited reports of the outcomes of autologous chondrocyte implantation (ACI) in the literature.[27] Most published outcomes relate to cartilage restoration of the knee joint and have shown good to excellent results,[28] both in intermediate and long-term follow-up.[29] Romeo and coworkers[27] reported a case of ACI in the treatment of a full-thickness cartilage defect of the humeral head, but no outcomes have been reported to date. The authors revealed painless full
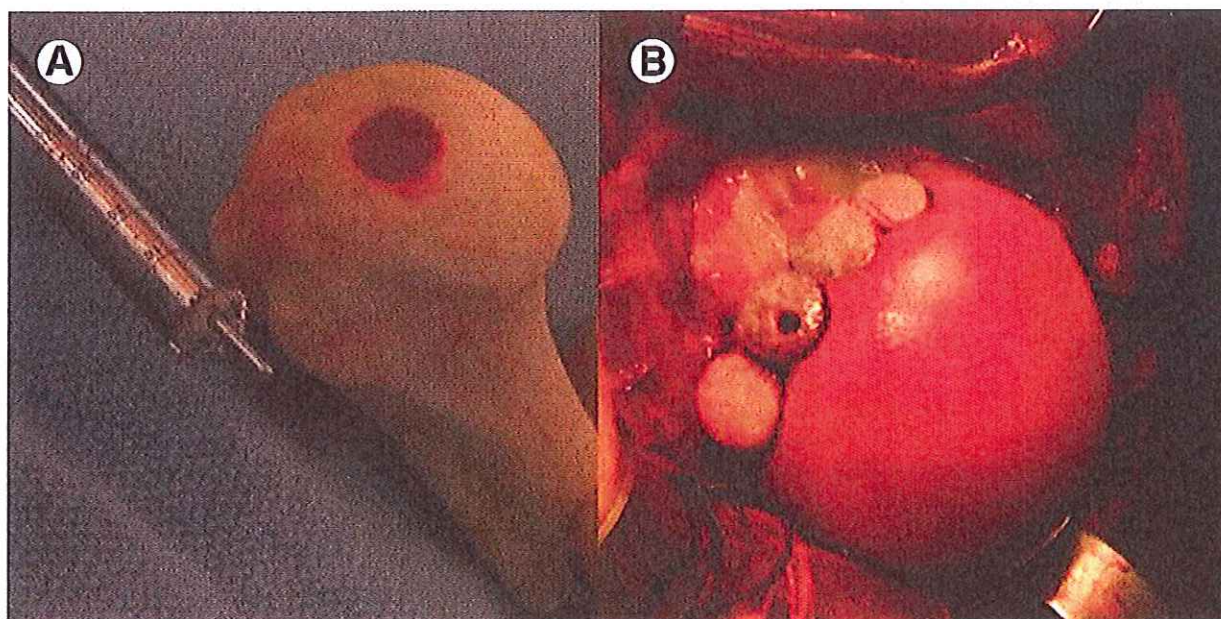

Figure 3 Harvest of the OATS donor cylinder from an appropriate size allograft (A), after implantation of the OATS cylinders in the humeral head (B).

range of motion at 12 months after surgery and no further complaints of rest pain or pain related to weather changes.

ACI Technique

In ACI, autologous cartilage has to be initially harvested. In knee surgery, the most common harvest site is the intercondylar notch or the superior-lateral trochlea. The cells must be cultured in a corporate laboratory and can be subsequently implanted after 3 to 4 weeks.

Although the harvest can be accomplished arthroscopically, the implantation requires an open or mini-open surgical approach. Once the defect has been exposed, it must be accurately debrided, leaving the tidemark intact at the base. The defect must be sized with a sterile ruler or by mapped onto sterile paper and a slightly oversized periosteal patch has to be harvested. For the shoulder, we recommend harvesting the patch from the humerus at the region just distal the bicipital groove, using some of the distal long head biceps tendon sheath as needed. The patch is secured to the circumfluent cartilage, using 6-0 Vicryl sutures and fibrin glue, leaving only a small opening at the superior aspect for injection of the chondrocytes. After injecting the chondrocytes, the opening is closed by additional sutures and fibrin glue.

Another, more recent approach to treat cartilage lesions is the matrix induced autologous chondrocyte implantation (MACI),[30] a collagen bioscaffold which traffics cultured autologous chondrocytes into the defect. The bioscaffold simplifies the technique somewhat, because no coverage of the applied cells is necessary. To date, there are no reports in the literature on MACI for treatment of cartilage lesions of the humeral head in the literature. MACI implantation shows potential in the glenohumeral joint, as a stable cell-based delivery system that has demonstrated regeneration of hyaline-like cartilage in a high percentage in the knee.

Rehabilitation. Rehabilitation follows the same principles as described for microfracture, with protected loading conditions and continuous motion considered integral to healing.[26] Continuous passive range of motion is recommended for 6 to 8 hours a day in the early postoperative period. Pain-controlled active-assist exercise is started without limits after 2 weeks, and active range of motion begins at 4 weeks postoperatively.

Management of Small, Focal Osteochondral Defects of the Humeral Head Osteochondral Autograft

Osteochondral autograft transfer (OATS) is a procedure used for small- to medium-sized (approximately 2.5 cm-3.5 cm) areas of isolated chondral and osteochondral damage. The underlying principle is that osteochondral plugs of healthy cartilage and bone are transferred into focal cartilage defects.

There is only 1 published case series of OATS for the treatment osteochondral defects in the humeral head that has been reported to date.[31] In this series of 8 patients, an osteochondral plug was transferred from the superolateral trochlea of the knee to the articular portion of the humeral head. The results showed a significant improvement in the Constant

score from 73.9 points preoperatively to 88.7 points postoperatively ($P < 0.05$), but no observed alteration in the postoperative development of osteoarthritis or the progression of pre-existing osteoarthritic changes. There was a single poor outcome attributed to the complication of donor site morbidity. The authors of this study have subsequently advocated the use of allografts for plug transfer in the humeral head, independent of the size of the lesion, to avoid donor site morbidity.

Technique. The patient may be positioned in the beach chair position, with a pneumatic arm-holder to position the arm, or in the lateral-decubitus position, as decided by surgeon's preference. First, a complete diagnostic glenohumeral arthroscopy is performed, using a standard posterior portal. Further shoulder pathologies should be first excluded or addressed. An additional anterior-superior portal is created, and the defect is inspected and classified by its location, stability, and size. In most instances, it is easier to perform this procedure open through a standard deltopectoral approach.

Preparation of Recipient Site. The appropriate sized OATS harvester cylinder is chosen. The OATS harvesting tube is inserted over an additional lateral portal that is chosen to allow a direct, straight approach to the defect, and the OATS receipt harvester cylinder is placed over the OCD. The harvester is driven into the bone with a mallet into the subchondral bone to a depth that is deeper than the OCD, approximately 10 mm. The harvester cylinder is removed by applying axial load while rotating the harvester 90° clockwise and counter clockwise. For any lesion greater than 1 cm in diameter, multiple plugs should be used. Furthermore, for large lesions or for challenging locations, an open approach is recommended through a standard deltopectoral approach.

Harvesting of Donor Site. Graft harvest is performed from 1 of 3 sites of the knee: the peripheral medial femoral condyle, the lateral femoral condyle superior to the sulcus terminalis, or the superolateral aspect of the intercondylar notch. The authors prefer the superolateral aspect of the knee or a fresh humeral head allograft. Careful consideration should be made to match the donor site to the planned recipient site, including the number of plugs needed. Plugs are harvested from the knee performing a mini arthrotomy, or from the allograft (Fig. 3). The donor harvester is inserted in the same angle as the receipt harvester before. Once a good position is established, the donor harvester is driven with a mallet in the subchondral bone 2 mm deeper than the receipt harvester. The harvester should be removed by applying axially load while rotating the harvester 90° clockwise and counter clockwise. After graft removal, the length of the graft is carefully determined by either measuring the graft directly or using a plunger device in the harvest site.

Transfer to the Recipient Site. With the corresponding OATS alignment stick, the recipient socket depth and angle are measured again, before inserting the donor cylinder. Graft implantation is performed with the assistance of delivery

tubes, which are seated firmly against the recipient hole. The graft is advanced with gentle taps on the impactor plunger.

Rehabilitation. Active and passive free range of motion is allowed after surgery. Again, early passive range of motion is advocated and excessive loading of the joint is delayed for 6 to 8 weeks.

Management of Large Osteochondral Defects of the Humeral Head

There are many reported techniques for treating large osteochondral humeral head defects, including partial or complete humeral head prosthetic replacement, soft-tissue transfers such as the McLaughlin procedure or remplissage,[32-35] allograft OATS,[35-38] transfer of the lesser tuberosity,[35,39,40] and derotational osteotomies.[41,42] The surgical strategy should be adapted to the location, size, and age of the defect.

Smaller Hill Sachs and reverse-Hill Sachs lesions of up to 25% of the articular surface have been successfully treated with soft tissue techniques, such as the McLaughlin procedure or remplissage with good results. Surgical options for larger defects of up to 55% of the articular surface include allograft reconstruction and transhumeral bone grafting. For chronic posterior instability associated with large defects, a transfer of the lesser tuberosity into the defect has been performed with good results. In bony defects greater than 45% of the articular surface, arthroplasty should be considered as a treatment option.

Transhumeral Bone Grafting

Disimpaction and bone grafting of humeral head defects up to 50% of the articular surface has been described for both Hill Sachs[36,37] and reverse-Hill Sachs lesions.[35,43] The principle of both procedures is the same. A standard deltopectoral approach is used. In defects of the anterior aspect of the humeral head (reverse-Hill Sachs) exposure is accomplished by taking down the subscapularis tendon approximately 1 cm medial to its insertion on the lesser tuberosity and performing vertical capsulotomy. Disimpaction can be performed when the cartilage is attached to the impacted defect and is in good condition.

The procedure is facilitated by identifying a good place for creating a bone window in direct line to the defect near the greater or lesser tuberosity. For anterior defects, the arm is internally rotated and a cortical window is created laterally. Under direct visualization, the bone defect is elevated using curved bone tamps and cancellous bone graft is impacted in place. To maintain the reduced defect, 2-3 parallel 3.5 mm cortical screws can be used, which are placed just below the subchondral bone from starting points adjacent to the lesser tuberosity.[35]

With posterior defects in the humeral head, the lesion can be palpated and visualized with the patient's arm in external rotation.[37] A cortical window is created anteriorly and the defect is disimpacted and grafted. Damage to the anterolat-

eral ascending branch of the anterior circumflex artery must be avoided. The defect is gently elevated with bone tamps. Bone graft is used to fill the bone tamp tunnel. Early motion may be initiated, if the arm is stable under anesthesia.

Results. In a technical note paper Re and coworkers[37] presented a case series of 4 patients who have been treated with transhumeral head plasty for recurrent anterior instability and engaging Hill Sachs defects. None of the patients had remaining instability or other complications at an average follow-up of more than 1 year. Kazel and colleagues[36] performed a cadaveric study on large Hill-Sachs lesions that were treated with percutaneous humeroplasty in 14 specimens. The authors were able to significantly reduce the size of the Hill Sachs lesion in all specimens.

Structural Allograft Reconstruction

Allograft humeral head reconstruction can be used for large lesions of the anterior and posterior aspect of the humeral head that comprise 55% of the articular surface. Careful preoperative planning is required to obtain an adequately sized humeral head allograft, calibrated radiographs of the opposite shoulder should be taken, to facilitate matched radius of curvature in the allograft.

In lesions of the anterior aspect of the humeral head, a standard deltopectoral approach is used, as described previously. The defect is visualized and humeral head stability in internal rotation is assessed. A uniform defect is created with an oscillating saw, and the crescent shaped defect is measured. Aluminum foil, which is readily available from the packaging of scalpel blades, can be used to create a template of the defect. A fresh osteoarticular allograft is used. A slightly oversized matching segment of the allograft is then created. The graft is inserted and secured with two 3.5-mm partially threaded cancellous screws that are lagged and countersunk or with headless screws designed for this type of application.

Alternatively, in defects up to 35 mm in diameter, a large allograft plug or multiple plugs can be used (Allograft OATS, Arthrex, Naples, FL).[38] Once the defect is visualized, the appropriate cannulated allograft OATS sizer is chosen and a drill tip guide pin is drilled through the sizer into the bone. The orientation of the donor is noted so the graft can be inserted correctly. The graduated Allograft OATS recipient counterbore is placed over the drill pin and is then drilled to a depth of 8 mm (Fig. 4). The humeral head allograft is secured in the workstation and the adequate donor cylinder is harvested from the same humeral head area in the same angle. The graft is appropriately measured, marked by referencing the four quadrant depths recorded and trimmed with a saw. The OATS dilator is introduced and the graft is inserted in the appropriate orientation and to the appropriate depth. In lesions of the posterior aspect of the humeral head, either technique may be used. Typically an anterior, deltopectoral surgical approach is used.

Results. Miniaci and coworkers[44] published a series of 18 patients with osteoarticular allograft reconstruction of the
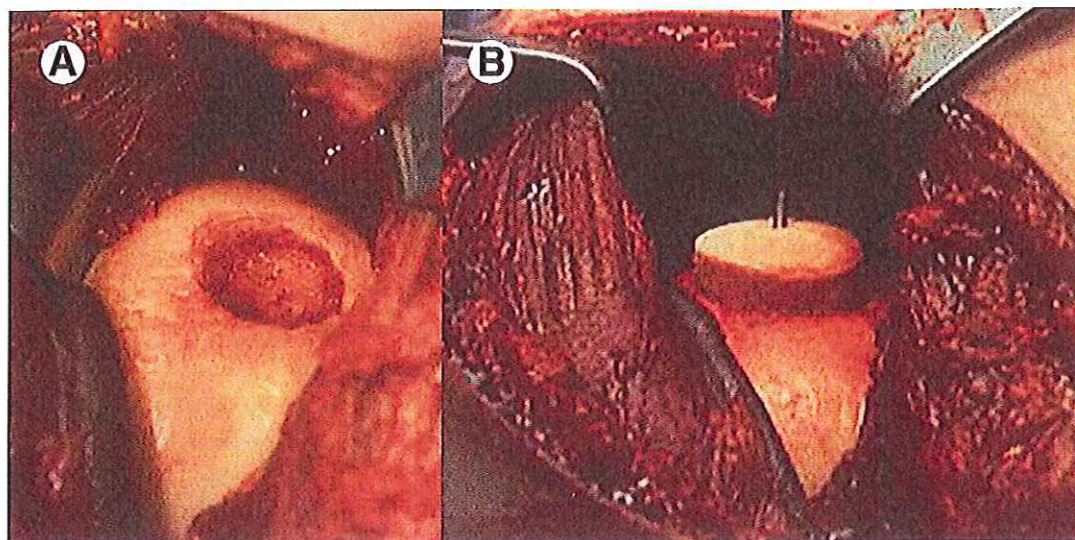
Figure 4 Recipient site humeral head (A), application of the OATS allograft (B). Courtesy of Jon J.P. Warner, MD.

humeral head for failed instability repairs. At 2 years' follow-up, no recurrent episodes of instability occurred. Two patients required removal of symptomatic hardware as a secondary procedure. A few case reports describing osteochondral allograft reconstruction have also shown good results with no recurrent instability and good shoulder function at 1 year follow up.[38,45]

Soft-Tissue Interposition

The principle of this type of procedure, which was first described by McLaughlin in 1952,[46] is to fill the osteochondral defect in the humerus with soft tissue (subscapularis tendon for anterior defects and infraspinatus tendon for posterior defects).[32-35] This limits rotation and also fills the defect so that it is no longer biomechanically relevant to stability. Both, open[33,34,47] and arthroscopic[32,48] techniques have been described.

In patients with engaging Hill Sachs lesions, remplissage, or filling, can be used as to fill the posterior defect. A diagnostic arthroscopy is performed first to confirm the pathology. If an anterior Bankart repair is necessary, this procedure should be performed before the remplissage. A subacromial bursectomy should always be performed before the remplissage is performed. Once this is completed, the camera should be switched to the anterior-superior portal, and a cannula should be placed intra-articularly through the posterior portal. The Hill Sachs lesion should be freshened with a shaver to remove soft tissue while avoiding weakening of the bone. The posterior cannula is then be pushed back through the infraspinatus tendon into the subdeltoid space. The first anchor is now passed transtendinously through infraspinatus tendon and the posterior capsule into the osteoarticular defect. With a penetrating grasper or a shuttling device, the posterior capsule and infraspinatus tendon are penetrated approximately 1 cm inferior to the initial portal entry side to pull out one suture limb. The second anchor is placed in the same way, superior to the first one and one suture limb is passed

through the posterior capsule and infraspinatus tendon approximately 1 cm superior to the initial portal entry side. The knots are tied in the subdeltoid space, starting with the inferior sutures.

Rehabilitation. The arm is immobilized with passive range of motion only for 6 weeks. Flexion and abduction is limited to 60° for 6 weeks, with external rotation 0° for 2 weeks and 30° for 4 weeks.

Results. Purchase and coworkers[32] report good results with recurrent instability in 2 of 24 patients (7%). Both patients who failed had a history of significant trauma. No significant complications have been reported.

Lesser Tuberosity Transfer

Neer modified the McLaughlin soft-tissue procedure by transferring the lesser tuberosity with attached subscapularis tendon into the defect at the anterolateral aspect of the humeral head.[47] The rationale for this procedure was to provide more stability and more secure fixation of the subscapularis tendon by preserving its attachment to the bone. In this procedure a standard deltopectoral approach is used. The subscapularis tendon and the bicipital groove are identified, and the rotator interval is carefully opened. Violation of the bicipital groove when performing the tuberosity osteotomy must be avoided. If the biceps tendon or groove is damaged, a tenodesis should be performed. After performing the osteotomy, the tuberosity with the attached subscapularis tendon and capsule are elevated to reveal the glenohumeral joint and to refresh the defect with an elevator or burr, creating a bone bed for the transfer. The lesser tuberosity is transferred into the defect under digital control and secured with two 3.5 mm screws (Fig. 5). After testing the stability of the glenohumeral joint, the rotator interval is closed.

Results. Hawkins, et al[47] reported a series of four patients treated with a lesser tuberosity transfer for locked posterior
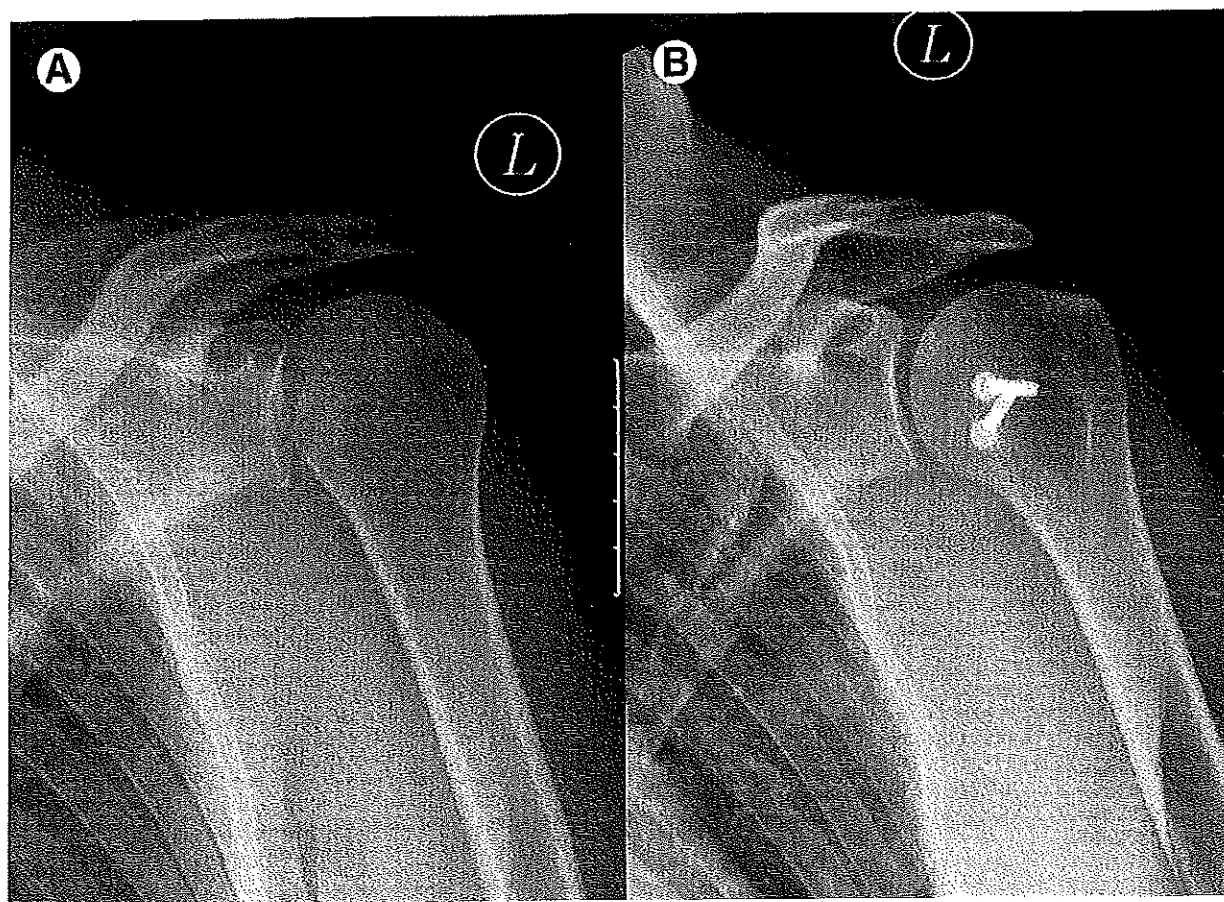
Figure 5 Locked posterior dislocation with large reversed Hill Sachs defect (arrow) (A); after lesser tuberosity transfer (B).

dislocation. After follow-up of 2 to 9 years, none of the patients had any pain or limitations in the activities of daily living or work. Another series of 7 shoulders in 5 patients published by Finkelstein, and co-workers[40] also showed good results with no redislocations and only a slight restriction of internal rotation at a mean follow up of 5 years.

Conclusions

The treatment of focal chondral and osteochondral defects of the humeral head remains challenging, especially in younger patients. Well-designed outcome studies for the principal surgical approaches to this difficult problem in the glenohumeral joint remain scarce. Subsequently, shoulder surgeons have adapted techniques from research performed on cartilage repair and restoration in the lower extremity. Protected loading conditions have been shown to be critical to the healing process in most of these procedures; therefore, results in the shoulder joint should be predictably good. There are now many promising options to treat chondral and osteochondral defects with more case series and prospective studies underway. Furthermore, many research efforts are in progress to deepen our knowledge of how to best address these challenging conditions.

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