The Management of Localized Articular Cartilage Lesions of the Humeral Head in the Athlete

Courtney K. Dawson, MD,* Robert H. Rolf, MD,† and Thomas F. Holovacs, MD‡

Localized articular cartilage lesions of the humeral head can be a source of persistent pain and functional decline in patients who have failed conservative treatment measures. Many are younger, active patients who pose a challenging management decision for surgeons. The goals of treatment should focus on maintaining humeral bone stock, restoring the contour of the articular surface, minimizing soft-tissue disruption, and relieving symptoms. There has been a trend toward humeral resurfacing arthroplasty and away from stemmed components over the past few decades for younger patients potentially requiring future revision surgery. More recently, the HemiCAP resurfacing system (Arthrosurface, Franklin, MA) has been used for localized defects in patients with Hill-Sachs and reverse Hill-Sachs lesions, avascular necrosis, focal chondral defects, and humeral head osteoarthritis. Early, short-term outcome results of the HemiCAP system are encouraging. In this article, we describe our technique for management of localized articular cartilage defects of the humeral head using the HemiCAP resurfacing system.

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Localized articular cartilage lesions of the humeral head are becoming a more commonly recognized problem in the evaluation of patients presenting with shoulder pain. With the rising young athletic population, many patients requiring surgical intervention represent a challenging clinical dilemma. Humeral resurfacing is not a new concept in shoulder arthroplasty, but the trend toward limited prosthetic resurfacing in the younger population is becoming more attractive. The evolution of shoulder arthroplasty from the more conventional-stemmed components of Charles Neer to the early Copeland resurfacing of the 1970s has paved the way for the introduction of newer bone-conserving and anatomic resurfacing techniques.²

Focal chondral defects of the humeral head seen in the younger population include Hill-Sachs and reverse Hill-Sachs lesions, avascular necrosis, traumatic or iatrogenic osteochondral lesions, and osteoarthritis. One of the major advantages of limited prosthetic resurfacing in these patients is conservation of bone stock, making later revision easier in cases of failure.³ Revisions can be done with an additional surface replacement, transition to a stemmed humeral component, glenoid resurfacing, or arthrodesis. Current humeral resurfacing designs include the Copeland Humeral Resurfacing Head (Biomet, Warsaw, IN),⁴ the DePuy Global C.A.P. system (DePuy, Warsaw, IN), the Aequalis Resurfacing Head (Tornier, Stafford, TX), and the DUROM cup⁷ (Zimmer, Winterthur, Switzerland). Each of these surface-replacement techniques is a viable option for patients with diffuse articular involvement but is inappropriate for focal, discrete defects as often seen in the younger patient population.

Other biological alternatives for addressing focal cartilage lesions include osteoarticular allografts, Carticel (Genzyme, Cambridge, MA), and osteochondral autograft transfer. These will be discussed in greater detail elsewhere in this journal. Carticel has primarily been used for symptomatic cartilage defects of the femoral condyle, and, to date, it has not been thoroughly assessed for use in the shoulder. Osteochondral autograft transfer procedures have been used in the knee and talus with promising results. Benefits of autologous osteochondral transfer include restoration of both the osseous and chondral deficiencies, but donor-site morbidity as well as the quality and quantity of transferable tissue are limiting factors.⁸ Osteoarticular allograft plugs can be used to reconstruct focal defects associated with Hill-Sachs lesions and concurrent shoulder instability.⁹ The osteoarticular...
plugs can be matched to approximate the patient’s normal articular anatomy, but inherent problems associated with allografts must be considered. It is both a technically challenging and time-consuming procedure, disease transmission is a possibility, and precise matching of the articular curvature is difficult.

In our practice, we have found the HemiCAP (Arthrosurface, Franklin, MA) system to be beneficial in maintaining humeral bone stock while restoring the anatomic articular surface and contouring the prosthesis to the adjacent healthy cartilage. Here, we describe our approach for the evaluation and management of young patients with localized articular cartilage lesions of the humeral head using the HemiCAP system.

Preoperative Evaluation

When evaluating a younger, athletic patient for limited resurfacing, there must be an understanding of various patient factors and expectations. Age, medical comorbidities, prior surgeries, current functional status, and future demands on the shoulder must be considered. With a careful history, the patient’s primary complaint of pain, weakness, instability, or loss of motion should be determined. Physical examination should begin with a comprehensive evaluation of the shoulder, cervical spine, and upper extremity. Inspection should include the assessment of previous surgical scars, atrophy, and asymmetry when compared with the contralateral shoulder. Careful palpation of bony prominences should accompany the measurement of ranges of motion in forward flexion, abduction, internal rotation, and external rotation. Testing of any limitations both actively and passively can help to assess for the presence of a mechanical block. Strength testing should focus on the deltoid and rotator cuff, with the liftoff, bellypress, and drop arm tests being helpful in assessing insufficiency.\textsuperscript{10,11} It is also important to include testing for instability in both the anterior-posterior and inferior directions to evaluate the integrity of the soft-tissue envelope. In addition, a thorough neurovascular exam must be performed to assess distal sensation, strength, reflexes, and pulses. Specific findings of a click or clunk during the examination may indicate the presence of instability, an intra-articular loose body, and cartilage or labral injuries.

Imaging studies should begin with standard radiographs, including anteroposterior, scapular “Y,” and axillary views. Computed tomography scans can be helpful in determining
proximal humeral bone stock, glenoid version and involvement, and overall alignment. Magnetic resonance imaging is useful in identifying patients with rotator cuff tears, significant proximal humeral bony collapse associated with avascular necrosis, and osteochondral loose bodies. Arthrography may have a role in further assessing chondral lesions in cases in which standard imaging fails to fully qualify articular involvement.

After this comprehensive evaluation, patients with persistent pain and limitations after failed conservative treatment may be candidates for surgical intervention. We have found that the HemiCAP resurfacing technique is a viable option for these young, active patients. The HemiCAP incorporates a titanium taper post, a cobalt chromium articular surface, and a titanium spray undercoating as displayed in Fig. 1. It treats localized articular cartilage lesions by maintaining proximal humeral bone stock, restoring the articular congruity in 2 planes, and minimizing soft-tissue trauma.

**Surgical Technique**

The patient is placed in the beach-chair position with the optional use of an articulated arm holder, which may be helpful in positioning for exposure of the humeral head. We use an anterior deltopectoral approach, but it should be noted that an anterosuperior (Mackenzie) approach\(^\text{12,13}\) or a superolateral approach can also be used. A standard deltopectoral incision is made from the coracoid tip to the pectoralis major insertion. This incision can easily be converted to an extensile approach if needed. The deltopectoral interval is developed, and the cephalic vein is identified and retracted medially.

![Figure 3](image-url) Measurement of the surface curvature in 2 planes allows for a more precise recreation of the patient’s anatomic articular surface. (Image reproduction courtesy of Arthrosurface, Franklin, MA.)

![Figure 4](image-url) Proximal humerus malunion. Preoperative anteroposterior and axillary lateral radiographs (A and B). Postoperative anteroposterior and lateral radiographs (C and D) after using a HemiCAP-contoured articular prosthesis and glenoid component.
Subdeltoid and subacromial adhesions are released, and the deltoid and pectoralis major muscles are retracted with the help of either a multipronged self-retaining retractor or blunt Hohmans. The lateral border of the conjoined tendon is identified and retracted medially as the underlying interval between the subscapularis is developed. Flexion of the shoulder during this step helps to relax the conjoined tendon and minimize risk to the musculocutaneous nerve. The anterior humeral circumflex vessels along the inferior border of the subscapularis and the axillary nerve are identified and protected. If necessary for exposure, the circumflex vessels can be suture ligated and divided. The subscapularis is incised off of the lesser tuberosity. If the patient is a candidate for capsular shift because of underlying instability, the subscapularis and capsule can be dissected separately. The release of the capsule from its attachment on the anatomic neck of the humerus allows for adequate visualization of the humeral head. Posterior humeral head defects can be addressed via the anterior deltopectoral approach when the inferior capsule is completely released off the anatomic neck. The use of a blunt Hohman or Cobra during this step can help to minimize injury to the axillary nerve inferiorly. Adduction, extension, and external rotation are used to dislocate the joint and expose the humerus for HemiCAP insertion.

The 2 main steps involved in implanting a HemiCAP involve insertion of a taper post and attachment of the articular component as outlined in Fig. 2. The articular defect is identified with adequate exposure of the humeral head as described previously. A drill guide is used to circumscribe and excise the defect with a centrally placed guidepin. A cannulated drill is used to prepare and place the headless titanium alloy taper post perpendicular to the articular surface. A trial cap is used to verify the depth of the post, noting that the peak height of the cap should be flush with the surrounding articular cartilage to ensure proper articulation.

**Figure 5** Reverse Hill Sachs. A preoperative computed tomography scan (A) can be compared with postoperative AP and axillary lateral radiographs (B and C) after treatment with a HemiCAP.
cartilage. The centering shaft is used to measure the dimensions of the defect using 4 index points: superior, inferior, medial, and lateral. Fig. 3 shows the varying surface curvatures in 2 planes used to recreate the patient’s natural anatomy. A sizing card is then used to select the appropriate articular component. One of the advantages of the HemiCAP system is its ability to restore the inherently asymmetric sphericity of the humeral head in cases of a peripheral defect.\textsuperscript{1,2} The central portion of the humeral head articular surface is spherical, but the peripheral dimension is more elliptical.\textsuperscript{14,15} HemiCAP’s 3-dimensional mapping technique allows the surgeon to implant a prosthesis that recreates the patient’s anatomic articular surface geometry and joint biomechanics. The articular component comes in 4 diameters, from 25 mm to 40 mm, and is available in over 37 different symmetrical and asymmetrical curvatures.

The appropriately sized circle cutter is used to score the articular cartilage down to the subchondral bone, which is

Figure 6  Hill-Sachs lesion. Preoperative radiographs (A and B) and magnetic resonance imaging (C) compared with postoperative radiographs (D and E) after treatment with a HemiCAP prosthesis.
then reamed to the level of the taper post. Any residual unstable edge of the chondral defect should be debrided. At this point, a trial articular component is set in place, making sure it is flush with the surrounding cartilage. A slightly recessed component is favored over a prominent component because cartilage will fill over the edges resulting in reduced contact pressures. The final articular component is secured into the post via a Morse taper interlock. Optimal resurfacing will show complete coverage of the chondral lesion, a component that is seated flush with the level of the surrounding cartilage, and a congruent transition between native cartilage and the prosthesis.

**Indications**

The HemiCAP resurfacing system is indicated in patients with humeral head osteoarthritis, focal chondral defects, avascular necrosis, isolated lesions associated with rheumatoid arthritis, Hill-Sachs, and reverse Hill-Sachs lesions. Preoperative and postoperative radiographs of several patients after HemiCAP resurfacing are presented in Figs. 4 through 7. Fig. 4 shows a 52-year-old woman 20 years out from a proximal humerus fracture who presented with malunion and secondary osteoarthritis. Fig. 5 shows a 43-year-old patient with a reverse Hill-Sachs lesion after a ground level fall. Fig. 6 shows a 36-year-old man who sustained a traumatic shoulder dislocation that was treated with an arthroscopic Bankart repair. He presented with continued shoulder pain after failed microfracture. Fig. 7 shows a 45-year-old woman with a long history of shoulder pain found to have avascular necrosis. Avascular necrosis of the humeral head may arise from either traumatic or atraumatic etiologies. Disruption of blood supply due to fracture or dislocation may lead to focal lesions causing pain and functional limitations. Atraumatic etiologies may include steroid or alcohol use, sickle cell disease, or connective tissue disorders. In cases of isolated lesions without complete glenohumeral involvement, limited resurfacing may be a feasible option for pain relief and functional improvement.

**Postoperative Rehabilitation**

The patients are kept in a standard sling or shoulder immobilizer for the first 4 to 6 weeks. Rehabilitation is initiated on the first postoperative day and progresses through 3 phases. Phase I includes passive- and active-assisted range of motion in elevation and external rotation within the safe limits as defined by intraoperative testing. The goals during this phase focus on edema control and a gentle increase in joint mobility to avoid stiffness and scarring.

Phase II, from 6 to 12 weeks, includes active and active-assisted range of motion and initiation of gentle stretching with care not to stress the repair. The goals during this phase focus on improving functional active motion and coordinat-

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*Figure 7* AVN: preoperative anteroposterior radiograph and correlating magnetic resonance imaging (A and B) along with postoperative radiographs (C and D).
ing scapular-humeral rhythm. Patients are encouraged to begin light activities of daily living as tolerated.

Phase III, beginning at 12 weeks, involves gradual muscle strengthening. The goals during this phase are aimed at maximizing shoulder functional capacity in activities of daily living in addition to improving strength and endurance. Return to sport is determined on an individual basis but is generally allowed between 4 and 6 months postoperatively.

**Results**

There have only been limited, short-term results reported for the HemiCAP resurfacing system, but overall we have had positive clinical outcomes among our patient population. Scalise et al reported on 62 patients at 6 institutions undergoing humeral resurfacing with the HemiCAP prosthesis in a mean follow-up of 8 months. The mean age was 60 years, and indications for resurfacing included osteoarthritis, avascular necrosis, focal chondral defects, cuff tear arthropathy, and rheumatoid arthritis. In 26 patients, an additional rotator cuff repair or subacromial decompression was performed at the time of the resurfacing. The results showed a significant improvement in both American Shoulder and Elbow Surgeons scores (from 38 to 70) and Constant scores (55-78) with only 1 patient failing to improve clinically.

Despite early encouraging results, it should be noted that HemiCAP resurfacing is not indicated for all patient populations. Contraindications include severe Hill-Sachs lesions with chronic locked dislocations; significant glenoid involvement; rotator cuff arthropathy; or significant humeral head collapse because of avascular necrosis, rheumatoid, or osteoarthritis. In these cases, an alternative resurfacing prosthesis, arthroplasty, or biologic resurfacing of the glenoid may be a more suitable option.10-18

In young active patients, we find that localized articular cartilage lesions of the humeral head can be treated successfully with limited resurfacing using the HemiCAP system. Maintaining bone stock, restoring the articular surface geometry, and minimizing soft-tissue disruption allow for future revision procedures if needed in this population. Overall, the short-term results of the HemiCAP resurfacing technique are encouraging, and further investigation is needed to determine long-term outcomes.

**References**