Technical Note

Humeral Head Resurfacing for Isolated Primary Humeral Osteoarthritis With a Large Chondral Defect

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Abstract: Primary, isolated humeral head arthritis or focal chondral defects are uncommon and difficult to diagnose preoperatively. While these lesions have traditionally been treated with total shoulder arthroplasty, shoulder hemiarthroplasty is a viable option for patients with isolated humeral head disease and minimal degenerative changes in the glenoid. This approach can be performed in a minimally invasive fashion, which preserves bone stock and native biomechanics, and can be beneficial if conversion to total shoulder arthroplasty is required in the future and avoids risk of glenoid loosening or failure in younger and more active individuals. In this Technical Note and accompanying video, we describe our technique of humeral head resurfacing in a patient with isolated primary humeral osteoarthritis with a large focal chondral defect in the humeral head.

Isolated focal chondral defects of the glenohumeral joint, although rare, are a clinically significant pathology. Large humeral head chondral lesions have been shown to result from a number of etiologies including trauma, previous surgery, avascular necrosis (AVN), osteoarthritis, or idiopathic chondrolysis.[1-3] Such lesions, which are typically located on the humeral head, are difficult to diagnose via preoperative clinical examination and imaging techniques and are often discovered during arthroscopy.[1,4]

Although joint-preservation techniques are sometimes indicated in young patients without arthritis, shoulder arthroplasty traditionally has been the treatment of choice to treat isolated, large chondral defects of the humeral head in older patients. Anatomic total shoulder arthroplasty (TSA) or reverse TSA are the mainstays of treatment for symptomatic osteoarthritis in older patients with or without a functioning rotator cuff.[5] Humeral head resurfacing can be an excellent option to preserve native bone stock and shoulder biomechanics by maintaining an anatomic center of rotation.[5,6] Furthermore, in comparison with stemmed hemiarthroplasty, humeral head resurfacing offers a bone-preserving approach, shorter operative time, and lower risk of periprosthetic fracture, all of which allow for easier revision and conversion to total shoulder or reverse shoulder prothesis if necessary.[7,8]

While humeral head resurfacing has been described in the setting of AVN and in end-stage glenohumeral osteoarthritis in younger, active patients after a failed Trillat procedure, it can also be an option for middle-aged patients with large chondral defects with humeral osteoarthritis.[2,9] In this Technical Note and accompanying video, we discuss our surgical technique for humeral head resurfacing for patients with isolated primary humeral osteoarthritis with a large chondral defect (Video 1).

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Surgical Technique (With Video Illustration)

Indications and Preoperative Imaging

The diagnosis of glenohumeral chondral disease should be determined based on a thorough history and physical examination in addition to evaluating diagnostic imaging tests. Discussion with the patient should include inquiring about a history of risk factors for AVN such as trauma to the shoulder, previous steroid use, or sickle cell anemia. Surgeons also should ask about a history of inflammatory and crystalline arthropathy, including rheumatoid arthritis, gout, and pseudogout. In addition, common pathology to the labrum, biceps, rotator cuff, and acromioclavicular joint should be ruled out. Preoperative radiographs should comprise an axillary lateral, outlet, and true anteroposterior (Grashey) view (Fig 1). A computed tomography scan with 3-dimensional reconstruction may be used to evaluate the glenoid morphology and if there is any associated rotator cuff arthropathy. Magnetic resonance imaging is also a valuable tool to evaluate the status of the cartilage and rotator cuff. Lastly, if the patient has had a previous surgery, intraoperative arthroscopic images must be obtained for review.

Patients with rotator cuff, biceps, or labrum pathology based on examination and imaging, or who experience persistent pain despite conservative care, may warrant diagnostic shoulder arthroscopy to assess and stage the cartilage damage. During this procedure, a thorough arthroscopic evaluation of the glenoid and the humeral head articular surface should be performed and may reveal isolated humeral arthritis or focal chondral defects (Fig 2). Humeral head resurfacing is indicated for patients with isolated humeral arthritis with no glenoid involvement who live a physically active lifestyle or have a labor-intensive occupation.

Anesthesia and Positioning

Anesthesia is performed using an interscalene block in conjunction with general anesthesia. The patient is placed in a 30° inclined supine position with the neck in neutral position. The scapula is supported to allow for glenoid exposure if necessary, and the patient is positioned toward the side of the operative extremity to allow for intraoperative shoulder rotation and dislocation. The shoulder is prepared and draped in standard sterile fashion.

Approach and Exposure

The coracoid is identified, and an approximately 8-cm incision is made. The deltopectoral interval is identified with the cephalic vein, which is dissected carefully and retracted laterally (Fig 3A). The deltoid and pectoralis major muscles are retracted and the clavipectoral fascia is identified. The proximal 1 to 2 cm of the pectoralis major tendon insertion may be released from the humerus in order to improve visualization of the humeral head. The clavipectoral fascia is then incised along the lateral border of the conjoint tendon. The conjoint tendon is retracted medially, exposing the subscapularis tendon. At this point, the anterior circumflex humeral artery and its 2 venae comitantes ("Three Sisters") are coagulated. The subscapularis tendon and anterior capsule are detached from the lesser tuberosity via a tenotomy technique, exposing the glenohumeral joint (Fig 3B). The anterior and inferior capsules are subsequently released as needed for exposure and to recover any preoperative range of motion deficits. External rotation, extension, and adduction of the shoulder dislocates the joint, exposing the humeral head. Additional retractors are placed superiorly, under the coracoacromial ligament, and inferomedial, underneath the humeral head, to expose the head and reveal the

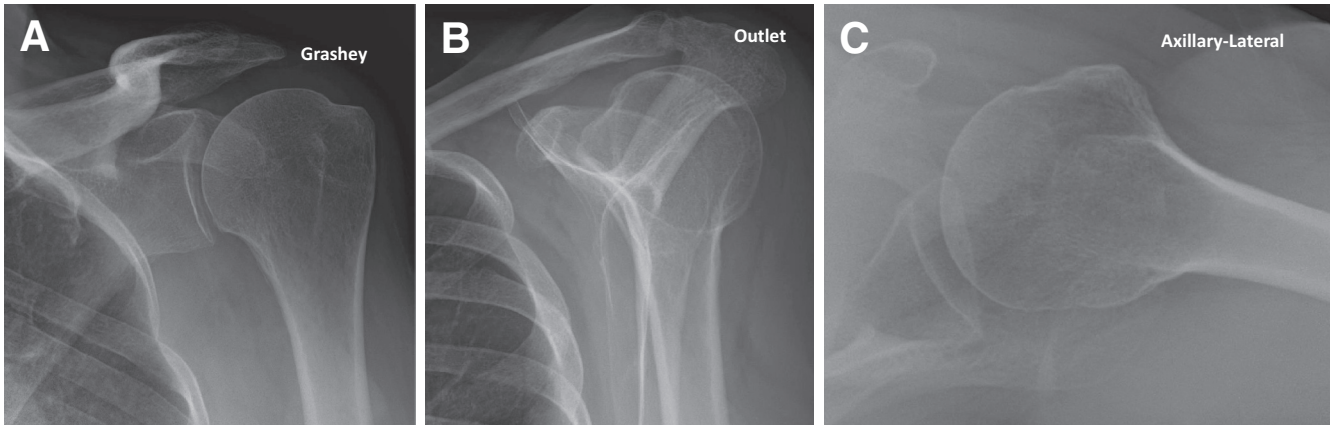

Fig 1. Preoperative radiographs of the left shoulder. (A) Preoperative radiographs of the left shoulder in true anteroposterior of the glenohumeral joint (Grashey), (B) outlet view, and (C) axillary–lateral views. All 3 radiographic views are part of standard workup during initial evaluation of patients presenting with shoulder pain to assess for glenohumeral arthritis, acromioclavicular arthritis, dislocation, and fracture.

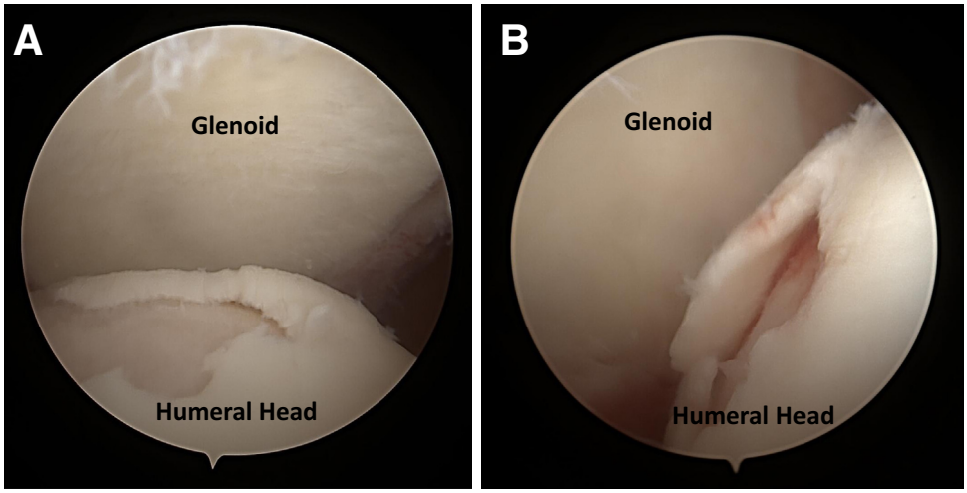

Fig 2. Arthroscopy photos of the left shoulder during index procedure. (A, B) Patient underwent previous arthroscopy due to biceps and acromioclavicular pathology and during the diagnostic arthroscopy a large chondral defect (16-18 mm) to the humeral head is found with no evidence of glenoid involvement.

capsule and rotator cuff. Exposure of the anatomic neck is performed by complete removal of humeral head osteophytes, if present (Fig 3C).

Humeral Head Preparation

Once adequate exposure of the humeral neck is achieved, sizing of the humeral head is completed using a head sizer (43 mm × 16 mm Head Sizer; Tornier, Bloomington, MN). It is important to ensure that the head sizer is in full contact with the humeral head. Multiple trials are placed to determine the appropriate size (Fig 4A). The sizer is oriented to recreate normal inclination and provide adequate coverage of the native articular surface. After the humeral head is carefully measured, a central guide pin is placed with the associated pin positioning guide which is again oriented to recreate normal inclination and provide maximal coverage of the native articular surface. The guide pin must be along the axis of the anatomic neck and must reach the lateral cortex of the humerus, allowing for stronger fixation. Verification of proper guide pin positioning can be performed after removal of the pin positioning guide (43-mm × 16-mm Pin Positioning Guide; Tornier) (Fig 4 B and C).

The humeral head is reamed until the edge of the reamer is in contact with the humeral neck based on the previously measured head sizer (43-mm × 16-mm Reamer; Tornier). Care should be taken to prevent damage of the rotator cuff insertion while reaming (Fig 4D). The reamer creates a ridge against which the final implant will be placed. The trial head is then placed through the alignment pin and care is taken to ensure the initial trial head is in full contact with the humeral neck (43-mm × 16-mm Initial Trial Head; Tornier).

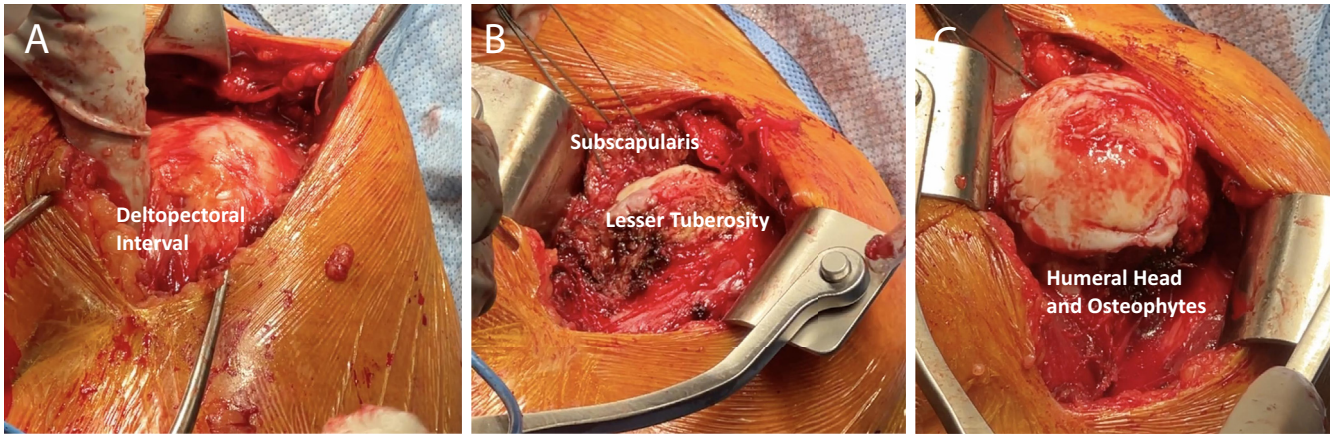

Fig 3. Surgical approach to access the left humeral head. (A) The deltopectoral interval is identified with the cephalic vein, which is dissected out and taken laterally in order to gain access to the underlying musculature. (B) The subscapularis tendon and anterior capsule are detached from the lesser tuberosity via a tenotomy technique, exposing the glenohumeral joint. The subscapularis is tagged with two #5 ETHIBOND for later repair at the end of the surgical procedure. (C) Exposure of the anatomic neck is performed allowing for complete removal of humeral head osteophytes prior to implant sizing.

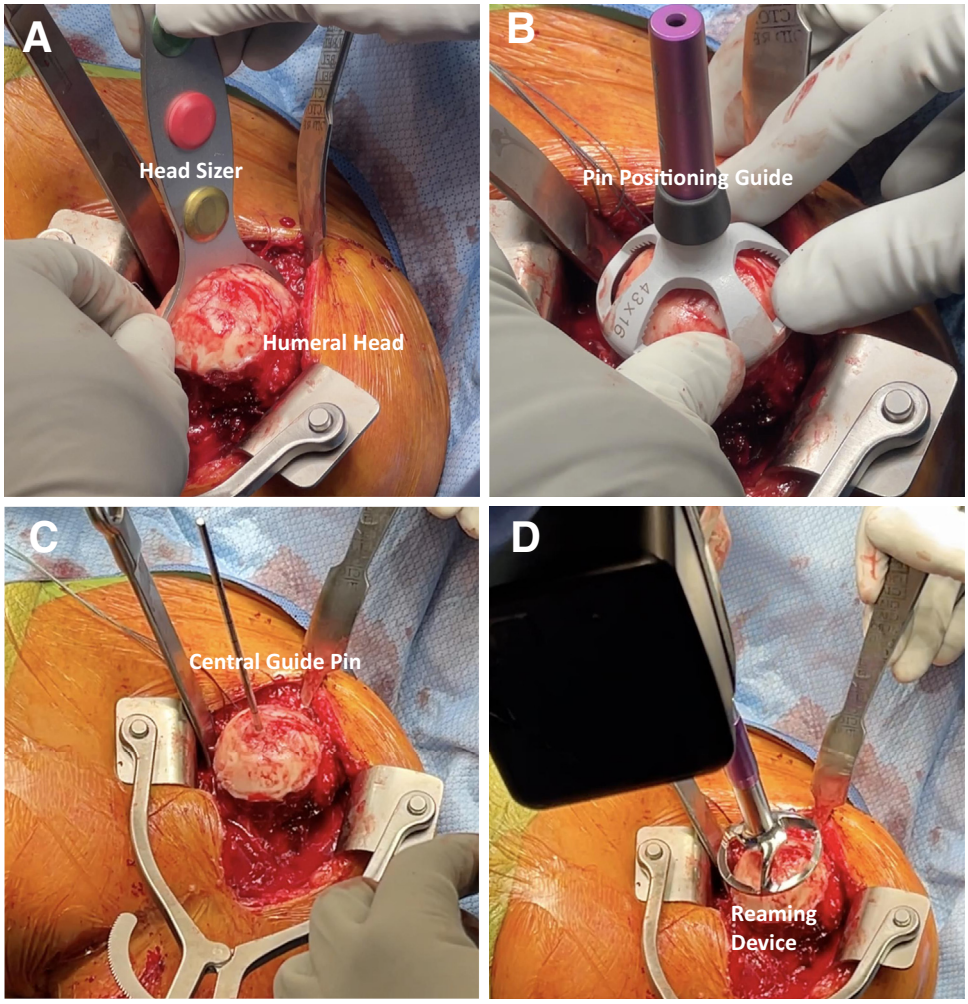

Fig 4. Left shoulder humeral head sizing and preparation. (A) Sizing of the humeral head is completed using the head sizer (43-mm × 16 mm-Head Sizer; Tornier, Bloomington, MN). It is important to ensure that the head sizer is in full contact with the head, and multiple trials are placed to determine the appropriate size. (B) A central guide pin is placed with the associated pin positioning guide. The guide pin must be along the axis of the anatomic neck and must cross the lateral cortex of the humerus, allowing for stronger fixation. (C) Verification of proper guide pin positioning can be performed after removal of the pin positioning guide (43-mm × 16-mm Pin Positioning Guide; Tornier). (D) The humeral head is reamed until the edge of the reamer is in contact with the humeral neck based on the previously measured head sizer (43-mm × 16-mm Reamer; Tornier).

Stem Preparation

The stem preparation is done to allow a press-fit fixation for the final implant. The stem punch is selected according to the humeral size previously measured and is positioned over the alignment pin (30 mm Stem Punch; Tornier). The stem punch is then impacted up to the collar (Fig 5A). Care must be taken avoiding bending the alignment pin during this step. A final trial head can be placed and the alignment pin is removed to confirm complete seating of the trial and its soft tissue balance (43-mm × 16-mm Final Trial Head; Tornier) (Fig 5B). Several small holes are created with a 0.045-inch or 0.054-inch Kirshner wire throughout the humeral head to encourage bleeding and stimulation of growth factors for enhanced implant fixation (Fig 5C).

Final Implant Seating

After irrigation of the reamed surface, the final component (43-mm × 16 -mm Aequalis Resurfacing Head; Tornier) is placed and carefully oriented by the tri-fin pattern previously created with the stem punch (Fig 5D). The final implant is impacted until it is in complete contact with the prepared humeral head surface.

Closure

The humeral head is then reduced, soft tissue balance is confirmed, and the native insertion site of the subscapularis tendon on the lesser tuberosity is assessed for tensioning. Microfracture along the lesser tuberosity allows for the stimulation of bleeding and release of growth factors to allow for healing of the subscapularis back to its native insertion site. The subscapularis is firmly reattached in the lesser tuberosity by 5 proximal-to-distal oriented #5 ETHIBOND (Ethicon, Raritan, NJ) transosseous sutures (Fig 6A). Alternatively, suture anchor-based constructs can be used, given the absence of a humeral stem. The shoulder can be placed in neutral position during transosseous repair of the subscapularis to avoid any future deficit of external rotation. The anterior capsule rotator interval is closed with high-strength suture (#2 FiberWire; Arthrex, Naples,

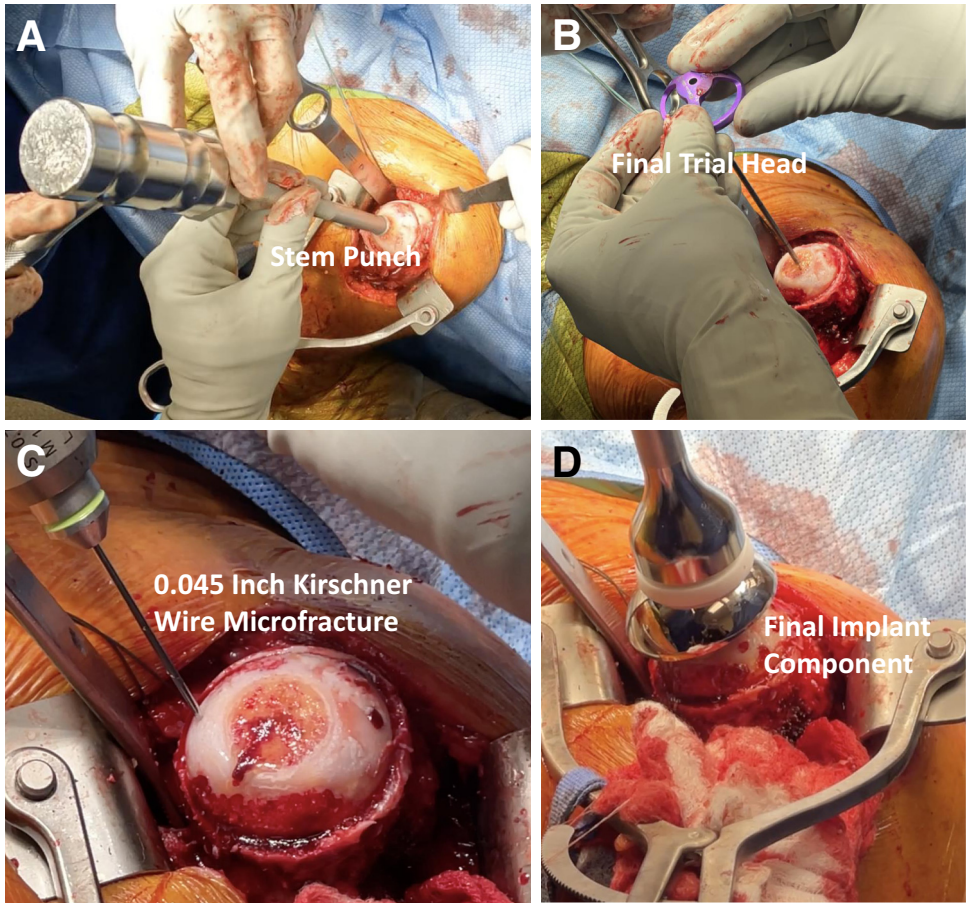

Fig 5. Left shoulder stem preparation and final implant placement. (A) The stem punch is selected according to the humeral size previously measured and is positioned over the alignment pin (30 mm Stem Punch; Tornier, Bloomington, MN). The stem punch is then impacted up to the collar. (B) A final trial head can be placed and the alignment pin is removed to confirm complete seating of the trial and its soft tissue balance (43-mm × 16-mm Final Trial Head; Tornier, Bloomington, MN). (C) A series of small holes are created with a Kirshner wire throughout the entire humeral head for healthy bleeding and stimulation of growth factors for enhanced implant fixation. (D) 43-mm × 16-mm Aequalis Resurfacing Head (Tornier) is placed and carefully oriented by the tri-fin pattern previously created with the stem punch. The final implant is impacted by the impactor until the implant is completely in contact with the previously reamed humeral head surface.

FL) (Fig 6B). The deltopectoral interval is closed and the wound is then closed in a layered fashion. A sterile dressing and a sling are applied.

Postoperative Care

In the first phase after surgery, the goals of recovery include healing of soft tissue and maintenance of joint integrity. During this initial phase, a sling should be worn continuously for 4 weeks. The sling can be removed for home exercises for elbow, hand, and wrist range of motion, as well as gentle pendulum exercises for the shoulder and for hygiene. During this time, there is no active internal rotation or backwards extension allowed in order to protect subscapularis

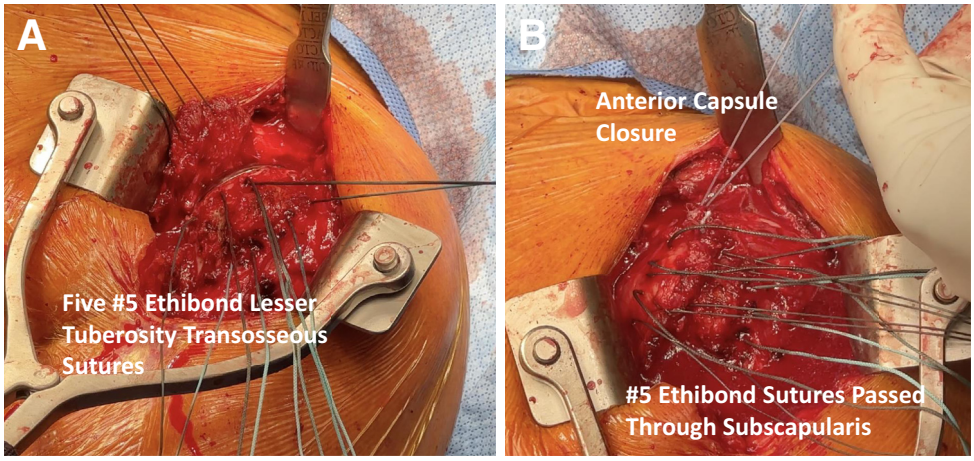

Fig 6. Left shoulder subscapularis and capsular repair. (A) The subscapularis is firmly reattached to the lesser tuberosity by five proximal to distal oriented #5 ETHIBOND transosseous sutures. The shoulder can be placed in neutral position during transosseous repair of the subscapularis in order to avoid any future deficit of external rotation. (B) The anterior rotator interval is closed with high strength suture (#2 FiberWire; Arthrex, Naples, FL).

healing. Patients can begin passive forward flexion in the supine position as tolerated, along with gentle external rotation to approximately 30° in the scapular plane. Radiographs should be obtained 2 weeks postoperatively to assess for implant fixation and positioning (Fig 7 A-C). During weeks 6 to 12, focus is transitioned to active assisted range of motion with progression to active range of motion and gentle stretching at end ranges of motion. Light resisted external rotation, forward flexion, and abduction are slowly incorporated with concentric motions only. During months 3 to 12 postoperatively, resisted internal rotation and backwards extension is introduced with light bands and weights. Advanced strengthening for rotator cuff, deltoid, and scapular stabilizers is slowly introduced over the same time period.

Discussion

In this Technical Note, we describe our technique of humeral head resurfacing for the treatment of an isolated large humeral head chondral defect in the setting of primary osteoarthritis. The goal of this procedure was to eliminate pain and restore functional deficits associated with this pathology while maintaining native glenohumeral anatomy and bone stock. Furthermore, resurfacing requires shorter operative time, is less invasive, and is less technically demanding compared with anatomic TSA or reverse TSA.[10,11] Lastly, resurfacing leaves the native glenoid intact, which reduces risk of glenoid loosening or failure in young active individuals, which can allow for greater shoulder functional demands. Stemless implant designs may provide an additional advantage of improved outcomes as compared with their stemmed counterparts. In a cross-sectional analysis of patients undergoing humeral head resurfacing and stemmed shoulder hemiarthroplasty, Fourman et al.[8] found that those undergoing resurfacing had improved American Shoulder and Elbow Surgeons pain scores and similar range of motion function, at greater than 8 years postoperatively. The authors concluded that stemless resurfacing may be preferable to stemmed hemiarthroplasty in the treatment of isolated humeral head arthritis. Comparatively, Werner et al.[12] found that of the 38 shoulders that underwent humeral head resurfacing at their institution, the mean Constant score improved to 55.4 ± 23.6 points, although symptomatic glenoid erosion resulted in revision in 37% of patients. Beck et al.[13] found that preoperative comorbidities and postoperative complications did not impact overall patient satisfaction or most patient-reported outcome measures at a mean follow up of 5.6 years postoperatively, indicating the clinical viability of humeral resurfacing on a wide array of patients.

Peebles et al.[9] described a technique of resurfacing the glenohumeral joint in a young, active patient with a previous failed Trillat procedure that resulted in end-stage osteoarthritis of the shoulder. They employed a nonspherical humeral implant with an inlay polyethylene glenoid component in a patient with diffuse degenerative changes throughout the glenohumeral joint. Although this patient had bipolar arthritis, the authors noted that humeral resurfacing was chosen as the treatment option over stemmed hemiarthroplasty or TSA due to the patient's high preoperative activity level. Bixby et al.[2] described partial humeral head resurfacing for a large chondral lesion of the humeral head in a patient with humeral head AVN. The authors

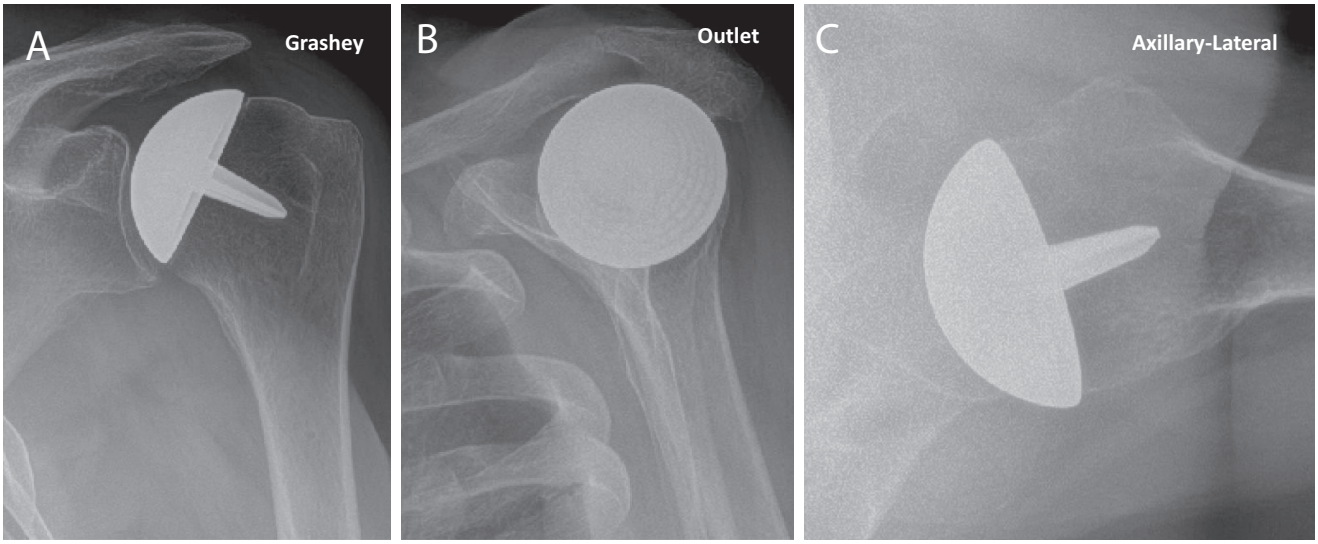

Fig 7. Postoperative radiographs of the left shoulder 2 weeks after humeral head resurfacing. Radiographs are obtained for the (A) Grashey, (B) outlet, and (C) axillary–lateral views 2 weeks postoperatively showing appropriate placement of the humeral head resurfacing implant and no evidence of periprosthetic fracture, dislocation, or component loosening.

Table 1. Pearls and Pitfalls

Pearls
• Patient should be positioned on a standard operating room table with the head of the bed elevated to 30° to allow for adequate exposure of the glenohumeral joint during dissection and implant fixation
• Positioning the patient at the side edge of the operating table facilitates external rotation and shoulder extension to allow for humeral exposure
• Subscapularis tenotomy from the less tuberosity and tagged with suture allows for anatomic repair at the end of the case
• The anterior and inferior capsular release during the approach facilitates the excursion of the subscapularis and restores range of motion
• Assessment of the glenoid after capsular release and before implantation of the resurfacing device is critical to decide whether consideration of an alternative procedure (i.e., total shoulder arthroplasty) is warranted
• Complete removal of osteophytes is essential to avoid an oversized measurement of the humeral head
• Multiple attempts at measuring the humeral head with a sizing device are needed to ensure the most accurate size from the anatomical neck of the humerus. Similarly, close attention must be paid to positioning the guide for pin placement to maintain normal inclination, version, and provide coverage of the articular surface.
• The alignment pin must cross the lateral cortex of the humerus, allowing a stronger fixation and avoiding any bending during the next steps of the procedure
• Adequate retraction of the rotator cuff muscles and deltoid is necessarily to avoid iatrogenic injury during reaming of the humeral head
• Microfracturing with a Kirshner wire and drill allows for healthy bleeding of the humeral head and enhanced future bony fixation of the resurfacing device
• A #2 FiberWire suture at the anterosuperior capsule restores the native capsule that was previously disrupted
Pitfalls
• Inability to re-establish the inferior rotator cuff interval may result in altered biomechanics, pain, and poor functional outcomes
• The insertion of the rotator cuff can be damaged during the reaming process when care is not taken to protect the surrounding cuff
• Incorrect implant positioning can occur if the alignment is not placed along the axis of the anatomical neck of the humerus or the pin is bent during any steps of the procedure
• Implanting a prosthesis that is larger compared to the native anatomy
• Reattaching the subscapularis with the shoulder in internal rotation can cause a future restriction in external rotation of the shoulder

Table 2. Advantages and Limitations

Advantages
• Humeral resurfacing is a shorter procedure, applicable to a minimally invasive approach that is less technically demanding compared with total shoulder arthroplasty
• Great surgical option in those without any signs of glenoid arthritis and are relatively young to preserve bone stock if total shoulder arthroplasty is indicated in the future
• Eliminates risk of glenoid component failure allowing for more active postoperative lifestyle
• Hardware can be easily exchanged during another surgical procedure
• Does not require reaming of a humeral stem component
Limitations
• Procedure is only indicated in a small number of patients with isolated humeral arthritis and no other associated pathologic burden to the joint
• Abnormal glenoid morphology is a limiting factor in patient selection due to possible early failure of the implant
• Potential for future progression of glenoid erosion resulting in need for conversion to total shoulder arthroplasty

argued that partial humeral head resurfacing maintains the native humeral head radius of curvature and offset as well as the native glenohumeral joint center of rotation. Furthermore, they noted that due to the stemless nature of humeral head resurfacing and minimal changes on the native biomechanics, as compared with TSA and hemiarthroplasty, contact pressures and joint stress along the glenohumeral joint are possibly relatively unaffected. Although there are several indications for humeral resurfacing, this procedure is not without disadvantages.

One disadvantage of the technique relates to conversion rates to TSA, particularly due to progressive glenoid erosion. While some authors have reported up to a 20% conversion rate of humeral head resurfacing to reverse TSA,[14] others have theorized that this is likely due to use of this implant in patients with asymmetric native glenoids.[15,16] The risk of progressive glenoid erosion after this procedure can be mitigated by employing proper patient selection by analyzing the glenoid for deformity or eccentric wear on preoperative imaging. Bülhoff et al.[17] found that 78% of patients were able to return to work or sport after resurfacing and concluded that patients who led active lifestyles preoperatively had an excellent chance of returning to activity postoperatively, further emphasizing the importance of proper patient selection for this procedure.

Osteochondral allograft (OCA) transplantation also has been reported in the literature as a surgical option for patients with similar presentation usually as a result of traumatic Hill–Sachs lesions. Riff et al.[18] evaluated 20 patients at their institution with a 2 year follow up who had undergone a humeral OCA procedure. Four patients required conversion to TSA at 25 months postoperatively and those with bipolar disease or on a pain pump postoperatively had increased failure rates. Saltzman et al.[19] performed a systematic review to evaluate the outcomes after OCA of the humeral head. At latest follow up, complication rates ranged from 20% to 30%, and there were glenohumeral arthritic changes in 35.7% of the cohort as well as a reoperation rate of 26.67%. When patients were followed 5 or more years after OCA, 50% required conversion to TSA. This review highlights that the high complication and reoperation rates of humeral head OCA make this a last resort option in patients who have exhausted several other treatment modalities.

The technique presented here is a viable option for patients with isolated humeral head chondral lesions in

whom joint-preserving procedures are not optimal, but with degenerative changes not advanced enough to warrant total shoulder arthroplasty. Table 1 lists the salient pearls and pitfalls of this technique. Proper patient positioning is key to adequate exposure of the humeral head, allowing the surgeon to correctly size and place the implant. A thorough and complete assessment of the joint, particularly the glenoid, should be performed after capsular release to confirm the indication for humeral head resurfacing. The rotator cuff must be adequately protected during reaming to avoid iatrogenic damage. Microfracture of the implantation surface with a Kirshner wire or drill creates bony bleeding that can improve the fixation potential of the resurfacing device. Finally, care must be taken to place the guidewire along the axis of the anatomic neck of the humerus and through the lateral cortex to ensure correct reaming and implant placement. Table 2 outlines the major advantages and disadvantages of this technique. Stemless humeral head resurfacing represents a desirable anatomy-preserving alternative to total shoulder arthroplasty that minimizes surgical risks while improving pain and restoring function. In cases in which total shoulder arthroplasty becomes necessary, the presented technique preserves bone stock allowing for an easier conversion.

As both TSA and hemiarthroplasty implants trend toward shorter stem and stemless designs to allow for reduced risk of periprosthetic fracture and preservation of bone stock, humeral head resurfacing presents a viable and efficacious surgical treatment option to treat isolated humeral head osteoarthritis with large chondral lesions.

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