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REVIEW

Superior Instrumentation Through the Rotator Cuff Defect From a Deltopectoral Approach for Hemiarthroplasty for Cuff Tear Arthropathy

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ABSTRACT

Rotator cuff tear arthropathy remains a challenging problem for the orthopaedic surgeon. In these cases, humeral prosthetic arthroplasty has yielded improvements in pain, whereas functional improvements have been less predictable. In North America and Europe, the deltopectoral or superior surgical approach is typically used to gain access to the glenohumeral joint for purposes of performing a hemiarthroplasty. Each approach violates different portions of the remaining soft tissue structures, which have been shown to be important for good postoperative function in patients with rotator cuff–deficient arthropathy. A modified surgical technique for humeral prosthetic arthroplasty in patients with rotator cuff–deficient arthropathy is described. In appropriately selected patients, this surgical technique allows for sufficient exposure of the glenohumeral joint while preserving the essential functional tissues, which have been shown to be important in promoting an optimal outcome in these patients.
Keywords: rotator cuff tear arthropathy, hemiarthroplasty

HISTORICAL PERSPECTIVE

Glenohumeral arthrosis associated with an irreparable rotator cuff tear represents a therapeutic challenge for the orthopedic surgeon. Although rotator cuff tear arthropathy (CTA) represents a small subset of glenohumeral arthrosis, there are many other causes of arthritis associated with large and massive irreparable rotator cuff tears. These other diagnoses include rheumatoid arthritis, psoriatic arthritis, crystal-induced inflammatory arthritis, and posttraumatic arthritis. Each of these problems can result in rotator cuff deficiency and arthritis (RCDA) and is associated with adverse joint mechanics and profound functional limitations.

As the glenohumeral joint lacks inherent osseous constraints, it relies significantly upon its soft tissue elements to provide stability throughout its range of motion. The rotator cuff functions as both motor and stabilizer of the proximal humerus during motion. It assists with external and internal rotation as well as strength in elevation. Importantly, it applies a compressive centralizing force to the humeral head in a synergistic manner during shoulder motion that is powered by the larger deltoid, latissimus dorsi, and pectoralis major muscles. Large tears of the rotator cuff can weaken this centralizing function, resulting in impaired joint mechanics, diminished function, and in some instances, painful arthrosis.[1–4]

Several reports have discussed the concept of a transverse force couple in the rotator cuff.[5–9] This concept, supported both biomechanically and clinically, demonstrates that the anterior portion of the rotator cuff (subscapularis) may be balanced by the posterior portion of the rotator cuff (infraspinatus and teres minor) despite a large deficiency of the superior portion of the rotator cuff (supraspinatus). The remaining balanced cuff affords some patients sufficient joint compressive forces through a transverse force couple and therefore preservation of arm elevation. In many cases, portions of the anterior and posterior rotator cuff remain attached despite the presence of a massive rotator cuff tear and arthrosis. Although not sufficient to provide normal mechanics to the glenohumeral joint, when combined with a functioning deltoid and a stable and intact coracoacromial (CA) arch, it affords some degree of functionality by way of a force couple.

When this balance is compromised, the unopposed pull of the deltoid leads to increased superior humeral head migration and articulation with the CA arch. Several studies have pointed out the importance of maintaining the CA arch integrity in patients with irreparable rotator cuff tears.[1,3,10–12] It has been suggested that the CA ligament may provide a fulcrum in cuff-deficient shoulders on which the humerus may

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articulate during a functional range of motion.[2,13] In addition, anterosuperior instability has been demonstrated clinically and experimentally when the CA ligament is incompetent or absent or the normal anterior-posterior dimension of the acromion is decreased as a result of prior surgical acromioplasty.[10,14–16] A large retracted rotator cuff tear with an incompetent CA arch may therefore lead to disabling anterosuperior humeral escape. When this occurs, the mechanical advantage of the deltoid muscle is severely diminished, with resultant poor shoulder function.[17]

Surgical intervention is indicated in patients with large irreparable rotator cuff tears and painful glenohumeral arthropathy and in patients in whom nonoperative measures have failed. When surgical intervention is indicated, hemiarthroplasty has been shown to provide predictable improvements in pain. However, functional improvement has been more difficult to predict.[1,3,4,18–21] The reasons for these variations are likely multifactorial and arise from differences in rotator cuff involvement, CA arch integrity, deltoid muscle function, and the ability of the patient to engage in appropriate postoperative rehabilitation program.[1,3,10,22,23]

In North America, the deltopectoral approach is commonly used when performing shoulder hemiarthroplasty. The deltoid origin is left attached to the acromion, and the CA ligament can be protected through this approach. However, to dislocate the joint and instrument the proximal humerus, any remnants of the anterior rotator cuff are typically elevated from the humerus and subsequently repaired.

The anterosuperior approach to the shoulder, more commonly used in Europe, is a deltoid-splitting approach. As its name implies, it provides exposure of the glenohumeral joint from a superior direction just anterior to the acromion. The anterior deltoid is elevated at its origin off the anterolateral acromion. The acromial insertion of the CA ligament is also violated during the deltoid elevation. With extension and adduction of the humerus, the proximal humerus can be delivered from the joint under the CA arch. In cases of RCDA, this approach typically provides sufficient exposure to initiate instrumentation of the humerus through the defect left by the absence of a superior cuff. Furthermore, the intact portions of the subscapularis insertion can typically be preserved without compromising humeral head exposure. As noted previously, however, this exposure comes at the expense of the CA ligament and deltoid origin.

Therefore, a surgical approach to hemiarthroplasty that spares the remnants of the anterior rotator cuff, CA arch, and deltoid origin could provide an optimum combination of soft tissue protection and adequate exposure while lending itself to a better functional result.

In the senior author's experience over the last 12 years, the ideal surgical technique for hemiarthroplasty for RCDA avoids detachment and repair of the CA arch, deltoid origin, and remaining rotator cuff. Consequently, the objectives of the procedure are to remove the pathological bursal tissue; remove the intraarticular portion of an abnormal biceps tendon, which can be a pain generator; replace the humeral head with an anatomically sized prosthesis; correct eccentric glenoid wear by creating a smooth concave surface for humeral articulation; preserve the CA arch; protect the deltoid origin; and preserve any intact portions of the rotator cuff.

INDICATIONS/CONTRAINDICATIONS AND RATIONALE FOR THE SURGICAL TECHNIQUE

The indications for this technique are identical to the indications for hemiarthroplasty for RCDA; namely, the ideal candidate is a patient with a massive irreparable

FIGURE 1. Preoperative radiographs demonstrating findings characteristic of rotator cuff–deficient arthropathy including narrowing of the acromial-humeral interval, femoralization of the humeral head, acetabularization of the CA arch, and subchondral sclerosis of the superior humeral head.

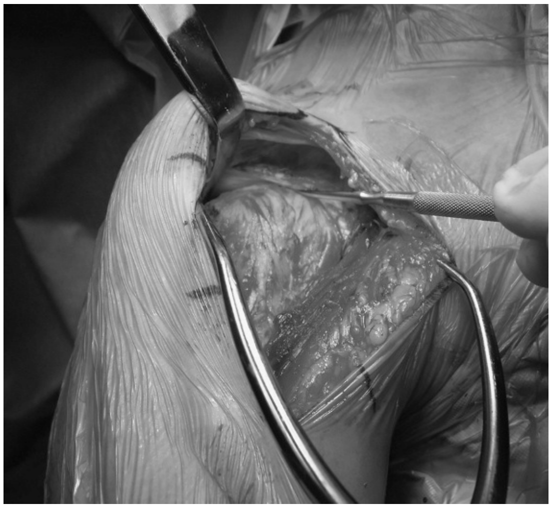

FIGURE 2. The proximal humerus shown in the deltopectoral interval and beneath the CA arch. The CA ligament is preserved.

cuff tear, painful glenohumeral arthropathy, an intact CA arch, competent deltoid, and preoperative active elevation to shoulder level (90 degrees). Pain relief should be the patient's primary goal, as functional improvements are less predictable for above-shoulder-level activities. Although the functional level above shoulder height is difficult to predict preoperatively, when the patient has active elevation to 90 degrees preoperatively, then many of these patients will have good functional use of the hand above shoulder level for simple activities of daily living after hemiarthroplasty. When these preoperative conditions occur, it is assumed that the patient has a high center of humeral rotation but a stable fulcrum for rotation under the CA arch. In addition, it is inferred from this level of preoperative function that there is sufficient rotator cuff and deltoid function to allow for active elevation to shoulder level.

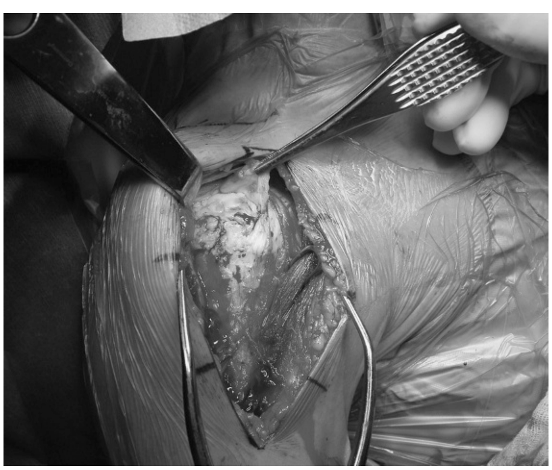

FIGURE 3. Abnormal bursal tissue is removed while preserving intact portions of the rotator cuff.

FIGURE 4. Humeral extension, adduction, and external rotation allow delivery of the humeral head into the deltopectoral interval. The intact portion of the subscapularis remains attached anteriorly.

With these assumptions, the goal of the surgery is to preserve the CA arch and this stable fulcrum for shoulder elevation and humeral rotation, and preserve the remaining intact portion of the rotator cuff and deltoid through the surgical approach. If these surgical goals are achieved and if the patient achieves good pain relief with improved shoulder mechanics by providing a smooth painless humeral surface with restoration of the lateral humeral offset, then the postoperative rehabilitation will improve rotator cuff and deltoid strength as well as scapulahumeral and scapulathoracic kinematics. When this occurs, there will be an improvement in the active elevation after humeral hemiarthroplasty. It is the goal of the superior approach to the humerus through the deltopectoral interval to maximize the potential to achieve these goals through preservation of the CA arch and the remaining intact rotator cuff.

Unlike standard glenohumeral osteoarthritis, most patients with RCDA will demonstrate near-full passive

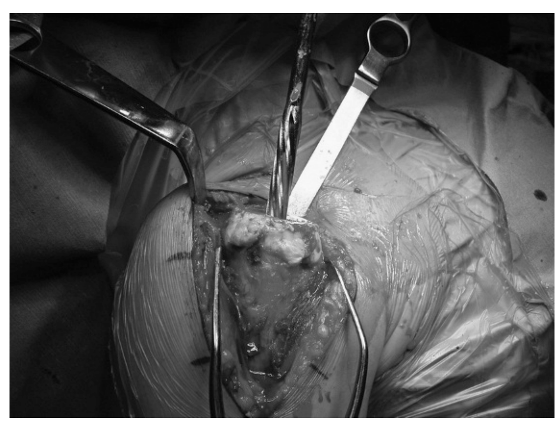

FIGURE 5. With the proximal humerus delivered under the CA arch, instrumentation is possible through the osteotomized surface of the proximal humerus.

FIGURE 6. The trial humeral stem is placed in the canal so that the collar of the stem abuts the remaining portion of the humeral head.

range of motion preoperatively because capsular contracture is rarely an element of the pathology. Access to the inferior capsule is limited through this approach, making complete capsular releases and capsulectomy difficult. As such, a prerequisite for this approach is good passive range of motion.

If the patient has anterosuperior humeral escape or any deltoid deficiency, hemiarthroplasty performed with any surgical technique is unlikely to improve above-waist function. However, in patients with a functioning deltoid and anterosuperior escape, the reverse total shoulder prosthesis has shown in early series to provide an effective means of treating this difficult problem.[24–27]

PREOPERATIVE PLANNING

A thorough clinical examination should delineate the extent of the rotator cuff tear. An external rotation lag sign and the belly press test should be assessed as a means to ascertain the extent of rotator cuff deficiency. Both active and passive range of motion should be documented, but most patients with RCDA without superior escape have full passive motion. Some patients are inhibited by pain and are unable to actively elevate their arm much above chest level. A glenohumeral injection of local anesthetic can temporarily relieve the pain such that the patient can obtain active elevation above chest level. This finding represents a favorable prognostic indicator for improved postoperative active range of motion with hemiarthroplasty. Hemiarthroplasty should not be expected to provide a predictable improvement in active forward elevation in those patients whose range of motion does not improve despite adequate analgesia. Although the precise indications are yet to be delineated, in this setting, the reverse shoulder arthroplasty may provide a better functional result when adequate deltoid function is present.

Imaging studies should include routine anteroposterior, Grashey, and axillary radiographs of the shoulder (Fig. 1). These preoperative radiographs allow planning for implant sizing and assessment of glenoid morphology. Although many patients will present with magnetic resonance imaging studies obtained previously, after a careful examination of the shoulder, the magnetic resonance imaging usually serves to confirm the diagnosis and rarely presents new information.

SURGICAL TECHNIQUE

The senior author has incorporated the above goals into a modified approach to the shoulder for hemiarthroplasty in cases of RCDA for the last 12 years. The patient is positioned in a standard beach chair configuration. The operative shoulder is brought beyond the edge of the

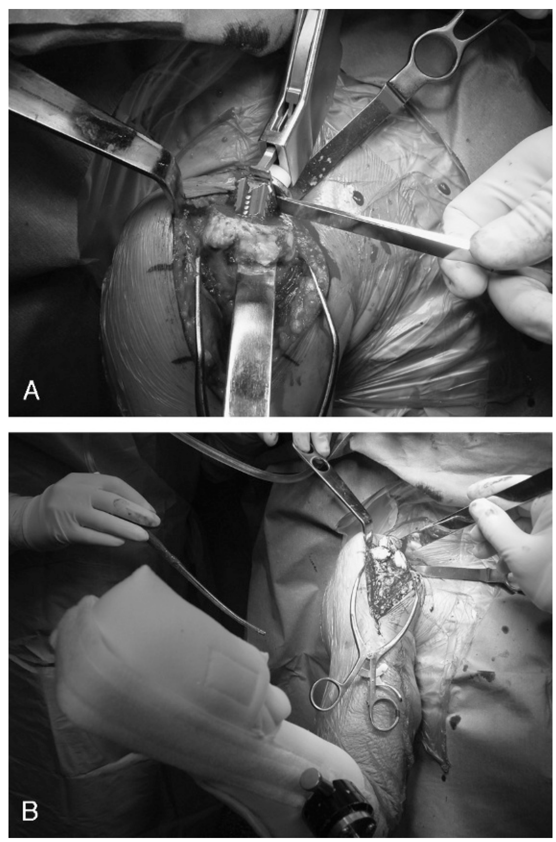

FIGURE 7. A, Version is measured using the flat back of the broach collar as a reference. A flat instrument (an osteotome) is used to better visualize the version of the prosthesis with relation to the forearm. B, Version of the prosthesis is compared with the long axis of the forearm with 90 degrees of elbow flexion. The stem is rotated to a position approximately 10 degrees more retroverted than anatomic.

table so that full adduction and extension of the shoulder can be achieved. Superficially, a standard deltopectoral skin incision is used and the deltopectoral interval is developed, mobilizing the cephalic vein laterally. The upper 2 cm of the pectoralis tendon is detached at the musculotendinous junction for 1 to 2 cm in the mid tendon to facilitate exposure and avoid excessive soft tissue retraction. The biceps tendon is tenodesed to the remaining pectoralis tendon. Care is taken so as not to disrupt the CA ligament as the clavipectoral fascia is incised along the lateral border of the conjoined tendon (Fig. 2). Abnormal bursal tissue is removed around the humeral head and from the CA arch (Fig. 3). Portions of the rotator cuff that remain intact are preserved, and the extent of the cuff deficiency is assessed. Even in advanced cases of RCDA, inferior insertions of the subscapularis and infraspinatus may still be present. A large Darrach retractor is placed between the humeral head and glenoid through the rotator cuff defect, and the humeral head is gently levered from the joint and from under the CA arch. Humeral extension, adduction, and external rotation will allow delivery of the humeral head into the deltopectoral interval (Fig. 4). Narrow Homan retractors placed beneath the remaining portions of the anterior and posterior rotator cuff exposes the proximal humerus from a superior aspect. A reciprocating saw is used to make a freehand cut approximately 5 mm distal to the top of the humeral head and perpendicular to the humeral shaft. In this manner, the top of the humeral head is removed, exposing the cancellous bone and providing access to the intramedullary canal. Starting with the smallest humeral medullary reamers, the canal is sequentially enlarged (Fig. 5). A trial humeral stem is placed in the canal so that the collar of the stem abuts

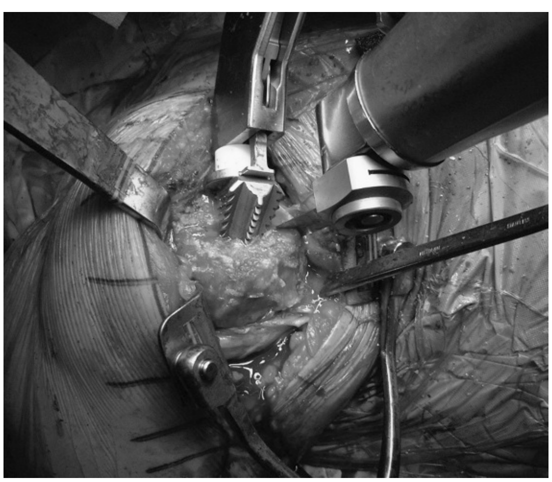

FIGURE 8. The blade of the reciprocating saw is now made parallel to the back of the broach collar, using it as a cutting guide; and the remaining humeral head is removed.

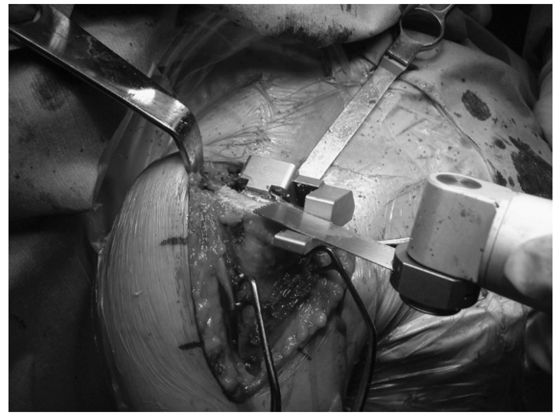

FIGURE 9. If a DePuy CTA prosthetic (DePuy, Johnson and Johnson) is used, then the tuberosity osteotomy is made using the supplied cutting guide.

the remaining portion of the humeral head (Fig. 6). Alternatively, an extramedullary cutting guide can be used to estimate the humeral neck shaft angle and thereby the plane of the humeral osteotomy. The stem is rotated to a position approximately 10 degrees more retroverted than anatomic. To measure retroversion, the flat back of the broach collar is compared with the long axis of the forearm with 90 degrees of elbow flexion. Two straight osteotomes can be placed along the axis of the forearm and the flat back of the broach collar to help visualize the correct retroversion (Fig. 7). Close attention should be given to the proximal humerus osteotomy so that excessive retroversion is avoided. The combination of an absent posterior rotator cuff and rounded posterior articular margin osteophytes may mislead the surgeon into creating an inappropriately retroverted osteotomy. Using the osteotomes in the above manner has alleviated this potential pitfall (Fig. 7). The blade of the reciprocating saw is now

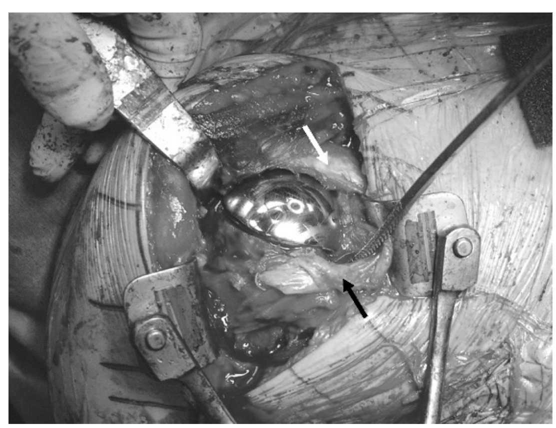

FIGURE 10. The final prosthesis should sit directly and precisely upon the cut surface of the humerus. The deltoid origin, CA arch (white arrow), and the anterior rotator cuff (black arrow) remain intact.

FIGURE 11. Postoperative radiographs after hemiarthroplasty for rotator cuff–deficient arthropathy through the modified superior approach.

made parallel to the back of the broach collar, using it as a cutting guide (Fig. 8). The remaining humeral head is removed at the level of the anatomic neck, being careful to keep the cut within the joint to preserve the remaining rotator cuff and protecting the axillary nerve. With the head removed, the inferior portion of the osteotomy is palpated. Any inferior osteophytes are removed with a curved osteotome. In most cases of RCDA, these inferior osteophytes are minimal or absent. If a capsular release is needed, it can be released from the glenoid side. A Fukuda retractor is used to displace the proximal humerus inferiorly and posteriorly such that the glenoid surface can be inspected. Glenoid irregularities or biconcavity is corrected by using a concave glenoid reamer or by hand with a burr, leaving a smooth concave surface. The goal of glenoid preparations in these cases is to preserve the cortical surface and remove only those irregularities that would otherwise prevent a smooth articulation with the humeral head. Degenerative soft tissue and synovial tissue is also removed, and the joint is irrigated thoroughly. The proximal humerus is again delivered from the joint as previously described. The medullary canal is prepared for stem placement according to the manufacturer's guidelines. When the appropriate trial stem is implanted, the trial head is applied and the joint reduced to assess stability and range of motion. If a DePuy CTA prosthetic (DePuy, Johnson and Johnson; Warsaw, IN) is used, then the additional cut in the tuberosity is made from the trial head or using the supplied cutting guide (Fig. 9). With the final components selected, they are assembled and implanted with or without bone cement, depending upon the prosthetic stem design, stem stability, and bone quality. The final prosthesis should sit directly and precisely upon the cut surface of the humerus (Fig. 10). A standard layered closure is performed with a subcuticular running stitch for skin closure.

In appropriately selected patients and with proper surgical technique, the remaining anatomical structures that have been shown to be important in patients with RCDA can be preserved (Figs. 11 and 12).

■ POSTOPERATIVE CARE

Gentle passive elevation and external rotation stretching exercises are encouraged for the first 2 postoperative weeks, at which time cross-body adduction stretching is added. The goal of the exercises during the first 6 postoperative weeks is to maintain the range of motion demonstrated intraoperatively. At 6 weeks, a supervised strengthening program is initiated. When this procedure is performed as described, there is a very stable prosthetic within an intact CA arch and the rotator cuff

FIGURE 12. Postoperative clinical photographs demonstrating range of motion after hemiarthroplasty of the right shoulder for rotator cuff–deficient arthropathy using the modified superior approach.

that was intact remains intact. Under these circumstances, there is little to prevent active range of motion or resistive exercises as soon as the patient's pain level will allow. In addition, there is little need to protect the shoulder in a sling other than for the management of early postoperative pain. Full or near-full passive range of motion is a common preoperative clinical finding in RCDA. Using this approach, passive range of motion has remained good. A near-complete absence of rotator cuff tissue and a lack of capsular contracture preoperatively have yielded maintenance of good passive arcs of motion postoperatively.

SUMMARY

In appropriately selected patients, we believe this modified surgical technique for hemiarthroplasty provides an optimal approach to the proximal humerus in cases of RCDA. The purpose of this technique is to provide sufficient exposure to the proximal humerus without violating the remaining subscapularis, deltoid origin, and CA ligament. Leaving the subscapularis undisturbed helps sustain the transverse force couple with the posterior rotator cuff, which may help preserve postoperative function. Preserving the deltoid origin helps minimize the chance of postoperative deltoid dysfunction, which is the primary source of motion of the shoulder in patients with massive cuff tears. Not violating the CA ligament helps preserve the CA arch and thus minimizes the chance for anterosuperior humeral escape. Therefore, this modified technique to the deltopectoral approach for hemiarthroplasty in patients with RCDA aims to leave undisturbed the remaining soft tissue structures of the shoulder, which have been shown to be important in facilitating a favorable outcome in these patients.

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