A Review Paper

The Arthritic, Cuff-Deficient Shoulder—When Is Hemiarthroplasty Enough?

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Abstract

This article outlines the role of hemiarthroplasty in the treatment of cuff-tear arthropathy. Rotator cuff tear arthropathy, kinematics, and classification are reviewed.

Rotator cuff arthropathy is a relatively newly recognized condition. In 1934, Codman[1] described a case of arthritis as the result of a large retracted rotator cuff tear. Previous reports of patients with massive cuff tears and degenerative conditions of the shoulder had been reported as early as 1857.[2] Neer and colleagues[3] coined the term *cuff-tear arthropathy* and described the pathoanatomical changes of a chronic massive rotator cuff tear combined with superior migration of the head, instability, erosion of the acromion, and head osteoporosis with collapse of subchondral bone. Superior displacement of the humerus into the subacromial space resulted in erosion of the greater tuberosity (*femoralization*) and subsequent morphologic changes to the coracoacromial arch (*acetabularization*). This article outlines the role of hemiarthroplasty in the treatment of cuff-tear arthropathy.

Neer and colleagues[3] proposed 2 interdependent mechanisms—nutritional and mechanical—for the development and progression of cuff-tear arthropathy. When a patient sustains a rotator cuff tear, several nutritional and mechanical changes take place in the shoulder. There is loss of the normal envelope and capsule about the shoulder, which can result in loss of containment of synovial fluid, with subsequent malnutrition of the articular cartilage.[3] Loss of cuff function can cause unbalanced forces about the shoulder, with subsequent superior migration of the humeral head. This results in mechanical impingement of the head under the acromion and mechanical abrasion of the cartilaginous surfaces. The incidence of rotator cuff arthropathy is unknown. Neer and colleagues suggested that about 4% of patients with cuff tears later develop cuff arthropathy.

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Kinematics

The glenohumeral joint lacks significant intrinsic bony stability. Dynamic stabilization of the joint is provided by ligament support, coupled with the rotator cuff compressive force vector within the concavity of the glenoid fossa. The infraspinatus and supraspinatus offer inferiorly directed forces, which exert a centering effect throughout shoulder motion.[4] Radiographic and electromyographic analysis of patients with rotator cuff–deficient shoulders has provided further insight into the kinematics of the shoulder. Stable force couples can exist in a cuff-deficient shoulder if transverse forces between subscapularis and posterior–inferior structures are balanced.[4] Disruption of the stable kinematics or loss of coronal deltoid forces leads to unstable kinematics and loss of overhead function. Captured fulcrum mechanics is a condition in which the cuff-deficient shoulder is able to function with stable kinematics. Some patients with cuff-tear arthropathy maintain overhead function with captured fulcrum mechanics; they depend on the coracoacromial arch, balanced rotator cuff force couples, and a functional anterior deltoid to contain the head, thus stabilizing the shoulder for active forward elevation.[5] In the absence of captured fulcrum kinematics, overhead function cannot be restored with hemiarthroplasty. Therefore, preoperative kinematics and postoperative patient functional expectations are 2 of the most important guiding factors in choosing between hemiarthroplasty and reverse arthroplasty for the arthritic, cuff-deficient shoulder.

Patient Evaluation

The most common conditions associated with cuff-tear arthropathy—and the only true consistent findings—are atrophy of the supraspinatus and infraspinatus muscles and weakness of external rotation. Because an external rotation lag sign (Figure 1) may be present as a result of loss of function of external rotators, specifically the infraspinatus and teres minor, it is important to determine strength of external rotation. The status of the subscapularis, the loss of which can have significant detrimental effects on shoulder function, should be assessed with a lift-off or stomach push test (Figure 2). Active and passive motion should be assessed. Passive motion is typically well preserved in patients with cuff arthropathy. Loss of passive external rotation is unusual; however, excessive passive external rotation may be indicative of subscapularis rupture. Posterior capsular contracture can be assessed

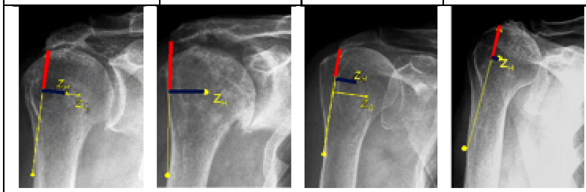
Figure 1. An external rotation lag sign (left) is indicative of posterior rotator cuff deficiency.

Figure 2. Inability to compress the abdomen and hold the arm forward (positive abdominal compression test) is indicative of subscapularis deficiency.

by checking internal rotation with the arm abducted 90° and the scapula stabilized. Significant posterior capsular contracture may shift the instant center of rotation of the humeral head anterosuperiorly during flexion, exacerbating any impingement problems. Anterosuperior migration might be the cuff-arthropathy equivalent of obligate posterior translation of the humeral head resulting from internal rotation contracture, commonly found in glenohumeral osteoarthritis with an intact cuff.

Several functional parameters may predict successful hemiarthroplasty for cuff-tear arthropathy. Active forward flexion beyond 70° is one such parameter. As loss of active elevation may be exacerbated by pain, 10 mL of lidocaine can be injected into the subacromial space to treat pain and better evaluate active elevation. Demonstration of active initiation and force against gravity with forward flexion indicates that the patient likely has stable kinematics that can be addressed without resorting to a reverse prosthesis. A critical assessment of anterior deltoid and subscapularis function is needed in the decision-making process. Deficient anterior structures that may have been violated or weakened by prior surgical procedures involving the coracoacromial arch may contraindicate the choice of hemiarthroplasty for cuff-tear arthropathy. If hemiarthroplasty is performed in the setting of complete subscapularis rupture, pectoralis major transfer should be considered.

Type IA Centered stable	**Type IB Centered-medialized**	**Type IIA Uncentered-limited stable**	**Type IIB Uncentered-stable**
No superior migration		Superior translation	Anterior–superior dislocation
Acetabularization of CA arch; femoralization of humeral head	Medial erosion of the glenoid	Minimum stabilization by CA arch	No stabilization by CA arch



CA indicates coracoacromial

Figure 3. The Seebauer classification divides cuff tear arthropathy based on absence (type I) or presence (type II) of fixed proximal migration. Type IB is characterized by medial erosion. Types IIA and IIB differ in degree of fixed proximal migration. From: Visotsky JL, Basamania C, Seebauer L, Rockwood CA, Jensen KL. Cuff-tear arthropathy: pathogenesis, classification and algorithm for treatment. *J Bone Joint Surg Am.* 2004;86(suppl 2)35-40.[6] Reprinted with permission from The Journal of Bone and Joint Surgery, Inc.

Seebauer[6] proposed a radiographic classification of cuff-tear arthropathy and related conditions (Figure 3). This classification is based on analysis of failed treatments and the presumed biomechanics leading to those failures.[6] Two types of patients (4 distinct subgroups) have been formed on the basis of the biomechanics and clinical outcomes of arthroplasty for cuff-deficient shoulders. In type I, kinematics are stable; in type II, kinematics are unstable from loss of a captured fulcrum. Types I and II are distinguished by the presence of static superior migration of the center of rotation, the amount of instability of the center of rotation, and associated changes to the coracoacromial arch structures. Type I patients lack static superior migration. Type IA patients have typical cuff arthropathy changes—specifically, acetabularization of the acromion and femoralization of the head. Type IB patients exhibit medial erosion. Type II patients demonstrate varying degrees of static superior migration. Type IIA patients have significant proximal migration but maintain relatively stable kinematics. Finally, type IIB patients have anterosuperior escape because of the loss of the coracoacromial arch.

Treatment Options—Humeral Hemiarthroplasty or Reverse Arthroplasty

The treatment goals of cuff-tear arthropathy are similar to those of standard degenerative and inflammatory arthritis: pain relief, restoration of glenohumeral stability, and improvement of functional motion. Cuff-tear arthropathy presents a unique surgical challenge. Numerous surgical procedures, including total shoulder arthroplasty (TSA), bipolar arthroplasty, large

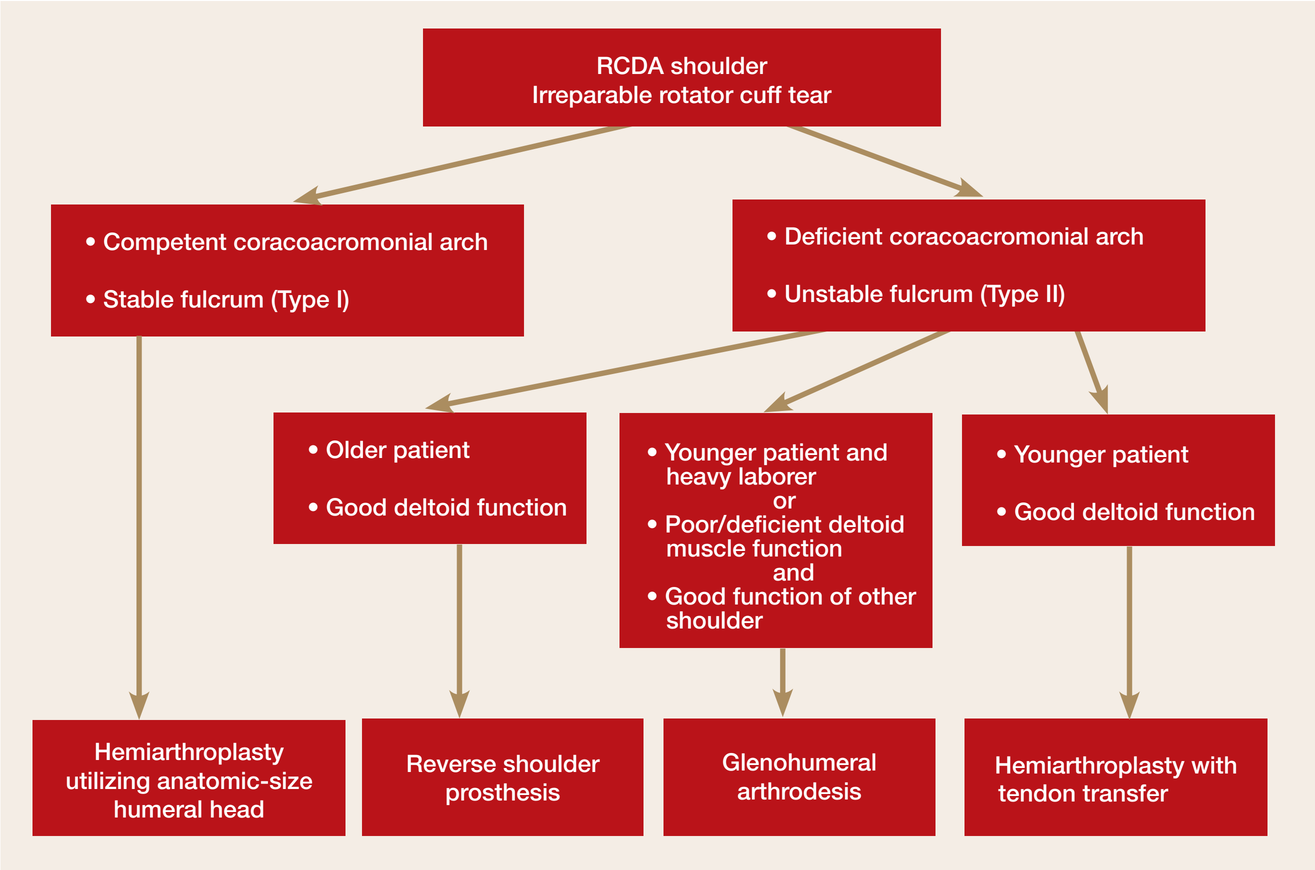


Figure 4. Algorithm for management of cuff tear arthropathy. RCDA indicates rotator cuff–deficient arthroplasty. From: Visotsky JL, Basamania C, Seebauer L, Rockwood CA, Jensen KL. Cuff tear arthropathy: pathogenesis, classification and algorithm for treatment. *J Bone Joint Surg Am.* 2004;86(suppl 2)35-40.[6] Reprinted with permission from The Journal of Bone and Joint Surgery, Inc.

head hemiarthroplasty, and arthroplasty with constrained glenoid components, have been used to treat the superior migration and associated degeneration of cuff-tear arthropathy.[7] Because the rates of glenoid component failures are high, anatomical total shoulders are generally not considered in cuff-tear arthropathy.[8] Large head hemiarthroplasty and bipolar arthroplasties have not consistently demonstrated improved patient function in limited reported series. Large head implants and bipolar implants also have the potential for overstuffing the joint and increasing joint reaction forces, leading to bone loss, attritional failure of acromial arch, and progressive instability. A review of the literature finds the results of hemiarthroplasty in cuff-tear arthropathy to be good but not completely predictable.[8] Recent implants have been designed to increase the surface area of the hemiarthroplasty head without the recognized negative effects of overstuffing and increased joint reaction forces.

The 2 main options for surgical management of cuff-tear arthropathy are hemiarthroplasty and reverse arthroplasty. Use of hemiarthroplasty has a relatively long history. Pain relief is generally good, but not as good as with TSA with an intact cuff. Functional improvement has been unpredictable and related to coracoacromial arch integrity, deltoid integrity, and the amount of rotator cuff remaining. Early designs of reverse arthroplasty were abandoned because of unacceptably high rates of infection, implant failure, and early loosening. Complication rates are lower with more recent reverse designs but remain consistently higher than with hemiarthroplasty and can reach 50%. However, in patients with unstable kinematics and an inability to raise the arm, reverse arthroplasty offers the best chance for restoration of stable kinematics and overhead elevation. It should be obvious that adequate glenoid bone stock is needed to accept a reverse glenoid component.

Assuming that all patients would like to preserve or regain substantial overhead function, the most influential factor in choosing between hemiarthroplasty and reverse arthroplasty is the patient's preoperative ability to maintain captured fulcrum kinematics during humeral elevation. In the absence of stiffness, the amount of active elevation may be thought of as a proxy for stable kinematics. Unfortunately, this is often not an all-or-none phenomenon. Pseudoparalysis with obvious anterosuperior escape is clearly an indication for reverse arthroplasty. Likewise, hemiarthroplasty is the treatment of choice if active preoperative elevation is normal or near normal. Many patients fall somewhere in between these extremes. The lower limit of active elevation required for a hemiarthroplasty to be successful is unknown and varies among individual surgeons. We have used 70° of preoperative elevation as our threshold for performing a hemiarthroplasty. As already mentioned, intra-articular or subacromial injection of lidocaine may be required to accurately assess active elevation.

Seebauer's radiographic classification can be used in conjunction with clinical examination to choose between hemiarthroplasty and reverse arthroplasty.[6] Using this classification, clinicians can treat type IA and type IB patients adequately with a standard hemiarthroplasty or a specific cuff-tear hemiarthroplasty with an extended head to allow greater surface area for articulation. Reverse TSA is the best choice for restoring stability and overhead function in type IIB patients. The best treatment for type IIA patients with limited stability is less clear. The type IIA patient may benefit from hemiarthroplasty when the patient's functional demands are matched with expected outcome. Patient age and physical shoulder demands play important roles in the physician's decision. Younger type IIA patients, particularly those with deltoid deficiency, are not good candidates for reverse arthroplasty. Using this classification has led to development of an algorithm for treating cuff-tear arthropathy (Figure 4). These treatment recommendations should be considered guidelines, not rigid rules. There may not be only one correct treatment solution for each patient, and successful outcomes depend on many factors, including patient age, activity level, deltoid integrity, coracoacromial arch integrity, treatment choice, and precise surgical execution. The implant used is ultimately selected by individual surgeons and patients after careful consideration of these issues.

Authors' Disclosure Statement

Both authors wish to note they are consultants for DePuy Orthopaedics, Inc. Dr. Basamania also receives royalty payments for some of the DePuy products.

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