Abstract: Rotator cuff tear arthropathy encompasses a broad spectrum of pathology, but it involves at least three critical features: rotator cuff insufficiency, degenerative changes of the glenohumeral joint, and superior migration of the humeral head. Although many patients possess altered biomechanics of the glenohumeral joint secondary to rotator cuff pathology, not all patients develop rotator cuff tear arthropathy, and thus the exact etiology of rotator cuff tear arthropathy remains unclear. The objectives of this manuscript are to (1) review the biomechanical properties of the rotator cuff and the glenohumeral joint, (2) discuss the proposed causes of rotator cuff tear arthropathy, (3) provide a brief review of the historically used surgical options to treat rotator cuff tear arthropathy, and (4) present a treatment algorithm for rotator cuff tear arthropathy based on a patient’s clinical presentation, functional goals, and anatomic integrity.

Rotator cuff tear arthropathy is a term coined by Neer in 1983, and it encompasses a broad spectrum of pathology. However, all patients with rotator cuff tear arthropathy possess at least three critical features: (1) rotator cuff insufficiency, (2) degenerative changes of the glenohumeral joint, and (3) superior migration of the humeral head. Neer et al. originally proposed that, following a massive rotator cuff tear, both mechanical and nutritional factors lead to degeneration of the glenohumeral joint and subsequent osteopenia of the humeral head. However, this mechanism does not explain why only some patients with a massive rotator cuff tear develop rotator cuff tear arthropathy. Although the true etiology of rotator cuff tear arthropathy is unclear, what is evident is that it is a difficult condition to treat, and surgical techniques for the management of rotator cuff tear arthropathy continue to evolve.

The objectives of this manuscript are to review the biomechanical properties of the rotator cuff and the glenohumeral joint, to discuss the proposed causes of rotator cuff tear arthropathy, to provide a brief review of historically used surgical options for the treatment of rotator cuff tear arthropathy, and to present a treatment algorithm for rotator cuff tear arthropathy. Although a patient may present with characteristic clinical examination findings and radiographs consistent with rotator cuff tear arthropathy, appropriate management requires a global assessment of that patient’s initial presentation, anatomic integrity, and functional goals.

Biomechanics of the Glenohumeral Joint

The rotator cuff complex, consisting of the supraspinatus, infraspinatus, teres minor, and subscapularis muscles, plays...
a pivotal role in providing dynamic stability to the glenohumeral joint. The glenohumeral joint lacks substantial intrinsic osseous restraints, and thus the joint’s stability relies heavily on the rotator cuff’s ability to center the humeral head within the glenoid fossa. This key concept has been coined concavity-compression, as the rotator cuff actively compresses the convex humeral head into the concave glenoid, especially during the middle and end of the range of shoulder motion. Through this mechanism, the shoulder musculature—including the rotator cuff—becomes the primary stabilizer of the glenohumeral joint as the arm moves through positions in which the capsuloligamentous structures are lax. This dynamic stability also relies on the interplay between the deltoid muscle and the rotator cuff. Whereas the rotator cuff provides a net inferiorly directed and compressive force vector, the strong deltoid muscle provides a superiorly directed force, resulting in a net force balance or force coupling of the glenohumeral joint. Loss of rotator cuff integrity creates an unstable fulcrum of motion, leading to superior migration of the humeral head on the glenoid and altered glenohumeral joint biomechanics.

The glenohumeral joint’s remarkable mobility is attributable to both the small contact surface area of the humeral head on the glenoid, estimated to be 4 to 5 cm², and the shallowness of the glenoid fossa. Itoi et al. noted the maximum depth of the cartilage-covered glenoid fossa to be approximately 2 to 4 mm transversely and 7 to 9 mm vertically, leaving approximately 85° of humeral articular cartilage unconstrained by the glenoid transversely and 65° unconstrained vertically (Fig. 1). However, although the osseous geometry of the glenohumeral joint provides little intrinsic stability, static restraints including the glenoid labrum and the surrounding ligaments, tendons, and skeletal muscles play a crucial role in glenohumeral joint stability. In addition, negative pressure within the glenohumeral joint capsule, maintained by the presence of synovial fluid within a closed compartment, acts as a key static restraint.

Thus, both dynamic and static restraints allow the glenohumeral joint to maintain a wide range of motion yet remain stable. However, the development and progression of massive rotator cuff tears result in both a loss of mechanical stability and a change in the normal intra-articular milieu that contributes to cohesive stability of the joint.

Pathogenesis of Rotator Cuff Tear Arthropathy

In 1981, Halverson et al. proposed a crystal-mediated theory of rotator cuff tear arthropathy in which hydroxyapatite crystals induce a phagocytic degeneration of the rotator cuff tendons and articular cartilage. They coined the term Milwaukee shoulder syndrome, and they hypothesized that rotator cuff tear arthropathy was in fact an inflammatory arthropathy since basic calcium phosphate crystals such as hydroxyapatite were identified in diseased synovium and articular cartilage. Phagocytosis of these crystals was hypothesized to result in further tissue degeneration, which in turn resulted in release of additional crystals, propagating a cycle of increasing joint degeneration and instability. Thus, this proposed etiology implies that the rotator cuff is not actually torn in rotator cuff tear arthropathy, but instead undergoes a physiologic process of severe degeneration due to a crystal-induced arthropathy.

In contrast, Neer et al. hypothesized in 1983 that a massive rotator cuff tear was the inciting event in the development of rotator cuff tear arthropathy, and that both mechanical and nutritional factors contributed to the subsequent progression of the arthropathy. Mechanically, the presence of a massive rotator cuff tear leads to unbalanced force coupling and loss of the concavity-compression mechanism, resulting in excessive upward migration of the humeral head, erosion of the superior glenoid or acromion, and abnormal

Fig. 1

**Fig. 1-A** Anterior view of the right glenohumeral joint. The glenoid fossa is approximately 2 to 4 mm deep transversely and 7 to 9 mm deep vertically.

**Fig. 1-B** The humeral head presents 160° of articular cartilage in both the transverse and the coronal plane. This is apposed by 75° of glenoid articular cartilage in the transverse plane and 95° in the coronal plane, leaving 85° and 65°, respectively, of humeral articular cartilage unconstrained by the glenoid.

(Reprinted from J Hand Ther. 22[4], Hurov J., Anatomy and mechanics of the shoulder: review of current concepts, 328-42, Copyright [2009], with permission from Elsevier.)

http://www.sciencedirect.com/science/journal/08941130.)
joint forces. Without the inferiorly directed force of the rotator cuff, superior migration of the humeral head resulting from the unopposed contraction of the deltoid leads to pseudoparalysis, defined as “inability to actively elevate the arm in the presence of free passive range of motion [ROM] and in the absence of a neurologic lesion.” The compromised rotator cuff integrity leads to loss of the negative pressure within the glenohumeral joint, leakage of synovial fluid into the surrounding soft tissue, and a decrease in the quality of the synovial fluid remaining within the compartment. Accompanying the synovial fluid that escapes the compartment are vital nutrients necessary for the health of articular cartilage. In addition, decreased shoulder activity secondary to pain further reduces the delivery of synovial nutrients, hastening articular cartilage degeneration and disuse osteopenia. However, although numerous pathologic mechanisms for the development of rotator cuff tear arthropathy have been proposed, it remains unclear why only some patients with a massive rotator cuff tear progress to rotator cuff tear arthropathy or why patients with similar radiographic findings may have widely variable clinical presentations, including retention of full active shoulder elevation in some cases.

**History and Physical Examination**

As in every orthopaedic examination, the physician should elicit basic information regarding the onset of pain, qualitative weakness, prior injuries or surgical procedures, neurologic history, and functional deficits. Patients with rotator cuff arthropathy are typically elderly, have a history of progressively worsening pain, and have limited shoulder motion and stiffness. These symptoms may or may not have been precipitated by an acute, traumatic event. Patients with a diagnosis of rheumatoid arthritis or of another inflammatory arthropathy may also present with polyarthralgia and a prior history of medical treatment for their systemic disease.

The physical examination begins with a global inspection of the shoulder joint. Patients with rotator cuff tear arthropathy may present with anterosuperior escape of the humeral head from the glenoid, indicating a grossly deficient subscapularis and supraspinatus. However, more commonly, only marked atrophy of the shoulder musculature, especially of the supraspinatus and infraspinatus muscles, is appreciated. A “fluid sign” or shoulder swelling, resulting from increased fluid pressure in the subacromial bursa, may also be observed. Prior to assessing the range of motion of the glenohumeral joint, a cervical spine examination should be performed to rule out a cervical spine disorder that may be causing referral of pain to the shoulder area. Both passive and active glenohumeral motion in patients with rotator cuff tear arthropathy will be limited by weakness, pain, and stiffness, but to varying degrees. Some patients will demonstrate a tolerable range of active shoulder motion because of compensation by the deltoid muscle and a relatively stable fulcrum of motion, whereas others will present with pseudoparalysis during attempted abduction and forward flexion. Deficiencies in the active range of motion will also be apparent in external rotation. In addition, patients may develop a painful hemarthrosis.

The strength of the rotator cuff musculature should be assessed in the standard fashion. The supraspinatus can be assessed by applying a resisted downward pressure with the shoulder abducted 90° in the plane of the scapula, the elbow in extension, and the arm in maximal internal rotation. The infraspinatus can be assessed by testing external rotation strength with the arm in 0° of abduction and the elbow flexed to 90°. The lift-off test, as described by Gerber and Krushell, can be used to assess subscapularis strength. With the arm in maximal internal rotation and the dorsum of the hand resting on the mid-lumbar region, resisted movement away from the body is assessed. Alternatively, the examiner can place the hand away from the mid-lumbar region and assess the patient's ability to...
maintain this position. In addition, the abdominal compression test, initially described by Burkhart and Tehrany, can be performed. In this test, the patient presses the palm against the abdomen with the wrist in the neutral position and the elbow anterior to the thorax. If the wrist flexes volarly or if the elbow falls posterior to the thorax when pressed against the abdomen, this indicates a subscapularis tear. Lastly, the teres minor can be assessed by testing resisted external rotation of the arm with the shoulder in 90° of abduction in the plane of the scapula and the elbow in 90° of flexion. The inability to maintain the externally rotated position, or difficulty bringing the hand to the mouth without shoulder abduction, has been described by Walch et al. as a positive hornblower’s sign (Fig. 3). Patients with rotator cuff tear arthropathy often demonstrate severe pain and weakness with attempted strength testing of the rotator cuff musculature.

**Diagnostic Imaging**

Rotator cuff tear arthropathy can frequently be diagnosed on the basis of only the clinical examination and radiographs, as standard radiographic views (anteroposterior, scapular, and axillary) may demonstrate characteristic findings. The examiner should assess for gross shifting or medialization of the glenohumeral center of rotation, and the axillary view radiograph will provide good visualization of the glenoid bone stock. Characteristic findings of rotator cuff tear arthropathy include, but are not limited to, (1) femoralization, or erosion of the greater tuberosity of the humerus due to contact with the acromion; (2) acetabulization, or thinning of the coracoacromial arch and destruction of the superior glenoid; (3) a decreased glenohumeral distance secondary to superior migration of the humeral head; (4) osteopenia in both the proximal aspect of the humerus and the glenoid; (5) glenohumeral subluxation; (6) osteophyte formation at points of fixed contact between the humeral head and glenoid; and (7) joint space narrowing (Fig. 4). In contrast, patients with primary degenerative joint disease and an intact rotator cuff often demonstrate osteophytes on the inferior and medial aspects of the humeral head, wear that predominantly involves the posterior aspect of the glenoid, and no superior migration of the humeral head.

Computed tomography (CT) of the glenohumeral joint can provide useful preoperative information regarding the glenoid bone stock and version. If substantial subacromial wear is seen on radiographs, a CT scan can assess the competence of the coracoacromial arch or detect the presence of an acromial stress fracture. Magnetic resonance imaging (MRI) is useful for assessing the integrity of the rotator cuff and the presence of a reparable tear in patients with physical examination findings that are difficult to interpret. Key aspects for preoperative planning include the extent of the tear, the integrity of the articular cartilage, and the presence of fatty infiltration of the muscles. Fatty muscle infiltration secondary to disuse may occur following a chronic, massive rotator cuff tear, but infiltration may also indicate the presence of pathologic nerve compression. Although CT, MRI, or ultrasonography is beneficial for confirmation of a suspected rotator cuff insufficiency and for preoperative planning, they are often not required for diagnosis.
Classification Systems

Classification systems applicable to rotator cuff tear arthropathy include the Hamada system and the Seebauer system. The Hamada classification system divides massive rotator cuff tears into five radiographic stages, with successive stages demonstrating findings consistent with progression of the rotator cuff tear arthropathy. In Stage 1, the acromiohumeral interval is >6 mm. In Stage 2, the acromiohumeral interval is <5 mm. In Stage 3, the acromiohumeral interval is <5 mm and acetabulization of the coracoacromial arch is present. In Stage 4, the gleno-humeral joint is narrowed, either without acetabulization (Stage 4a) or with acetabulization (Stage 4b). In Stage 5, humeral head osteonecrosis results in collapse.

The Seebauer classification system is a biomechanical description of rotator cuff tear arthropathy, in which each type is distinguished on the basis of the degree of superior migration from the center of rotation and the amount of instability. The amount of decentralization seen on radiographs is dependent on “the extent of the rotator cuff tear, the integrity of the coracoacromial arch, and the degree and direction of the glenoid bone erosion,” and thus this classification system is intended to be a radiographic correlate of the underlying pathology seen in rotator cuff tear arthropathy (Fig. 5).

History of Treatment Options

The initial management of rotator cuff tear arthropathy should begin with conservative measures, including activity modification, oral analgesics, physical therapy, and intra-articular injections. Patients with an intact deltoid and an adequately stable fulcrum of motion may present with an acceptable degree of shoulder motion, and such patients are ideal candidates for nonoperative management. Intra-articular corticosteroid injections may initially be effective, although repeated injections are discouraged because of diminishing utility and a possibly increasing risk of infection. Although the initial management of rotator cuff tear arthropathy should begin with conservative measures, surgical intervention is often required.

Rotator cuff tear arthropathy remains a complicated pathologic process to manage surgically, and a wide array of surgical techniques and prostheses have historically been used with limited success. The primary difficulty has involved reliably creating a stable fulcrum of motion that eliminates pain but preserves shoulder motion and long-term survival. Past surgical options have varied with regard to the amount of constraint inherent in the prosthesis design. In general, implants with greater constraint provide greater initial stability but at the expense of shoulder motion and implant longevity.

One surgical option has been glenohumeral arthrodesis, which has the goal of relieving pain by eliminating motion. The most glaring drawback to this procedure is that the patient will lack glenohumeral joint motion, and compensatory scapulothoracic motion may expose the acromioclavicular joint to excessive motion and result in pain. However, glenohumeral arthrodesis remains a possible salvage procedure in patients with rotator cuff arthropathy who have undergone multiple failed surgical procedures, have an irreparable rotator cuff defect, have a history of infection, or have a deficient deltoid. At the opposite end of the spectrum with regard to constraint, resection arthroplasty has been attempted to treat rotator cuff tear arthropathy, but the creation of a flail shoulder, with the accompanying risk of brachial plexus traction neuritis, keeps this a salvage procedure as well.

Numerous arthroplasty options have been designed to treat rotator cuff tear arthropathy. Total shoulder arthroplasty should be considered in patients with a functional deltoid muscle, preferably accompanied by an intact coracoacromial arch. One of the earliest arthroplasty designs was the hinged, or fully constrained, total shoulder arthroplasty design. The rationale for this design was the creation of a stable fulcrum of motion, located at the...
glenoid, through which the deltoid muscle could move the humerus. This design is no longer used in the setting of rotator cuff tear arthropathy because the fully constrained glenohumeral articulation leads to excessive stresses at the interface between the bone and the glenoid implant, leading to rapid implant loosening; complication rates have been reported to be as high as 87.5%.

Semi-constrained total shoulder arthroplasties were designed to resist superior translation of the humerus through the use of an enlarged glenoid component. However, despite the decrease in constraint relative to the hinged total shoulder arthroplasty design, increased stress at the interface between the bone and the glenoid implant also predisposes this design to early glenoid implant loosening and failure.

Conventional total shoulder arthroplasty has also been used in the setting of rotator cuff tear arthropathy, with initial reports (Table I) demonstrating improved outcomes compared with constrained and semi-constrained designs. Conventional total shoulder arthroplasty can reduce pain and improve shoulder motion, especially in patients with a reparable rotator cuff tear. In 1982, Neer et al. reported the results of total shoulder arthroplasty in sixteen patients with rotator cuff tear arthropathy; 91% of the procedures were successful, according to “limited goals” criteria, at a mean of thirty months postoperatively. However, in 1988, Franklin et al. retrospectively reviewed the results of conventional total shoulder arthroplasty in fourteen patients with rotator cuff tear arthropathy and found that 50% had glenoid component loosening at a mean of thirty-seven months postoperatively, with 30% requiring a component revision. In addition, 46% of patients had persistent pain and 15% had instability. Without the compressive and inferiorly directed force vector of the rotator cuff, the humeral head displaced superiorly with arm motion, leading to eccentric loading of the glenoid component (the “rocking horse” phenomenon).

More recently, Nwakama et al. found only a 14% success rate, according to “limited goals” criteria, in seven patients with rotator cuff tear arthropathy treated with conventional total shoulder arthroplasty. Consequently,
Rotator cuff tear arthropathy is now considered a contraindication to the performance of conventional total shoulder arthroplasty because of the high rates of component failure and complications. Hemiarthroplasty remains a viable option for the treatment of rotator cuff tear arthropathy, especially in patients who have coped with the rotator cuff deficiency and maintained a functional range of shoulder motion preoperatively. The risk of glenoid component failure is avoided by replacing only the articular surface of the humerus. In addition, the use of a larger, "cuff tear arthropathy" humeral head designed to articulate with both the glenoid and acromion has been shown to improve the stability of the implant. Williams and Rockwood reported the results of hemiarthroplasty in twenty-one patients with rotator cuff tear arthropathy; 86% of the patients had a successful result, according to "limited goals" criteria, at a mean of forty-eight months postoperatively. Sanchez-Sotelo et al. reported anterosuperior instability in seven of thirty patients with rotator cuff tear arthropathy treated with hemiarthroplasty, and only 67% of the procedures were considered successful at a mean of five years postoperatively.

More recently, the popularity of reverse total shoulder arthroplasty for the management of rotator cuff tear arthropathy has increased. This design reverses the anatomy of the native glenohumeral joint by placing the "ball" at the glenoid position and the "socket" on the humerus (Fig. 6). Modern reverse total shoulder arthroplasty designs, based on modifications made by Professor Grammont, have shown encouraging results. Biomechanical improvements, such as moving the center of rotation distally and medially to improve deltoid function, have led to improved implant stability and an increase in the range of shoulder motion prior to subacromial resorption of the glenoid and the acromion, along with the limited improvement in shoulder motion, remain concerns associated with the use of hemiarthroplasty in cases of rotator cuff tear arthropathy. In addition, humeral instability continues to be a long-term concern, especially in patients with a prior acromioplasty or an incompetent coracoacromial arch. Sanchez-Sotelo et al. reported anterosuperior instability in seven of thirty patients with rotator cuff tear arthropathy treated with hemiarthroplasty, and only 67% of the procedures were considered successful at a mean of five years postoperatively.

### TABLE I Reports of Clinical Outcomes Following Arthroplasty for the Treatment of Rotator Cuff Tear Arthropathy (CTA)

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Follow-up (mo)</th>
<th>Subjective Outcome</th>
<th>Functional Score*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total shoulder arthroplasty†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neer, 1982†</td>
<td>16</td>
<td>30</td>
<td>91% successful§</td>
<td></td>
</tr>
<tr>
<td>Franklin, 1988†</td>
<td>14</td>
<td>37</td>
<td>46% pain, 15% instability</td>
<td></td>
</tr>
<tr>
<td>Nwakama, 2000†</td>
<td>7</td>
<td>63</td>
<td>14% successful§</td>
<td></td>
</tr>
<tr>
<td>Hemiarthroplasty#</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Williams, 199620</td>
<td>21</td>
<td>48</td>
<td>86% successful§, 0% excellent</td>
<td></td>
</tr>
<tr>
<td>Field, 199740</td>
<td>16</td>
<td>33</td>
<td>63% successful§</td>
<td></td>
</tr>
<tr>
<td>Zuckerman, 200031</td>
<td>15</td>
<td>28</td>
<td>87% satisfied</td>
<td>UCLA, 22</td>
</tr>
<tr>
<td>Sanchez-Sotelo, 200132</td>
<td>37</td>
<td>60</td>
<td>67% successful§</td>
<td></td>
</tr>
<tr>
<td>Goldberg, 200841</td>
<td>34</td>
<td>44</td>
<td>76% successful§</td>
<td>ASES, 67</td>
</tr>
<tr>
<td>Reverse total shoulder arthroplasty**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sirveaux, 200435</td>
<td>80</td>
<td>44</td>
<td>96% no or little pain</td>
<td>Constant, 65.6</td>
</tr>
<tr>
<td>Werner, 200535</td>
<td>58</td>
<td>38</td>
<td>Subjective Shoulder Value, 56%</td>
<td>Constant, 64</td>
</tr>
<tr>
<td>Boileau, 200642</td>
<td>21</td>
<td>40</td>
<td>95% satisfied or very satisfied</td>
<td>Constant, 66</td>
</tr>
<tr>
<td>Frankie, 200543</td>
<td>60</td>
<td>33</td>
<td>68% good or excellent</td>
<td>ASES, 68.2</td>
</tr>
<tr>
<td>Wall, 200744</td>
<td>59</td>
<td>40</td>
<td>93% satisfied or very satisfied</td>
<td>Constant, 65.6</td>
</tr>
<tr>
<td>Young, 200936</td>
<td>33</td>
<td>38</td>
<td>89% good or excellent</td>
<td>ASES, 70</td>
</tr>
</tbody>
</table>

*UCLA = University of California Los Angeles score, and ASES = American Shoulder and Elbow Surgeons score. †FF = forward flexion, ER = external rotation, RTSA = reverse total shoulder arthroplasty, and abd. = abduction. §Because of the high rate of component failure (loosening in up to 50%) and the complication rate of 50% to 71%, cuff tear arthropathy is considered a contraindication to performing a total shoulder arthroplasty. #Based on Neer’s “limited goals criteria.” **Hemiarthroplasty remains a viable option in the treatment of CTA, especially in patients who have coped with the rotator cuff deficiency and maintain a functional range of motion preoperatively. Promising results have been demonstrated with the use of reverse TSA to treat CTA; however, complication rates remain high, demonstrating the importance of strict patient selection and surgeon experience.
### TABLE I (continued)

<table>
<thead>
<tr>
<th>Revision Rate (%)</th>
<th>Component Failure Rate (%)</th>
<th>Complication Rate (%)</th>
<th>Infection Rate (%)</th>
<th>Other†</th>
</tr>
</thead>
<tbody>
<tr>
<td>6%</td>
<td>30% radiolucencies</td>
<td>50%</td>
<td>71%</td>
<td>Based on “limited goals” criteria (Neer)</td>
</tr>
<tr>
<td>30%</td>
<td>50% glenoid loosening</td>
<td>50%</td>
<td>0%</td>
<td>Coined term “rocking horse glenoid”</td>
</tr>
<tr>
<td>29%</td>
<td>43% loosening, 14% gross position shift</td>
<td>71%</td>
<td>0%</td>
<td>“Limited goals” criteria</td>
</tr>
<tr>
<td>0%</td>
<td>No clinical failures</td>
<td>38%</td>
<td>0%</td>
<td>“Limited goals” criteria</td>
</tr>
<tr>
<td>13%</td>
<td>0%</td>
<td>7%</td>
<td>0%</td>
<td>FF 69° to 86°, ER 15° to 29°</td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
<td>5%</td>
<td>0%</td>
<td>FF 72° to 91°, “limited goals” criteria</td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
<td>6%</td>
<td>0%</td>
<td>FF 78° to 111°, “limited goals” criteria</td>
</tr>
<tr>
<td>4%</td>
<td>6% loosening, 9% dissociation</td>
<td>12% at 5 years, 71% at 7 years</td>
<td>16% grade-3 or 4 notching</td>
<td></td>
</tr>
<tr>
<td>33%</td>
<td>7% loosening, 9% dislocation, 2% dissociation</td>
<td>50%</td>
<td>Revision RTSA had significantly worse results</td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>0% loosening</td>
<td>24%</td>
<td>0%</td>
<td>11% grade-3 or 4 notching</td>
</tr>
<tr>
<td>12%</td>
<td>3% glenoid loosening</td>
<td>17%</td>
<td>3%</td>
<td>FF 55° to 105°, abd. 41° to 102°</td>
</tr>
<tr>
<td>27% revision procedures (54 cases)</td>
<td>8% dislocation</td>
<td>19%</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
<td>8%</td>
<td>0%</td>
<td>24% notching</td>
</tr>
</tbody>
</table>

---

**Fig. 6**
Anteroposterior radiograph of the left shoulder demonstrating a hemiarthroplasty performed to treat a proximal humeral fracture (left). The hemiarthroplasty was later converted to a reverse total shoulder arthroplasty, using the same humeral stem, because of rotator cuff deficiency (right).
impingement. Sirveaux et al. presented the results of reverse total shoulder arthroplasty in eighty patients with rotator cuff tear arthropathy; the mean Constant score was 65.6 at a mean of forty-four months postoperatively, with 96% of patients having little or no pain. Similarly, Young et al. noted 89% of patients to have good or excellent results at a mean of thirty-eight months postoperatively, with a mean American Shoulder and Elbow Surgeons (ASES) score of 70 points. In a review of sixty patients, Frankle et al. noted significant improvements in the mean ASES score from 34.3 to 68.2 points, in forward flexion from 55.0° to 105.1°, and in abduction from 41.4° to 101.8° after reverse total shoulder arthroplasty. However, despite these encouraging results, complications after reverse total shoulder arthroplasty for rotator cuff tear arthropathy remain a concern, as reported complications include aseptic loosening, instability, implant dissociation, infection, fracture, neurapraxia, and radiographic signs of scapular notching. Revision rates and overall complication rates have been reported to be as high as 26% and 71%, respectively, in studies with medium to long-term follow-up. Thus, although reverse total shoulder arthroplasty has demonstrated promising clinical results, it remains a technically difficult procedure with a high risk of complications.

 Proposed Treatment Algorithm

During the initial evaluation of a patient with rotator cuff tear arthropathy, several key aspects of the patient's presentation may guide the surgeon toward a specific treatment plan. Although a unique decision analysis must be performed for each patient, a simplified treatment algorithm is presented in Figure 7. This algorithm begins with a patient with a massive, irreparable rotator cuff tear with or without glenohumeral arthritis. Thus, although only those patients with glenohumeral arthritis are considered to have rotator cuff tear arthropathy, patients without glenohumeral arthritis are also included in this algorithm as patients in both groups may present with similar symptoms.

Two key aspects to consider when evaluating a patient are the patient's age and desired activity level. Certain patients may have a physiologic age that does not match their chronologic age, and some of these patients may wish to return to a higher level of activity and may expect a greater functional range of shoulder motion postoperatively compared with other patients of similar age. Such patients may be more satisfied with a reverse total shoulder arthroplasty than with a hemiarthroplasty. In contrast, relatively sedentary patients may be seeking only pain relief, and such patients may be better suited for a hemiarthroplasty. It is helpful to distinguish whether a patient's primary complaint is pain or decreased shoulder motion.

Another key aspect to consider is the presence or absence of pseudoparalysis of the glenohumeral joint. Patients with pseudoparalysis are often unable to cope functionally, in the setting of glenohumeral arthritis; such patients often require a reverse total shoulder arthroplasty to restore a functional range of motion. Although high complication rates have been reported following reverse total shoulder arthroplasty, this option can be very effective in patients with both pseudoparalysis and glenohumeral arthritis. A concomitant latissimus dorsi transfer can be performed to further improve shoulder external rotation. In contrast, hemiarthroplasty may be indicated for...
patients with glenohumeral arthritis without pseudoparalysis, as this procedure can provide good results in patients with stable shoulder kinematics and a functional subscapularis muscle that prevents anterosuperior escape. Thus, assessing a patient’s physiologic age and functional goals and performing a thorough clinical and radiographic examination will help to guide the surgeon to the appropriate surgical treatment for a patient with rotator cuff tear arthropathy.

**Summary**

Adequate treatment of the pathologic process of rotator cuff tear arthropathy remains a complicated problem. Numerous pathways have been proposed as the cause of rotator cuff tear arthropathy, but the exact etiology remains unclear, as does the reason that only some patients with massive rotator cuff tears develop rotator cuff tear arthropathy. Characteristic clinical examination findings include superior migration of the humeral head, pseudoparalysis with attempted elevation of the upper extremity at the shoulder, and a positive hornblower’s sign. Radiographs demonstrating “femoralization” of the humeral head and “acetabulization” of the coracoacromial arch in cases of end-stage rotator cuff tear arthropathy can be diagnostically. Although the initial management of rotator cuff arthropathy should begin with conservative measures, surgical intervention is often required. Promising results following reverse total shoulder arthroplasty have led to an increase in the utilization of this procedure. However, complication rates remain high, demonstrating the importance of strict patient selection and careful operative technique as well as the necessity of future design modifications.

**References**