

# Reverse Total Shoulder Arthroplasty for Treatment of Massive, Irreparable Rotator Cuff Tear



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**Abstract:** Massive tears of the rotator cuff can result in severe functional deficits due to loss of the axial force couple and effective fulcrum that the intact cuff normally provides. For massive, irreparable rotator cuff tears, especially in the setting of early to moderate degenerative changes, reverse total shoulder arthroplasty functions to modify the center of joint rotation, allowing the deltoid and intact components of the cuff to carry out shoulder function more effectively. Our preferred technique uses a standard open deltopectoral shoulder approach with a 3-dimensional glenoid baseplate model and a 135° prosthesis in an onlay configuration to reduce the risk of scapular notching and increase lateralization of the humerus.

Massive rotator cuff tears (MRCTs) have been reported to comprise between 10% and 40% of rotator cuff tears<sup>1</sup> and can cause significant impairment in shoulder function. An MRCT traditionally has been defined as a tear greater than 5 cm in the anterior-posterior or medial-lateral direction or complete tearing of at least 2 rotator cuff tendons.<sup>2,3</sup> However, the size of a rotator cuff tear does not always correlate predictably with patient symptoms, and new definitions

have been proposed based on our improved understanding of both the structural pathophysiology and the characteristic findings on diagnostic imaging in the setting of MRCTs. A Delphi method consensus study among the American Shoulder and Elbow Surgeons identified a 90% rate of consensus around the definition of an MRCT as coronal- or axial-plane retraction of tendons to the glenoid rim and/or at least 67% exposure of the greater tuberosity in the sagittal plane.<sup>4</sup>

Failure of the rotator cuff musculature can result in loss of the axial force couple that allows for a stable fulcrum for shoulder movement. Loss of stabilization results in superior subluxation of the humeral head,<sup>5</sup> creating shearing forces and significant loss of function in elevation and/or rotation. Reverse total shoulder arthroplasty (rTSA) functions to restore the compressive forces that are necessary for effective shoulder function. This is accomplished by placement of a prosthesis that modifies the center of joint rotation, allowing the intact cuff and supporting musculature to effectively take over shoulder function, particularly abduction by the deltoid. Since its introduction by Grammont, the rTSA technique and its specific indications have continued to evolve.<sup>6</sup> Along with cuff tear arthropathy, rTSA is accepted as the preferred treatment for patients of an older age with MRCTs that include an irreparable subscapularis with dynamic instability and pseudoparesis.<sup>4</sup> Patient selection is more complex in younger active patients with MRCTs, with or without glenohumeral arthritis. In these cases, the benefits of rTSA must be weighed against potential

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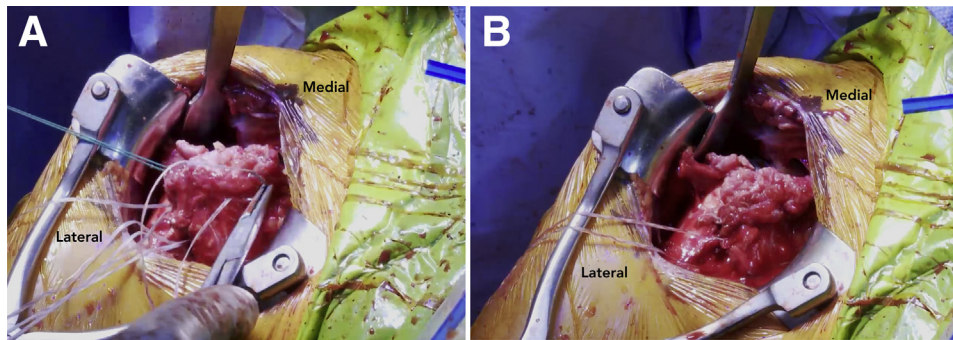
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**Fig 1.** Incision. A standard deltopectoral approach is performed in the right shoulder with the patient in the beach-chair position. (A) The incision point is made between the coracoid process and the proximal humeral shaft toward the deltoid insertion. (B) The exposed deltoid is retracted laterally and the conjoint tendon is retracted medially, with care taken to avoid the musculotendinous nerve and underlying brachial plexus.

complications and the projected survivorship of the implant.<sup>5</sup> Ideal prosthetic length and alignment, as well as the resulting moment arms and planes of action for each muscle, must be identified to optimize synergistic functioning between the prosthesis and the intact shoulder musculature.<sup>7</sup>

Successful repair of tears of the rotator cuff, even when extensive, is possible if the elastic quality of the remaining tendons allows for repair without excessive tension. Conversely, an irreparable subscapularis, a high degree of fatty infiltration of the cuff musculature, or an eliminated acromiohumeral interval<sup>1</sup> can each preclude effective rotator cuff repair.<sup>4</sup> Beyond salvage with cuff debridement and biceps tenotomy or tenodesis, repair strategies include capsular and bridging reconstruction, augmentation, tendon transfer, and placement of a balloon spacer.<sup>5,8</sup> For massive, irreparable tears of the rotator cuff in patients with evidence of instability and functional deficits, rTSA remains the optimal treatment strategy. In this Technical Note, we describe our preferred technique for rTSA using a standard open deltopectoral shoulder approach with a 3-dimensional (3D) glenoid baseplate model and a 135° prosthesis in an onlay configuration to reduce the risk of scapular notching and increase lateralization of the humerus.

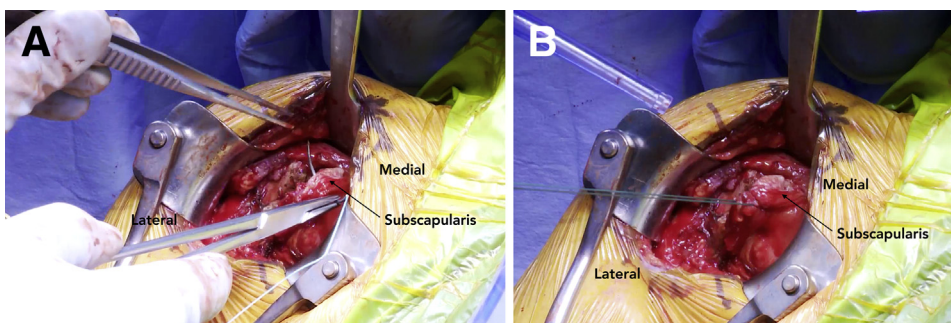
## Surgical Technique

### Patient Positioning and Anesthesia

The patient is placed in the supine position on the operating table and undergoes induction of general anesthesia. Single-shot or catheter-infusion regional anesthesia may be used as well. An interscalene nerve block with an indwelling catheter was used in this case. The patient is then placed in the beach-chair position with all bony prominences well padded. The position of the head and neck is carefully assessed before the procedure is started. A well-padded Mayo stand is placed under the elbow for arm positioning and holding.

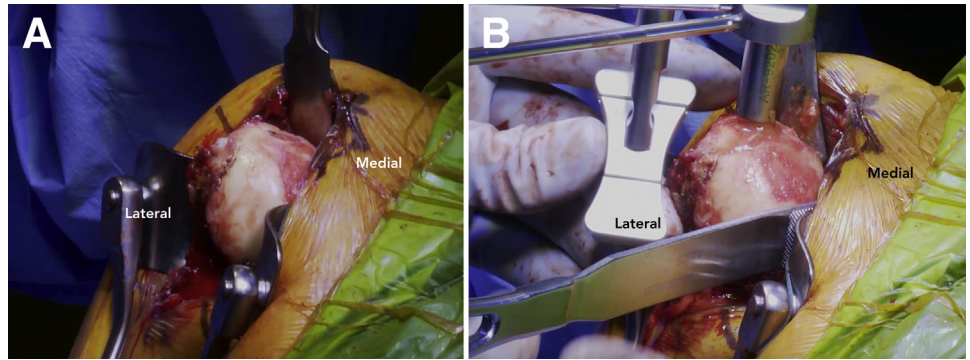
### Open Approach

An open incision is made for a standard deltopectoral total shoulder approach (Fig 1). Careful dissection is carried through the deltopectoral interval using Metzenbaum scissors and a needle-tip Bovie device (Bovie Medical, Clearwater, FL) to maintain hemostasis. The cephalic vein should be preserved when possible and retracted laterally to increase the ease of glenoid exposure. The coracoid and conjoint tendon are identified. In our patient, significant scarring was noted



**Fig 2.** Subscapularis peel. (A) A lateral subscapularis peel is performed on the right shoulder using needle-tip Bovie electrocautery. (B) A No. 2 Ethibond whipstitch is placed in the top rolled edge of the subscapularis.

**Fig 3.** Exposure of humeral head. The humeral head is brought out of the right shoulder anteriorly using a 2-point Hohmann retractor (A), and with external rotation, it is brought anteriorly out of the shoulder joint (B).



beneath the deltoid, indicating rotator cuff arthropathy. This scar tissue was gently elevated off of the humeral head with Cobb and Mayo scissors. The anterior conjoint tendon fascia is then elevated to insert a Kolbel retractor beneath it. The long head of the biceps was noted to be absent from the bicipital groove in our patient.

Dissection continues until the subscapularis is identified. A lateral subscapularis peel off of the lesser tuberosity is performed using needle-tip Bovie electrocautery. Moving inferiorly, the axillary nerve is identified and protected with digital palpation. A No. 2 Ethibond whipstitch (Ethicon, Somerville, NJ) is placed in the top rolled edge of the subscapularis (Fig 2). The capsule is released from the humerus with a Key elevator, with the axillary nerve carefully protected at all times.

#### Humeral Head and Shaft Exposure and Preparation

A 2-point Hohmann retractor is used to expose the humeral head, and with external rotation, it is brought anteriorly out of the shoulder joint (Fig 3). The anatomic cuff footprint is marked with a needle-tip Bovie device. A humeral head cut is made in 20° to 25° of retroversion by use of a 135° external cutting guide. Thereafter, canal preparation is carried out. In

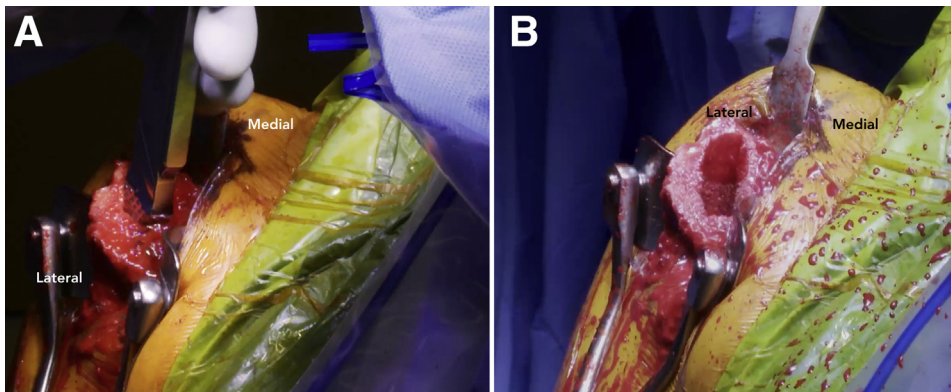
this case, progressive hand reaming is performed first with a 6-mm reamer then a 7-mm reamer, followed by 5-mm then 6-mm broaches with a 20° version guide (Fig 4).

#### Glenoid Exposure and Preparation

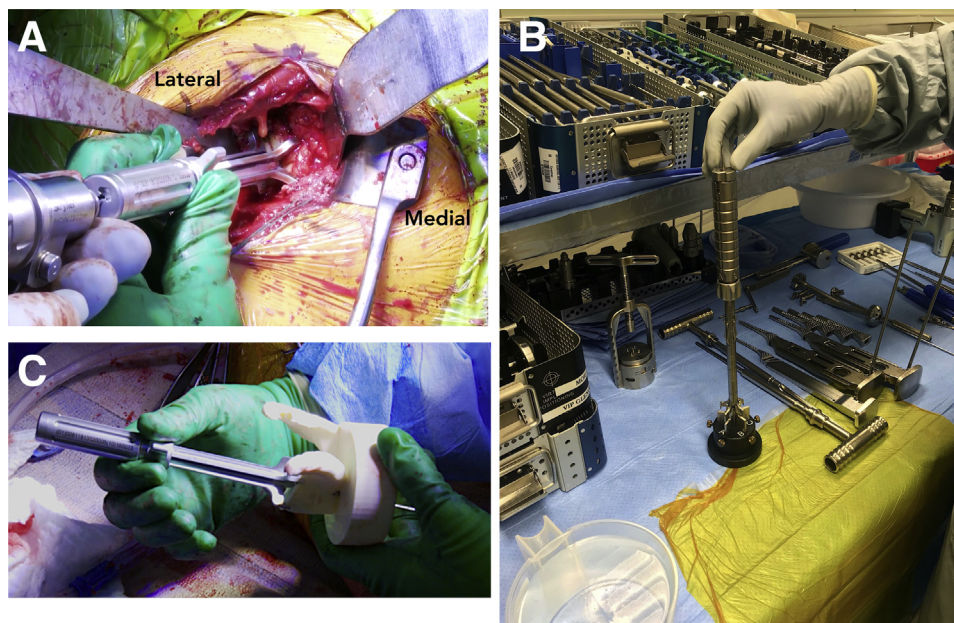
By use of humeral head and anterior glenoid retractors, the subscapularis and anterior, inferior, and posterior labrum are released off of the glenoid. The axillary nerve is protected with digital palpation at all times. Mayo scissors are used to release the capsule from the glenoid anteriorly, inferiorly, and posteriorly from the 3-o'clock position to the 9-o'clock position. The center point of the glenoid is marked, a guide pin is placed, and a canal is reamed with a 7-mm reamer (Fig 5 A and B). Correct positioning is confirmed with a sterile 3D printed model of the glenoid, which is kept on the back table (Fig 5C).

#### Baseplate and Glenosphere Fixation

A small baseplate is placed, with anatomic positioning confirmed from the 12-o'clock position to the 6-o'clock position. After drilling and tapping, a 20-mm compression screw is placed in the center of the baseplate (Fig 6A). Flush positioning is confirmed, in addition to excellent compression and hold. By use of a drill



**Fig 4.** Humeral head removal. Removal of the humeral head in the right shoulder is performed at 20° to 25° of retroversion using a 135° external cutting guide. (A) After humeral canal reaming, the humeral canal broach is performed using 5-mm then 6-mm broaches with a 20° version guide. (B) The proximal humeral canal will be used later to place the final 6-mm press-fit humeral stem.



**Fig 5.** Glenoid preparation. A guide pin is placed (A), and the glenoid canal in the right shoulder is reamed with a 7-mm glenoid reamer (B). (C) A sterile 3-dimensionally printed model is used to ensure correct positioning of the glenoid guide pin.

guide, a 30-mm compression screw is placed superiorly and a 24-mm compression screw is placed inferiorly. Excellent bite and purchase are confirmed. Next, a 36-mm glenosphere with +4 offset is placed on the baseplate without difficulty (Fig 6B), as planned pre-operatively with the Arthrex virtual implant planning system (Naples, FL). The baseplate and glenosphere are tapped and checked circumferentially with a dental pick to ensure that they are fully seated.

### Humeral Stem Implantation

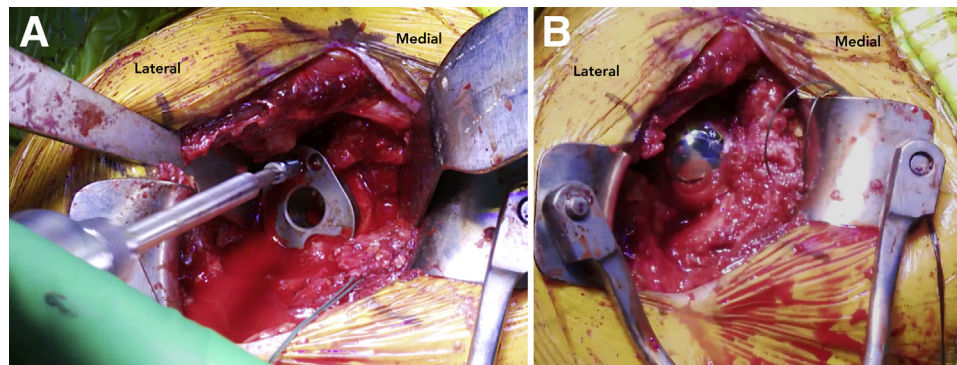
Prior to implant positioning, 3 suture tape sutures are placed through drill holes in the humerus; these will be used to repair the subscapularis after final implant placement and shoulder reduction. The humerus is tested using a 36-mm cup and +6 constrained offset (Fig 7A). Excellent fixation is noted, with good suction and no inferior translation. Arm range of motion is then tested multiple times, with external rotation to 60°

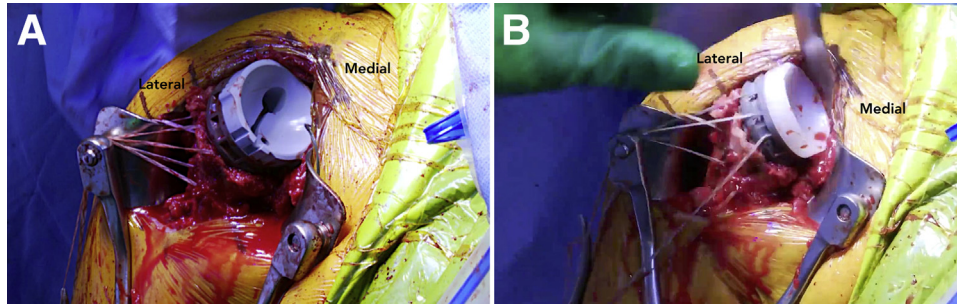
without liftoff, internal rotation to 40° without anterior impingement, and full abduction and cross-body adduction without anterior impingement. The final 6-mm press-fit humeral stem is placed, and good fit and fill of the proximal humeral canal are confirmed (Fig 7B). A 36-mm cup with +6 constrained offset is noted to have excellent fixation without settling. This is tamped into position, subscapularis suture tapes are threaded through the implant, and the shoulder is reduced. At this point, final motion is assessed. Our patient had external rotation to 40°, flexion to 160°, and abduction to 140° with the scapula held in position. The subscapularis is then repaired with the 3 suture tape sutures (Fig 8). The skin and subcutaneous tissues are closed in routine fashion.

### Postoperative Rehabilitation

A padded abduction sling is worn for 4 weeks to preserve the subscapularis repair. Passive range of

**Fig 6.** Glenoid baseplate fixation. (A) The baseplate is positioned in the glenoid of the right shoulder with a central 20-mm compression screw for fixation. By use of a drill guide, a 30-mm compression screw is placed superiorly and a 24-mm compression screw is placed inferiorly. (B) A 36-mm glenosphere with +4 offset is placed on the baseplate.





**Fig 7.** Humeral component fixation. (A) Three suture tape sutures are placed through proximal humeral drill holes in the right shoulder. These will be used to repair the subscapularis after final implant placement and shoulder reduction. A 6-mm press-fit stem and a 36-mm cup with a +6 constrained liner are tested in the humeral shaft. (B) Excellent fixation is noted, with good suction and no inferior translation, and the press-fit stem and the 36-mm cup with the +6 constrained liner are tamped into position.

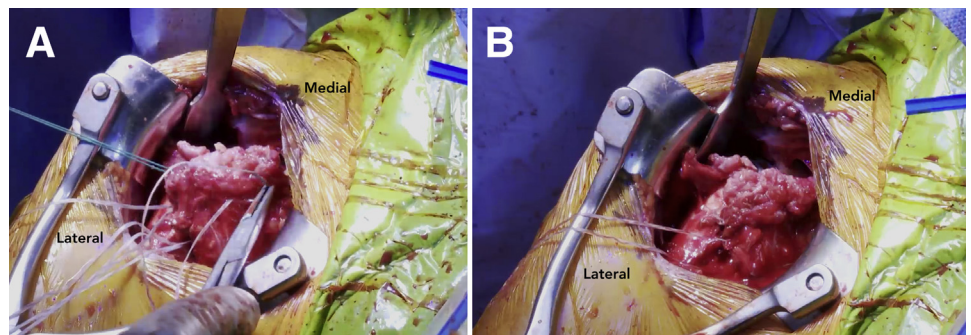
motion is begun immediately but limited to 30° of external rotation, with no internal rotation strengthening for 6 weeks. Passive and gentle active-assisted motion is allowed to 120° of flexion and 60° of abduction. A standard postoperative rehabilitation protocol for rTSA with progression to early-strengthening and full-strengthening exercises should be prescribed. A return to full activity is expected at 5 months postoperatively.

## Discussion

This Technical Note and [Video 1](#) describe our technique for rTSA in the setting of a massive, irreparable rotator cuff tear with significant rotator cuff arthropathy. Recommended surgical planning for patients presenting with severe rotator cuff pathology includes imaging with advanced 3D preoperative planning software and the use of a 135° prosthesis for templating and surgery to reduce the likelihood of postoperative complications,<sup>9</sup> as noted among the pearls and pitfalls listed in [Table 1](#).

Glenoid component positioning is critical for postoperative function and long-term implant survivorship in rTSA.<sup>10</sup> Failure of the glenoid component has been reported as one of the most common complications in

shoulder arthroplasty procedures, resulting in implant loosening, early failures, and inferior clinical outcomes.<sup>11-13</sup> Kolmodin et al.<sup>14</sup> emphasized the importance of accurate implant positioning, noting that a glenosphere positioned insufficiently inferiorly by only  $-0.3 \pm 3.4$  mm or posteriorly by  $-0.3 \pm 3.5$  mm was significantly associated with scapular notching and implant failure. Over the past decade, complications such as those reported by Kolmodin et al. have been described in the literature,<sup>9,15,16</sup> reinforcing the importance of precise and correct placement of the glenoid component. Innovative surgical navigation and patient-specific instruments (PSIs) have proved to be effective tools in improving the accuracy of prosthetic placement. In their review, Burns et al.<sup>10</sup> illustrated the significant effect of both surgical navigation and PSIs on radiographic outcomes after shoulder arthroplasty, reporting significant reductions in version error using surgical navigation and PSIs by  $-5.0^\circ$  and  $-2.2^\circ$ , respectively, and in inclination error by  $-8.0^\circ$  and  $-5.6^\circ$ , respectively. Such findings show that preoperative templating with 3D planning software, as well as the use of surgical navigation technology, can improve the precision of component positioning, which potentially decreases subsequent postoperative complications.



**Fig 8.** Subscapularis repair. The 3 suture tape sutures previously placed through the proximal humeral drill holes in the right shoulder are identified (A) and are used to repair the subscapularis (B).

**Table 1.** Pearls and Pitfalls of Reverse Total Shoulder Arthroplasty for Treatment of Massive, Irreparable Rotator Cuff Tear

Pearls	
	Use of a 3D glenoid model improves the understanding of optimal glenoid baseplate placement and reduces surgical time.
	Use of a 135° prosthesis can reduce the risk of scapular notching and, when an onlay configuration is selected, lateralizes the humerus. This optimizes muscle tensioning of the rotator cuff and increases deltoid wrapping.
	A CT radiograph should be obtained to facilitate preoperative planning.
Pitfalls	
	At fixation, failing to check for flush positioning of the glenoid baseplate can leave the shoulder at risk of future complications.
	Medializing the center of rotation decreases the neck-shaft angle, which increases the concern for scapular notching. Use of a 155° prosthesis has been shown to increase the rate of scapular notching.
	Excessive deltoid tensioning can result in instability, forced abduction of the arm, and acromial fractures.

CT, computed tomography; 3D, 3-dimensional.

Another recommendation from our technique is to use a 135° prosthesis, as opposed to a 155° prosthesis. Appropriate humeral component inclination in rTSA is critical for overall construct stability, and components with increased inclination have been reported to increase the incidence of scapular notching.<sup>17</sup> Scapular notching results from contact between the scapular neck and inferior portion of the humeral polyethylene. A 155° prosthesis increases the humeral component inclination angle and, consequently, the surface area of contact between the scapular neck and the inferior portion of the humeral implant.<sup>18-20</sup> Erickson et al.<sup>18</sup> described these findings in their systematic review, reporting that the rate of scapular notching was nearly 8-fold greater in patients with a 155° prosthesis versus a 135° prosthesis (16.8% vs 2.83%,  $P < .001$ ). A 135° prosthesis yields greater adduction and reduces the risk of scapular notching, and when combined with an onlay configuration, it also lateralizes the humerus.<sup>21</sup> Such lateralization of the humerus optimizes muscle tensioning of the rotator cuff and increases deltoid wrapping. Jeon et al.<sup>22</sup> described the biomechanical importance of lateralization of the humeral head, reporting that a neck-shaft angle of 135° lateralized the humerus such that increased tension on the rotator cuff maximized total horizontal range of motion of the shoulder by more than 60° compared with a 155° prosthesis.

Our described rTSA technique is a powerful and effective option for the treatment of massive, irreparable rotator cuff tears with significant rotator cuff arthropathy. Three-dimensional preoperative planning software and a 135° prosthesis ensure templating

accuracy, decreasing the likelihood of component malposition, scapular notching, and implant failure.

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