Technical Note

Revision Reverse Total Shoulder Arthroplasty for Failed Anatomic Total Shoulder Arthroplasty With Massive Irreparable Rotator Cuff Tear

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Abstract: Anatomic total shoulder arthroplasty (TSA) has become more common as surgical indications have expanded. However, the burden of revision shoulder arthroplasty has inevitably increased as well. Multiple studies have examined the use of reverse total shoulder arthroplasty (rTSA) as a revision option for failed anatomic TSA with a massive irreparable rotator cuff tear. Successful reconstruction of failed TSA with rTSA requires sufficient glenoid bone to place the glenoid segment, enough proximal humeral bone to allow for implantation of the humeral component, and sufficient tension in the soft-tissue envelope to ensure implant stability. In this article, we describe our preferred rTSA revision technique for the treatment of a failed TSA.

Anatomic total shoulder arthroplasty (TSA) has become more common as surgical indications have expanded, as implant survival has improved, and as surgery has been offered to younger patients.[1,2] Singh et al.[3] found 5-, 10-, and 20-year revision-free survival rates for primary TSA of 94.2%, 90.2%, and 81.4%, respectively, noting that male sex and rotator cuff disease are independent risk factors for revision after TSA. Similarly, in a retrospective review of shoulder arthroplasties performed at 2 tertiary centers over a period of 10 years, Gauci et al.[4] found a revision rate for TSA of 6.7%, with glenoid implant loosening and prosthetic instability as the leading 2 indications for the first reintervention.

In their retrospective review of articles published between 2006 and 2015, Bohsali et al.[5] described the most common complications, irrespective of surgical intervention, after anatomic TSA. In order of decreasing frequency, they were component loosening (specifically glenoid loosening), glenoid wear, shoulder instability, rotator cuff tear, periprosthetic fracture, neural injury, infection, hematoma, deltoid injury, and venous thromboembolism. Multiple diagnoses, sometimes in the same patient, can contribute to failure of a primary TSA and the need for revision surgery. In a case series of 40 patients who underwent revision of TSA to reverse total shoulder arthroplasty (rTSA), Sheth et al.[6] categorized their various indications for revision as

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isolated rotator cuff failure (including rotator cuff tear and clinical insufficiency), rotator cuff failure with component failure (glenoid or humeral loosening), rotator cuff failure with instability, fracture sequelae (tuberosity nonunion, malunion, or resorption after proximal humeral fracture), and recalcitrant stiffness. The 2 leading causes of TSA revision to rTSA were (1) cuff failure with instability and (2) cuff and component failure (glenoid or humeral loosening). In another case series of TSA revision to rTSA in 75 patients, the 3 most common indications for surgery were painful arthroplasty (n = 62, 82.7%), rotator cuff failure (n = 56, 74.7%), and unstable arthroplasty (n = 25, 33.3%), with most patients having multiple indications for surgery (n = 69, 92%).[7]

Multiple studies have examined the use of rTSA as a revision option for failed anatomic TSA due to failure of the rotator cuff, instability, implant component loosening, ongoing pain and infection, or TSA failure with bone loss.[4,7] In rTSA, the center of joint rotation is modified, allowing the intact cuff and deltoid to take over shoulder function, particularly abduction. The rTSA technique continues to evolve with improved functional outcomes and decreased postoperative pain and complication rates.

Successful reconstruction of failed TSA with rTSA requires sufficient glenoid bone to place the glenoid segment, enough proximal humeral bone to allow for implantation of the humeral component, and sufficient tension in the soft-tissue envelope to ensure implant stability.[8] If extensive loss of glenoid or proximal humeral bone is present, revision frequently requires bone graft or component augmentation to create a stable platform for implantation of the revision prosthesis. In this article, we describe our preferred rTSA revision technique for the treatment of failed TSA.

Surgical Technique

The surgical technique is presented in Video 1.

Patient Positioning and Anesthesia

The patient is placed in the beach-chair position. An interscalene nerve block with an indwelling catheter and pec-2 a single-shot block between the pectoralis minor and serratus anterior; the patient undergoes light general anesthesia afterward. The surgical site is cleaned, prepared, and draped in a sterile fashion. All bony prominences are well padded, and a padded towel is placed on the posteromedial edge of the scapula to ensure adequate shoulder positioning during surgery. The head of the bed is elevated about 45° during the case. A padded Mayo stand is used for arm positioning and holding during the procedure. After patient positioning, an examination under anesthesia is carried out to confirm the diagnosis and assess shoulder range of motion.

Surgical Approach and Open Biceps Tenodesis

A deltopectoral approach is chosen. Skin incision begins from just lateral to the coracoid process through the deltopectoral interval (Fig 1A). Metzenbaum scissors and a needle-tip Bovie electrocautery device (Bovie Medical, Clearwater, FL) are used to perform careful dissection and to control bleeding. The cephalic vein is identified; retracted laterally or medially, whichever is easiest; and protected throughout the case. The coracoid process and the conjoint tendon are carefully identified. The scar tissue underneath the deltoid and capsule is expected owing to the revision case and rotator cuff arthropathy. This scar tissue is released and elevated off the humeral head using a Cobb elevator, Mayo scissors, and an electrocautery device (Fig 1B). Next, the clavipectoral fascia is identified and incised lateral to the conjoint tendon and inferior to the coracoacromial ligament. A Kolbel retractor is inserted underneath the short head of the biceps medially and the deltoid laterally to increase surgical exposure (Fig 1C). The whole footprint of the subscapularis tendon (SSc) is identified, which is completely torn in the presented case. However, a lateral SSc peel-off technique is needed to elevate the SSc from the lesser tuberosity in cases with an intact SSc. A stay suture—nonabsorbable No. 2 Ethibond Excel Polyester Suture (Ethicon, Somerville, NJ)—is used to suture the top rolled edge of the SSC and to help mobilize the tendon (Fig 1D).

The long head of the biceps tendon (LHB) is identified at the bicipital groove of the humerus. The upper border of the pectoralis major insertion on the humerus is identified. The LHB is proximally released through the bicipital groove, transverse humeral ligament, rotator interval, and coracoid base. Next, a 2-mm FiberTape (Arthrex, Naples, FL) is used to secure the LHB with the proximal portion of the pectoralis major, with care taken to tie the tendon in its anatomic length-tension relation, with 2 figure-of-8 sutures.

Humeral Head Component Exposure, Removal, and Preparation

A 2-pointed Hohmann retractor is used to expose the humeral head while the shoulder is in a fully externally rotated, adducted, and slightly extended position. Then, the humeral head TSA component is identified with a Cobb elevator and a mallet (Fig 2A). At this point, the humeral component is clearly identified. An osteotome, a flexible osteotome (8-mm-wide blade), the Cobb elevator, and the mallet are used to remove the humeral stem (Fig 2B). Care should be taken not to break the humeral bone, especially in a patient with osteoporosis or a well-fixed humeral stem. Next, the humeral implant sizing is measured to appropriate fit with the humeral shaft. Progressive hand reaming is performed, starting from the smallest size of 6 mm up to the estimated reamer size (Fig 2C). Afterward, press-fit

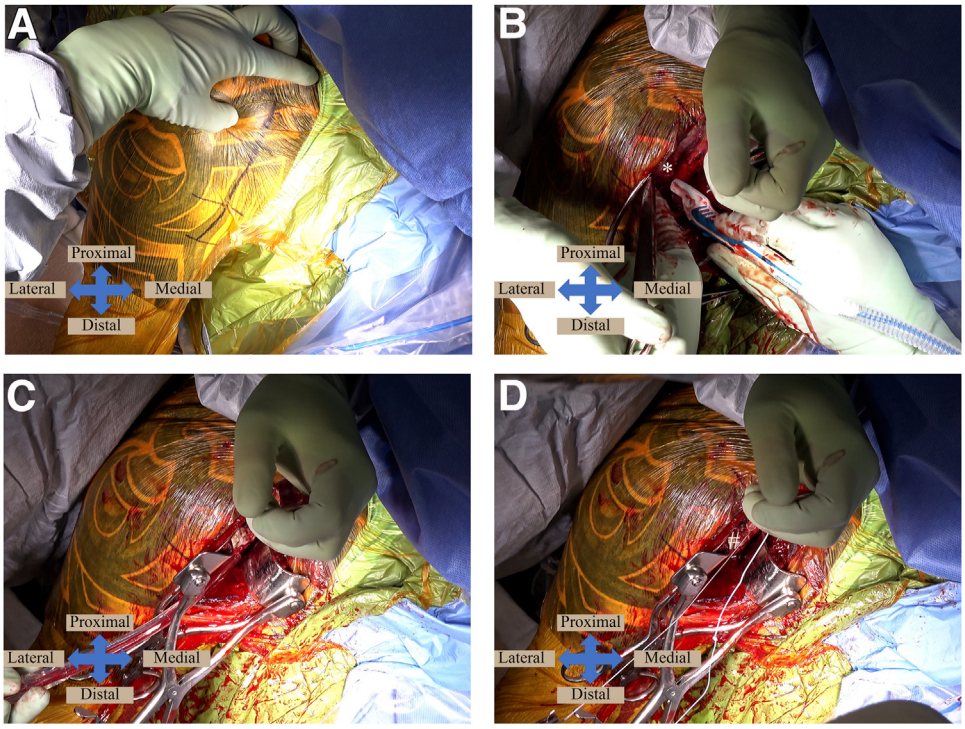

Fig 1. Intraoperative pictures of surgical approach in right shoulder (beach-chair position). (A) A deltopectoral approach is chosen. Skin incision begins from just lateral to the coracoid process through the deltopectoral interval. (B) The scar tissue underneath the deltoid (asterisk) and capsule is expected owing to the revision case and rotator cuff arthropathy. This scar tissue is released and elevated off the humeral head using a Cobb elevator, Mayo scissors, and an electrocautery device. (C) A Kolbel retractor is inserted underneath the short head of the biceps medially and the deltoid laterally to increase surgical exposure. (D) A stay suture (nonabsorbable suture) is used to suture the top rolled edge of the subscapularis tendon (pound sign) and to help mobilize the tendon.

broaches using a 20° version guide are placed, starting with 6 mm up to the final press-fit size (Fig 2D).

Axillary Nerve Neurolysis and Glenoid Component Exposure, Removal, and Preparation

The humeral head retractor and anterior glenoid retractor are used to increase glenoid exposure. The axillary nerve is carefully identified using gentle digital palpation. The axillary nerve is released from the fascia using Metzenbaum scissors and mobilized around the anterior glenoid (Fig 3). This is performed to prevent scar entrapment and deltoid dysfunction postoperatively. Next, tissue cultures are taken from inside the joint, and preoperative antibiotics are administered (Fig 4). The anterior capsule and SSc are identified, debrided, and completely released. Care is taken to always protect the axillary nerve with gentle digital palpation. The glenoid labrum and tissue are released from approximately the 1-o'clock position anterior to the 9-o'clock position posterior (for a right shoulder) (Fig 5A).

The previous plastic component is identified and removed with osteotomes (Fig 5B). The glenoid surface is carefully debrided and irrigated with normal saline solution. The significance of glenoid bone loss is anticipated from the preoperative planning. A 20° full-wedge augmented guidewire (Univers Revers Augmented Modular Glenoid System; Arthrex) is placed and marked at the optimal location with an electrocautery device (Fig 5C). A guide pin is inserted, and progressive glenoid reaming is performed. In this step, the goal is to obtain glenoid exposure with minimal penetration and achieve circumferential reaming. Then, a 7-mm central post drill is inserted over the guide pin (Fig 5D).

Glenosphere and Baseplate Fixation and Humeral Implantation

In the presented case, a 24-mm with +2 mm lateralized baseplate, modular with a 20° full-wedge augmented baseplate and +2 mm lateral augmentation options (Univers Revers Augmented Modular Glenoid System) is chosen based on 3-dimensional preoperative planning software. One compression screw and three peripheral locking screws are inserted into the baseplate (Fig 6A). Next, an over-the-baseplate peripheral reamer is inserted, and reaming is performed to prevent impingement at the backside of glenosphere (Fig 6B). Then, a 39-mm glenosphere with 0 mm of inferior offset and +4 mm lateralized offset is introduced onto the baseplate as planned preoperatively and

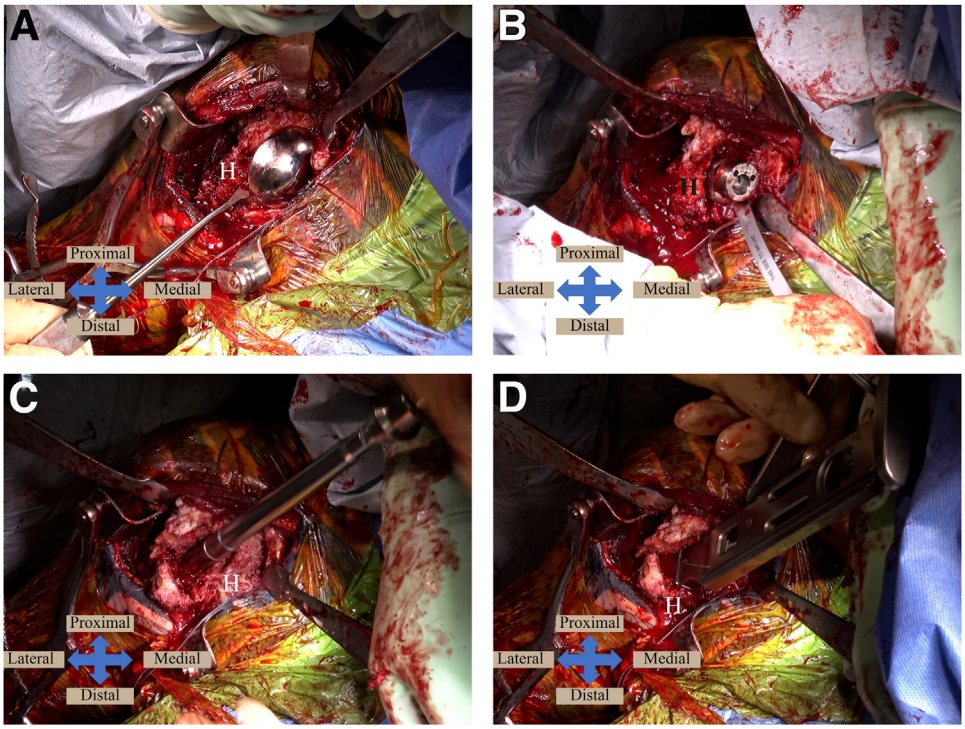

Fig 2. Intraoperative pictures of humeral head component exposure, removal, and preparation in right shoulder (beach-chair position). (A) The humeral head total shoulder arthroplasty component is identified with a Cobb elevator and a mallet. (B) An osteotome, a flexible osteotome, the Cobb elevator, and the mallet are used to remove the humeral stem from all the adjacent corners of the humeral shaft. Care should be taken not to break the humeral bone, especially in a patient with osteoporosis or a well-fixed humeral stem. (C) Progressive hand reaming is performed, starting from the smallest size of 6 mm up to the estimated reamer size. (D) Press-fit broaches using a 20° version guide are placed, starting with 6 mm up to the final press-fit size. (H, humerus.)

secured into the glenosphere with a locking screw (Fig 6C).

After baseplate and glenosphere fixation are completed, the corresponding humeral trial cup and liner are inserted to assess stability and range of motion. A good suction effect should be shown with minimal inferior translation, with some lateral translation being optimal. After soft-tissue balancing and stability are

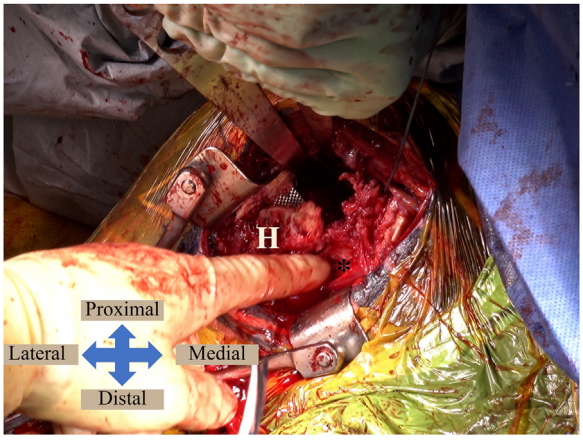

Fig 3. Intraoperative picture of right shoulder (beach-chair position). The axillary nerve (asterisk) is carefully identified using gentle digital palpation. The axillary nerve is released from the fascia using Metzenbaum scissors and mobilized around the anterior glenoid. (H, humerus.)

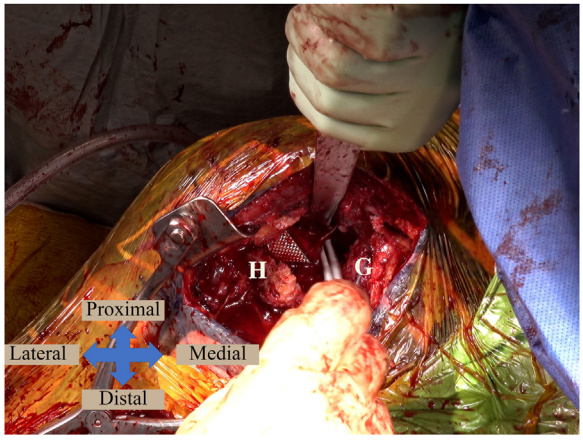

Fig 4. Intraoperative picture of right shoulder (beach-chair position). Tissue cultures are taken from inside the joint, and preoperative antibiotics are administered. (G, glenoid; H, humerus.)

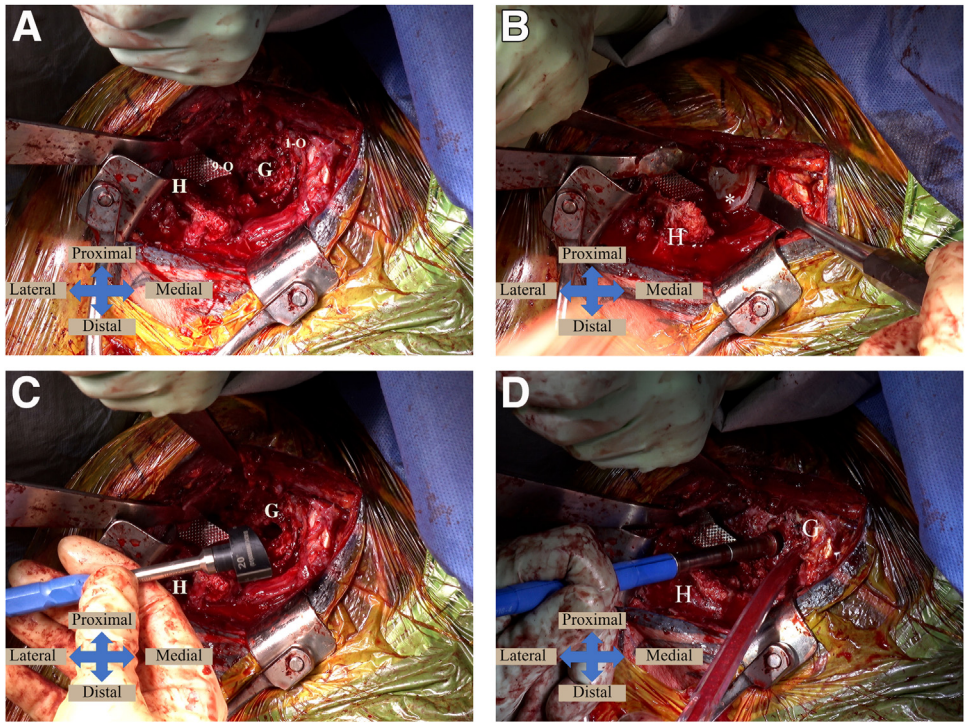

Fig 5. Intraoperative pictures of glenoid component preparation in right shoulder (beach-chair position). (A) The glenoid labrum and tissue are released from approximately the 1-o'clock position (1-0) anterior to the 9-o'clock position (9-0) posterior (for a right shoulder) for increased exposure in glenoid preparation. (B) The previous plastic glenoid component (asterisk) is identified and removed with osteotomes. (C) A 20° full-wedge augmented guidewire is placed and marked at the optimal location with an electrocautery device, as confirmed with the 3-dimensional preoperative planning software. (D) a 7-mm central post drill is inserted over the guide pin. (G, glenoid; H, humerus.)

achieved, all humeral trials are removed. The cemented humeral component technique is chosen for the presented case, given the revision situation (Fig 6D). In this case, the final humeral components are as follows: size 10 humeral stem with SutureCup and constrained humeral liner (39+6 mm/42 mm, CONSTRAINED Combination Humeral Insert, Univers Revers Shoulder System; Arthrex).

Finally, motion and stability are reassessed. The surgical wound is copiously irrigated with pulse lavage. One gram of vancomycin is applied in the joint, followed by deep skin closure. All wounds are closed in a layered fashion.

Postoperative Rehabilitation

A padded abduction sling is worn for 2 weeks postoperatively. Passive and active range of motion is begun immediately but limited to 30° of external rotation, with no internal rotation strengthening for 2 weeks. Active-assisted motion to 120° of flexion and to 60° of abduction is allowed immediately. A standard postoperative rehabilitation protocol for rTSA with progression to early-strengthening and full-strengthening exercises is prescribed. In general, a sling is used for 2 to 3 weeks, and a return to light activity is allowed at 6 to 8 weeks. A return to full activity, including golf and swimming, as well as light gym work, is started at 10 to 12 weeks postoperatively. The return to full activity is expected at 2 to 3 months postoperatively.

Discussion

In this Technical Note, we describe our technique for revision of TSA using an rTSA implant in the setting of glenoid bone loss and significant rotator cuff arthropathy (Video 1). Recommended surgical planning for patients presenting for revision rTSA includes imaging with advanced 3-dimensional preoperative planning software and the use of a glenoid structural augmentation when needed, as noted in the pearls and pitfalls listed in Table 1.

Glenoid component positioning is critical for postoperative function and long-term implant survivorship in rTSA,[9] and glenoid component failure is one of the most common complications in shoulder arthroplasty, resulting in implant loosening and poor clinical outcomes.[10] In primary rTSA, humeral head autograft

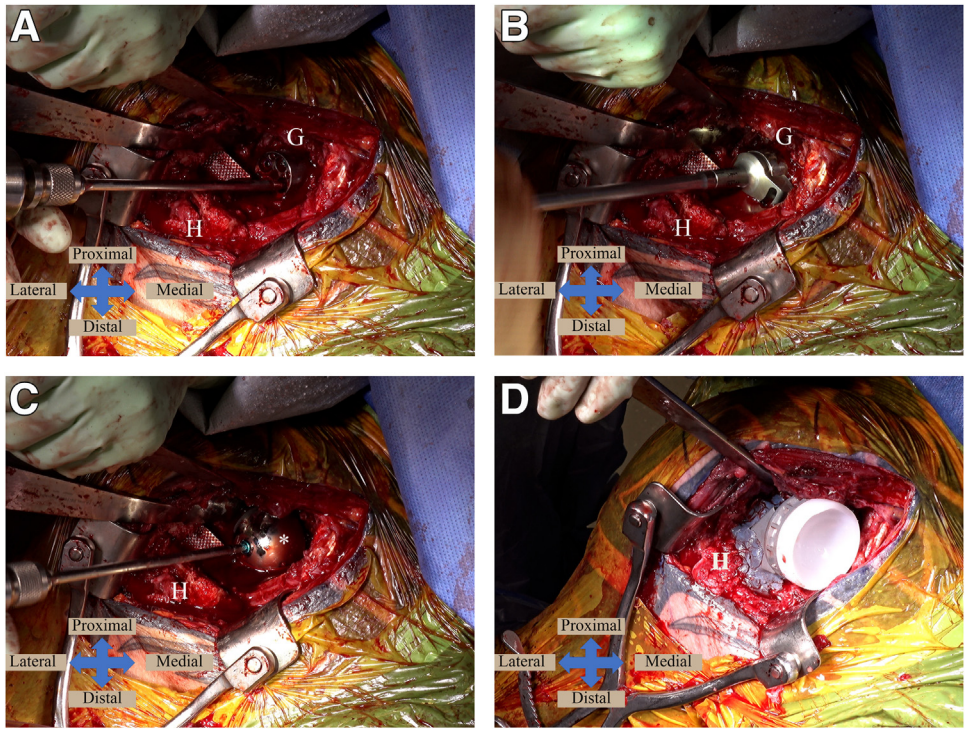

Fig 6. Intraoperative pictures of glenosphere (asterisk) and baseplate fixation and humeral implantation in right shoulder (beach-chair position). (A) A 24-mm with +2 mm lateralized baseplate, modular with a 20° full-wedge augmented baseplate and +2 mm lateral augmentation options is chosen and fixed with 1 compression screw and 3 peripheral locking screws. (B) An over-the-baseplate peripheral reamer is inserted, and reaming is performed to prevent impingement at the backside of the glenosphere. (C) A 39-mm glenosphere with 0 mm of inferior offset and +4 mm lateralized offset is introduced onto the baseplate and secured into the glenosphere with a locking screw. (D) The cemented humeral component technique is chosen for this case. Final motion and stability are reassessed. (G, glenoid; H, humerus.)

transplantation has been described for addressing extreme glenoid retroversion with advanced osteoarthritis.[11] Other techniques such as eccentric reaming and baseplate augmentation allow surgeons to tailor treatment to the patient's altered glenoid anatomy.[12] In the revision setting, such as in the presented case, the

Table 1. Pearls and Pitfalls of Revision Reverse Total Shoulder Arthroplasty for Failed Anatomic Total Shoulder Arthroplasty With Massive Irreparable Rotator Cuff Tear

Pearls
Preoperative planning software with advanced imaging such as CT scans and 3D modeling will help to facilitate accurate component placement, especially glenoid baseplate placement.
A flexible osteotome is used to remove the humeral stem from all the adjacent corners of the humeral shaft.
Axillary nerve neurolysis is essential to prevent scar entrapment and deltoid dysfunction.
The surgeon should carefully release the scar tissue, subscapularis tendon, and capsule to increase surgical exposure.
The glenoid labrum and tissue are released from approximately the 1-o'clock position anterior to the 9-o'clock position posterior (for a right shoulder) to increase glenoid exposure.
Glenoid baseplate augmentation and lateralization can address altered glenoid anatomy due to bone loss, restoring glenoid volume and version.
Tissue cultures are taken before preoperative antibiotics are administered.
Pitfalls
Component malpositioning may interfere with stability and range of motion despite good preoperative planning.
There is an increased risk of iatrogenic fracture (both humerus and glenoid), especially in a patient with osteoporosis or a well-fixed humeral stem.
Injury to the axillary nerve is possible; the surgeon should perform digital palpation and mobilization of the axillary nerve around the anterior glenoid to decrease the risk.
The preoperative planning software required may be unavailable and/or costly.
Excessive deltoid tensioning can result in instability, forced abduction of the arm, and acromial fracture.

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

humeral head is not available, so a 20° glenoid baseplate augmented with +2 mm lateral augmentation options is used to restore glenoid volume and version.

The most common indications for revision rTSA are TSA failure due to pain, rotator cuff tear, and instability. Revision rTSA has been shown to improve pain, function, and quality-of-life measures in patients with various causes of TSA failure, but postoperative range of motion and patient-reported outcomes have not been shown to reach the values seen in the primary rTSA population.[6,7] In a study of the mid-term outcomes of 75 patients undergoing revision rTSA, Otte et al.[7] found no significant improvement in active external rotation and observed that 28% of patients experienced complications and 12% underwent reoperation. In a matched-cohort study comparing primary rTSA patients with patients who underwent conversion from TSA to rTSA for rotator cuff failure or component loosening, Shields and Wiater[13] observed similar improvements in function, but the revision group had a lower satisfaction rate and a higher complication rate (31% vs 13%). This information helps inform patient discussions when considering the risks and benefits of revision rTSA.

Our described revision rTSA technique is an effective option for addressing the unique challenges posed by failed TSA. Three-dimensional preoperative planning software, as well as lateralization and augmentation of the glenoid implant, will allow for accurate planning and successful placement of a well-positioned and well-tensioned implant in the setting of the altered anatomy encountered in revision shoulder arthroplasty.

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