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Treatment of coronal split glenoid fracture utilizing open reduction internal fixation with immediate intraoperative conversion to rTSA: a novel approach

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Glenoid fractures can be devastating injuries from which many patients do not fully recover. These patients frequently have residual range of motion limitations, pain, and recurrent instability.[5,13] Despite awareness of these limitations, there has been little progress in the development of novel approaches for the treatment of glenoid fractures. This is likely secondary to the rarity of the injury, with the actual incidence of glenoid fracture reported as 0.04%-0.1% of all fractures across all age groups.[6] Typically, these injuries are treated with open reduction and internal fixation (ORIF) for incongruent joint surfaces and nonoperative management for congruent joints. While the exact rates of post-traumatic arthritis following glenoid fracture are not well-defined, there appears to be a consensus that there is a 25% rate of post-traumatic glenohumeral arthritis following impaction injury, with the rate increasing after fractures involving greater than 30% of the glenoid surface.[6] For these reasons, up to 12.6% of fractures in patients of all ages treated with ORIF are later converted to total shoulder arthroplasty or reverse total shoulder arthroplasty (rTSA), with a relative risk for conversion of 4.77.[16] Given these statistics, along with our patient's advanced age of 76 years old, preinjury osteoarthritis and low functional status, the fixation method of open reduction, internal fixation with immediate conversion to rTSA was chosen for our patient.

Case

Our patient is a 76-year-old right-hand dominant female who sustained a ground-level fall at home. At the time, she reported feeling her shoulder "popping out," with an inability to lift her arm at the shoulder secondary to pain. Imaging studies interpreted by the emergency department physicians revealed an anterior glenohumeral dislocation (Fig. 1). The decision was made to proceed with closed reduction under conscious sedation. Successful reduction was believed to have been accomplished based on clinical exam by the emergency department physician. Upon reversal of sedation, the patient was noted to have re-dislocation of her right glenohumeral joint on the postreduction radiograph (Fig. 2).

Repeat radiographs demonstrated a previously overlooked coronal split anterior glenoid fracture, with glenoid fossa impaction and mild glenohumeral osteoarthritis. An orthopedic surgeon was then consulted for further evaluation. At the time of consultation, a computed tomography (CT) scan of the right shoulder was ordered to determine the nature of the fracture pattern and degenerative joint disease (Figs. 3-8). The glenoid fracture was found to be coronally oriented, involving approximately 40% of the glenoid surface, with extension into the anterior scapular body and centrally oriented impaction of the glenoid fossa.

This study was exempt from institutional review board approval by UPMC Central PA Region Institutional Review Board.

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Figure 1 Initial injury film attempted right Grashey view.

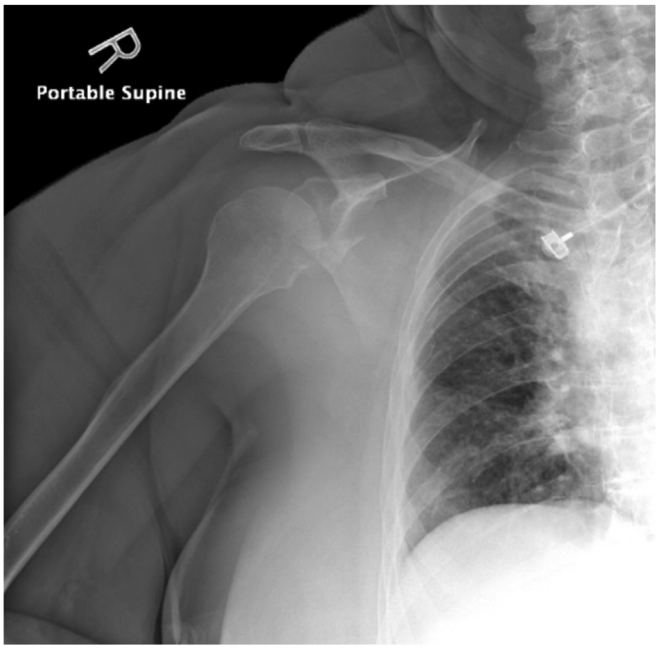

Figure 2 Initial injury film attempted right Velpeau view.

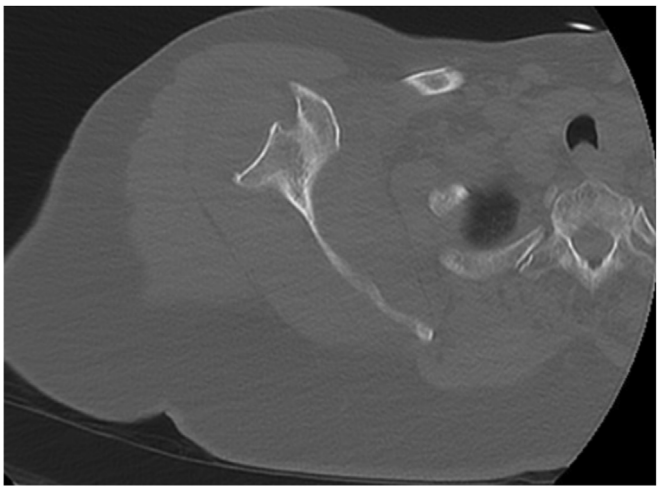

Figure 3 Multiple axial cuts of CT of the right shoulder for preoperative planning. *CT*, computed tomography.

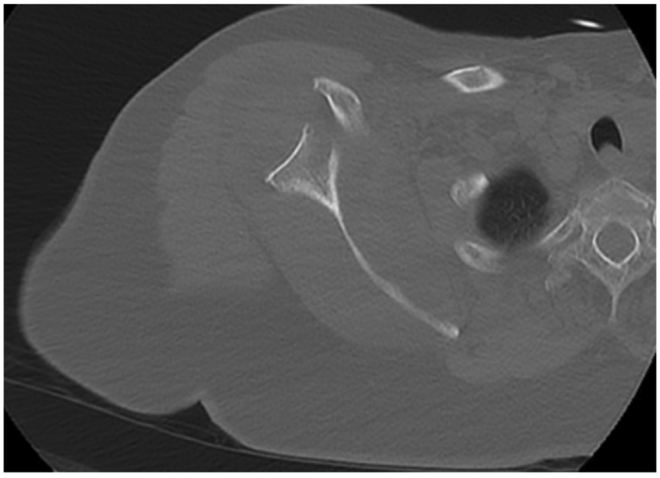

Figure 4 Multiple axial cuts of CT of the right shoulder for preoperative planning. *CT*, computed tomography.

Initially, nonoperative treatment was considered due to the patient's age and functional status. However, due to her recurrent instability, it was deemed inappropriate to attempt such treatment because of the displacement of the fragment on CT and the length of time the shoulder would remain dislocated while the fracture healed. There was also thought given to the idea of ORIF alone. As stated previously, the gold standard for glenoid fracture in patients of all ages is to treat with ORIF for displacement greater than 4 mm and greater than 25% joint surface involvement. This was ultimately deemed to be an inappropriate option for this patient for a multitude of reasons not the least of which being extended rehabilitation time.

During preoperative discussions with the patient, she revealed that she had been seeing an orthopedic surgeon for several years for bilateral osteoarthritis in her knees and glenohumeral joints. The patient stated that she had undergone rotator cuff repair 8 years prior in her left shoulder due to weakness, limited range of motion, and recurrent pain. She also said she had been losing function in her right shoulder in the same way but was told she was not a candidate for rotator cuff repair now that she was in her 70s. Additionally, it was presumed that the patient likely suffered a rotator cuff tear due to the high association between dislocations in the elderly and rotator cuff pathology.[6,11] For this reason, the orthopedic team presented the idea of repairing her injury and proceeding with "shoulder replacement" due to her preinjury decreasing function. The patient stated understanding of the options and agreed with the proposed plan of reverse total shoulder following ORIF. Due to the limited comminution present on the CT scan, it was deemed that augments and revision components would not be necessary for the operation as the bone stock available would be sufficient.

Surgical technique

After preparing and draping the patient according to standard sterile procedure and identifying the appropriate landmarks, the right glenohumeral joint was exposed using a standard deltopectoral approach.

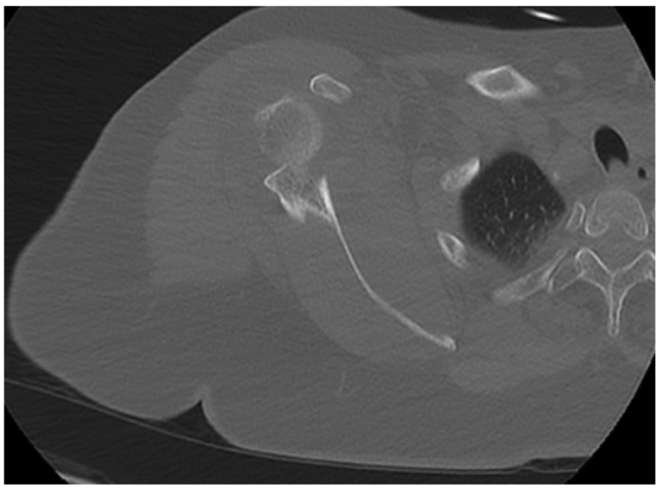

Figure 5 Multiple axial cuts of CT of the right shoulder for preoperative planning. *CT*, computed tomography.

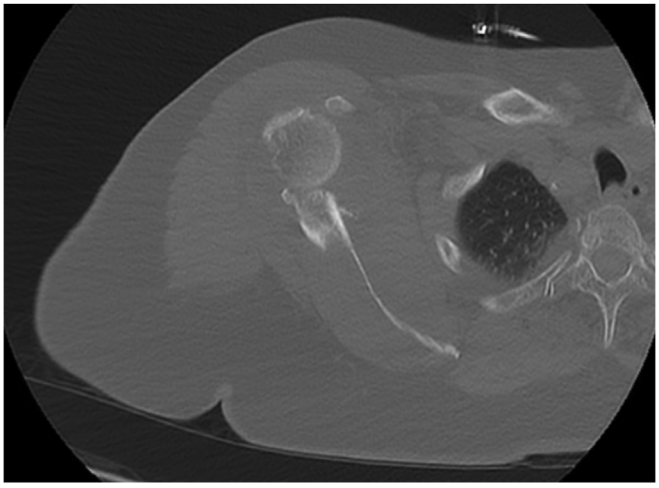

Figure 6 Multiple axial cuts of CT of the right shoulder for preoperative planning. *CT*, computed tomography.

Attention was then turned to the humerus. At the time of the exposure, the humerus was without fracture or Hill-Sachs lesion; however, there was a massive rotator cuff tear that included the entire supraspinatus and superior aspects of both the infraspinatus and subscapularis, as well as a moderate osteoarthritis of the articular glenoid surface with impaction injury to the articular cartilage. Due to the presence of a massive rotator cuff tear and the obvious degenerative changes seen on the humeral head and glenoid surface, the team felt assured that proceeding with the preoperative plan of ORIF with conversion rTSA was correct. Retractors were placed and the humeral canal was found using a blunt awl. The humeral canal was reamed progressively until a snug fit and proper "chatter" was appreciated. The humeral head was then resected with ten degrees of retroversion. A protective plate was placed over the prepared humeral surface and the humerus was reduced back into the shoulder capsule.

Retractors were placed to expose a full 360 degrees of the glenoid. At that time, it was discovered that the fracture fragment involved approximately 50% of the joint surface, with moderate joint impaction and damage to the articular cartilage. Through direct visualization, the glenoid fracture was reduced using manual reduction and tentatively held in place with a point-to-point

Figure 7 3D CT reconstructions of the right glenoid. *3D CT*, three dimensional computed tomography.

tenaculum. After adequate reduction of the glenoid fossa was achieved, a K-wire was placed from anterior to posterior along the superior aspect of the fracture line. A 3.5 mm cannulated drill was then placed over the K-wire and the near cortex was drilled. A 2.7 mm cannulated drill was then placed over the K-wire and the far cortex was then drilled. A cannulated 3.5 mm screw was then placed over the K-wire in a lag-by-technique fashion, with adequate compression across the fracture. The process was then repeated along the inferior aspect of the fracture fragment, keeping in mind the need to allow adequate space for the central peg of the glenosphere baseplate to pass between the screws.

After confirmation of reduction of the joint surface, the central guide wire was drilled into place through the center of the glenoid, between the two lag screws, to allow for reaming of the glenoid articular surface. The power reamer was used to expose bleeding subchondral bone. Peripheral surface reaming was carried out manually. The central peg of a standard-sized glenosphere baseplate was placed centrally on the glenoid surface. There was no interference from either of the lag screws while placing the central peg. The superior, inferior, and posterior glenosphere screws were then placed to secure the baseplate. This was done on a trial-and-error basis by directly visualizing the lag screws trajectory and aiming away from their projected course. For both the superior and posterior baseplate screws, the drill was able to pass without inference by this method and the subsequent screws placed. However, with the inferior screw, there was interference from the inferior lag screw and a second trajectory was attempted. The second trajectory was successful while drilling, but while placing the inferior baseplate screw there appeared to be some mild interference again from the inferior lag screw, however, the screw was ultimately able to be advanced into proper position. The anterior baseplate screw was attempted a total of three times with each attempt resulting in obstruction of the drill by the previous lag screws for ORIF.

Figure 8 3D CT reconstructions of the right glenoid. *3D CT*, three dimensional computed tomography.

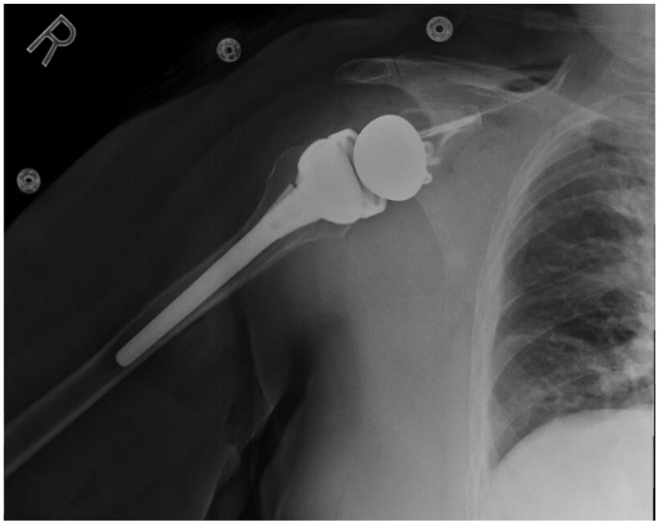

Figure 9 Immediate postoperative AP right shoulder status post-rTSA. *AP*, anterior-posterior; *rTSA*, reverse total arthroplasty.

The glenosphere was placed upon the baseplate. Attention was then returned to the previously prepared humerus. The size of the humeral stem was reconfirmed and cemented into place. A +3 humeral spacer was trialed, with adequate stability. The final +3 polyethylene and +9 humeral spacer was placed. The wound and implants were irrigated. Unfortunately, the subscapularis was unable to be repaired due to lack of a functional tendon remnant and excessive lateralization of the lesser tuberosity caused by the inclusion of the +9 humeral spacer. The shoulder joint and surrounding soft tissue were then closed in sequential fashion.

The patient tolerated the procedure well and was made non-weight bearing of the right upper extremity in a shoulder immobilizer for two weeks. An immediate postoperative radiograph demonstrated a well-fixed prosthesis and ORIF without dislocation (Fig. 9). She was found to be neurovascularly intact on post-operative day one when her interscalene block had worn off. The patient was discharged home on postoperative day three.

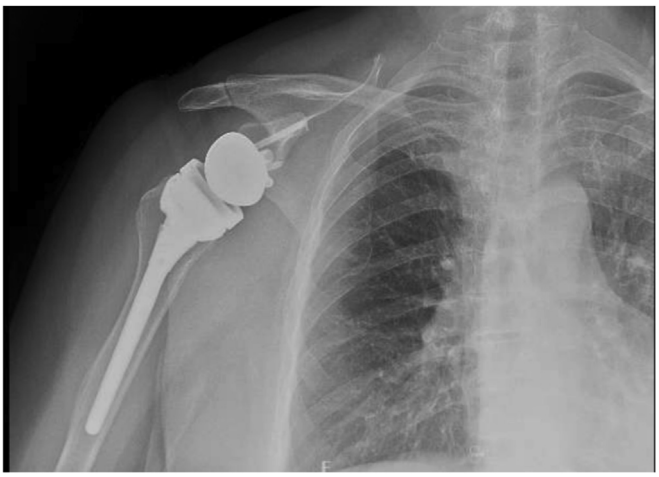

Figure 10 Postoperative day 10 office visit AP right shoulder. *AP*, anterior-posterior.

Results

The patient followed up in clinic on postoperative day ten, when she reported adequate pain control. Her right upper extremity had remained in a shoulder immobilizer since discharge, which is a change from the standard post-reverse total shoulder protocol in which the patient is generally allowed to begin passive range of motion prior to the first follow-up appointment. Her staples were removed, and she was advised to begin pendulum swings, and to intermittently remove the immobilizer, to allow the extremity to hang with gravity. Radiographs obtained at the visit demonstrated appropriate healing of the glenoid fracture, with a stable, well-located reverse total shoulder prosthesis. (Figs. 10 and 11) After this visit, the postoperative course followed a typical post-rTSA protocol without additional precautions as the patient's outcomes were similar to patients who had undergone the same procedure electively.

Her next visit was six weeks postoperatively. At this visit, her full active range of motion was evaluated. She demonstrated 110 degrees of forward flexion (FF), 15 degrees of external rotation (ER), and internal rotation to the level of the iliac crest. She was noted to have 5/5 strength with FF and 3/5 with both internal and external rotation. Radiographs obtained at the visit demonstrated appropriate healing of the glenoid fracture with a stable, well-located reverse total shoulder prosthesis. (Figs. 12 and 13) She was then made weight bearing as tolerated and allowed to return to full activity. Given her function at 6 weeks, she was scheduled to return for a 6-month follow-up.

At her six-month postoperative visit, she demonstrated results exceeding the average results of patients who underwent elective rTSA for treatment of osteoarthritis. The patient could forward flex to 165 degrees, externally rotate to 45 degrees, internally rotate to L2, and had full strength with each movement when compared to the contralateral shoulder. She denied any sensation of instability and had not sustained any dislocations since the procedure. Radiographs obtained at the visit demonstrated a healed glenoid fracture with a stable, well-located reverse total shoulder prosthesis (Figs. 14 and 15).

All measurements taken throughout her postoperative course were obtained by the senior surgeon who performed the procedure

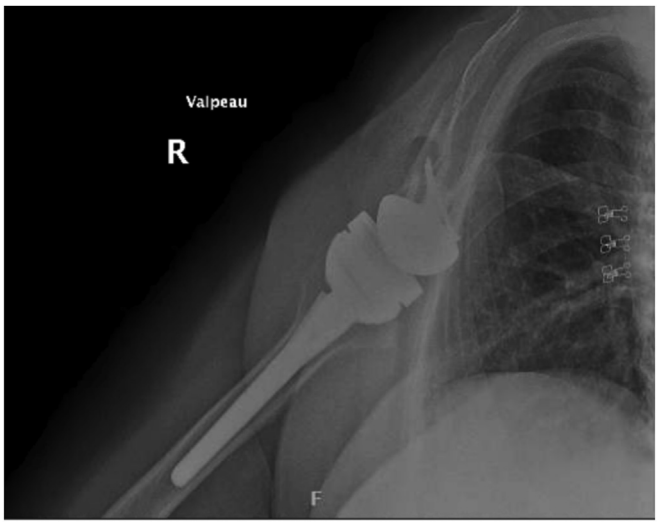

Figure 11 Postoperative day 10 office visit Velpeau view right shoulder.

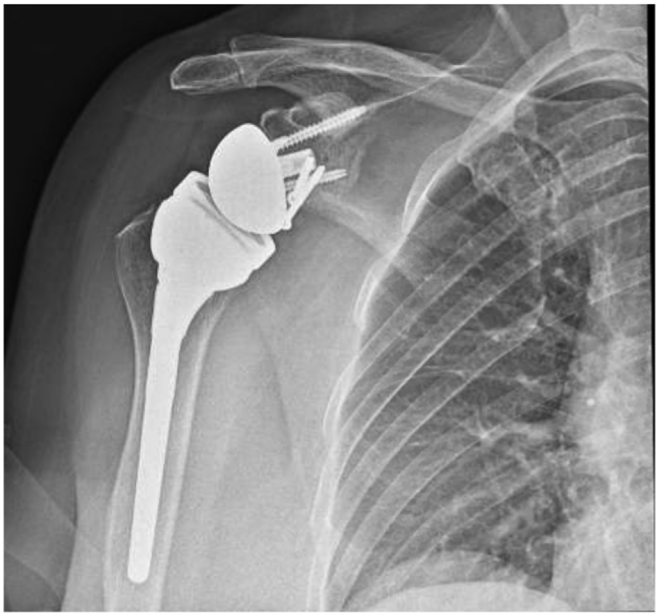

Figure 12 Postoperative week 6 visit: AP right shoulder. *AP*, anterior-posterior.

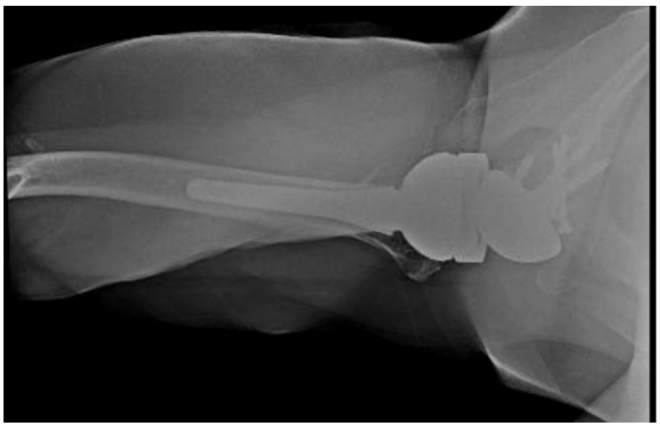

Figure 13 Postoperative week 6 visit: axillary view right shoulder.

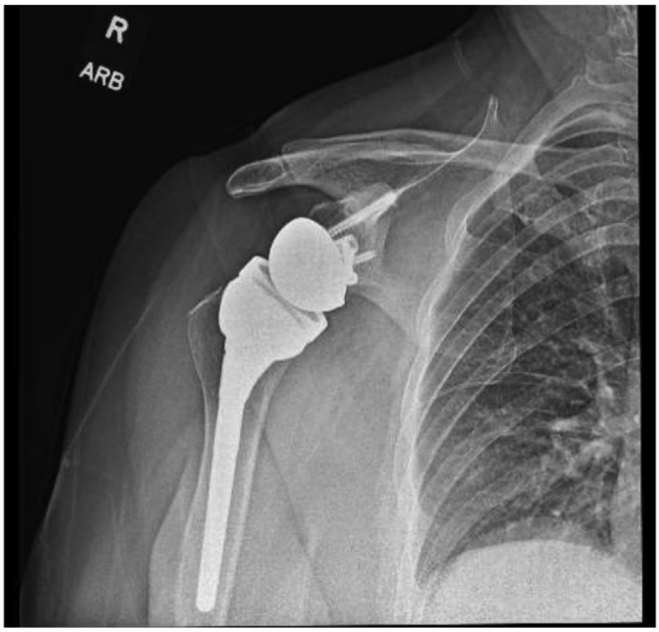

Figure 14 Postoperative month 6 visit: AP right shoulder. *AP*, anterior-posterior.

and were obtained utilizing a goniometer for exact measurements. An American Shoulder Elbow Surgeons (ASES) score was obtained following her 6-month visit which was found to be 80/100.[4,12] She currently remains without complication at a modest 6-month follow-up. The patient is scheduled for a one-year follow-up to further evaluate stability and function.

Discussion

Treatment options for intra-articular glenoid fracture have remained consistent in the literature for years.[1,6,8] The current gold standard remains ORIF for articular step-off >4 mm and >20% anterior or posterior glenoid lip involvement. Nonoperative management for nondisplaced fractures is nonweight-bearing of the affected upper extremity in a sling for 6-8 weeks. A review of relevant literature reports good outcomes for ORIF in young patients, with return to work in nearly every circumstance.[1] However, patients >65 years of age with preexisting osteoarthritis or rotator cuff pathology tend to have poorer functional outcomes with glenoid fractures treated nonoperatively or with ORIF alone.[8] Furthermore, many of these patients go on to undergo total shoulder arthroplasty or rTSA.[2]

In our case, the fracture pattern most closely resembled an Ideberg 1b,[7] with substantial involvement of the glenoid surface (approximately 40%-50%) and impaction of articular cartilage. Additionally, the patient had previously complained of bilateral shoulder pain and limited range of motion prior to this injury. For these reasons, as well as the inevitable increase in post-traumatic arthritis following the injury, the decision was made preoperatively to use ORIF to stabilize the glenoid bone stock before preparing the joint surface for arthroplasty due to glenoid surface impaction seen on CT. The fixation was strong enough to allow us to ream bleeding subchondral bone without displacing the fracture. By directing the trajectory of the superior, posterior, and inferior screws for the glenosphere base away from the trajectory of the two ORIF lag screws, we were able to secure the baseplate in place with reasonable security.

Figure 15 Postoperative month 6 visit: Velpeau view right shoulder.

When comparing our patient's results to the results from patients receiving rTSA for osteoarthritis, our patients FF and ER were comparable at both six weeks (110 vs. 120 FF, 15 vs. 30 ER) and six months postoperatively (165 vs. 140 FF, 45 vs. 40 ER).[6,9,10,14] Our patient has also remained well located since this procedure, with minimal pain at her six-week follow-up and no pain after six months. Additionally, her reported ASES was 80/100, which is comparable to patients undergoing reverse total shoulder for osteoarthritis.[3,4,12]

While many patients who undergo ORIF tend to be younger than our patient—Anavian et al reported a mean of 44 years old—our patient still performed well comparatively. The average patient who received ORIF was able to regain motion of 151 degrees of FF, 105 of abduction, 52 degrees of ER, internal rotation to the level of T5 with a minimum follow-up of 12 months.[1] Our patient was able to FF to 165, ER to 45, and internal rotation to L2 at her 6-month follow-up at the age of 76 years old.

Conclusion

Even though the treatment option described in this report is rare, we found a few reports describing the treatment of intra-articular glenoid fractures with ORIF with conversion to rTSA within 2 weeks of ORIF.[15] Additionally, a case report was published describing rTSA for glenoid fracture by using revision augments as well. Both previous publications demonstrate good results for the patients who have undergone this treatment option. While our report is limited to a single case, our patient's comparable function outcomes to that of a rTSA for osteoarthritis at a modest six-month follow-up, as well as the good outcomes in the previously published case reports, suggest reasonable viability of this treatment. This patient's outcomes demonstrate that this operative technique may be an appropriate treatment of large intra-articular glenoid fractures in low-demand patients, over 65 years old, with preexisting osteoarthritis and/or rotator cuff pathology when recurrent instability, limited range of motion, and consistent pain are concerns.

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