Case Report

Revision of a Complex Periprosthetic Humerus Fracture with Two-Thirds of Humerus Bone Loss with an Allograft-Prosthetic Composite Reverse Shoulder Arthroplasty

Pedro Tort^d Brian Howard Goldman^a Matthew J. Deal^b David Beaton^c

^aDepartment of Orthopedic Surgery, Larkin Community Hospital, South Miami, FL, USA;

^bUniversity of Central Florida College of Medicine, Orlando, FL, USA; ^cDepartment of Orthopaedic Surgery, University of Puerto Rico School of Medicine, San Juan, PR, USA;

^dTort Orthopedic Institute, Professional Hospital, Guaynabo, PR, USA

Keywords

Shoulder · Periprosthetic fracture · Reverse total shoulder arthroplasty revision

Abstract

Shoulder arthroplasty is becoming an increasingly standard procedure in the United States. In conjunction with an aging population and increased prevalence of osteoporosis, proper management of periprosthetic humerus fractures is of great interest to orthopedic surgeons. Several periprosthetic humeral fracture classification systems take into consideration the fracture location and implant stability, but they do not address the type of bone defects or amount of bone available for revision surgery. The lack of description and guidance in the different varieties of humerus bone defects limits current classification system utility in cases with severe bone loss. There are previous case reports of revisions of periprosthetic humerus fractures with an allograft-prosthetic composite reverse total shoulder replacement. Different from previously reported cases, the case described in this article presented the treatment of a complex humerus fracture with loss of more than two-thirds of the patient's native humerus. Due to the extensive humerus bone loss, we modified the surgical techniques previously published to allow for a successful surgery.

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Introduction

Shoulder arthroplasty is becoming an increasingly standard procedure in the United States [1]. Due to an aging population and increasing prevalence of osteoporosis, there is a growing risk for periprosthetic fractures [2]. There are several periprosthetic humerus fracture classifications. The Worland classification considers both factors of fracture anatomy and implant stability for treatment management [3]. Type A postoperative periprosthetic humeral fractures occur around the tuberosities. Type B fractures occur around the stem and are subdivided into type B1 (spiral fractures with a stable implant), B2 (short oblique fractures at the tip of the stem with a stable implant), and B3 (fractures about the stem with an unstable implant). Lastly, type C fractures occur distal to the tip of the stem. Treatment options of these periprosthetic fractures range from conservative nonoperative treatment to internal fixation or full revision of the prosthesis [4].

The treatment of periprosthetic fractures remains complex. There are limited studies on managing complex humerus periprosthetic fracture revisions, particularly those in the elderly with severe periprosthetic bone loss. Several periprosthetic humeral fracture classification systems consider fracture location and implant stability, but do not address the type of bone defects and available bone for revision surgery.

We report a case report of a reverse shoulder periprosthetic humerus fracture with more than two-thirds of bone loss that was successfully treated with a modified allograft-prosthetic composite (APC) reverse total shoulder reconstruction. Written informed consent was obtained from the patient for possible publication of this case.

Case Report

This case is of a 79-year-old female with a medical history of osteoporosis, hypertension, and diabetes mellitus, who suffered a left humerus greater tuberosity fracture and acute rotator cuff tear after sustaining a fall. She subsequently underwent successful open reduction and internal fixation (ORIF) of the greater tuberosity with supraspinatus tendon repair. Three years later, the patient sustained a second fall. Imaging studies revealed a massive irreparable rotator cuff lesion and advanced arthritis in the previously treated shoulder. After failing initial conservative management, the patient then underwent a successful reverse total shoulder replacement with the reacquisition of a functional range of motion and strength by the fourth postoperative month. Five months after the reverse total shoulder replacement surgery, she suffered a third fall. Imaging studies revealed a displaced periprosthetic Worland type B3 fracture of the left humerus. She underwent a revision reverse total shoulder replacement surgery with an exchange of the previous humerus stem to a cemented long humeral stem. During the revision, the patient suffered mild proximal humerus bone loss, but adequate fixation was obtained. The glenoid component was well fixed, and the humerus component liner was revised to obtain stability of the shoulder prosthesis. The patient obtained a range of motion of forward flexion of 100 degrees and abduction of 90 degrees. At zero degrees of abduction, the external rotation was 40 degrees and the internal rotation was 20 degrees.

Eighteen months later, the patient suffered her fourth fall and re-injured her previously affected shoulder. Imaging studies revealed another Worland type B3 periprosthetic fracture with bone loss of approximately two-thirds of the patient's humerus proximal length. Significant osteoporosis changes were noticed on the X-rays (Fig. 1). Different nonsurgical and surgical treatment options were considered and discussed with the patient. We concluded that

the two best surgical treatment revision options were the proximal humerus substituting tumoral reverse total shoulder endoprosthesis and the extralong APC reverse total shoulder replacement with plate and cables ORIF. Benefits and risks were presented and discussed with the patient. The advantages of the tumoral reverse total shoulder endoprosthesis include possible lower rates of infection and no requirement of bone healing to an allograft, although it does lead to increased incidence of dislocation and mobility loss due to the lack of attachment sites for soft tissue [5–8]. The APC provides the advantage of providing additional soft tissue and prosthetic support, but with the risk of higher rates of infection, non-union, and the potential need for eventual revision surgery [8–10]. The cost is another factor that we took into consideration, the tumoral endoprosthesis being more expensive and limiting its access. After a thorough analysis and discussion with the patient and an accompanying family member, we recommended the revision APC long stem reverse total shoulder replacement with ORIF.

Surgical Technique

The patient was positioned in the supine semi-beach-chair position. The patient's previous deltopectoral incision was utilized. Careful soft tissue dissection was done to identify and protect anatomical structures. After the surgical approach was made, a severely comminuted periprosthetic humerus fracture with significant bone loss and humeral component loosening was found. The pectoralis major, latissimus dorsi, and teres major were noted to be partially attached to the displaced bone fragments. Other areas were detached from the original insertion and healed to scar tissue. The proximal humeral bone segment was fragmented and determined to be incapable of accepting a new prosthesis. Preoperative planning was done by measuring the contralateral humerus length. A 150-mm APC, consistent with the preoperative measurement, was used. A step-cut in the allograft was not utilized because it was determined to not add significant advantages for either stability or bone healing. A transverse bone cut was done in both the allograft and the native distal humerus. APC construction in this case differed from previously described techniques. Previous reports described preparing the APC by introducing the humeral component in the allograft prior to host bone fixation. This case describes fixation of the allograft to the host bone, followed by the prosthetic placement. With a bone defect close to two-thirds of the native humerus, it was easier to fix the allograft to the host bone with a five-hole 6.5" Dall-Milles plate (Stryker, Kalamazoo, MI, USA) and four 2.0-mm tension cables and one 1.6-mm tension cable, followed by insertion of long stem revision prosthesis (Fig. 2 and Fig. 3).

Several precautions were taken to avoid the cement interposition affecting bone healing between the host bone and the allograft. First, a near-perfect transverse cut was done in both the allograft and the native bone. Second, the fixation of the allograft and the native bone was done before the preparation and implantation of the reverse total shoulder replacement. Third, during the plate and cable fixation, the bones were compressed as much as possible. Fourth, before the cementation process, Gelfoam was used to fill out any gaps between the contact of the allograft and the native bone, and using Ethibond #5, it was fixed around the interface to avoid cement dripping.

A 198 × 6 mm Comprehensive-Biomet revision humeral reverse total shoulder stem (Biomet, Warsaw, IN, USA) was cemented using 3 Cobalt™ HV bone cement packs.

During repair of the tendons to the APC, the subscapularis and the posterosuperior rotator cuff tendon were found chronically torn and irreparable. The pectoralis major and the deltoid tendon were fixed to the humeral allograft using drill holes and Ethibond #5 sutures. A

latissimus dorsi and teres major tendon transfer were not done due to a significant amount of scar tissue. The surgery was done without peri- or postoperative complications. The patient was discharged 48 h after surgery with instructions of using a shoulder sling at all times except for daily elbow flexion and extension exercises.

At 1 week of follow-up, the patient reported “mild pain,” decreased range of motion, and mild weakness and numbness along the volar and dorsal aspect of the lateral forearm. At 2 weeks of follow-up, she had fully regained forearm sensation and began physical therapy.

During the patient’s 6-month follow-up, the X-rays already revealed complete incorporation and healing of the allograft to the native bone. The activities of daily living were not severely affected, the patient was satisfied with results with decreased pain limited mobility.

At the patient’s 12-month follow-up, the patient denied extremity numbness or weakness. Despite the efforts of providing physical therapy and home range of motion exercises, the patient continued with limited shoulder mobility. Despite the significant loss in the range of motion, the patient reported satisfaction with her results. After modification of activities, she was able to carry out self-sustaining activities like self-grooming and light cooking (Fig. 4).

Two different validated questionnaires used to assess patient outcomes following RTSA were administered; in the UCLA shoulder score, the patient scored 21 out of 35, and in the Constant-Murley score, 28 out of a 100. These scores represented an overall “fair” surgical outcome. At the patient’s 12-month follow-up, the physical examination revealed mild atrophy of the anterior deltoid. The final range of motion gained was 20 degrees of forward flexion, 30 degrees of active extension, 20 degrees of active abduction, internal rotation to her lower lumbar spine, and with the arm, at 0 degrees of abduction, there was no appreciable external rotation. The drop arm test was negative, and the rubber band test was positive. The follow-up shoulder and humerus AP and lateral X-rays continued revealing complete incorporation and healing of the allograft to the native distal humerus bone without any radiolucency. The reverse total shoulder replacement alignment was appropriate without any loosening, no fracture, and no dislocation (Fig. 3).

Discussion

Periprosthetic fractures of the humerus remain a challenge to orthopedic surgeons with reported complication rates of 39–43% [2, 5, 6, 9]. Classifications such as the Wright-Cofield and Worland classification system of periprosthetic humeral fractures have been described in order to guide the treatment of these fractures [11]. However, these classification systems do not account for bone defects and may not accurately direct or assist in treatment for patients with these findings. In this case report, the patient sustained a Worland type B3 periprosthetic fracture with severe bone loss and prosthetic loosening. The available periprosthetic humeral fracture classifications provided very limited treatment guidelines for choosing the right surgical treatment option.

In cases of periprosthetic fractures with concomitant prosthetic loosening, stem revision utilizing strut allograft with plate and screws is recommended [4]. However, the severe bone defect and poor bone quality present in this case deemed this treatment option as a poor choice due to insufficient bone stock for prosthesis placement. The available literature for such a complex fracture was limited. To the best of our knowledge, there is no previous case report describing the surgical technique for humerus periprosthetic fractures with bone loss involving two-thirds of the humerus.

The treatment options for humeral oncological limb salvage were most similar to the bone loss presented in this case. Our review of the available literature showed endoprosthesis and APC as the two most suitable treatment options, without a clear distinction of which surgical technique is superior [5, 9]. The endoprosthesis leads to lower rates of infection or need for revision, though it does lead to increased incidence of dislocation and mobility loss due to the lack of attachment sites for soft tissue [5–8]. Conversely, the APC provides the unique advantage of providing additional soft tissue and prosthetic support, albeit with higher rates of infection, non-union, and risk of possible revision surgeries [8–10]. A report by King et al. [10] on the use of APC reverse total shoulder replacement in oncological resections showed satisfactory functional outcomes, with the majority of patients having the ability to perform activities of daily living. Another study by Chacon et al. [12] using a reverse shoulder APC showed similar satisfactory outcomes with patients regaining similar mobility and functional outcome scores. As such, the use of either endoprosthesis or APC are viable surgical options, and both techniques warrant consideration on a case-to-case basis.

The case presented underwent successful surgery with an APC reverse total shoulder arthroplasty. No significant complications developed except for a transient radial nerve palsy, a complication that has been described in other series [13]. Follow-up radiographs showed that the allograft component was well incorporated with no signs of non-union, which is the most common major complication reported in this type of surgery [8]. Unfortunately, the patient did present with rather significant limited range of motion at the 1-year follow-up, but the patient's prior history of numerous shoulder operations along with multiple events of trauma were likely significant contributing factors to this outcome. Furthermore, the patient's goal of regaining functionality required to perform activities of daily living was achieved at 1 year of follow-up.

Conclusion

To the best of our knowledge, this is a unique case report describing a successful APC revision reverse total shoulder arthroplasty in a Worland type B3 periprosthetic fracture with bone loss of close to two-thirds of the native proximal humerus. The current classification system for these types of fractures is limited, leading to difficult management that does not adequately guide treatment. Further studies should focus on developing a new classification system that accounts for bone loss, bone quality, and prosthetic loosening. Additionally, further investigation to devise new treatment options for these cases is warranted.

Statement of Ethics

Informed consent was obtained authorizing treatment and documentation of clinical results. A thorough discussion was had with the patient regarding publication of her case, to which she consented.

Disclosure Statement

The authors of this article have no conflicts of interest to declare.

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Author Contributions

Authors Brian Howard Goldman, Matthew J. Deal, David Beaton, and Pedro Tort were involved in the following capacities: substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND drafting the work or revising it critically for important intellectual content; AND final approval of the version to be published; AND agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

The following authors were involved in specific aspects of writing the paper: Brian Howard Goldman, Matthew J. Deal, David Beaton: writing the abstract, introduction, case report, surgical technique, discussion, and conclusion sections; editing all sections of the manuscript. Pedro Tort: Writing the abstract, introduction, case report, surgical technique, discussion, and conclusion sections; editing all sections of the manuscript, providing the clinical images, providing the clinical case data and patient chart information.

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Fig. 1. Anteroposterior radiograph of the shoulder showing a type B3 displaced Worland periprosthetic fracture with extensive bone loss and loosening of the humeral component.

Fig. 2. Open reduction and internal fixation was done using a five-hole 6.5" plate Dall-Milles (Stryker, Kalamazoo, MI, USA), four 2.0-mm tension cables, and one 1.6-mm tension cable. After the fixation was done, a Gelfoam was placed and attached with Ethibond #5 around the allograft-native humerus junction to avoid cement dripping and interposition in expected bone healing areas. Next, the humerus was prepared for the long stem cemented reverse total shoulder replacement.

Fig. 3. Postoperative view showing the proximal humerus revision APC long stem reverse total shoulder replacement and the fixation with plate and tension cables. Proper prosthesis alignment with no signs of loosening and bony union at allograft incorporation site can be seen.

Fig. 4. Functional outcome evaluation of the patient. **a** Arm extension and the ability of the patient in reaching her buttock area. **b** Elbow flexion and ability of the patient in touching her face. **c** Wrist extension without any radial nerve injury.