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Case Report

Treatment of Periprosthetic Fracture of the Proximal Humerus with Structural Allograft

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Abstract

The authors present a case of periprosthetic fracture of the proximal humerus in an 80-year-old female patient who underwent revision surgery with reconstruction of the proximal humerus using a femoral structural graft from a tissue bank.

Keywords: Periprosthetic Humeral Fracture; Allograft; PFPH

Introduction

Periprosthetic fractures of the proximal humerus (PFPH) have an incidence of 0.6% to 3% and are not frequently addressed in the literature [1-3]. It may occur intraoperatively or secondary to trauma during the postoperative follow-up.

Initially, because of PFPH, there is a loss of rotator cuff insertions [4] and in more severe situations, the pectoralis major, latissimus dorsi, and deltoids can also be compromised [1,4,5]. The treatment of choice is self-stabilizing reverse arthroplasty in cases of bone loss in the proximal humerus. Metaphyseal bone loss in patients with PFPH poses two problems during revision surgery. The first is the loss of tension in the soft tissues adjacent to the arthroplasty, and the second is the difficulty of fixing long revision nails with good rotational resistance [4-7].

There is no consensus in the literature regarding the resolution of metaphyseal-diaphyseal bone deficiency, including the proximal humeral endoprostheses, and the use of structural grafts, such as the allograft prosthetic composite (APC) [4].

Case Report

The patient MACZ, 78 years old, was seen electively examined on July 4, 2019, presenting with pain and a limited range of motion in the right shoulder. There was a limitation in the active forward flexion (AFF) of 70˚, a lateral rotation (LR) of 20˚, a medial rotation (MR) bringing the right thumb to the spinous process of T12, and lateral abduction (LA) of 45˚. Radiological examination revealed Hamada 5 type Cuff Tear Arthropathy (CTA). The MRI revealed a chronic posterosuperior cuff lesion with retraction of the tendon stumps up to the glenoid, and grade two fatty degeneration of the teres minor.

Initially, conservative treatment was performed with analgesia and physiotherapy for 90 days without satisfactory results due to persistent pain and functional limitations.

On October 31, 2019, a Reverse Shoulder Arthroplasty was performed using a deltopectoral approach on the right shoulder (Figure 1). The patient was immobilized in a sling for 15 days to maintain the neutral rotation of the upper limb. Active range of motion exercises were started 15 days postoperatively, and deltoid isometric strengthening exercises and isotonic reinforcement of the scapular stabilizers were started on the 30th day postoperatively.

Clinical revisions were performed monthly by the surgeon until six months postoperatively, after which the patient was instructed to return to the service annually for routine revision visits.

The last registered visit was 24 months postoperatively on October 21, 2021. The patient did not complain of pain and was satisfied with her ability to perform activities of daily living. The range

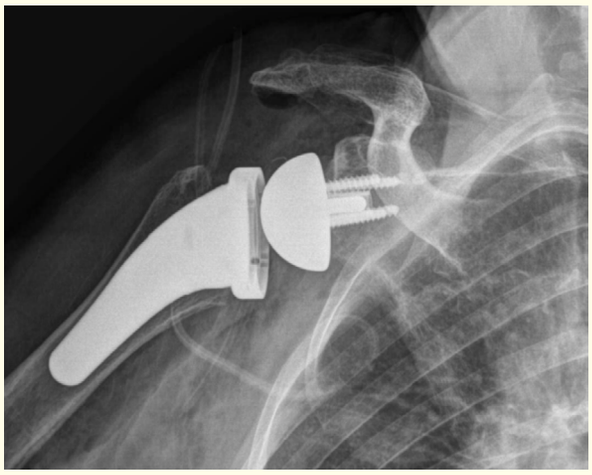

Figure 1: Post-operative radiograph of right shoulder.

of motion verified at this visit consisted of an AFF of 130º, LR was 30º, MR that allowed the right thumb to reach the spinous process of L5, and LA was 90º (Figure 2).

Figure 2: Functional outcome of elective surgery.

At 33 months postoperatively, the patient went to the emergency room due to fall, presenting with shoulder pain and sudden loss of function in the right upper limb. Radiography revealed PFPH (Figure 3A).

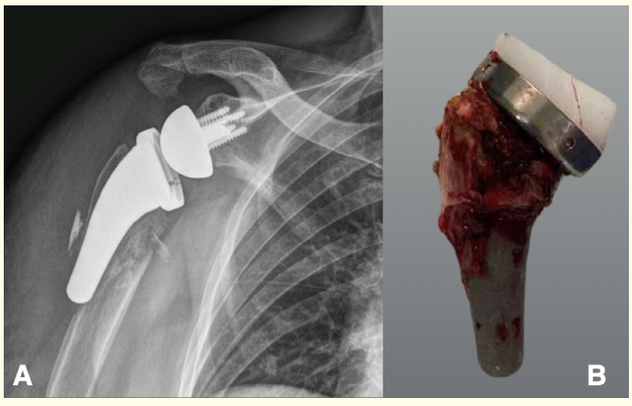

Figure 3: 3A: Periprosthetic fracture of the right shoulder. 3B: Photograph of the humeral stem after removal with adherent metaphyseal bone.

Surgical planning was performed by analyzing the radiographs, and it was determined that the removal of the humeral component of the arthroplasty could generate a significant lack of metaphyseal-diaphyseal bone. The team requested a structural graft of the right proximal femur from a female donor.

The revision surgery was performed on August 16, 2022, with the removal of the humeral stem, which left an area of metaphyseal-diaphyseal bone loss of 8 cm and compromised the insertion of the deltoid (Figure 3B). The structural femur graft remained immersed in a saline solution heated to 37˚ without the addition of antibiotics for approximately one hour before being modeled to correspond to the humeral bone loss. To model the structural graft of the femur to an approximate drawing of the proximal humerus, the femoral neck stump was removed, and part of the greater trochanter was osteotomized at a cervicodiaphyseal angle of 132º (Figure 4A and 4B).

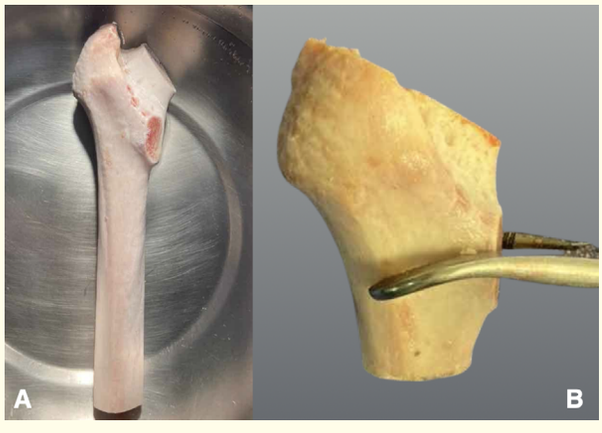

Figure 4: 4A: Structural graft of the right proximal femur. 4B: Structural graft after modeling.

The decision for stem diameter (number 9) was made because of the ability of the structural graft to receive the revision stem along the scrapings with broaches of increasing diameter. Initially, nine long humeral stem number 9 were initially cemented into the structural graft (Figure 5A). After confirming the desired retroversion of 30º, the distal third of the revised humeral stem was cemented onto the diaphyseal fragment (Figure 5B). To control the rotation, a plate with proximal and distal locking screws was placed on the anterior surface of the reconstruction. Two distal cables were used to reinforce the plate fixation in the diaphysis (Figure 6).

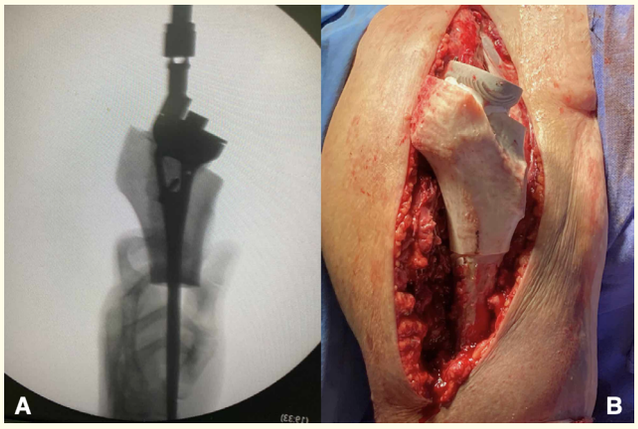

Figure 5: 5A: Revision stem cemented on the allograft. 5B: Revision stem and allografts in place.

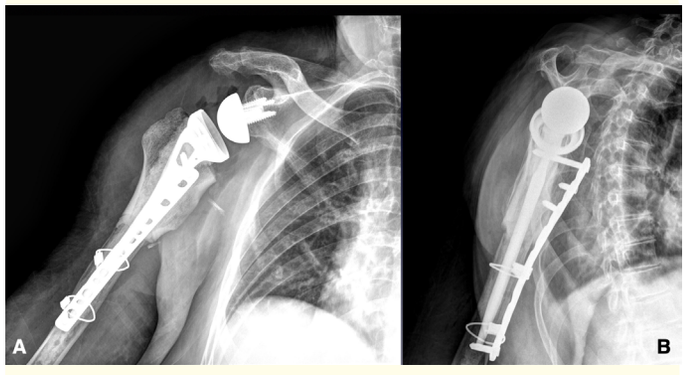

Figure 6: Post-operative radiograph of the revision surgery.

The original components of the baseplate and glenosphere, which were previously placed in 2019, did not change. Surgical reduction of the arthroplasty was performed, and the soft tissue tension was adjusted using a polyethylene connection component. The patient was immobilized for 30 days with a sling while maintaining neutral rotation of the upper limb. Active exercises involving anterior flexion, lateral rotation, and isotonic reinforcement of the scapular stabilizers were started on the 30th postoperative day.

The last evaluation of the patient was performed in April 2023, eight months postoperatively. The patient did not complain of any pain. The AFF was 60˚, LR was 20˚, MR was 0˚, and LA was 45˚. The patient reached her head with slight difficulty and performed personal hygiene (Figure 7). Control radiographs suggest an integrated callus at the host-graft junction (Figure 8, green arrow) and some degree of resorption in the greater trochanter region (Figure 8, red arrow).

Figure 7: Eight months functional outcome of the revision surgery.

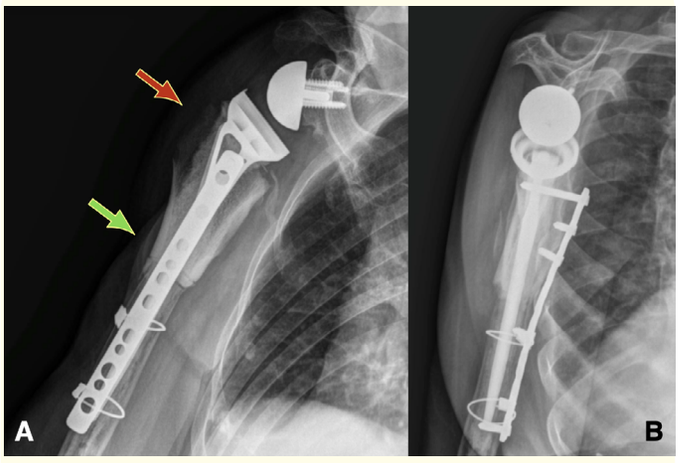

Figure 8: Green arrow: callus formation at the host-graft junction. Red arrow: resorption in the greater trochanteric region.

Discussion

Old age and female sex are considered as the risk factors for PFPH [1,2,5]. A height of 1.50 meters may have contributed to the bone loss, compromising the insertion of the deltoid, placing the case among the highest risk of instability cases (types C and D) [8]. Bone loss in the proximal humerus leads to a decrease in tension in the soft tissue that must stabilize the arthroplasty, leading to complaints of instability, loosening, and weakness of the upper limb [4]. The literature suggests that ignoring bone loss when it occurs generally leads to a worse clinical outcome, [4,9], with humeral shortening, poor implantation of the revision nail, and the consequent instability. Sotelo., *et al.* [4]. reported that a metaphyseal bone loss of 4 cm already compromises the fixation of the revision nail.

Treatment of the bone loss depends on several factors. Although the patient was 80 years old with poor bone quality, two factors were decisive for the use of the structural graft: the fact that there were no other clinical comorbidities and the excellent clinical result presented by the patient in the last elective visit performed nine months before the trauma.

Several factors hinder the availability of proximal humeral structural grafts in tissue banks, and the lower limbs are prioritized by the collection teams. The upper limb is more difficult to reconstruct in the donor's body and generally does not yield sufficient bone for harvesting. Although the humerus contains a reasonable amount of bone, the radius and ulna are usually end up just being crushed. Another factor that reduces the availability of structural humeral grafts is that the upper limb is the preferred site for venous access during the hospital stay of patients with the potential to become donors. These multiple venous accesses can be a contamination factor for bone harvesting.

The use of APC-type structural grafts to increase the proximal humeral strength is associated with several complications. Arthroplasty instability was a problem cited in 4% of cases by Sotelo., *et al*. [4]. and 8% by Chacon., *et al*. [10]. Other risks associated with the use of APC include the possibility of nonunion or graft reabsorption, infection, prolonged surgical time, and cost of the procedure [4], with a total complication rate of approximately 23%-32% [4,8].

The lasting fixation capacity of long stems has always been a matter of concern in shoulder arthroplasty revisions. Cuff., *et al*. [7], managed to demonstrate micro-rotational movement of the prosthetic rods in cases of humeral metaphyseal bone deficiency. The rotational stress caused during the postoperative period in these patients has historically led to failures in the distal fixation stem, mainly in cases in which the proximal humerus is left without bone support [7,8]. Boileau., *et al*. [8]. comparatively evaluated the fixation of long cemented and locked stems without finding any difference between the two types. The brand of arthroplasty used in this case report did not have long locked stems in the arsenal of products.

The association of osteosynthesis to improve the quality of the fixation, facilitate the consolidation of the host-graft junction, and decrease the rate of graft resorption has been suggested in the literature [4,7,8]. Sotelo., *et al*. [4]. recommend adding a locking plate to the anterior surface of the reconstruction using compression in addition to the rotational control. They believed that this implant could be responsible for the high rate of allograft integration. On the other hand, Chacon., *et al*. [10], used cables to fix the host-graft junction with significantly less compression capacity. Radiological examination performed nine months postoperatively suggested the formation of a bone callus at the host-graft junction. Sotelo., *et al.* [4], found an average of seven months for graft integration (allograft host-graft junction), with a minimum of three months and a maximum of 13 months.

Positioning the humeral stem retroversion at 30˚ can help increase the stability of arthroplasty. In this case report, we used 30˚ as recommended by Sotelo., *et al.* [4]. The literature is not definitive regarding the use of 30˚ retroversion, and some authors do not define a retroversion to be used routinely [8]. Thus far, during the active use of the upper limb within the achieved range of motion, the patient has not complained of instability.

Reinsertion of the deltoid or other peripheral muscles into the allograft is controversial in the literature, and its validity has been questioned [4,8]. Sotelo., *et al*. [4], suggest that the use of a humeral allograft with preserved rotator cuff inserts allows the reattachment of any useful remnants of the patient's rotator cuff to the tendinous allograft. In addition, it allows the possibility of transferring the pectoralis major to the subscapularis tendinous allograft, thereby increasing arthroplasty stability. In this case, we did not reinsert any peripheral muscles into the structural graft.

The re-establishment of the deltoid curvature (Deltoid Wrap) is important to guarantee a fulcrum of action for this muscle [4,8]. In the case described, it is questionable whether this wrap is beneficial in any way, since the humeral insertion of the deltoid was compromised by metaphyseal bone loss. The literature does not define whether deltoid adhesion can occur spontaneously in a structural graft.

Sotelo., *et al*. [4] suggest that the use of APC seems to be an excellent solution for PFPH. However, late resorption of these grafts is not yet known, and their durability after 10 years is yet to be

proven. Boileau., *et al*. [8] also found that after 10 years, there was a deterioration in the clinical results, similar to that found in revision hemiatroplasty and reverse arthroplasty.

Conclusion

Proximal humeral reconstruction of a periprosthetic fracture with massive metaphysodiaphyseal bone loss using a structural femoral graft has achieved good clinical outcomes.

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