MULTIMODAL MANAGEMENT OF POST-INFECTIVE NON-UNION OF HUMERAL SHAFT FRACTURE: A CASE REPORT AND LITERATURE REVIEW

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Abstract

Background: Chronic humeral shaft non-union poses a challenging clinical scenario, particularly in patients with multiple comorbidities. Orthopedic infections, including osteomyelitis, present further complexities in treatment, often requiring a comprehensive approach.

Case Report: We present a case of a 62-year-old male with chronic humeral shaft non-union, complicated by previous infection and surgical intervention. Despite challenges, the patient underwent successful multimodal surgical management, including debridement, autografting, locking plate fixation, and adjunctive therapies such as the application of antibiotic-impregnated calcium sulfate beads and tricalcium phosphate granules along with parathyroid hormone therapy. Postoperative rehabilitation contributed to a satisfactory functional outcome, highlighting the importance of a comprehensive approach in managing complex orthopedic conditions.

Conclusion: This case underscores the effectiveness of a multimodal approach in managing chronic humeral shaft non-union. Despite comorbidities and previous complications, surgical intervention coupled with adjunctive therapies can lead to favorable outcomes and restoration of function in selected patients.

Introduction

In orthopedic surgery and traumatology, bone infection poses a significant challenge for patients and surgeons. Diagnosis can be tricky, and treatment often involves lengthy and complex procedures, sometimes requiring multiple surgeries [1]. This not only puts a significant financial strain on the patient, along with added psychological stress due to loss of earnings and social dependency, but also imposes an increased financial burden on the healthcare system, mainly in the developing world. Despite advancements in musculoskeletal infection treatment, studies indicate that infection rates in elective surgeries remain relatively high, and revision surgeries have a notable failure rate [2].

The expenses associated with treating bone infections are substantial and are expected to rise as the number of affected patients increases [3]. There are two main types of orthopedic infections: those that affect only the bone (osteitis/osteomyelitis) and those that involve both bone and an implanted device, such as a joint replacement or osteosynthesis hardware. While these infections require different approaches, there is some overlap in their management. Biomaterials have been utilized to combat infection, fill bone defects, and support the remaining bone and implants to improve treatment outcomes. Some biomaterials serve as antibiotic-delivery systems, such as gentamicin-loaded beads or spacers, developed in the

1970s by Wahlig and Dingeldein [4]. These devices release high concentrations of antibiotics locally, exceeding what can be achieved through systemic administration. This targeted approach helps eradicate a significant portion of the local bacterial load, aiding in treating bone infections [5].

Polymethylmethacrylate (PMMA) has traditionally been used as a carrier for locally released antibiotics, either as pre-prepared bead chains or in the form of antibiotic bone cement requiring manual bead preparation. However, PMMA is non-biodegradable, necessitating a second surgery for bead removal, and its use is limited to heat-stable antibiotics due to heat generation during the reaction process [6]. Concerns about increased bacterial antibiotic resistance and bacterial colonization on PMMA surfaces have also been raised. Moreover, using PMMA could induce foreign body reactions, and there might be a need for a relook surgery to remove the PMMA beads/spacers and fill the void with bone graft [7]. Alternative materials such as calcium sulfate, polycaprolactone, polylactide/polyglycolide, chitosan, and calcium carbonate have been explored to address these limitations. Among these, calcium sulfate and its mixtures with calcium carbonate or hydroxyapatite have gained popularity as substitutes for PMMA. However, the clinical evidence supporting the superiority of these materials over others remains limited [8]. Stimulan is an absorbable calcium sulfate applied directly to the infected site to manage the infection and address dead space in conditions such as infected non-union, osteomyelitis, and prosthetic joint infections (PJIs). One of its key advantages is that it gets completely absorbed by the body within six to eight weeks, eliminating the need for a second surgery for removal [9].

We present a case of a 62-year-old male with chronic humeral shaft non-union, complicating factors including infection and comorbidities, who underwent surgical intervention using open reduction and fibular strut auto-graft and auto-iliac corticocancellous graft with plate osteosynthesis along with antibiotic-impregnated calcium sulfate (AICS) beads and tricalcium phosphate granules.

Case Presentation:

A 62-year-old male presented with complaints of painless abnormal mobility of the left arm and a healed sinus over the surgical scar on the anterior aspect of the left arm. The patient had sustained a left humeral shaft fracture four years prior due to a road traffic accident and had undergone fixation with a plate osteosynthesis at an outside center. Subsequently, there was pouring out of pus discharge from the surgical site, for which the implant was removed. However, the fracture failed to unite, resulting in persistent disability (Figure 1).

Figure 1: The X-ray showed a non-union of the proximal humerus shaft fracture with osteoporosis of the bone with sclerotic bone ends.

Figure 2: Clinical picture showing a healed surgical scar over the anterior aspect of the left arm along with a healed sinus with atrophy of the muscles.

The challenges for surgery for this patient were considerable. The patient's poor general condition, characterized by uncontrolled diabetes mellitus (DM) and hypertension (HTN) posed significant risks both from a surgical and anesthetic point of view. Additionally the patient had atrophy of muscles with scar tissue and restricted range of movement in the shoulder and elbow, complicating the surgical approach (Figure 2). The presence of disuse osteoporosis in the humeral shaft further increased the likelihood of fixation failure. Moreover, maintaining a sterile union bed was essential to prevent any postoperative wound infections, given the patient's overall compromised health status. The patient underwent thorough evaluation and optimization for surgical intervention at our center. The surgical strategy involved debridement of the non-union site, freshening of sclerotic bone ends, and opening of the medullary canal proximally and distally. Autologous fibular and iliac bone grafts were harvested. The fibular strut graft was tailored to fit the medullary canal and inserted into the humeral shaft, maintaining reduction. Given the fracture's location in the proximal third of the humerus shaft, fixation was achieved with a proximal humerus locking plate. The gap at the non-union site was bridged with autologous iliac tricortical bone graft, supplemented with fully absorbable beta-tricalcium phosphate mixed with cancellous graft.

Additionally, antibiotic-impregnated calcium sulfate beads were placed along the humeral shaft to address infection (Figure 3). During the postoperative period, the patient was given IV antimicrobial therapy of IV Cefuroxime 1.5gm twice daily for two weeks. After that, the patient was given clindamycin 300 mg cap and tab cotrimoxazole for four weeks. In the postoperative period, the hematological parameters like hemoglobin level, platelet level, and blood glucose levels were constantly monitored. A quantitative level of CRP was done at weekly intervals, which came down to an average level within three weeks of the postoperative period.

Figure 3: Immediate Postoperative X-ray showing the implant in situ with fibular bone graft and calcium sulfate antibiotic-impregnated beads.

Postoperatively, the operated limb was kept in an arm pouch sling for two weeks. Rehabilitation commenced with elbow range of motion exercises, followed by gradual shoulder range of motion exercises at two weeks postoperatively. Overhead abduction was initiated at eight weeks. At the end of 12 weeks of the postoperative period, we could achieve a completely healed surgical scar and satisfactory union at the fracture site. (Figure 4).

Figure 4: Twelve weeks post-operative X-ray showing good bony union with the implant in situ.

The patient was followed up regularly. He was on parathyroid hormone therapy along with daily calcium and vitamin supplements. During the six-month post-operative follow-up, the patient had good union with no history of pus discharge and was able to carry out activities of daily living satisfactorily (Figure 5).

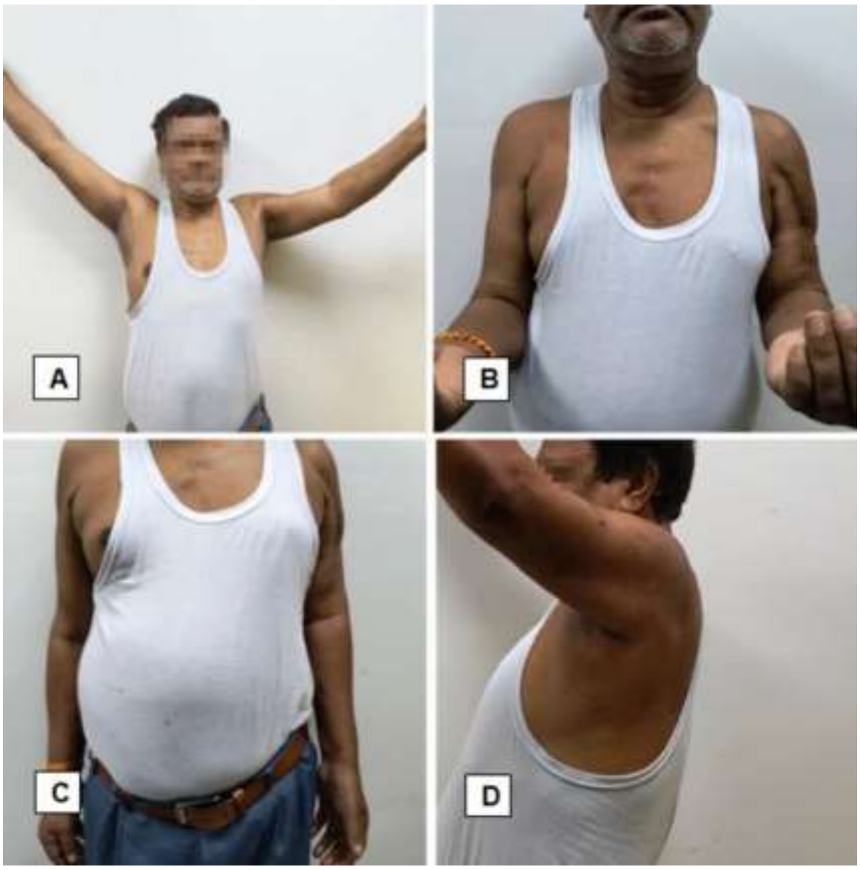

Figure 5: Six-months post-operative follow-up showing healed scar without pus discharge and satisfactory movements at the left shoulder and elbow, (A) Shoulder Abduction (B) Elbow Flexion (C) Elbow Extension (D) Shoulder Flexion.

Discussion:

Managing post-infective nonunion of the shaft of the humerus poses a big challenge. Poor bone and soft tissue conditions complicate the situation by preventing good fixation and wound coverage. In addition, the continuous threat of getting the construct infected in the postoperative period with wound healing issues increases the complexity further. Various methods have been proposed for managing nonunion fractures of the humerus, each with limitations. Internal fixation with interlocking nails is inappropriate for nonunion fractures because it does not provide adequate compression at the fracture site. While some surgeons advocate for Ilizarov and bone transport, its complexity, technical challenges, and reduced stability in osteoporotic bones make it less favourable. Using vascularized fibular grafts is a promising technique but requires technical expertise [10]. In our case, after thorough debridement of the sinus tract and preparation of the bone ends, the trimmed fibular strut graft was placed intramedullary, and internal fixation was carried out with the proximal humerus locking plate. The presence of an intramedullary fibular strut increases the purchase from two to four cortices, resulting in increased pull-out strength of the screws and enhances the strength of the construct. The intraosseous presence of the fibular strut may help in union by helping the creeping substitution and preventing collapse [11].

The success rates of treating osteomyelitis in long bones range from 70% to 90%, with recurrence occurring in 6-9% of patients, depending on the severity of the injury [12]. Localized antibiotic delivery has shown a success rate of approximately 90%, but this can vary based on several factors [13]. Typically, localized antibiotics can be used alone or with intravenous (IV) antibiotics. Studies have demonstrated the effectiveness of combination treatments. For example, Gaul and colleagues treated 323 patients with chronic osteomyelitis of the lower extremity using a combination of debridement and localized delivery beads without IV antibiotic administration, achieving a success rate of 86.4% [14]. Another study applied gentamicin-loaded calcium sulfate/carbonate beads locally, with half of the patients not receiving IV antibiotics, resulting in an infection control rate of 80% without adverse effects on the kidneys or liver [15]. Combining IV antibiotic administration with localized antibiotic beads has been shown to yield better outcomes than IV antibiotics alone. Calhoun and colleagues reported a success rate of 83.3% with IV antibiotic administration alone. In comparison, the combined treatment of gentamicin-loaded PMMA beads and IV drug administration achieved a success rate of 89.3% [16].

McNally and colleagues reported on the mid-to-long-term outcomes of single-stage surgery for chronic osteomyelitis patients using a bioabsorbable gentamicin-loaded calcium sulfate/hydroxyapatite material, achieving an infection control rate of 94% [17]. After treatment, leaving PMMA bead chains in place is not feasible because they can hinder bone growth and pose a risk of secondary infection on their surface [18]. There was a need for an antibiotic carrier that could remain in the wound without requiring subsequent removal. Calcium sulfate emerged as a promising biodegradable antibiotic carrier with a resorption time ranging from 3 to 12 weeks, as determined radiologically [19]. In our case, we used antibiotics-impregnated calcium sulfate beads over the non-union site, along the humerus cortex, and in the subcutaneous plane, which acted like a local antibiotic delivery system, maintaining the sterility at the fracture site. Our patient was also on antibiotic therapy for the six-week post-operative period. However, the bone regeneration capacity following the dissolution of calcium sulfate beads varied and remained inconclusive [9]. The resorption rate of calcium sulfate was lowered by mixing it with calcium phosphates, allowing sufficient time for bone growth. This approach resulted in a significantly higher percentage of new bone formation than calcium sulfate alone at 1- and 6-months post-treatment [20]. In our case, we used fully absorbable beta-tricalcium phosphate mixed with autoiliac cancellous graft. Postoperatively, our patient was on parathyroid hormone therapy along with calcium and vitamin D supplements. At the end of the six-month follow-up, the patient had an excellent bony union and satisfactory functional recovery.

Conclusion:

In this case, the successful management of chronic humeral shaft non-union demonstrates the efficacy of a multi-modal approach in tackling complex orthopedic conditions. Despite the patient’s challenging medical history and previous complications, comprehensive surgical intervention coupled with adjunctive therapies led to a satisfactory functional outcome. Antibiotic calcium sulfate helped cure the local infection by delivering antibiotics directly to the affected area, ensuring high local concentrations that effectively targeted the infection. The bone graft facilitated bony union by providing a scaffold for new bone growth, promoting natural healing, and stabilizing the affected area to ensure proper integration and strength. Further research and continued advancements in treatment strategies will enhance our ability to manage such challenging cases effectively.

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