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Salvage of Infected Non-Union Fracture of Humeral Shaft: A Case Series

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ABSTRACT

Infected non-union fractures of the humeral shaft present a significant challenge in orthopaedic surgery, often resulting from open fractures, previous surgical interventions, or inadequate initial fracture management. This case series aims to evaluate various salvage procedures used in treating infected non-union of the humeral shaft, providing insights into strategies that may improve patient outcomes. This retrospective case series analyzed five patients with infected non-union of the humeral shaft treated at our institution. All patients underwent a staged treatment approach, including debridement, antibiotic therapy and definitive fixation with autologous bone grafting. Surgical techniques, clinical outcomes and post-operative recovery were documented and evaluated. All five cases demonstrated successful infection control through debridement and targeted antibiotic therapy. Definitive treatment involved open reduction and internal fixation (ORIF) with autologous iliac crest and fibular strut grafting. Post-operative radiographs showed satisfactory alignment and early signs of bone healing in all cases. However, patients experienced varying degrees of functional limitations, particularly in elbow range of motion. The management of infected non-union fractures of the humeral shaft requires a multi disciplinary approach combining infection control and structural stabilization. Staged procedures involving debridement, spacer insertion and definitive fixation with autologous bone grafting offer a reliable strategy for achieving union. However, restoring full function remains challenging, emphasizing the need for continued research into surgical techniques and post-operative rehabilitation strategies.

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Key Words

Infected non-union, humeral shaft fracture, autologous bone grafting, staged treatment, ORIF, debridement, antibiotic therapy, functional recovery

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INTRODUCTION

The management of infected non-union fractures of the humerus presents a formidable challenge in orthopaedic surgery, necessitating a multi disciplinary approach to achieve optimal outcomes[1]. Non-union is defined by U.S. Food and Drug Administration (FDA)as the persistence of a fracture for a minimum period of nine months without any signs of healing for three months[2]. This non-union is further complicated by infection, which compromises both the structural integrity of the bone and the surrounding soft tissue[3]. The humerus, being a critical component of upper limb function, poses unique difficulties when affected by non-union and infection, as it significantly impairs arm mobility and quality of life[4]. The incidence of infected non-unions is typically associated with open fractures, previous surgical interventions, or inadequate management of the initial fracture. These are a frequent complication of humeral fractures, with an incidence ranging from 2-30%. The occurrence rate varies, with non-operative management showing rates between 2% and 13%, while surgical treatments exhibit rates between 15-30%[5]. These cases often require complex surgical strategies, combining debridement, stabilization and antibiotic therapy, to eradicate infection and promote bone healing.[3,6] Despite advances in surgical techniques and infection control, achieving successful fracture union in these cases remains challenging, with high rates of morbidity and recurrence[5,7].

MATERIALS AND METHODS

This case series aims to provide a comprehensive evaluation of various salvage procedures utilized in the treatment of infected non-union of the humeral shaft. By presenting clinical outcomes, surgical interventions and post-operative recovery, this series seeks to contribute to the growing body of literature on the management of this difficult condition, offering insights into strategies that may improve patient outcomes in future cases.

Case 1: A 26-year-old female presented with chronic pain, restricted mobility and functional impairment of her right upper limb following a motorcycle accident 2.5 years prior. The patient sustained a compound fracture of the right humeral shaft as a result of the trauma and was initially managed with open reduction and internal fixation (ORIF) and plating at a private healthcare facility the day after the injury (Fig. 1 (a) and 1 (b)). Post-operative recovery was complicated by the development of a deep-seated infection at the surgical site. Despite conservative management, the infection persisted, leading to repeated episodes of pain, swelling and purulent discharge.

Fig. 1(a): X-ray Showing Fracture Shaft of Right Humerus

Fig. 1(b): X-ray Showing ORIF and Plating Right Humerus Shaft

In the months following the initial ORIF, the patient underwent multiple debridement surgeries in an attempt to control the infection (Fig. 1(c)) However, the infection remained resistant to these interventions. Approximately five months after the initial plating, implant removal was performed due to the ongoing infection and non-union of the fracture. During this procedure, non-viable bone tissue was debited, resulting in a significant bony defect, which was temporarily managed with the insertion of a bone cement spacer. (Fig. 1(d)).

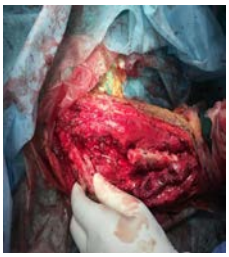

Fig. 1(c): Surgical Debridement of Infected Bone Tissue in Case of Non-Union Right Humeral Shaft Fracture

Fig. 1(d): X-ray Showing Insertion of an Antibiotic -Impregnated Cement Spacer Following Debridement in Case of Infected Non-Union Right Humeral Shaft Fracture

Despite these interventions, the patient continued to experience chronic pain and functional impairment, prompting her presentation to our hospital. On general examination, the patient was well-nourished, afebrile, and in no acute distress. There were no signs of systemic illness or sepsis and vital signs were stable.

On local examination of the Right upper limb, a well-healed surgical scar was observed along the lateral aspect of the Right arm. Mild erythema and tenderness were present over the humeral shaft, but no signs of active infection, such as purulent discharge or fluctuation, were noted. The arm was immobilized in a sling. The elbow joint exhibited restricted mobility, while sensory and motor function in the hand and forearm remained intact. No signs of distal neuro vascular compromise were detected and the radial pulse was palpable with a normal capillary refill time. Radiographic evaluation revealed evidence of non-union at the humeral fracture site, with the previously inserted plate removed and a bone cement spacer visible. Laboratory investigations, including blood work, were within normal limits, suggesting no acute systemic infection at the time of presentation. C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) were mildly elevated, indicating low-grade chronic inflammation rather than an active infective process. Swabs from previous surgeries had cultured Staphylococcus aureus, which had been treated with targeted antibiotic therapy. At presentation, no active wound discharge was present, and previous wound cultures had tested negative for ongoing infection following the insertion of the spacer and administration of antibiotics. Given the chronicity of the non-union and the failure of previous interventions, a second ORIF was planned. Autologous grafting, using a fibular strut graft along with an iliac crest bone graft, was performed to address the significant bone loss and provide structural support to promote union. Intra operatively, thorough debridement of the infected area was conducted, with care taken to remove any remaining necrotic tissue. The autologous grafts were successfully placed and internal fixation was achieved with a locking plate. Post-operative imaging confirmed proper positioning of the grafts and fixation hardware. Radiographs were taken periodically to monitor healing (Fig. 1(e) and (f)). At seven months post-operatively, partial union of the fracture was observed. However, the patient continued to experience functional limitations, with a restricted elbow range of motion from 50-150 degrees (Fig. 1(g)). Continued follow-up and rehabilitation were planned to optimize joint mobility and functional recovery.

Fig. 1(e): Post-operative X-ray at 2 months

Fig. 1(f): Post-Operative X-ray at 7 Months

Fig. 1(g): Range of Motion at the Elbow: 50-150 Degrees Post-Operatively

Case 2: A 24-year-old male presented to the Department of Orthopaedics with persistent pain and reduced function in his right upper limb, one year after a road traffic accident that had resulted in a fracture of the right humeral shaft. Immediately following the injury, the patient was treated with open reduction and internal fixation (ORIF) and plating on the same day (Fig. 2(a)). However, two weeks post-surgery, the patient developed infection at the fracture site. Radiographs following the ORIF showed satisfactory alignment but later revealed signs of infection and non-union. Necessitating multiple debridement procedures to control the infection. Wound cultures from the debridement surgeries grew Staphylococcus aureus, guiding targeted antibiotic therapy.

Fig. 2(a): X-Ray Showing ORIF and Plating Right Humerus Shaft

Six months after the initial plating, the infection had not resolved and radiographs revealed non-union of the fracture. Blood tests showed elevated inflammatory markers (CRP, ESR) during this phase. Due to the persistent infection and failure of the bone to heal, the plate was removed and the infected site was debrided once again. Non-viable bone was excised, leaving a defect, which was temporarily managed by inserting a bone cement spacer to maintain alignment and assist in infection control. CRP and ESR returned to normal following the removal of the plate and administration of antibiotics. Twelve weeks later, definitive treatment was undertaken. The bone cement spacer was removed and a second ORIF was performed, this time using a PHILOS plate. To address the bone defect and encourage healing, an autologous fibular strut graft along with an iliac crest bone graft was used. Post-operatively, the patient followed a structured rehabilitation plan with regular follow-up visits to assess progress. Fig. 2(a) and (b)) At the nine-month follow-up, partial union was observed and patient reported improved pain levels and further rehabilitation was advised to enhance joint mobility and strength.

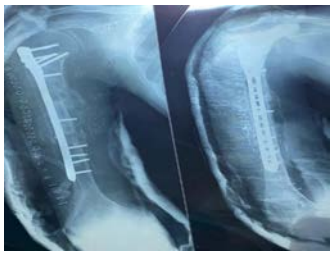

Fig. 2(b): Post-Operative X-Ray at 3 Months

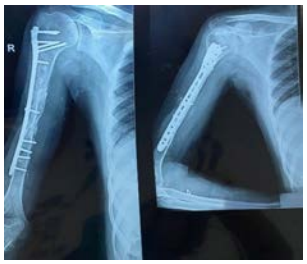

Fig. 2(c): Post-Operative X-Ray at 9 Months

Case 3: A 22-year-old male presented with recurrent complications following a series of traumas affecting the right humeral shaft. The patient's initial injury occurred in 2015 when he sustained a fracture of the right humeral shaft in a road traffic accident. He was managed at a private hospital with open reduction and internal fixation (ORIF) using plating. (Fig. 3(a)) The recovery appeared uncomplicated at the time and the patient regained function in the affected limb.

Fig. 3(a): X-Ray Showing Fracture of Shaft Right Humerus (Left Image) and ORIF and Plating (Right Image)

Six years later, the patient experienced a second trauma, this time from a fall from his bed. radiographs showed disruption at the implant site. This new injury necessitated the removal of the original implant and a re-plating procedure (Fig. 3(b)).

Fig. 3(b): X-Ray Showing Second Trauma Resulting in Disruption at Implant Site Followed by Re-Plating Procedure

The patient recovered from this surgery, but a year later, he developed a discharging sinus at the surgical site. Radiographs taken when the patient presented with a discharging sinus showed a stable implant. Wound cultures identified an Enterococcus infection, and he was managed conservatively with antibiotics based on culture sensitivity results. The sinus healed after the antibiotic course, and the patient resumed his regular activities. However, another year later, the patient sustained a low-intensity injury to the same arm, which resulted in a new fracture of the humeral shaft, accompanied by implant failure (Fig. 3(c)).

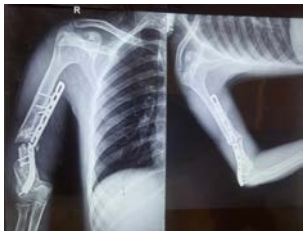

Fig. 3c: X-Ray Showing Low-Intensity Injury to Same Arm, Resulting in New Fracture of the Humeral Shaft, Accompanied by Implant Failure

The vitals were stable and there were no systemic signs of infection or illness.Sensory and motor functions in the hand and forearm remained intact, with a palpable radial pulse and normal capillary refill, indicating preserved neurovascular function.This time, due to the repeated nature of the injury and the associated hardware failure, a more extensive management plan was required. The initial step was the removal of the failed implant and the insertion of a cement spacer to control infection and maintain alignment (Fig. 3(d).

Fig. 3(d):X-Ray Showing Insertion of an Antibiotic -Impregnated Cement Spacer

Eight weeks after the cement spacer was placed, the patient returned for definitive treatment. The spacer was removed and ORIF was performed again, this time using a combination of iliac crest cancellous graft and fibular strut graft to provide structural support and promote union. The fracture site was stabilized with a plate and the bone grafts were placed to facilitate osteogenesis. Radiographs confirmed satisfactory alignment and hardware placement. At the three-month post-operative follow-up, partial union was observed. Clinically, the patient reported improved pain levels, but elbow mobility remained restricted, with a range of motion between 40 and 120 degrees (Fig. 3(f)). Ongoing follow-up and rehabilitation were initiated to improve functional limitations and restore joint mobility and strength.

Fig. 3(f): Range of Motion at the Elbow: 40-120 Degrees Post-Operatively.

Case 4: A 68-year-old female presented with a history of repeated injuries and surgical interventions affecting the left humerus. The patient's initial injury occurred five years ago when she sustained a compound fracture of the humeral shaft following a road traffic accident. She was managed with open reduction and internal fixation (ORIF) and plating at a private hospital the day after the injury. Her recovery proceeded uneventfully at that time and she regained functional use of the arm. Three months ago, the patient experienced a second trauma, this time from a fall from her bed, which resulted in a refracture of the humeral shaft accompanied by implant failure as seen on X-ray. She sought care at our hospital. The failed implant was removed and the fracture was stabilized with the application of an external fixator (Fig. 4(a).

Fig. 4(a):X-Ray of the Left Arm Showing External Fixation Applied

One month after the external fixator was placed, it was removed and the patient's care transitioned to definitive management (Fig. 4(b).

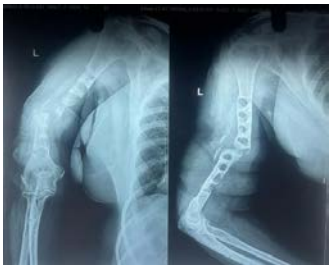

Fig. 4(b):X-Ray of the Left Arm Showing External Fixation Removed

Four weeks later, she underwent a second ORIF procedure using an extra-articular plate combined with autologous iliac crest bone grafting and fibular strut grafting.(Fig. 4(c)).

Fig. 4(c): Extra Articular Plate with Iliac and Fibular Graft

Radiographs taken after the second trauma revealed implant failure and refracture of the humeral shaft. The patient was initially managed with the application of an external fixator, followed by definitive internal fixation using a TENS (Titanium Elastic Nail System) nail combined with autologous iliac crest and fibular strut grafting. Post-operative radiographs demonstrated satisfactory alignment of the TENS nail and early signs of bone healing. Radiographs taken two months post-operatively showed satisfactory alignment of the hardware, with early signs of bone healing and integration of the iliac and fibular grafts. (Fig. 4(d). The patient's recovery remains ongoing, with continued focus on rehabilitation to restore joint function and strength.

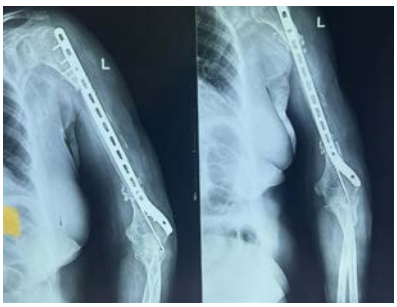

Fig. 4(d): Post-Operative X-Ray at 2 Months

Case 5: A 57-year-old male presented with a history of chronic pain and instability in his right upper limb following a complicated course of treatment for a humeral shaft fracture. The initial injury occurred two years ago when the patient sustained a closed fracture of the right humeral shaft after falling from a ladder. He was managed with open reduction and internal fixation (ORIF) with plating at a local hospital and his early recovery appeared uncomplicated. However, three months post-surgery, the patient noticed increasing pain and swelling at the surgical site. He presented with a low-grade fever and a sinus tract had developed over the incision, with intermittent purulent discharge. Cultures from the wound grew Pseudomonas aeruginosa and the patient was treated with targeted intravenous antibiotics. Despite the infection management, radiographs at the time revealed non-union of the fracture, with signs of implant loosening. Given the non-union and persistent infection, the patient was referred to our facility for further evaluation and management. On initial presentation, the patient had stable vital signs and no other systemic signs of infection. However, he reported persistent pain and an inability to bear weight on the affected arm. There were no significant comorbid conditions, although the patient had mild hypertension, controlled with medication. On inspection, a discharging sinus was present near the previous incision site, with surrounding erythema. The elbow joint was stiff, with a limited range of motion between 50 and 100 degrees. Muscle atrophy in the upper arm was noticeable, likely due to disuse over the prolonged course of infection and immobilization. The distal neurovascular examination was normal, with no sensory deficits or impaired circulation. X-rays taken during the initial injury showed a mid-shaft humeral fracture, which was managed with ORIF. Follow-up radiographs at three months post-ORIF indicated non-union and peri-implant loosening. Additional imaging revealed areas of osteolysis around the screws, suggesting chronic infection. Two months after referral to our facility, post-operative imaging following definitive surgery demonstrated good alignment and early signs of bone graft integration. Inflammatory markers (CRP, ESR) were elevated at presentation, consistent with ongoing infection. These values decreased after treatment with targeted antibiotics. The wound culture grew Pseudomonas aeruginosa, a common pathogen in chronic osteomyelitis, which guided the selection of antibiotics. Cultures following debridement were negative, confirming infection control. The initial management at our facility involved removing the infected implant and performing thorough debridement of the surrounding necrotic tissue. A temporary antibiotic-impregnated cement spacer was inserted to control the infection and maintain limb alignment. The patient was treated with six weeks of intravenous antibiotics based on the culture and sensitivity results.Eight weeks later, after confirming that the infection had resolved, the patient underwent a second ORIF procedure. Autologous iliac crest bone grafting and a fibular strut graft were used to bridge the bony defect. Internal fixation was achieved with a locking plate and post-operative radiographs confirmed stable hardware positioning and early signs of bone healing. The patient was followed closely post-operatively with regular radiographs and clinical evaluations. At the three-month follow-up, X-rays showed partial union of the fracture. Clinically, the patient's pain had decreased and he reported improved function in the right upper limb. However, elbow mobility remained limited, with a range of motion from 50-110 degrees. Continued rehabilitation was advised to address joint stiffness and enhance functional recovery.

RESULTS AND DISCUSSION

The humerus, a major long bone in the upper limb, is essential for arm mobility and functionality. When

infected non-union occurs, it severely impairs not only the structural integrity of the bone but also the patient's quality of life due to chronic pain, restricted movement and recurrent infections. Similarly, Jia[4], discussed that non-union of humeral shaft fractures is often associated with significant clinical consequences, including persistent pain, prolonged disability and frequently leads to reoperation. These fractures can result in long-term absence from work and a diminished quality of life for the affected individuals. They further added that infection is one of the several risk factors linked to increased risk of non-union. In this case series, the need for individualized treatment plans based on the severity of infection, degree of bone loss, and functional limitations becomes apparent. In all cases in the present case series, infection control was a priority and was achieved through a combination of surgical debridement, removal of infected hardware, and targeted antibiotic therapy guided by culture sensitivity results. Chronic osteomyelitis in particular can involve low-virulence organisms that form biofilms around the implants, complicating treatment. A tailored antibiotic regimen based on the bacterial strain's resistance profile was critical in resolving the infection. The use of antibiotic-impregnated cement spacers, as demonstrated in several of the cases, provided localized high-dose antibiotic delivery while also maintaining limb alignment before definitive reconstruction.As discussed by Pawar[8], compound fractures and open wounds following trauma are key etiological factors for humeral osteomyelitis, while other causes include post- operative infections, local skin infection spread and rarely, hematogenous seeding during bacteraemia. They added that management focusing on eradicating infection and restoring function. Involved intravenous antibiotics based on culture sensitivity, combined with surgical debridement to remove the sequestered bone. Additionally, the cavity left can be filled with antibiotic-laden bone cement. Pagliarello[5] also stated that the essential elements in treating infected non-union of long bones include debridement, rigid fixation and extended antibiotic therapy.This was also in agreement with Jain AK and Sinha[9] and Struijs[10] Pagliarello[5] further added that using a custom-made cement spacer helps maintain limb length and promotes osteoinduction, supporting bone healing by encouraging stromal cell differentiation into osteoblasts. Management of non-union in present cases series was complicated by the presence of large bone defects following debridement, which required structural grafting to bridge the gaps and promote bone healing. The use of autologous bone grafts (iliac crest and fibular strut) in all cases reflects the standard of care for reconstructing significant bone loss in infected non-union. These grafts not only provide mechanical stability but also encourage osteogenesis, an essential element in promoting fracture union. Radiographs from the case series revealed satisfactory alignment of hardware and early signs of bone healing, though full union was delayed in some cases due to the extensive nature of the bone defects. Borus[7] discussed that compression plating combined with autogenous bone grafting, is considered the gold standard for treatment, achieving a success rate of over 90%. Feng[11] also discussed that plating combined with bone grafting is generally regarded as the preferred treatment for humeral shaft non-union. Peters[12] in their systematic review concluded that plate fixation with autologous bone grafting was recommended for humeral shaft non-union as it had high union rates and relatively low complication rates. Similarly, Hornicek[13] reported successful healing in six patients with diffuse osteopenia and refractory non-union, using cortical allograft bone plates or struts combined with internal fixation by metal plates, following the failure of two previous surgeries. While successful union of the fracture is the primary goal, the ultimate objective is to restore function to the upper limb. The long periods of immobilization and multiple surgeries can lead to significant joint stiffness and muscle weakness. In each case, post-operative rehabilitation was a critical component of the recovery process, aimed at improving joint mobility and rebuilding strength in the affected limb. Kandemir[14] discussed that patients should be encouraged to begin range of motion exercises on the operated extremity as tolerated and to bear weight through the treated arm as tolerated.

CONCLUSION

The management of infected non-union fractures of the humeral shaft remains a complex challenge, requiring a multidisciplinary approach that addresses both infection control and structural stabilization. The use of staged procedures, including debridement, spacer insertion and definitive fixation with autologous bone grafting, offers a reliable strategy for achieving union in many cases. However, restoring full function remains a significant challenge, highlighting the importance of continued research into both surgical techniques and post-operative rehabilitation strategies to optimize patient outcomes.

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