Staged Surgery with Autologous Fibula Grafting for Humeral Non-union - A Case Report

Stephen Kamau Mwaura[1] and *Mordicai Atinga*[2]

[1]Thematic Unit of Orthopaedics, University of Nairobi, Nairobi, Kenya

[2]Department of Orthopaedics, Aga Khan University Hospital, Nairobi, Kenya

Correspondence to: Stephen K. Mwaura; email: kamausteve@ymail.com

Received: 8 Mar 2024; Revised: 3 Sep 2024; Accepted: 10 Sep 2024; Available online: 23 Sep 2024

Summary

Recalcitrant humeral non-unions after multiple fixation attempts pose a challenge to the surgeon when it comes to selecting effective and reliable management strategies. Confounding factors such as infection and bone segment loss may hamper achieving osteosynthesis even with suitable fixation. This is a case report of a 35-year-old man with a 4-year complex history of recalcitrant humerus non-union. It highlights a combination of various accessible strategies that encompass biological stimulation and mechanical stabilization toward timely bone union with minimal morbidity and return to optimal function. The use of a free fibular intramedullary strut autograft with a locking compression plate (LCP) has been infrequently described in the literature and this report adds to the data bank of this treatment strategy.

Keywords: Humeral non-union, Fibula grafting

Ann Afr Surg. 2025; 22(1): 27-33

DOI: http://dx.doi.org/10.4314/aas.v22i1.5

Conflict of interest: None

Funding: None

Introduction

Humerus fractures are among the most common long bone fractures, with the bulk of the injuries being managed non-operatively. For those that are managed surgically, the majority progress to bone union without complications (1). Various methods of fixation including extramedullary and intramedullary fixation devices such as single or double plates, intramedullary nailing, Ilizarov fixators along with adjuncts such as bone grafts, mineralized bone substitutes, and bone morphogenic proteins have been reported (2, 3).

Despite these treatment options for humerus fractures, failure of union may occur with reports indicating an incidence ranging from 2% to 10% with non-surgical management and up to 15% with surgical intervention (4).

When there is a humeral non-union following surgery, the planning for revision surgery requires ruling out infection while critiquing the mechanical and biological environment prior to embarking on the surgery. In the cases of non-unions that fail to respond to revision surgery, there is an even greater need to ensure adequate biological stimulation and mechanical stabilization. The common biological stimulation strategy relies on bone grafting that may be obtained from the iliac crest, local graft, or allograft with augmentation from synthetic bone graft. There have been sporadic case reports on the use of autologous intramedullary fibula graft to manage revision of the humeral non-union and this report seeks to present the experience with this technique and the staged management of potential infection (4–7).

Case presentation

A 35-year-old healthy man presented with a humeral non-union 1 year after having had two previous surgical procedures under another surgical team. He had suffered a closed spiral humeral fracture (Figure 1) 2.5 years earlier that had initially been treated with plating via an anterolateral approach.

Figure 1. AP view showing initial humeral shaft spiral fracture.

The operation had been uncomplicated; however, he described having been on antibiotics, for a 2-week period, for a presumed wound infection shortly after surgery with full resolution. The immediate post-operative X-rays had been satisfactory (Figure 2). However, X-rays at the subsequent follow-up, 17 months later, revealed he had developed a non-union with evidence of catastrophic metal work failure (Figure 3). A revision operation was performed with removal of the plate and screws followed by freshening the bone ends and securing the fracture with a locked intramedullary humeral nail with iliac crest bone graft (Figure 4).

Figure 2. Immediate post-operative X-rays from initial fixation with plate and screws.

Figure 3. Seventeen months after initial fixation showing non-union of humerus shaft fracture and implant failure.

Figure 4. Initial non-union treatment with an intramedullary locking nail and iliac crest bone graft.

After a brief period of respite, his pain recurred 6 months later, with inability to lift his arm at which point he presented for further management. Further clinical assessment revealed he had no comorbidities, no history of drug or substance abuse, and his family and social history was non-contributory. He had a well-healed anterolateral scar with no overt signs of infection. The X-rays showed a right humerus shaft non-union with increased lucency around the distal locking bolts. His initial blood tests had been unremarkable with a white blood cell count of 4.4×10^9/L, CRP > 4 mg/L, and ESR of 12 mm/hour.

Given the pain and loss of function, revision surgery was indicated, and the patient was counseled accordingly. The plan was to first obtain tissue samples to assess for infection to help in determining whether to proceed with a single-stage or staged revision procedure. This procedure was performed in theatre under local anesthetic. Approximately 10 mL of purulent fluid, suspicious for infection, leaked from the fracture site and was collected along with soft tissue and bone samples for microbiology.

Figure 5. Initial-stage post-operative X-ray showing use of antibiotic-laden cement-coated titanium elastic intramedullary nail.

No growth was obtained even after extended culture with only pus cells present. Despite the absence of microbes, the presence of the purulent fluid at the fracture site, the history of possible infection, and the two failed attempts at fixation led to the decision to proceed with a staged revision given the risk of a culture-negative infection.

Four weeks later under general anesthetic, the intramedullary implant was removed with further extensive debridement. The bone ends did not bleed much, raising the concern of an atrophic-type non-union with reduced biological healing capacity. Washout was performed with copious amounts of normal saline before a temporary cement nail was fashioned over an elastic nail. Gentamicin-impregnated cement was used in order to have elution of antibiotic into the bone. The cement nail was inserted in a standard antegrade fashion with the proximal end left prominent above the rotator cuff to allow easy retrieval at the second stage (Figure 5). He made an uneventful post-operative recovery and was discharged home on a 2-week course of oral antibiotics. He remained comfortable and functional with the temporary fixation and it was after 10 months that he elected to proceed with the second-stage revision. Given the atrophic appearance of the fracture ends (Figure 5), there was a need to maximize biological stimulation at the non-union site. The decision was made to use a non-vascularized intramedullary autologous fibula graft.

Figure 1. Immediate post-operative AP X-ray of the final stage of non-union treatment with a locking compression plate (LCP) and intramedullary free fibular strut graft.

The procedure was performed under general anesthetic with antibiotic cover. The old incisions were utilized and the intramedullary temporary nail was removed. The fibula graft was harvested via lateral incision made 15 cm above the tip of the lateral malleolus. A 15-cm length of fibula was obtained taking care to avoid the superficial peroneal nerve. The fibula graft was fashioned with a bone nibbler in order to fit into the humeral canal. The extra fragments of the fibula were morselized to provide further local graft at the fracture site, especially in the medial cortex where there was a 2.5-cm defect. The fibula strut graft was inserted intrafocally through the fracture site and centered in the humeral shaft.

Figure 7. Immediate post-operative lateral X-ray of the final stage of non-union treatment with alocking compression plate (LCP) and intramedullary free fibular strut graft.

A low-contact locking plate with a combination of locking and non-locking screws was then used to stabilize the humerus, with the screws additionally capturing the intramedullary fibula (Figures 6 and 7). The wounds were closed in a standard fashion and he was placed into a humeral brace with a sling. He was discharged home on 2 weeks of oral clindamycin.

He had minimal fibula graft-site morbidity and was fully weight-bearing on the first day following surgery. He subsequently underwent physiotherapy in the following recovery period.

The humerus united within 4 months and he demonstrated excellent function including normal rotator cuff strength and a good range of motion (Figures 8 and 9).

Figure 8. Four months post-operative X-rays showing radiological union after non-union treatment.

Figure 2. Four months post-operative image showing clinical union and restored optimal limb function.

Discussion

Culture-negative infections pose a difficult management question to surgeons. The challenge lies in the balance of ensuring eradication of the potential infection and also avoiding overtreatment. Studies show the rate of culture-negative infections after fracture fixation to range between 10% and 20% (8–11) with the risk being higher in upper limb fracture fixation. Fonkoue et al. additionally demonstrated a 15% culture-negative infection rate in their review of microbiological profiles in post fracture fixation fixations in a similar environment as in this report (11). Treatment planning in the acute setting is balancing the race between osteosynthesis and fixation failure. However, in an established non-union with prior attempts at fixation, salvage procedures are required. The initial surgical finding of pus along with the reported history of an early infection that required antibiotics led to the approach described in this report supported by the criteria of defining infection by Osmon et al. (12).

In the treatment of infected humeral non-union after intramedullary nailing, the surgical goals consist of eradicating infection, stabilizing the fracture adequately, and stimulating bone healing. Antibiotic-loaded intramedullary cement nails have been reported to be a successful means of eradicating infection (13) following long bone fracture fixation. The choice of bone graft is another important factor determining success in eventually achieving bone union. In the literature, various forms of bone grafts have been used including iliac crest bone graft (2), local bone graft and fibula allograft (5), and autograft (14). Vascularized fibula grafts have also been used to stimulate biology in combination with soft tissue flaps (6).

Wright et al. (15) were the first to describe the treatment of the complex humerus non-union with the intramedullary fibular strut graft. They introduced the concept of four-cortex fixation reducing risk of screw pullout (15). This technique improves the mechanical environment by acting as an internal splint conferred by the cortical properties of the graft and, therefore, unlike the iliac crest graft, is able to withstand mechanical stress before union is achieved, thus preventing excess motion at the fracture site.

The use of fibula intramedullary strut grafting has been described in the literature and has been shown to achieve union in up to 95% of the cases with a mean union time of 5 months (7). In this report, we used a staged management approach to deal with the infection by using an intramedullary cement nail with systemic broad-spectrum antibiotics. Union was achieved by combining a free fibular intramedullary autograft with a single locking plate. This construct reduces the risk of screw pullout enhancing the locking screw advantage by providing two additional cortical fixation points for each screw while catering for the biology with the autograft.

Sadek et al. (2021) used a staged approach in managing septic non-union following failed treatment. In that series, they used external fixation and antibiotic beads to manage the infection in the first stage prior to second-stage non-vascularized fibula autograft and plating 6–8 weeks later (16). The advantage of the cement nail lies in the fact that it is intramedullary and allows the patient to continue with most activities as comfort allows. There is no time pressure to achieve the definitive fixation as would be the case with an external fixator where the risk of pin-site infection may compromise the definitive fixation.

Autologous fibula strut graft is both osteoinductive and osteoconductive and additionally offers structural support that allows for a four-cortex fixation when plate-and-screw constructs are used. Of the fibula graft options, an intramedullary non-vascularized autograft, as used in this case report, presents an attractive choice that avoids the donor-site morbidity of an iliac crest graft (17) yet offers robust intramedullary support while stimulating the local biology.

A significantly longer graft was harvested in view of the fact the bone appeared osteopaenic radiologically and in addition the screw holes from the previously failed implants raised concerns about the quality of the bone. The longer graft was intended to provide a foundation for the locking screws in the plate to ensure there was a solid cortical hold providing stability. Contralateral iliac bone graft could have been considered but in his prior fixation a significant amount of graft had been taken from the ipsilateral iliac crest and the donor site morbidity had been significant.

The harvesting technique is uncomplicated and can be performed as humerus preparation proceeds. The graft harvest site in this case demonstrated low morbidity with minimal analgesic requirement, with the patient being able to fully weight-bear the following day. Bone union of the humeral non-union was achieved within 4 months. We did not utilize any functional outcome tool however in his preoperative assessment he had full active elbow movement. His shoulder movement was limited by pain at the fracture site. Passively he had full movement. Postoperatively he had full pain-free movements. The picture demonstrates his full range of movement in forward flexion and abduction (figure 9).

This case report highlights a staged reproducible salvage strategy to treat an infected humerus non-union that is accessible in low-income settings.

Conclusion

The staged use of a temporary antibiotic-impregnated cement rod followed by intramedullary non-vascularized autologous fibular strut graft with plating is a reliable technique for managing humeral non-union complicated by infection, offering stability during treatment and effectively bridging bone loss in challenging cases. This approach also enhances screw purchase, provides osteogenic and osteoconductive benefits, and involves a low-morbidity graft harvest that isn't technically demanding**.**

Ethical consideration

Informed consent was taken from the patient for publication of this case report.

Approval was obtained from the head of the orthopaedic department of the Aga Khan University Hospital and the Institutional Scientific and Ethics Review Committee before publication.

Author contributions

MA led in conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, validation, visualization and in writing, reviewing & editing of the original draft. SKM supported.

References

1. Azar FM, Canale ST, Beaty JH. Campbell's Operative Orthopaedics, 14th Edition, vol. 4. Elsevier; 2020.

2. Peters RM, Claessen FMAP, Doornberg JN, et al. Union rate after operative treatment of humeral shaft nonunion—a systematic review. Injury. 2015; 46(12): 2314-24.
3. Caterini R, Potenza V, Ippolito E, et al. Treatment of recalcitrant atrophic non-union of the humeral shaft with BMP-7, autologous bone graft and hydroxyapatite pellets. Injury. 2016; 47(Suppl. 4): S71-7.
4. Padhye KP, Kulkarni VS, Kulkarni GS, et al. Plating, nailing, external fixation, and fibular strut grafting for non-union of humeral shaft fractures. J Orthop Surg (Hong Kong). 2013; 21(3): 327-31.
5. Willis MP, Brooks JP, Badman BL, et al. Treatment of atrophic diaphyseal humeral nonunions with compressive locked plating and augmented with an intramedullary strut allograft. J Orthop Trauma. 2013; 27(2): 77-81.
6. González del Pino J, Bartolomé del Valle E, Graña GL, et al. Free vascularized fibular grafts have a high union rate in atrophic nonunions. Clin Orthop Relat Res. 2004; (419): 38-45.
7. Gopisankar G, Justin AS, Nithyananth M, et al. Non-vascularised fibular graft as an intramedullary strut for infected non-union of the humerus. J Orthop Surg (Hong Kong). 2011; 19(3): 341-45.
8. Shah NS, Simpson NA, Frederickson M, et al. Diagnosis of occult infection using fracture-related infection criteria at the time of nonunion repair. J Orthop Trauma. 2023; 37(6): 276-81.
9. Wagner RK, van Trikt CH, Visser CE, et al. Surprise positive culture rate in the treatment of presumed aseptic long-bone nonunion: a systematic review with meta-analysis of 2397 patients. Arch Orthop Trauma Surg. 2024; 144(2): 701-21.
10. Patel KH, Gill LI, Tissingh EK, et al. Microbiological profile of fracture related infection at a UK Major Trauma Centre. Antibiotics (Basel). 2023; 12(9): 1358.
11. Fonkoue L, Tissingh EK, Ngouateu MT, et al. The microbiological profile and antibiotic susceptibility of fracture related infections in a low resource setting differ from high resource settings: a cohort study from Cameroon. Antibiotics (Basel). 2024; 13(3): 236.
12. Osmon DR, Berbari EF, Berendt AR, et al. Diagnosis and management of prosthetic joint infection: clinical practice guidelines by the Infectious Diseases Society of America. Clin Infect Dis. 2013; 56(1): e1-25.
13. Qiang Z, Jun PZ, Jie XJ, et al. Use of antibiotic cement rod to treat intramedullary infection after nailing: preliminary study in 19 patients. Arch Orthop Trauma Surg. 2007; 127(10): 945-51.
14. Olasinde AA, Adetan O, Oluwasanjo M, et al. Use of free non vascularized fibular intramedullary strut graft as adjunct to dynamic compression plate in severe atrophic fracture non union in young adult. WNJMS. 2010; 3(3 May/June).
15. Wright TW. Treatment of humeral diaphyseal nonunions in patients with severely compromised bone. J South Orthop Assoc. 1997; 6(1): 1-7.
16. Sadek AF, Fouly EH, Allam AFA, et al. Non-vascularized fibular autograft for resistant humeral diaphyseal nonunion: retrospective case series. Orthop Traumatol Surg Res. 2021; 107(8): 102843.
17. Hierholzer C, Sama D, Toro JB, et al. Plate fixation of ununited humeral shaft fractures: effect of type of bone graft on healing. J Bone Joint Surg Am. 2006; 88(7): 1442-47.