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Case Report

JOURNAL OF ORTHOPAEDICS AND SPORTS MEDICINE

ISSN: 2688-5115

The use of 15 cm Non-Vascularized Fibular Graft Augmented by Platelet-Rich Plasma Injection for the Management of Aseptic Nonunion of Ulna Fracture: An 8-Year Follow-Up Case Report

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Abstract

Background: Nonunion of long bone fractures, especially forearm fractures, presents a significant challenge. Aseptic nonunion in the ulna requires innovative strategies for effective management.

Case Presentation: A 38-year-old male patient with aseptic nonunion of the ulna underwent staged reconstructive surgery, including induced membrane technique, 15 cm non-vascularized fibular graft (NVFG), iliac crest graft, and platelet-rich plasma (PRP) injections. The patient experienced full bone healing and restored function.

Conclusion: The combination of IMT, NVFG, and PRP demonstrates promising results in managing long bone defects caused by aseptic nonunion, offering a viable alternative to more complex procedures.

Keywords: Nonunion; Nonvascularized fibular graft (NVFG); Platelet Rich Plasma (PRP); Induced Membrane Technique (IMT)

Case Report

A 38-year-old male patient with no known previous medical or surgical history presented with a fracture of his left ulna resulting from blunt trauma at his workplace. The patient underwent ORIF using a 3.5mm DCP 3 years prior to presentation to our clinic. Upon presentation, the patient complained of pain at the surgical site, which limited his ability to use his left upper limb for both work and daily activities. After taking detailed history from the patient regarding his complaint, there was nothing eventful other than being a heavy smoker for 15 years. physical examination of the patient revealed a severe local tenderness at the site of surgery without any local signs of infection.

His initial blood workup and inflammatory parameters were normal, and his forearm X-ray showed significant bone resorption of his ulna, nonunion at the fracture site along with loosening of the prior fixation hardware. These findings were consistent with **aseptic nonunion of the ulna** (Figure 1).

we counseled the patient regarding the reconstructive surgery in details and the possible complications, we also advised him to quit smoking for at least three months prior to do any surgery. Four months later, the patient came back to our clinic again asking us to start his management plan as he claims that he had quit smoking for four months, we scheduled him for surgery and counselled him again about what we are planning to do and the overall risk of surgery and results. The patient admitted to the ward, new laboratory tests was ordered to confirm the absence of infection, and all were negative.

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Citation: Eyas mohammad Al Zuqaili, Fahad Al Serhan, Zaid Al Thunibat, Deya' Aldeen Al-Rashdan, Mutasem Al Dhoon. The use of 15 cm Non-Vascularized Fibular Graft Augmented by Platelet-Rich Plasma Injection for the Management of Aseptic Nonunion of Ulna Fracture: An 8-Year Follow-Up Case Report. Journal of Orthopedics and Sports Medicine. 7 (2025): 138-143.

Received: March 02, 2025
Accepted: March 12, 2025
Published: March 20, 2025

Al Zuqaili EM., J Ortho Sports Med 2025
DOI:10.26502/josm.511500189

Figure 1: AP and Lateral X ray of the forearm showed nonunion of the ulna, with bone resorption and loosing of the fixation plate and screws.

The Surgical Procedure and Postoperative Care

Under general anesthesia, the patient was positioned supine, with a tourniquet placed above the elbow and inflated to 250 mm/Hg. Direct approach to the ulnar shaft using the same old incision, the old metal found to be extremely loosed, after removal, the ulna was found to be severely resorbed, and abnormal looking bone marrow content was coming out from the ulna, culture and histopathology biopsy samples were taken. the resorbed part of the ulna was completely excised using the oscillating saw (Figure 2), and the gap was filled with bone cement spacer that was mixed with 40 mg gentamicin and 1 gm of Vancomycin, and the ulna was then fixed with temporary external fixator (Figure 3), and the skin closed in layers to enhance the developing of induced membrane technique (IMT). The post operative plan was to keep the patient in the ward on IV antibiotics which was Cefazolin 1g IV q 8 hours waiting for the results of culture and histopathology.

Four days later, the results of the culture revealed no growth and the histopathology also was unremarkable, we kept the patient on IV antibiotics for another 3 days as prophylaxis to prevent any possible post op wound infection and then discharged the patient home until the second stage of surgery which was planned to be 4 weeks after the first stage, the patient had 2 visits to the clinic to follow up the wound and pin tract care. After four weeks, the patient admitted again to the hospital and scheduled to remove the external fixator and curettage of the pin tract and removal of skin staplers of previous surgery to take a two weeks "Holiday" until the third "definitive" stage, and the forearm fixed using above elbow back slab in 90° elbow flexion and full forearm supination (Figure 4).

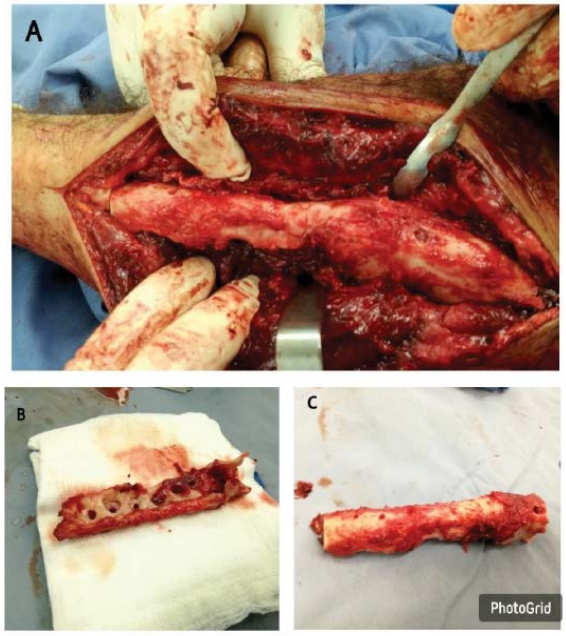

Figure 2: A) after removal of the metal, the ulna found to be resorbed B, C) after excision of the ulna, the obvious resorption of more than half of the diameter of the bone.

Figure 3: Ap and Lat views of the forearm after ulna excision and bone cement spacers with spanning external fixator.

.Two weeks later, the patient was admitted for definitive stage surgery. In the operating room the patient positioned supine, the exposed parts were the left forearm, the left leg and the right iliac crest. The ulna was exposed using the same old skin incision with meticulous soft tissue dissection to protect the membrane that formed around the bone cement spacer (Figure 5). After removal of the bone cement spacer, the measurement of the gap was taken to harvest the fibula graft accordingly, the gap was found to be 15.3 cm. torniquet applied the left thigh was inflated to 300 mm/Hg then, using direct lateral approach to left fibula, dissection with protection of the superficial peroneal nerve, measuring 15

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DOI:10.26502/josm.511500189

Figure 4: Ap and Lat view after Ex- Fix removal.

Figure 5: Intraoperative image showed the formation of membrane "black arrow head" around the cement spacer.

CM of fibula starting 7 CM above the ankle joint to protect the ankle stability, using the oscillating saw we harvested the fibula strut graft, and immediately closed the wound after inserting a drain in side to evacuate any residual post operative hematoma.

The diameter of the fibular graft was more than the diameter of the distal end of ulna. So, to overcome this mismatch a so called "**step osteotomy**" was performed to both the ulna and the fibula (Figure 6). The two ends fixed with lag screw; the proximal part attached to the proximal ulna and the overall construct was fixed using long 3.5 LCP, again, iliac crest cortico cancellous graft filled the around both edges of the graft (Figure 7). The membrane closed over the plate using 2.0 Vicryl suture, the subsequent layers were closed by the same suture size and the skin was closed using 2.0 Vicryl Suture in continuous horizontal mattress fashion, above elbow back slap was applied as well as below knee back slap to the leg of fibula donor. The postoperative period passed smoothly without any complications and the patient was discharged home on the 5th postoperative day, and planned to be seen after 1 week in outpatient clinic for wounds check.

His second follow up was two weeks later (3 weeks post op), the wound was completely healed and x ray was done and the cast removed (Figure 8). At this stage the patient was planned to take a PRP injections at both ends of the fibula graft to augment the bone healing potential. 6 ml of PRP was prepared, and under Xray guidance the patient was given 3ml at the distal end and 3ml at the proximal end. The PRP injection was also repeated in the same way after another 3 weeks. The patient's follow up plan was kept to be on monthly basis, looking for any signs on infections, bone healing status, pain score and range of motion of both his elbow and forearm.

During the subsequent follow up visits, the patient didn't complain of pain, the range of motion is getting better, and the Xray's showed complete healing of the fibular graft with the ulna (Figure 9).

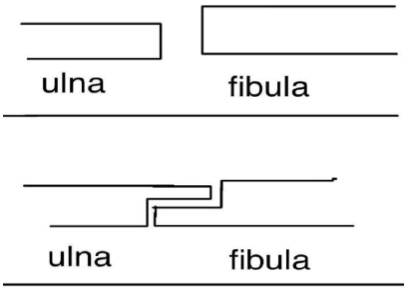

Figure 6: A scheme of "step osteotomy" to both ends of ulna and fibula to overcome the mismatch of radii

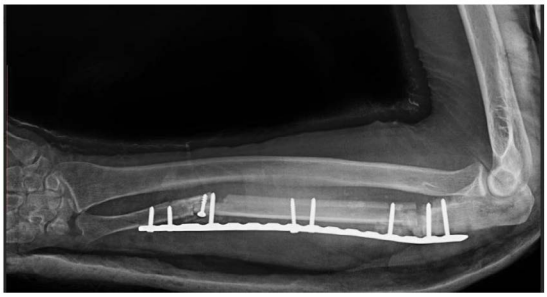

Figure 7: Immediate postoperative Xray, the graft was rigidly fixed at both ends and the iliac crest graft filled the ends of the gap between the fibula and ulna.

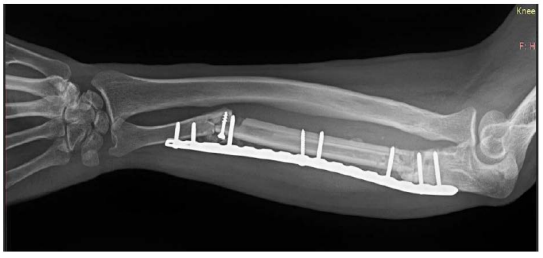

Figure 8: X ray 3 weeks post op, the cancellous bone graft had started to osteointegrate with both ends of the fibula graft.

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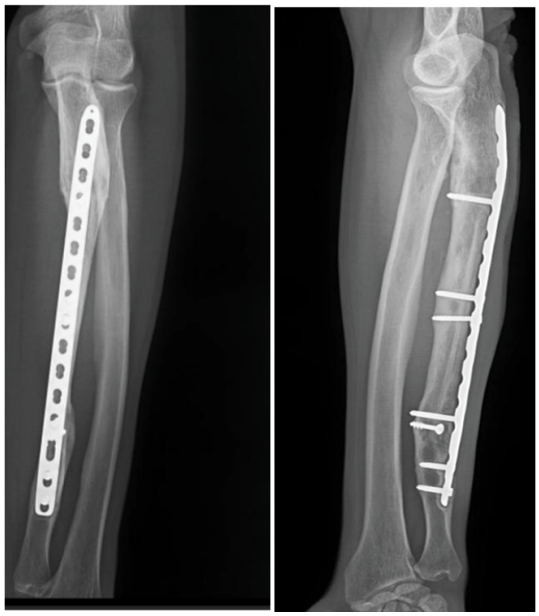

Figure 9: X ray, 19th of November 2024, complete healing of the fibula graft.

Discussion

Forearm nonunions are severely disabling and challenging to manage. Treatment of diaphyseal forearm nonunions differs from that of other types of diaphyseal nonunions due to the intimate relationship between the radius and ulna and their reciprocal movement [1]. Nonunion occurs in 2–10% of all forearm fractures due to various mechanical and biological factors, patient characteristics, and surgeon-dependent causes [2] The functional disability of this condition is due its unique anatomical integrity of both radius and ulna and their complex relationship between them and both the elbow proximally and the wrist distally.

Nonunion is due to failure of bone healing and is caused by many factors. In clinical practice, these factors are divided into mechanical and biological ones. The mechanical factor is mainly related to fracture stability either with or without internal or external fixations, the biological factors, however, have something to do with the fracture "local environment" like soft tissue status, fracture gap, comminutions and infection or the systemic illness of the affected patient like diabetes, chronic smoking, drugs and neuropathy.

The management plan is basically based on proper and precise assessment of the nonunion including medical history, social history, laboratory tests, clinical examination and radiological assessments. In this case report, the two main suspected causes of nonunion were the presence of infection and the chronic smoking habit of the patient, the infection cause was temporarily excluded reason as the inflammatory parameters were normal and there was no local sign of infection, but due to the severe osteolysis of the ulna that appeared on X ray, the intraoperative culture was the definitive test to exclude it.

After thorough resection of the devitalized ulna until healthy edges with bleeding had been reached, the gap defect was 15 cm length, and the soft tissue around the native osteolysied ulna was unhealthy looking and filled with fibrous tissue. The decision of filling the defect temporarily with cement spacer as "induced membrane technique" IMT was done.

The induced-membrane technique or Masquelet technique is used for bone defect reconstruction after infection, tumour excision and fractures. This technique is performed in two steps. The first phase consists of debridement, followed by the insertion of a polymethylmethacrylate spacer into the bone defect. Polymethylmethacrylate causes a mild foreign-body inflammatory response which induces the development of a thick pseudo-synovial membrane which acts as a newly performed periosteum. This pseudomembrane is highly vascularized and rich in growth factors. The second phase, which begins after 6–8 weeks, involves opening the membrane and removing the spacer, replacing it with a bone graft [3].

The options of filling the bone defect after spacer removal is very limited due to its **15 cm length.** The vascularized vs nonvascularized fibular graft were on the top of the list. There is general consensus in the literature to the superiority of vascularized fibular graft to fill large bone defect, Estrella EP et al showed a higher union rate was achieved using vascularized free fibular flaps compared with nonvascularized fibular grafts for long bone reconstruction after tumor resection [4]. Beris AE et al said the free vascularized fibular graft is a viable method for the reconstruction of skeletal defects of more than 6 cm, especially in cases of scarred and avascular recipient sites [5], but according to Allsopp BJ et al no compelling evidence was found to illuminate the origin of the 6-cm rule for vascularized bone grafts, or that such a rule is based on published research [6]. Gorski et al. [7], said that both vascularized Fibular Graft (VFG) and NVFG are used with successful results in the reconstruction of segmental bone tumour defects. With lower complication rates, NVFG showed comparable results to VFG but is limited in indication by size for greater defects, although he showed an excellent result with large bone defect that mandate 16 cm of NVFG [7]. Sheridan et al. [13] also showed that the use of non-vascularized fibular autograft for the reconstruction of tumors is an effective surgical technique in a pediatric cohort, however, due to high union rate and less union complications of pediatrics population in general, we cannot rely on his experience to do the same for adult large bone defects and he used to do "docking" of both ends of the fibula to the proximal and distal segment of the bone defect which in fact make the harvested fibula somehow longer the actual defect.

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Lenze et al. [9] in their results of reconstruction of large bone defect due to tumors, they strongly recommend the use of vascularized fibula grafts for segmental bone defects of 12 cm or greater due to the higher rate of complications like fracture of the graft and nonunion [9].

Due to the complexity of harvesting vascularized fibular graft and mainly the lack of the microsurgical facilities, the option of nonvascularized fibular graft was the only available in our institution to fill the bone defect. The fibular graft was harvested with meticulous concern to preserve the superficial peroneal nerve and also preservation of the ankle stability, so the distal osteotomy was 7cm proximal to the tip of latera malleolus, Pacelli LL et al. [10] in their biomechanical study showed that even shorter length of residual fibula can still has no effect of ankle stability [10], while Uchiyama et al. [11] recommend fixation of the syndesmosis or bracing to prevent ankle joint instability with rotation of the talus in the mortise, especially when the distal fibula is shortened 6 cm or more [11].

The idea of **"step osteotomy"** was done to overcome the mismatch between the distal end of the ulna and the fibular graft, this idea, which is taken originally from the technique that used in ulnar shortening osteotomy, in addition to the above mention benefit, this technique will increase the contact surface area, so more healing potential and providing more controlled fixation in terms of rotation control [12].

The step osteotomy was fixed first with lag screw, and then 3.5mm long LCP to rigidly fix the graft with ulna. After final fixation, the use of iliac crest graft to augment the fibular graft at both ends of the gap was used to get benefit from its highly osteoinductive and osteoconductive properties. The induced membrane was then closed over the fibular graft, with subsequent closure of layers till the skin, and back slab above elbow applied to the patient.

In his first follow up visit to the clinic, the wound was completely healed, and the last step of his management plan was to inject PRP in both ends of the fibular graft. PRP also known as autologous conditioned plasma, is a concentrate of plasma protein derived from whole blood, centrifuged to remove red blood cells but retaining platelets. As a concentrated source of blood plasma and autologous conditioned plasma, PRP contains multiple growth factors and other cytokines that can stimulate the healing of soft tissues and joints, the use of PRP in management of delayed union and nonunion had been mentioned in literature, Wiltfang J et al, showed a significant effect on bone regeneration was found in the autogenous graft initially when PRP is added to critical size bone defect in animal experiment [13]. Dehghankhalili M et al, in their randomized double-blind placebo controlled clinical trial being performed in a 12-month period, the application of PRP along with autologous bone graft in the site of non-union of long bone after intramedullary nailing or ORIF results in higher cure rate, shorter healing duration [13].

In this case, the use of multiple technique in the same time, i.e., the IMT, long non vascularized fibular graft, iliac crest graft and PRP injection had not been described in this combination way before, and the final results of this case which is fully healed graft with normal function limb can change the practice of long bone defect reconstruction and the use of such more simple available options [14].

Conclusion

The use of a long non-vascularized fibular graft is an effective option for managing long bone defects resulting from aseptic nonunion of the ulna, especially when combined with IMT and an iliac crest graft. The use of PRP is a promising option to add to the nonunion site and it will augment the healing process of the new graft, and it's worth to study the effect of this factor on larger series

Conflicts of Interest: The authors have no conflict of interest.

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