Addressing Bone Defects in Forearm Osteomyelitis: A Case Series

Bibek Banskota, MRCS, MS; Tarun Rajbhandari, MBBS, MS; Om P Shrestha, MBBS, MS; Ishor Pradhan, MBBS, MS; Ashok K Banskota, MD, FACS
Department of Orthopedics, B & B Hospital, Gwarko, Lalitpur, Nepal
Hospital and Rehabilitation Center for Disabled Children (HRDC), Janagal, Kavre, Nepal

Address for Correspondence:
Bibek Banskota, MRCS, MS
Department of Orthopedics, B & B Hospital, Gwarko, Lalitpur, Nepal
Hospital and Rehabilitation Center for Disabled Children (HRDC), Janagal, Kavre, Nepal
Email: research@hrdcnepal.org

Received, 17 October, 2017
Accepted, 15 November, 2017

We present a series of 5 patients with post-infective bone gaps of forearm bones, each managed with a different surgical intervention, and review the literature on management and the pros and cons of each modality.

Methods employed to bridge the bone gaps included tibial inlay graft, fibular onlay graft, Ilizarov fixator, centralization of the ulna over the carpus, and creation of a single bone forearm. Union was achieved in all 5 cases predictably with significant functional gain, except in the patient in whom an Ilizarov frame was used, where a docking site nonunion required additional bone grafting to achieve union.

Bone gaps in forearm osteomyelitis are challenging problems. Various options of management are available including inlay and onlay grafts, bone transport or radical procedures like conversion to a single bone forearm. We feel that if properly planned and executed all these options lead to outcomes where reasonable function can be expected.

Keywords: bone gaps, chronic osteomyelitis, forearm bones, management.

Segmental bone defects in the forearm as a result of chronic osteomyelitis are not an infrequent encounter in third world orthopaedic practice. It is a major disability from the patients perspective, more so when the dominant hand is involved, and a daunting challenge for the treating surgeon. Bone defects can occur as part of the natural history of chronic osteomyelitis or due to injudicious removal of a sequestrum before the involucrum is allowed to mature **(Figure 1)**.[1,2]

Figure 1: A) AP x-ray showing a large tubular sequestrum of the mid-distal radius B) AP x-rays 6 months later showing encouraging involucrum response around the sequestrum C) AP & lateral x-rays one and a half years later showing well consolidated involucrum

Case 1: Tibial inlay grafting.

Figure 2: A) Anteroposterior and lateral views of the right radius showing sequestration of the entire shaft. B) AP & lateral views post-sequestrectomy C) The large bone gap was bridged using a tibial inlay graft D) harvested from the right tibia E) 5 years and F) 10 years follow up AP & lateral x-rays showing complete incorporation of the graft

A 14 years old right hand dominant boy presented with a history of sudden-onset forearm swelling and fever of one and half years duration for which he had undergone incision and drainage at a local health post. He presented with a sequestered right radial shaft **(Figure 2A, B)** with resistant discharging sinuses. A sequestrectomy was performed to control sinus discharges, creating a large bone gap **(Figure 2C)**.

The 7 centimeters bone gap was bridged one year later, using a tibial cortical graft harvested from the anteromedial aspect of the right distal tibia **(Figure 2 D, E)**. This was stabilized with an external fixator until union was achieved, which took 4 months. At 10 years follow-up, the patient was painfree and fully functional with full elbow, wrist and hand function and was able to perform all activities of daily living.

Case 2: Centralization of ulna over the carpus

Figure 3 A) AP & lateral x-rays showing complete sequestration of the right radius B) & C) X-rays following sequestrectomy. D) & E) Centralization of the ulna over the carpus and held temporarily with a smooth pin. F) & G) 4 years follow up showing well centralized ulna. The patient had limited wrist and full elbow motion and was pain free.

A 5 years old right hand dominant girl presented with a post-infective right radial club hand deformity. Radiographs revealed complete sequestration of her right radius without any evidence of involucrum formation **(Figure 3 A, B, C)**. A sequestrectomy was performed followed by centralization of the ulna over the carpus **(Figure 3 D, E, F, G)** because the distal most radius remnant was found to be unhealthy looking and so was sacrificed. Although wrist function was compromised with dorsiflexion of 35^0 and palmarflexion of 30^0, the patient was pain free with good elbow function and no deformity at 4 years follow up.

Case 3: Bone transport by distraction osteogenesis

A 12 years old right hand dominant girl presented with an open right wrist injury 5 months after falling from a tree. She had been managed in a plaster cast locally for a distal radius-ulna fracture. At presentation, she had an open discharging wound on the volar aspect of her right wrist with exposed sequestrum **(Figure 4 A, B)**, which was removed creating a bone gap of 4.5 centimeters. Her wrist motion was very poor at presentation and elbow motion had an arc of 80^0 (40^0 to 120^0). She underwent distraction osteogenesis of the right radius through a proximal radial corticotomy in an Ilizarov frame over an intramedullary pin **(Figure 4 C, D)**. Over a period of 6 months, the regenerate allowed the proximal end to be docked at the distal nonunion site but this refused to unite so bone grafting was done and eventual union achieved at 8 months. At follow-up of 4 years, radiological consolidation was solid **(Figure 4 E, F)**, the wrist function was poor with stiffness, hand function was good with strong grip, pinch and opposition, and the elbow function was excellent with an arc of 140^0.

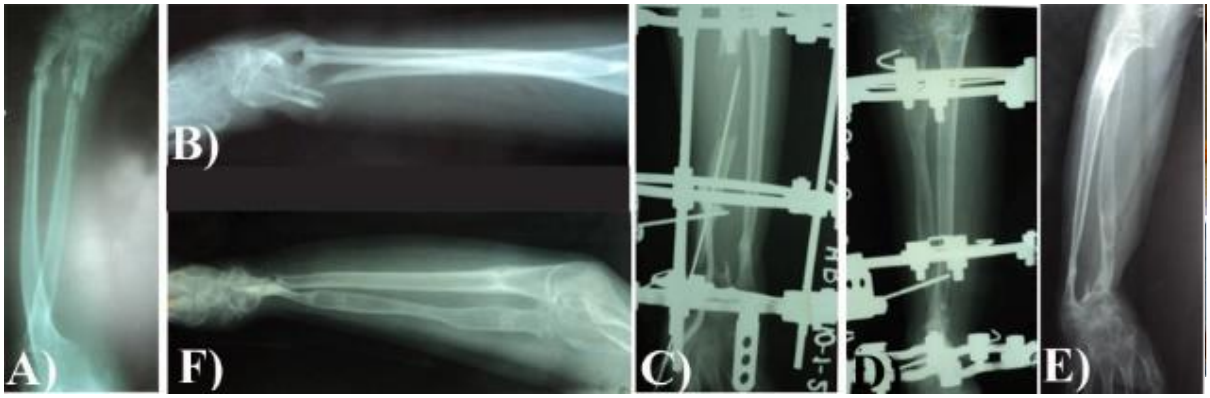

Figure 4 A) & B) AP & lateral views of the right wrist showing post-traumatic infective non-union with sequestrum which was jutting out of a volar wound and causing persistent discharge. C) AP x-ray showing distraction osteogenesis and bone transport in progress over an intramedullay rod after sequestrectomy. The regenerate length achieved to bridge the bone loss was 4.5 centimeters. D) AP x-ray showing fully consolidated regenerate. The distal docking site refused to unite so autologous iliac crest bone grafting was done at 6 months and eventual union achieved at 8 months. E) & F) AP & lateral x-rays taken at 4 years follow up showing consolidated union. The wrist function remained poor but the hand and elbow function as well as forearm rotation was fully restored by rigorous physiotherapy in and out of the frame

Case 4: Creation of a single bone forearm

A 13 years old girl presented with a 5 years history of gradually increasing deformity of her dominant right forearm and wrist. She gave a history of pain and fever at the outset which subsided over several weeks but the forearm gradually developed a bowing deformity. Radiographs made at presentation revealed that the entire mid to distal third of the ulna had completely resolved **(Figure 5 A, B)**. She had radial deviation of the affected forearm with

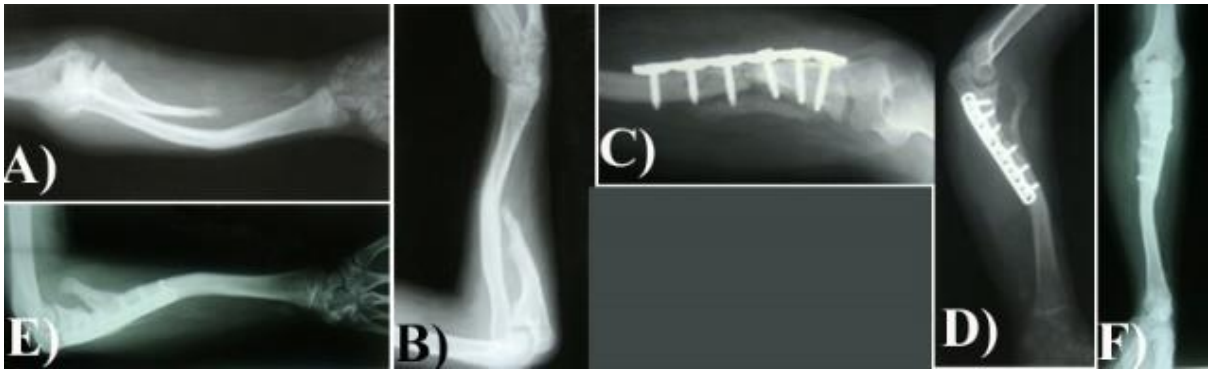

Figure 5: A) & B) AP & lateral x-rays showing complete destruction from the proximal to distal third of the ulna with a dislocated radial head of the right dominant forearm. The patient had some wrist motion but there was no motion at the elbow and there was pain on attempted motion. C) & D) AP & lateral x-rays following creation of a single bone forearm by uniting the radius and ulna at the proximal third. E) & F) AP & lateral x-rays at 7 years follow up showing well consolidated union.

limited wrist motion, stiffness at the elbow, absent pronation and supination, and had difficulty using the affected limb. The forearm was converted to a single bone at the level of the proximal third of the ulna; union was achieved in 3 months **(Figure 5 C, D)**. At 7 years follow up, the patient had solid radiological consolidation **(Figure 5E & 5F)** with dorsiflexion of 60^0 **(Figure 6A)** and palmar flexion of 45^0 **(Figure 6B)** at the right wrist, flexion of 100^0 **(Figure 6C)** and full extension **(Figure 6D)** at the elbow and was able to carry out all activities of daily living as well as write easily with her dominant right hand **(Figure 6E)**.

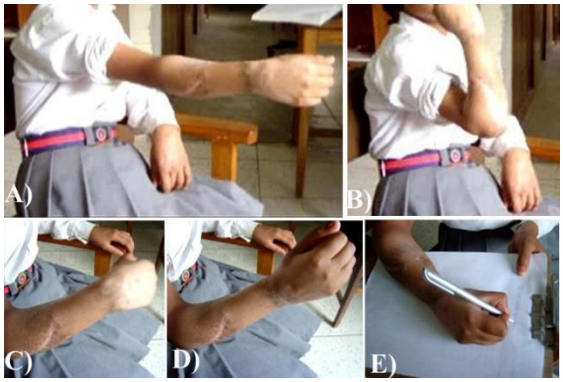

Figure 6: Clinical pictures at 7 years follow up showing good function at the wrist and elbow: A) Full elbow extension. B) 1000 elbow flexion. C) 450 wrist palmar flexion. D) 600 wrist dorsiflexion. E) Comfortable writing with her dominant hand.

Case 5: Fibular onlay graft

An 18 years old male presented with a post-infective pseudarthrosis of the mid-shaft of his right, dominant, ulna **(Figure 7A)**. He had pain and restricted rotation of his forearm. The elbow and wrist function was normal. He underwent a thorough debridement of all sclerotic and pseudarthrotic material which created a bone gap of 3 centimeters. This was bridged using an autogenous dual onlay fibular graft harvested from the ipsilateral leg **(Figure 7B)**. The graft was secured in place with two cortical screws at either end. Union was achieved in 7 months and the graft was fully incorporated by 1 year **(Figure 7 C, D)**. The patient regained full forearm rotation and was able to carry out all activities of daily living with the affected extremity.

Discussion

Options in management of post-infective non-unions with bone gaps in the forearm include tricorticocancellous grafting, tibial or fibular inlay or onlay grafting, free vascularized grafting, bone transport by distraction osteogenesis or the creation of a single bone forearm, either by centralizing the ulna over the carpus or achieving union of the radius to the ulna to create a single bone forearm. The last two mentioned options lead to absence of forearm rotation. Grafts can be autografts, allografts or vascularized grafts.[3] Autogenous grafts are preferred because of their increased osteoinductive, osteoconductive and osteogenic properties and absent risk of transferring infection or inciting an immunogenic response. In cases with soft tissue contractures secondary to bone loss, pre-operative stretching by physiotherapy and/or serial casting leads to less wound problems and better function post-operatively.[4] Priority must be given to excising all sclerotic and fibrotic residual bone ends until healthy vascular bone is reached, even if this means increasing the bone gap to be bridged, because this has

Figure 7: A) AP & lateral x-rays of the right forearm of a 18 years male showing post-infective non-union with pseudarthrosis of the mid-shaft of the ulna. He had pain and restriction of forearm rotation. B) Debridement of all sclerotic and pseudarthrotic tissue created a bone gap of 3 centimeters which was bridged with autogenous fibular dual onlay graft which was secured with two cortical screws on either end. C) X-rays made at one year follow up showing complete incorporation of the graft. D) X-rays made at 3 years follow up showing complete incorporation and cortication of the graft. The patient was fully functional with full pronation and supination of the forearm.

been shown to increase the vascularity of the graft and its eventual 'take'.[5] A similar debridement holds true for the muscular bed where the graft is to sit. Stabilization of the graft can be achieved by external, internal or intramedullary means. Non-union at one or both graft ends can be augmented by conventional cancellous bone grafting, which is usually successful. In a study of 38 patients with gap non-union of forearm bones treated by tricorticocancellous grafting (modified Nicoll's technique), Gupta et al reported primary union at both host-graft junctions in 36 patients at a mean duration of 17.5 weeks, two patients requiring augmentation cancellous grafting at one host-graft junction after 9 months of the primary procedure to achieve union.[6] A non-union rate of 11% at the graft-host site has been reported by Jupiter et al following autologous iliac crest bone grafting and compression plating.[7]

The Ilizarov fixator has been successfully used in the management of gap non-unions in forearm bones. It has the advantage of bridging the bone gap by distraction osteogenesis, compressing the non-union site as well as simultaneously allowing for wrist and elbow range of motion. In their review of 11 cases of atrophic non-union with bone gap, Smith et al[8] reported union primarily in 64% of patients and eventual union in 100% after the remaining (36%) cases underwent compression plating of non-union site once the regenerate had matured. The average regenerate length in this study was 4.2 centimeters and the average healing time 57.1 weeks. In spite of a steep learning curve and possibility of non-compliance, especially in our type of setting where regular follow-up may be missed, the authors advocate this form of treatment in view of its advantage in allowing for wrist and elbow motion and

obviating the morbidities associated with harvesting autografts.

Bridging forearm bone defects by using autogenous fibular graft has a high success rate but is technically demanding and has the disadvantage of donor site morbidity.[9] Tibial inlay and onlay grafts have also been successfully used to treat infected non-unions with a large bone defects and its usefulness was demonstrated in the treatment of large infected non-unions of long bones during and after the Second World War.[10,11]

Where bone gaps in the radius are large, creation of a single bone forearm by uniting the ulna to the radius, or centralizing the ulna over the carpus, have both been shown to restore adequate wrist function,[1,4,12] the disadvantage being loss of forearm rotation. The level of union in single bone forearm is dependent on the remaining radius and ulna and may be at the proximal, middle or distal third of the forearm.

In any case, pre-operative stretching, proper surgical technique and post-operative bracing where applicable, have been emphasized for optimal results.[4]

Our small case series limits in its ability to propose one technique over the other or recommend a particular technique for a particular problem, but is simply intended to highlight some of the options available to the surgeon when faced with large forearm bone defects secondary to chronic infection. The preference is on a case by case basis and the expertise available. Pre-operative stretching of soft tissues and post-operative physiotherapy are vital and should be emphasized for regaining motion at the elbow, wrist and hand, and where applicable, supination-pronation at the forearm. A premature sequestrectomy should be avoided because the involucrum response can obviate the scenario of a large bone defect, as even sizeable sequestra sometimes incorporate into the growing involucrum **(Figure 1 A, B, C)**. A larger series study to better define the indication and limitation of each technique is warranted.

Acknowledgement

Mr. Arjun Adhikari. IT Department B&B Hopsital / HRDC

References

1. Izhar-ul-haque. The production of a one-bone forearm as a salvage procedure after haematogenous osteomyelitis. JBJS (A) VOL. 64-B, No. 4, 1982.
2. Jain AK, Sharma DK, Kumar S. Incorporation of diaphyseal sequestra in chronic haematogenous osteomyelitis. Int Orthop 1995;19: 238-41.
3. Weiland AJ, Phillips TW, Randolph MA. Bone grafts: a radiologic, histologic, and biomechanical model comparing autografts, allografts, and free vascularized bone grafts. Plast Reconstr Surg 1984;74(3):368–79.
4. Bayne LG, Klug MS.Long-term review of the surgical treatment of radial deficiencies. J Hand Surg Am. 1987 Mar;12(2):169-79.
5. Siffert RS. Experimental bone transplants. J Bone Joint Surg Am. 1955;37: 742.

6. Gupta DK, Kumar G. Gap nonunion of forearm bones treated by modified Nicoll's technique. Indian J Orthop. 2010 Jan-Mar; 44(1): 84-8.
7. Jupiter JB, Gerhard HJ, Guerrero J, Nunley JA, Levin LS. Treatment of segmental defects of the radius with use of the vascularized osteoseptocutaneous fibular autogenous graft. J Bone Joint Surg Am (1997); 79(4):542–50.
8. Smith WR, Elbatrawy YA, Andreassen GS, Philips GC, Guerreschi F, Lovisetti L, Catagni MA. Treatment of traumatic forearm bone loss with Ilizarov ring fixation and bone transport. International Orthopaedics (SICOT) 2007;31:165–70.
9. Mack GR, Lichtman DM, MacDonald RI. Fibular autografts for distal defects of the radius. J Hand Surg [Am] (1979); 4 (6):576–83.
10. Robert Merle D'Aubigné. Surgical treatment of non-union of long bones. *J Bone Joint Surg Am.* 1949; 31:256-66.
11. Banskota AK. Radial clubhand-like deformity as a sequel of chronic pyogenic osteomyelitis of the radius. J. Inst. Med. 1983. 5; 93-6.
12. Malki A, Wong-Chung J, Hariharan V.Centralization of ulna for infected nonunion of radius with extensive bone loss. A modified Hey-Groves procedure. Injury. 2000 Jun; 31(5):345-9.