

## TREATMENT OF NONUNITED DIAPHYSEAL FRACTURES OF LONG BONES WITH STEP-CUT OSTEOTOMY OF BONE ENDS

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Despite recent advances in surgical techniques, nonunion of long bones continues to pose a challenging problem for the orthopedic surgeon. Many methods of treating nonunion fractures have appeared in the literature.<sup>1-14</sup> The essential principles of treatment for cases of nonunion of diaphyseal fractures include freshening of the fracture surfaces, fixation of the fracture, and cancellous bone grafting over the decorticated fragments.<sup>15</sup> No matter which therapeutic measure is used in an attempt to effect union, there is a residual failure rate of approximately 5%-10%.<sup>1</sup> The success rate decreases as the number of failed operations increases. The success rate after the first bone grafting procedure is 85%-90%; after the second bone grafting procedure 66%; and after the third 64%.<sup>2,16</sup> We report a surgical procedure which has been successfully used in nine patients with nonunion fractures of long bones. The procedure is most suitable for the treatment of diaphyseal nonunion of humerus and forearm bones, as well as infected nonunion bones.

### Materials and Methods

From January 1991 to December 1998, nine patients with nonunion diaphyseal fractures of long bones were treated at our institution using the technique of step-cut osteotomy of the bone fragments (Table 1). Among these patients were seven with nonunion of the humerus and two with nonunion of the radius and ulna. The duration of nonunion fractures ranged from six months to three years. One of the patients (Case 3) who had delayed union of radius and ulna had an infection with a discharging sinus on the radial side with loose implants (Figure 1).

Patients considered for treatment by step-cut osteotomy of bone fragments had nonunion diaphyseal fractures of long bones which had failed to heal after initial plaster cast immobilization or internal fixation. Because of the drawback of shortening in the lower limb, the procedure was used in the arm and forearm bones. In the patient with

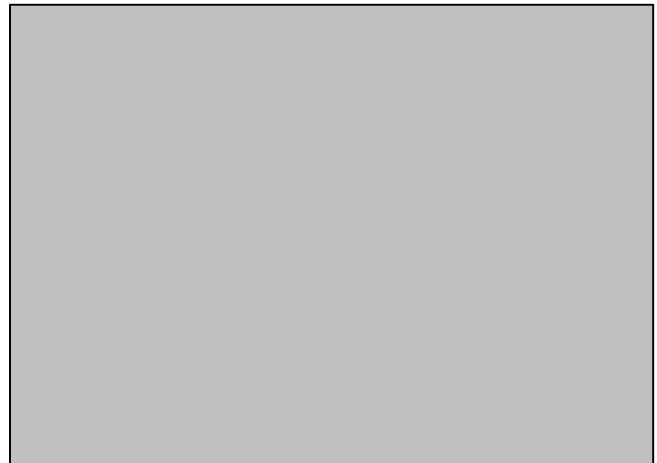


FIGURE 1. Radiographs of forearm showing: A) a six-month-old nonunion fractured radius and ulna with loose implants, fractured radius was infected; B) nonunion fractured radius and ulna have been treated by step-cut osteotomy and overlapping the bone fragments; C) radiographs at three months showing healed fracture of the radius and ulna.

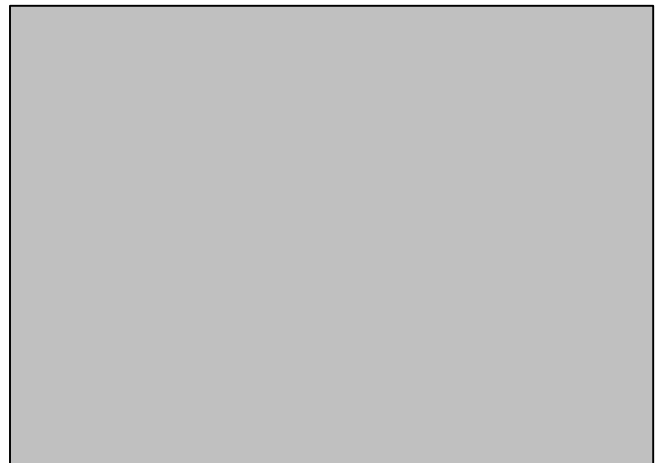


FIGURE 2. (Case 7) Radiographs of humerus showing nonunion of humerus treated by step-cut osteotomy of bone fragments and fixation with interfragmental screw and a compression plate.

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infected nonunion of radius with loose implants, only interfragmental screw was used to maintain bone

fragments. Postoperatively, the limb was immobilized by an above-elbow plaster for eight weeks.

TABLE 1. Summary of nine patients treated with step-cut osteotomy of bone fragments.

Age (years)/Sex	Bone involved	Time from injury	Previous treatment	Time to union after step-cut osteotomy	Final result
32/M	Humerus	8 months	Plaster cast	3 months	Healed
30/M	Humerus	2 years	Plate fixation	4 months	Healed
22/F	Radius and ulna	6 months	Plate fixation	3 months	Healed
26/M	Humerus	3 years	Plate fixation	4 months	Healed
25/M	Humerus	18 months	Plate fixation	5 months	Healed
22/M	Humerus	1 year	Plate fixation	4 months	Healed
42/M	Humerus	2 years	Plate fixation	4 months	Healed
45/M	Radius and ulna	3 years	Plate fixation	5 months	Healed
40/M	Humerus	1 year	Plate fixation	4 months	Healed

### Operative Technique

The site of nonunion was exposed through a standard approach. All fibrous tissue and sclerotic bone were exposed from the site leaving healthy, viable bone ends. With an oscillating saw, the bony ends were fashioned with step-cut osteotomy for 2 to 3 centimeters, either in an anteroposterior or side plane depending upon feasibility. The bone fragments were overlapped and fixed with an interfragmental screw and a compression plate (Figure 2). Use of interfragmental screw is optional and the fragments may be stabilized by compression plate. In patients with infected nonunion, minimum fixation with interfragmental screw is advisable and the limb is further stabilized in a plaster cast (Figure 1). In nonunion of radius and ulna, the bone fragments of both bones should be fashioned prior to their fixation. If the procedure is used for nonunion of tibia, the osteotomy of the fibula is a prerequisite. In long-standing nonunions, cancellous bone graft from the iliac crest may be added to the procedure. In the nine patients reported here, additional bone graft from the iliac crest was not used. At the end of the surgical procedure, the haemovac drain was routinely used.

In the postoperative period, the limb is supported with collar-and-cuff sling until the clinical union is achieved. Active exercises of the hand and shoulder are encouraged during the period of immobilization.

### Results

Nine nonunited fractures of arm and forearm bones were treated by step-cut osteotomy of the bone fragments (Table 1). All the patients were followed up until radiographic cortical bone healing. A solid bony healing was achieved in all nine patients within five months with no loss of limb function. There was no failure of osteosynthesis and no infection or wound complication. Patients with infected delayed union of radius and ulna had solid union at three months' follow-up with no recurrence of infection (Figure 1). At one-year follow-up, all nine patients had normal limb function with full range of elbow and shoulder movements.

### Discussion

Diaphyseal nonunion of long bones usually occurs during the most productive years of a patient's life and may cause near total disability for several years. Packing of autogenous cancellous bone graft about the site of nonunion is still the most popular method of promoting union.<sup>6</sup> Considering the fact that success rate decreases as the number of failed operations increases,<sup>2</sup> the first surgical procedure for a nonunited fracture should be chosen with great care.

The surgical procedure described here was successfully used in nine patients with nonunited fractures of long bones. The advantages of this procedure are: 1) fashioning the bone fragments with step-cut osteotomy provides fresh and healthy bone ends; 2) overlapping the fragments gives good contact of the healthy bone, which is essential for healing; 3) fixation with interfragmental screw and compression plate gives stability at the nonunion site; and 4) it is simple and also suitable for infected nonunion, where minimum internal fixation is preferred.

The procedure described here provides an adequate contact of the viable healthy bone fragment, which is lacking in the other available conventional methods. A few centimeters of shortening in the upper limb do not affect the limb function. The procedure has been found most suitable for nonunion of the humerus and selected cases of radius and ulna. The procedure cannot be used in the forearm for nonunion of one bone only. In nonunion of femur and tibia, it has limitations because of the drawbacks of shortening.

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