

Original Article

Ulnus formation for forearm fracture with segmental radial defect

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Abstract: One-bone forearm functions best when the proximal ulna and distal radius are present and joined (the ulnius). Six open forearm fractures accompanied by segmental radial defect were treated by the ulnius formation in a one-stage procedure. All patients had a stable and pain-free forearm, and were satisfied with the function and cosmetic appearance of the forearm.

Keywords: One-bone forearm, ulnius, forearm fracture, segmental radial defect

Introduction

The treatment of open forearm fracture accompanied by segmental bone defect is one of the most challenging problems for the orthopedic surgeon. There are a number of treatment options in the literature, including bone grafting with either autologous or allogenic bone graft, vascularized bone graft and distraction osteogenesis. Outcomes using these options are variable with many cases requiring repeat procedures to obtain a satisfactory result.

In 1921, Hey-Groves first described the one-bone forearm procedure for pseudarthrosis of the distal radius [1]. He transferred the proximal ulnar shaft to the distal radial metaphysis and fixed it in neutral forearm rotation after distal ulnar resection. Since then, this technique has been successfully utilized to treat segmental bone defects of the forearm, resulting from trauma, infection, or tumor resection [2-9].

The one-bone forearm is most optimally constructed and functions best when the proximal ulna and distal radius are present and joined (the ulnius). The ulna makes the elbow, and the radius makes the wrist [8]. Here we report on our experience of the treatment of six patients with open forearm fracture accompanied by

segmental radial defects by the ulnius formation with use of a plate and screws.

Patients and methods

Six patients who sustained forearm fracture accompanied by segmental defects of the radius between 2000 and 2010 were treated by the ulnius formation in Wuxi Number 9 People's Hospital Affiliated Soochow University. There were 5 male and 1 female patients, with a mean age of 31.8 at the time of surgery (range, 23 to 45 years) (**Table 1**). All six patients were manual laborers and had a work related injury.

All fractures were initially open and secondary to high-energy trauma. According to Gustilo & Anderson classification, four cases were III B and two cases were III C. The location of bone defect involved the distal third of the forearm in all cases. The mean defect of radius was 7.3 cm ranged from 6 to 9 cm. 5 patients were right-hand dominant and all the cases involved the non-dominant forearm. The operations were all performed within 8 hours of injury.

Surgical technique

Thorough wound irrigation and debridement of the soft tissues and bone was performed initially. Surgical approach was determined indi-

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Table 1. Patient data

Case	Age	Gender	Side	Gustilo & Anderson type	Length of segmental defect
1	37	Male	Right, non-dominant	III C	6
2	23	Male	Right, non-dominant	IIIB	6
3	27	Male	Right, non-dominant	III B	7
4	45	Male	Left, non-dominant	III B	8
5	34	Female	Right, non-dominant	III C	8
6	25	Male	Right, non-dominant	IIIB	9

Table 2. Results

Case	Duration of follow-up (y)	Fusion position	Score (points) [5]	Satisfaction
1	8	Neutral	8	7
2	4	Neutral	10	10
3	9	Neutral	10	10
4	7	15° pronation	6	8
5	8	Neutral	8	8
6	6	15° pronation	8	8



Figure 1. X-ray image at preoperation.

vidually based on preoperative fracture and soft tissue evaluation. In all cases, we created transverse osteotomies in the ulna and radius. We used rigid internal fixation with plate and screws in an end-to-end fashion. The rotation position of the fusion was either at neutral or in slight pronation.

The external fixation was used for immobilization and removed at six weeks, after which the

limb was protected with cast immobilization for a mean of 9 weeks postoperatively (range, 6-12 weeks), until radiographic and clinical evidence of synostosis consolidation were present.

Assessment

The clinical outcome was measured at the final follow-up, incorporating a 0-to 10-point treatment satisfaction scale (0, no satisfaction; 10, completely satisfied), and a 10-point subjective scoring system, described by Peterson et al [5], based on function, pain, and attainment of union. Bone union was defined as the presence of fracture healing on the anteroposterior and lateral radiographs with no tenderness or pain at the fusion site.

Results

The final follow-up examinations were made at an average of 7 years after surgery, ranging from 4 to 9 years. All six patients had a stable and pain-free forearm. There were no non-unions, infections, hardware failures, or fractures. The radioulnar junction had healed within 18 weeks in all patients. 5 outcomes were excellent and 1 was good according to the 10-point subjective scoring system, described by Peterson et al [5]; the mean score was 8.3 points (**Table 2**). All patients were satisfied with the function and cosmetic appearance of the forearm; the mean satisfaction score was 8.5 points (**Table 2**). No patients had obvious limb shortening compared with the contralateral forearm.

Illustrative case

A 23-year-old man sustained a Gustilo Anderson type III B open fracture of the forearm associated with 6-cm radial defect. After debridement and irrigation, the ulnus formation was performed with a plate and screws in end-to-end fashion. Postoperatively, the external fixation was used for immobilization and removed at six weeks, after which the limb was protected with cast immobilization for 6 weeks. The patient had a stable and pain-free forearm, and was satisfied with the function and cosmetic results (**Figures 1-5**).



Figure 2. X-ray image at postoperation.



Figure 3. X-ray image at final evaluation.

Discussion

The treatment of open forearm fracture with long segmental bony defects is extremely challenging. Early (<8 hours) operative debridement and irrigation are essential to reduce the risk of infection. In this series, we performed the ulnus surgery to manage open forearm fracture in



Figure 4. Clinical photographs.

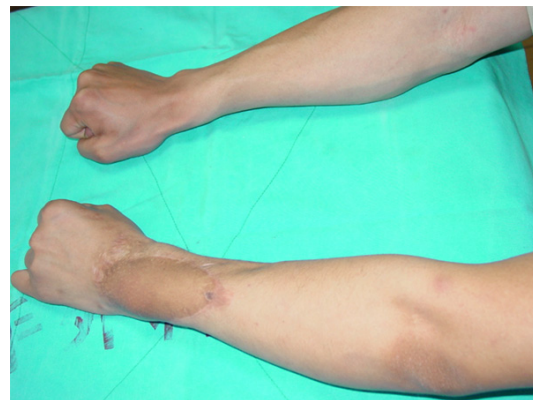


Figure 5. Clinical photographs.

a one-stage procedure. All patients had a stable and pain-free forearm; there were no non-unions, infections, hardware failures, or fractures; and they were satisfied with the functional and cosmetic results.

The ulnus formation attempts to create a single, stable, osseous bridge between the ulno-humeral and radiocarpal joints. The prerequisites of this procedure were a normal hand, a good proximal end of the ulna, a good elbow, and a good distal end of the radius and radiocarpal joint [3, 7, 8]. It would be optimal if the involved extremity is non-dominant. The main drawback of this procedure is the loss of forearm rotation. However, this can be compensated by shoulder position and development of wrist hypermobility. Shoulder abduction and internal rotation places the palm down. Shoulder abduction and external rotation turns the palm toward the face or the back of the head [9, 10]. In children, bone growth and limb

shortening are the matters of concern. In our study, all the cases were skeletally mature and no obvious limb shortening was noticed.

Rigid fixation between the radius and ulna was paramount for successful bone union. The fixation methods include side-to-side arthrodesis with cross-pin fixation or end-to-end arthrodesis with either plates and screws or intramedullary rods. Chen et al [11] treated 7 patients who developed nonunion after side-to-side one bone forearm surgery with cross-pin or wire fixation. The authors performed the revision surgeries with plate and screw fixation and noted successful union in 5 patients revised with end-to-end arthrodesis. Thus, side-to-side one bone forearm surgery is not preferred because of a potentially higher risk of nonunion. Castle [3] and Allende [12] used unlocked intramedullary fixation and reported no cases of nonunion. However, intramedullary fixation can't provide rotational stability. Therefore, we chose end-to-end arthrodesis with plate and screws in all six patients and achieved successful bone union.

In all six cases, we made transverse osteotomies, but it may be reasonable to assume that an oblique osteotomy could have optimized the environment for bone union. The position of the forearm fixation was neutral or in slight pronation, as recommended by many authors. In our study, we didn't noticed superiority of fusion in either neutral or pronation. It may be because shoulder rotation and abduction/adduction allow the neutral or pronated forearm to attain pronation, neutral, or even slight supination.

When chosen for right indication, the ulnus formation can provide a stable forearm with good functional and cosmetic results. It utilizes readily available implants, requires no special surgical skills and restores limb length. Early operative debridement and irrigation; rigid fixation; and protection until bone union were the key points to achieve the satisfactory results in this series.

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This study was approved by the Institutional Ethics Committee of Soochow University.

Disclosure of conflict of interest

None.

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