Callus distraction for the treatment of acquired radial club-hand deformity after osteomyelitis

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We report our experience of the use of callus distraction with a monolateral fixator for the treatment of acquired radial club-hand deformity after osteomyelitis. Between 1994 and 2004, 13 patients with a mean age of eight years (4 to 15) were treated by callus distraction with a monolateral fixator after a preliminary period of at least four weeks in a corrective short-arm cast.

All patients achieved bony union and were satisfied with the functional and cosmetic outcome. There were no major complications, but three patients required cancellous bone grafting at the docking site for delayed union. Local treatment and oral antibiotics were required for pin-site infection in six patients. There were no deep infection or recurrence of osteomyelitis.

Haematogenous osteomyelitis is rare in the radius, but absorption and lysis can produce a radial defect. Severe radial shortening may lead to overgrowth and angulation of the ulna, dislocation of the distal radioulnar joint and radial deviation of the hand. This acquired radial club-hand deformity is similar in appearance to that of the congenital deformity. However, the latter is always associated with bony abnormalities in the hand and wrist.

Acquired radial club-hand deformity presents a challenging reconstructive problem. Netrawichien¹ reported good functional and cosmetic results at follow-up at one year in two patients with acquired club-hand deformity which had been treated by cancellous bone graft and plating combined with ulnar shortening. Ono et al² reported good results in nine patients treated by interposition bone grafting, centralisation, radioulnar transposition and an Ilizarov external fixator (Smith & Nephew, Memphis, Tennessee), but the patients had residual shortening of the forearm of 4 cm to 8 cm. Sabharwal³ reported two patients with atrophic nonunion with bone loss after open fracture of the distal radius which had been treated by staged reconstruction using an Ilizarov apparatus (Smith & Nephew). Satisfactory results were obtained at follow-up at three years.

We report a retrospective study of 13 such patients who were treated by callus distraction using a monolateral external fixator.

Patients and Methods

Between 1994 and 2004, 13 patients with acquired radial club-hand deformity after haematogenous osteomyelitis were treated by callus distraction using a monolateral external fixator. There were eight boys and five girls with a mean age of eight years (4 to 15). All showed right hand dominance, the right hand being involved in seven, and the left in six. All had suffered from haematogenous osteomyelitis, but none had active infection when they presented at our hospital. Previous cancellous bone grafting and plating had been performed ten times in nine patients. The mean angle of radial deviation measured on radiographs was 54° (30° to 75°). The mean radial defect in the distal and mid portions of the radius measured as the discrepancy between the length of the radius and the ulna was 5.8 cm (3 to 8). The mean time from the onset of osteomyelitis and reconstructive surgery was 3.5 years (1 to 6). Fortunately, the distal radial growth plate was still intact in all patients. The presence of active osteomyelitis was determined by standard clinical tests, imaging, and laboratory investigations. If it was present, debridement and appropriate antibiotics were administered before proceeding to attempted skeletal reconstruction. Control of the osteomyelitis for a period of at least six months as demonstrated in all patients by normal blood tests including the leucocyte count, erythrocyte sedimentation rate (ESR), and level of C-reactive protein. Elbow, wrist

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Fig. 1

Photograph of the two-segment monolateral external fixator.

and hand mobility were improved pre-operatively by physiotherapy, followed by the application of a short-arm cast for at least four weeks to stretch the skin and soft tissues on the radial side.

Operative technique. Pre-operative radiographs were taken to assess the radial deviation and the length inequality between the radius and ulna, and to plan the application of the monolateral external fixator. The patients were operated on supine under general anaesthesia or brachial plexus block, with the forearm on a radiolucent table. Before skeletal reconstructive surgery, the wrist was corrected to as neutral a position as possible by manual traction and soft-tissue release. The ends of the bone were exposed and resected until bleeding was present at both ends. Under image investigation, one or two 3 mm diameter pins were inserted above and below the pre-planned level for the osteotomy in the distal radius.

All the pins had to be in the same plane after correction of rotation and angular deformity. The monolateral external fixator (The Third Medical Instrument Company, Wujin, China) was attached to the pins on the radial side of the forearm. It comprises two screw rod and link rails. It is a stable rectangular plane fixator which is connected to the bone by the pins. When the bone is elongated or compressed, the press board, which is used to make the fixator more stable, is removed. An S-needle is used to rotate the adjusting screw rod through adjusting hole in the middle of

the adjusting screw rod (Fig. 1). A distraction test was performed to confirm that the osteotomy was complete. Care was taken to preserve the distal radial growth plate.

Lengthening was started at a rate of 0.25 mm four times a day at seven days after operation. The rate was adjusted according to the discomfort and swelling of the hand and the quality of the regenerate bone. Physiotherapy was started within two days of surgery and included range-of-movement exercises for the fingers and elbow as well as the use of dynamic slings for finger extension. During the lengthening, all the patients were followed up weekly. Anteroposterior and lateral radiographs of the forearm were taken to monitor bone regeneration, measure the relative radial shortening and to adjust the rate of lengthening. The range of finger, wrist and elbow movement and neurological status were recorded pre-operatively, post-operatively, during distraction and at the latest follow-up. Pin care was limited to daily showers with antibiotics started immediately if there was any sign of pin-site infection. Distraction was performed until the radial wrist deviation was 0°. The monolateral external fixator was not removed until at least three of four bone cortices were seen on the radiograph to have achieved bony union. After removal of the external fixator a cast was applied for four weeks.

Outcome measurements. These included assessment of the healing index (the number of days required to gain 1 cm of healed bone), the residual angle of radial deviation, the presence or absence of complications, the final range of movement of the fingers, wrist and elbow, and patient satisfaction. Healing was defined as the presence of clinical and radiological union. Clinical union was defined as the resumption of activities of daily living without pain at the site of treatment and the absence of pain on stressing the forearm. Radiological union was defined as a minimum of three or four bridging cortices at the site of the skeletal defect.

Results

Clinical findings. At a mean follow-up of 4.5 years (2 to 12), all the patients had achieved bony union and were satisfied with the functional and cosmetic outcome (Fig. 2). The angle of radial deviation improved from a mean of 54° (30° to 75°) to 5° (0° to 10°). The mean length gained was 6.3 cm (3.8 to 8.2; Table I). Wrist mobility was painless and improved considerably in all patients. Flexion improved from a mean of 36.5° (30° to 45°) pre-operatively to 52° (40° to 80°) at the last follow-up, extension from 27° (20° to 35°) to 47° (30° to 60°), pronation from 52° (45° to 60°) to 79° (70° to 90°), and supination from 40° (20° to 65°) pre-operatively to 66.5° (45° to 85°) at final follow-up. Elbow and finger mobility returned to their pre-operative state, but grip strength was markedly improved. The mean healing index was 43 days/cm (30 to 51).

There was no recurrence of deformity, no refracture and no neurovascular injury.

Fig. 2a

Fig. 2b

Fig. 2c

Fig. 2d

A six-year-old girl presented with acquired radial club-hand deformity two years after haematogenous osteomyelitis because of lysis of the left radius. Radiographs showing a) radial angulation of approximately 35° and discrepancy between the radius and ulna of approximately 3.5 cm pre-operatively, b) Radiograph showing the application of the fixator and the osteotomy for lengthening two weeks after operation, c) bony union and correction of the deformity four months after operation, and d) at final follow-up four years after operation.

Table I. Details of the 13 patients

Case	Age (yrs)	Gender	Angle of radial deviation (°)		Target length (cm)	Length gained (cm)	Healing index (days/cm)
			Pre-operative	At latest follow-up			
1	5	M	42	5	4.9	5.5	45
2	6	F	35	0	3.5	4.3	41
3	8	M	57	5	5.6	6.0	30
4	10	M	70	7	6.9	7.1	48
5	15	M	75	10	8.0	8.2	43
6	6	F	48	5	5.8	6.4	39
7	9	F	64	5	5.9	6.3	47
8	7	M	50	0	5.7	6.5	38
9	4	M	30	0	3.0	3.8	43
10	10	F	62	10	6.3	6.8	49
11	8	M	57	5	6.7	7.0	39
12	5	F	46	8	5.8	6.5	51
13	11	M	66	5	7.3	7.5	46
Mean	8		54	5	5.8	6.3	43

Complications. Superficial pin infection which required treatment with oral antibiotics and local pin care occurred in six patients. There were no deep infections and no recurrence of osteomyelitis. Cancellous bone grafting for delayed union at the docking site was required in three patients after three months, all of whom proceeded to union. The mean angulation at the docking site was 5.8° (2° to 15°) in seven patients.

Discussion

Acquired radial club-hand deformity after haematogenous osteomyelitis is not common and surgical correction is challenging.

Treatment by cancellous bone graft and plating, combined with ulnar shortening, interposition bone grafting, centralisation and creation of a one-bone forearm have

been reported.^{1,2} Malki, Wong-Chung and Hariharan⁴ reported a case of infected nonunion of the radius with extensive bone loss which was treated by a modified Hey-Groves procedure. At follow-up at three years, the patient had a cosmetically-acceptable one-bone forearm with a stable wrist and a good grip but no forearm rotation.

Recently, reconstruction of skeletal defects of the tibia and femur by bone transport using the Ilizarov technique has generated considerable interest,⁵⁻⁹ and its use in the forearm reported.⁷⁻¹⁰ Hosny¹⁰ described the use of the Ilizarov lengthening technique in 11 patients with forearm shortening due to a variety of causes with good results in eight.

In our study, we used callus distraction with a mono-lateral external fixator to treat acquired radial club-hand

deformity after osteomyelitis. At a mean follow-up of 4.5 years, all the patients had achieved bony union, improved appearance and function of the finger, wrist, and elbow.

Callus distraction in the forearm may cause damage to the neurovascular structures particularly in patients with scarring from osteomyelitis and previous failed operations. There was no evidence of neurovascular injury in any of our 13 patients. The healing index and overall rate of complications were similar to those of previous reports in which a circular fixator had been used.^{10,11} A monolateral external fixation system can provide stable fixation at the site of the osteotomy^{12,13} without the use of tensioned transfixion wires. Some authors consider that there is less risk of neurovascular damage when using a monolateral external fixator.¹⁴⁻¹⁶ Careful pre-operative planning of the insertion of the pin to correct angular and rotational deformity at the time of surgery allows multiplanar correction with a monolateral fixator.^{12,14,15,17,18} The device is well-tolerated by children and relatively simple to adjust. However, in complicated multiplanar deformity, the circular external fixator with the advantage of gradual correction of multiplanar angular deformity and length at the same time may be the better choice.

In our study, the target length required as measured by serial radiographs during distraction increased in all patients by approximately 0.2 cm to 0.8 cm by the end of distraction. This may have been a result of bone absorption at the docking site. Distraction was continued until the angle of radial deviation was zero.

We were fortunate that the distal radial growth plate was intact in all our patients and had not been damaged or destroyed by the previous osteomyelitis. As a result, there was no recurrence of deformity because of growth arrest at this site.

Pin-site infection requiring local treatment and oral antibiotics occurred in six patients. There were no deep infections or recurrence of osteomyelitis. Nonunion at the docking site occurred in three patients and required cancellous bone grafting. Angulation with a mean of 5.8° (2° to 15°) developed at the docking site in seven patients. This may have been because we did not insert more pins into the proximal radius to reduce the risk of damage to the radial

nerve and vessels or because the proximal radius was too thin to hold the pins. However, in 2004 we introduced a modified monolateral external fixator for forearm bone transport together with direct surgical exposure of the radial nerve before inserting the pins. This may improve our results in subsequent patients.

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