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Bone transport for the treatment of infected forearm nonunion

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ABSTRACT

Objective: The objective of this study was to evaluate the effectiveness of the treatment of infected forearm nonunion by bone transport.
Materials and methods: We retrospectively reviewed 16 patients with infected forearm nonunion treated by bone transport. Our study included 10 males and 6 females with a mean of age 38.25 years. The site of bone defects involved 9 radius and 7 ulna. The average length of the bone defects after radical debridement was 3.81 cm (range 2.2–7.5 cm).
Results: The mean follow-up after removal of the frame was 39.63 months (range 26–55 months). No patient was lost to follow-up. All the patients had bone union and no recurrence of infection was observed. The mean external fixation time was 6.19 months (range 3–10 months), and the mean external fixation index was 1.63 months/cm (range 1.14–2.00 months/cm). The mean degrees of wrist flexion were 49.69° (range 45–55°), and the mean degrees of wrist extension were 50.63° (range 40–60°). The mean degrees of elbow flexion were 143.12° (range 135–150°), and the mean degrees of elbow extension were 4.69° (range 0–20°). The mean degrees of forearm pronation were 82.50° (range 70–90°), and the mean degrees of forearm supination were 83.75° (range 75–90°).
Conclusion: Our study suggested that bone transport in the treatment of infected forearm nonunion acquired satisfied functional results. Radical debridement is the key step to control bone infection.

Introduction

Infected forearm nonunion is rare in clinical practice, but the problem is usually very complex on account of the presence of segmental bone loss, bone necrosis, fracture instability, sinus tract formation, and scar adhesion of the soft tissue [1–3]. To date, the treatment of infected forearm nonunion has still been a challenge for orthopaedic surgeons [1–7]. Some different modalities of treatment have been described, but the results of the treatment are not completely satisfying. Corticocancellous bone grafting or a non-vascularized fibular graft has a limitation of the size of bone defects, which is only suitable for the treatment of bone defects <6 cm [8,9]. Although massive bone defects >6 cm can be managed with a vascularized fibular graft, the treatment is often complicated by a low rate of primary union and a high rate of infection and thrombosis [10,11].

Bone transport has been successfully used in lower limbs, being less invasive and more versatile compared to other methods, and it can treat infected nonunion with bone defects of any length. However, there are seldom reports about infected forearm nonunion treated by bone transport. Therefore, we describe our successful experience in the treatment of infected forearm nonunion by bone transport.

Patients and methods

Between January 2004 and January 2011, 22 patients with infected forearm nonunion were treated in our institution. Our eligible criteria were: (1) patients treated by bone transport, (2) patients ≥18 years of age, and (3) patients without an associated neurological impairment of the ipsilateral upper extremity. Sixteen patients were included in our study.

Our study included 10 males and six females with an average age of 38.25 years (range 19–62 years). The mechanisms of initial injury included traffic accident in 10 patients, falling in four

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patients, and injuries by machines in two patients. The site of bone defects involved nine radii and seven ulnae. Infected forearm nonunion existed at the time of surgery and the mean number of previous operations was 2.38 (range 1–5 operations). The mean length of bone defects was 3.81 cm (range 2.2–7.5 cm), which was measured in the operation. Infecting samples that were obtained from purulent drainage or deep bone at the site of infected nonunion were cultured and the outcomes were 11 patients with infecting organism of *Staphylococcus aureus*, three patients with *Pseudomonas*, one patient with *Escherichia coli*, and one patient with *Klebsiella*. Further details were listed in Table 1.

Surgical technique

The patients were positioned laterally on a radiolucent table. The operative incisions were performed in accordance with previous surgical incisions when possible. Then the infected scarred soft tissue and necrotic bone were debrided radically. Cortical bone bleeding, described as the so-called paprika sign, was accepted as an indication of vital tissue [12]. Representative tissue cultures were obtained from infected tissue for the sake of finding out the infectious bacterium to choose sensitive antibiotics. Two pins were inserted about 2–3 cm above and below the preselected osteotomy site under an image intensifier control. A 1–2-cm incision was made in order to expose the preselected osteotomy site, and then a subperiosteally transverse osteotomy was performed. The periosteum was sutured and the incisions were closed with drainage tubes. If the infected site had large soft tissue defects, open dressing changing or vacuum sealing drainage (VSD) were performed to close the wound.

Postoperative protocol

All patients received a course of sensitive antibiotics for 2–4 weeks intravenously and were encouraged to perform isometric muscle motions such as pushing a wall and joint range-of-motion exercises on the second day after the operation. Distraction was performed at the rate of 0.25 mm per 6 h after the latency period of 7–10 days. If the regeneration quality were poor, the speed of distraction would slow down. When bone transport was completed, the radius or ulna docked ends were compressed by 0.25 mm per day in order to provide full contact until the patient felt pain at the docking site.

Radiographs were reviewed every 2 weeks during the distraction period and monthly during the consolidation period. The monolateral external fixator was removed when the radiographs showed solid docking-site union and the regenerated area had a minimum of three complete cortices. The flexion and extension of the wrist and elbow joint and the pronation and supination of forearm were evaluated at the end of follow-up.

Results

The mean follow-up after removal of the frame was 39.63 months (range 26–55 months). No patient was lost to follow-up. All the patients had bone union and no recurrence of infection was observed. The mean external fixation time was 6.19 months (range 3–10 months), and the mean external fixation index was 1.63 months/cm (range 1.14–2.00 months/cm). The mean degrees of wrist flexion were 49.69° (range 45–55°), and the mean degrees of wrist extension were 50.63° (range 40–60°). The mean degrees of elbow flexion were 143.12° (range 135–150°), and the mean degrees of elbow extension were 4.69° (range 0–20°). The mean degrees of forearm pronation were 82.50° (range 70–90°), and the mean degrees of forearm supination were 83.75° (range 75–90°). Further details are listed in Table 2 (Fig. 1).

Complications

All the patients experienced pain during the distraction period and required oral analgesics. Ten patients had a pin-track infection (case 1, cases 3 and 4, case 6, case 9, cases 11–13, and case 16), and these patients presented with only local inflammation, which was treated by pin care and oral administration of empirical broad-spectrum antibiotics. Three patients required bone grafting at the docking site to obtain union (case 1, case 9, and case 15). Poor regenerated bone formation occurred in two patients (case 4 and case 11), who also required bone grafting to obtain union at last. One patient (case 2) had dislocation of the radial head, which was treated by reduction of the radial head and reapplication of an external fixator, and the patients had bone union at last (Fig. 2). There were no neurovascular complications or a compartment syndrome.

Discussion

This is a retrospective study of bone transport for the treatment of infected forearm nonunion. The present study showed that the infected forearm nonunion treated by bone transport acquired satisfying functional results. The motion ranges of the wrist, elbow,

Table 1
Characteristics of 16 patients with infected forearm nonunion.

Case number	Sex	Age (years)	Mechanisms of initial injury	Site of bone defect	Bone defect (cm)	Number of previous operations	Infecting organism
1	Male	62	TA	Radius	7.5	5	*Staph. aureus*
2	Female	38	TA	Ulna	4.4	2	*Staph. aureus*
3	Male	40	F	Radius	3.7	2	*Pseudomonas*
4	Male	28	TA	Radius	3.5	3	*Staph. aureus*
5	Female	30	TA	Radius	2.4	1	*E. coli*
6	Male	24	HM	Ulna	5	2	*Staph. aureus*
7	Male	19	TA	Ulna	2.2	1	*Staph. aureus*
8	Male	43	F	Radius	2.6	2	*Pseudomonas*
9	Male	41	TA	Radius	4.7	3	*Staph. aureus*
10	Female	54	F	Ulna	2.8	2	*Staph. aureus*
11	Female	32	HM	Radius	3.7	3	*Staph. aureus*
12	Female	29	TA	Ulna	3.5	2	*Pseudomonas*
13	Male	38	TA	Ulna	4	4	*Staph. aureus*
14	Male	50	TA	Ulna	3.3	1	*Staph. aureus*
15	Male	45	F	Radius	3.5	2	*Klebsiella*
16	Female	39	TA	Radius	4.2	3	*Staph. aureus*

F, falling; TA, traffic accident; HM, hurting by machine.