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Electrical treatment of non-united fractures

The semi-invasive technique for electrical stimulation of bone healing developed by Brighton et al. (1977) was used in 23 patients with nonunited fractures of the tibia (14 cases), humerus (4 cases), scaphoid, femur and fibula as well as one failed arthrodesis of the ankle. The fractures were clinically not healed and not operated on within a minimum of 6 months. The mean period from fracture to treatment was 18 months. Electrical stimulation led to solid bone healing in 10 cases. Two deep infections occurred during the treatment. Of 13 cases that did not unite, a great range of motion in the nonunion area was an obvious cause of failure in seven cases. The results in this series cannot compete with those of bone graft surgery for nonunions.

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Although it has not yet been possible to explain the exact mechanism by which electricity may enhance bone-healing, numerous reports have already been published concerning electrical treatment of fractures and nonunions (Jörgensen 1972, Bassett et al. 1978, Zichner & Happel 1979, De Haas et al. 1980, Khasigian 1980, Sharrard et al. 1982).

Several techniques for electrical stimulation, using either direct current (Brighton et al. 1977, Paterson et al. 1980) or pulsing electromagnetic fields (Bassett et al. 1977), are commercially available today. None of these systems has, to our knowledge, been shown to be more effective than any other. Using direct current, several authors have found that bone is formed in the vicinity of the cathode (Bassett et al. 1964, Friedenberg et al. 1970, 1974). Similar results, but significant only when calculating bone production by 85-Sr uptake, have recently been reported by Petersson et al. (1982).

The purpose of this prospective study was to investigate the possibility of using constant direct current in the treatment of nonunions.

Patients and methods

Patients

This study included fractures clinically not healed and not operated on within a minimum of 6 months. No radiographic signs of progressive healing during the preceding 3 months were allowed. Femoral neck fractures, pathological fractures and congenital as well as synovial pseudarthroses, defined by decreased bone formation in the nonunion gap revealed by bone scintigraphy (Desai et al. 1980), were excluded. Active infections at the nonunion site were considered a contraindication.

The series comprised 23 patients with an average age of 43 (18–70) years (Table 1). Only four of the tibial fractures were initially treated with closed reduction and plaster cast, while in seven cases external fixation was used and in three internal fixation. The fracture of the femur was initially treated with skeletal traction. Plaster casts were used for the fractures of the upper extremity. Only three of the nonunions were originally open fractures. Three patients had a history of previous deep infection but at the start of the treatment none of them had any sign of infection. Four nonunions had been operated on previously, two of them twice, in unsuccessful attempts to achieve bone healing.

Method

We have used the semi-invasive technique for electrical stimulation, developed and described by Brighton et al. (1977). Under local or general anesthesia, 2–4 teflon-coated Kirschner wires, acting as cathodes, were inserted into the nonunion area. The positions of the cathodes were radiographically controlled to ensure that the bare tips of the cathodes were safely placed into the nonunion gap and were not in contact with one another or with other metallic devices. The anode was placed on the skin, and a

Table 1. Locations and duration of nonunion and results of electrical treatment

Location	Mean duration months	Treated n	Healed n
Humerus	15	4	0
Scaphoideum	15	2	1
Femur	30	1	0
Tibia	18	14	7
Fibula	18	1	1
Ankle, failed arthrodesis	18	1	1

Mean duration = 18 (7–43) months.

small portable battery (supplied by Zimmer Corporation) delivered a constant direct current of 20 μA per cathode regardless of any change in resistance.

The period of electrical stimulation was 12 weeks. No patient was treated for more than one period. During electrical treatment the patients were routinely seen at the out-patient department once a month.

Nonunions of the lower extremity were immobilized in a non-weight-bearing plaster cast, and the patients were all strictly admonished not to put weight on the leg during the entire 12-week period. After that period, they received a weight-bearing cast. Nonunions of the scaphoid were immobilized in a cast below the elbow. The nonunions of the humerus were in one case immobilized in a thoraco-brachial cast and in three cases with a Hoffmann external fixator.

Results

Out of 23 patients treated, solid bone union was achieved in ten (Table 1). The healing time, defined as the time from when electrical treatment started until the end of fixation was: two nonunions were healed within 3 months, five within 4–6 months, one within 9 months, while the last two did not heal until about 1 year after the electrical treatment had started.

One patient, with a nonunion classified as not healed, was lost at follow-up after 4 weeks of treatment. Minor complications such as superficial skin irritation and broken or dislocated Kirschner wires, either during the operation or in the period of electrical treatment, were observed in nine cases, but only in one case did that influence the electrical treatment, reducing it to 8 weeks. Two serious complications were observed. In one case of tibial nonunion with a previous history of deep infection, the infection recurred during the last week of electrical treatment. The other major complication was a deep infection after 9 weeks of treatment in one patient with a nonunion of the scaphoid bone without any previous history of infection.

Discussion

Due to the variety of nonunions as far as location, duration, previous treatment etc. is concerned, the finding of comparable controls is a difficult task. Such a study, although of great interest, would be very difficult to accomplish, even if carried out on a multicentre basis. The definition of nonunion is difficult; the healing potential of the tibia, for example, is difficult to predict (Edwards & Nilsson 1965). Six months minimum observation and 3 months without radiographic changes were felt to be sufficient. However, it is not wholly unlikely that some nonunions might have healed anyway, regardless of treatment, during the time they participated in this study.

Electrical treatment of nonunions must be compared with the rate of healing achieved by bone-graft surgery. Boyd et al. (1961) reported a success rate of 94 per cent when treating 842 nonunions with one to four bone graft procedures; the average duration of nonunion was 8.5 months (Boyd & Lipinski 1960). ZumBrunnen & Brindley (1968) reported a healing rate of 85 per cent in 122 bone-grafted nonunions. Brighton et al. (1981), at the University of Pennsylvania, achieved a success rate of 84 per cent when treating 178 nonunions (mean duration 2.7 years) with constant direct current one to five times. In the same paper a multicentre study including 12 participating clinics was presented. Of 80 nonunions treated once (mean duration 3.3 years) a healing rate of 73 per cent was reached. Connolly (1981) reported a success rate of 69 per cent when treating 49 selected nonunions (mean duration 16 months) with direct current.

Electrical treatment of nonunions with constant direct current has in our hands been considerably less successful, with a healing rate of 10 out of 23 nonunions. In agreement with

most other reports, we have found that nonunions of the tibia are most likely to heal, while nonunions of the humerus remain problematic. All four of our nonunions of the humerus were very mobile, although none of them had a fracture gap exceeding half the diameter of the bone, a crucial distance according to many authors (Brighton et al. 1981, Sharrard et al. 1982). Neither did they show signs of synovial pseudarthrosis on bone scintigraphy. In three of the eight nonunions of the lower extremity that did not heal, a great range of motion was present as well. Probably a great range of motion in itself makes these nonunions unsuitable for electrical stimulation.

Twelve weeks of electrical treatment was surprisingly well tolerated by the patients. We had no clinically-diagnosed deep vein thrombosis and except for two deep infections, one of them a recurrence of a previous deep infection, no serious complications arose.

It has been emphazised in other papers that non-weightbearing is essential not only to avoid dislocation of the Kirschner wires but also for the process of healing. This is not in agreement with our experience. Out of five patients who were uncooperative as far as weightbearing was concerned, four of whom had nonunions of the tibia, three healed while two did not.

Even though the number of patients in our study was limited, it is obvious that electrical treatment in our hands has not been sufficiently successful to compete with bone graft surgery as the standard procedure for nonunions.

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