BIODEGRADABLE RODS VERSUS KIRSCHNER WIRE FIXATION OF WRIST FRACTURES

A RANDOMISED TRIAL

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In a prospective trial, biodegradable polyglycolic acid rods were compared with Kirschner wires for fixation of wrist fractures (Frykman types I, II, V and VI). Fifteen patients were randomly assigned to each treatment group. There was no significant difference between the groups with regard to age, sex ratio and fracture type. Kapandji's pinning technique was used in all cases. There were no significant differences in the results obtained in both groups at final follow-up. At three months and six months the functional results of the Kirschner-wire group were, however, significantly better ($p < 0.05$), due to numerous transient complications from foreign-body reactions to the polyglycolic acid rods.

The use of polyglycolic acid rods is therefore not recommended for the fixation of distal radial fractures.

Metal implants used for osteosynthesis have often to be removed once the fracture has united. This has prompted research into fracture fixation devices which are biodegradable. Polyglycolic acid (PGA) rods have been in clinical use for some years (Rokkanen et al 1985) but in most cases fracture fixation did not depend only on the rods, but was supplemented by a cast. Early joint mobilisation, one of the classical advantages of stable osteosynthesis, was not therefore possible (Hirvensalo 1989). Only two randomised studies have compared bio-absorbable with metal implants (Böstman et al 1987; Hope et al 1991).

We report a randomised, prospective study of wrist fractures fixed with PGA rods or Kirschner (K) wires without cast immobilisation.

PATIENTS AND METHODS

From November 1989 to August 1990 30 consecutive patients with wrist fractures of the Frykman (1967) types I, II, V or VI were entered into the trial. Informed consent was obtained before inclusion in the study.

All the fractures were closed and the patients had no

other injuries. Randomisation to either PGA-rod or K-wire treatment was made using sealed cards; 15 patients were allocated to each group.

All patients were operated on under general or regional anaesthesia. Table I shows the clinical details.

Table I. Details of 30 patients with wrist fractures

	K-wires	PGA rods
Age (yr) (range)	58.2 (23 to 85)	64.3 (22 to 82)
Female:Male	11:4	12:3
Cause		
Fall	11	14
Traffic injury	2	1
Sports injury	2	0
Left:right	9:6	10:5
Dominant hand affected	7	7
Fracture type (Frykman)		
I or II	9	9
V or VI	6	6
Anaesthesia		
General	11	13
Local or regional	4	2

Operative technique. The fractures are reduced by axial distraction on a fracture table with finger traps on the index and middle fingers, and on the thumb, in abduction. Counter-traction is applied by a post against the distal humerus, the elbow being flexed to 90°.

The fractures are pinned percutaneously using Kapandji's (1976) technique. Under fluoroscopic control, a 2 mm diameter K-wire is introduced through a small dorsal stab incision into the fracture gap perpendicular

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Fig. 1

Anteroposterior and lateral radiographs of K-wire Kapandji pinning of a Frykman type II fracture.

to the long axis of the bone. The pin is rotated until it is tangential to the distal fragment. It is then advanced in a proximal direction and drilled through the opposite cortex of the shaft of the radius. The same procedure is repeated from the lateral side of the radius. Both wires are then cut, with their distal ends left protruding a few millimetres beyond the cortex and lying against the metaphysis. They are buried under the skin and each stab incision is closed by a single stitch.

The K-wires do not transfix the distal fragment but support it like buttresses, or a basket, preventing dorsal and lateral displacement (Fig. 1).

A similar technique is used with the PGA rods (Biofix R: Cyanamid, Fareham, England). Holes have to be predrilled, however, as the rods have blunt ends. The drilling is first performed with a 2.5 mm K-wire, and enlarged by a 3.2 mm drill. The depth of the drill hole is measured so that PGA rods of the right length can be selected. The rods are never cut or shortened. The two 3.2 mm PGA rods are gently tapped home with an applicator sleeve and a mallet.

The rods are more difficult to use than the K-wires because of their radiolucency and the need for predrilling. No cast was applied in either group and patients were encouraged to move their wrists freely from the first postoperative day.

All K-wires were removed after six weeks, under local anaesthesia and without admission to hospital.

Evaluation. The patients were examined clinically and radiologically on the first postoperative day and after 1, 3, 6 and 12 months. A five-grade functional score was used to assess the results (Table II) based on the subjective opinion of the patient, the range of motion and the degree of swelling and deformity of the wrist.

The accuracy of reduction and the degree of consolidation were evaluated from anteroposterior and lateral radiographs. The angle between the articular

Fig. 2

Mean functional scores of K-wire and PGA treated groups postoperatively (0) and after 1, 3, 6 and 12 months. The differences are significant at three months and at six months ($p < 0.05$).

surface and the long axis of the radius was recorded in both planes. The relative lengths of the radius and ulna (radio-ulnar index) were measured on the anteroposterior radiograph.

Statistical evaluation of the data was performed using the *t*-test, the paired *t*-test and the Mann-Whitney U test.

RESULTS

Statistical analysis showed no significant differences preoperatively between the two treatment groups (Table I).

One patient in each group died more than six months postoperatively from causes unrelated to the wrist fracture. One patient in each group failed to attend the one-year follow-up. Both were interviewed by telephone and reported complete functional recovery with no residual disability.

All the fractures united and all the patients achieved either complete functional recovery (grade 1) or incomplete functional recovery with no restriction of daily living skills (grade 2).

The recovery was faster in the K-wire group than in the PGA group with significantly better functional scores ($p < 0.05$) at three and six months. The final scores showed no significant difference (Fig. 2).

The range of motion at one year was satisfactory in both groups and there was no statistical difference between them (Table III).

The radiographs showed a slight but significant ($p < 0.01$) loss of reduction in the K-wire group between the first postoperative day and the one-year follow-up. This was also observed in the PGA group, but statistical significance was not reached due to the broad range of the values. The final anatomical results were satisfactory

Fig. 3

Radiological evaluation of osteolysis around PGA rods at day 1 and 1, 3, 6 and 12 months, showing its appearance at 3 months progressive resolution at and after one year.

Table II. Functional grading based on subjective assessment and objective evaluation

	Grade
Complete functional recovery	1
Incomplete functional recovery No restriction of daily living skills	2
Moderate restriction of daily living skills and leisure activities	3
Severe restriction of daily living skills and leisure activities	4
Complete functional loss	5

Table III. Range of motion (degrees; mean $\pm$ SD) one year postoperatively in the two treatment groups

	K-wires	PGA rods
Dorsal extension	53.8 $\pm$ 13.7	55.0 $\pm$ 18.5
Volar flexion	63.1 $\pm$ 13.0	53.1 $\pm$ 17.9
Radial deviation	20.4 $\pm$ 5.6	23.1 $\pm$ 7.2
Ulnar deviation	20.8 $\pm$ 6.1	19.2 $\pm$ 7.9
Pronation	86.1 $\pm$ 8.7	86.9 $\pm$ 4.3
Supination	86.1 $\pm$ 5.5	85.0 $\pm$ 7.6

in both groups: there was no statistical difference between them (Table IV).

Complications. In the K-wire group two patients presented after four weeks with ruptures of the extensor pollicis longus tendon caused by the protruding pins. Both were treated by tendon grafting and achieved a grade 1 functional result, with satisfactory thumb motion and strength. In the same group, one patient developed reflex sympathetic dystrophy which had completely resolved at one year.

Complications were more frequent in the PGA group and were all related to the degradation and resorption of the PGA rods. After uneventful wound healing and progressive fracture consolidation, seven patients developed painful, erythematous, fluctuant swellings around the dorsal and/or lateral wound scars. This complication occurred between eight and 18 weeks postoperatively. In six of these patients a sinus formed and only closed after four to six weeks. Bacteriological cultures of the drainage fluid were all negative. Histological examination, performed in one patient, showed a non-specific foreign-body reaction with abundant giant cells.

Two other patients developed carpal tunnel syndrome from swelling around the volar extremity of a PGA rod introduced from the dorsum. Surgical de-

compression was necessary to relieve the symptoms in one but in the other the pain resolved spontaneously.

The radiological follow-up revealed severe osteolytic reactions around the rods in nine of the 15 patients in the PGA group. This was most obvious between three and six months, and had regressed or disappeared at one year (Fig. 3). Osteolysis was seen in both patients with carpal tunnel syndrome and in five of the seven who developed swellings. Milder degrees of osteolysis were seen in two wrists which did not have subcutaneous fluid accumulation. The mean age of the PGA-treated patients with fluid accumulation and/or osteolysis was 67.2 years (55 to 82) and did not differ significantly from the mean age of those without this complication (56.5 years: 22 to 74).

Fluid accumulation and osteolysis did not influence the final functional or anatomical result.

DISCUSSION

Our study has shown that the functional and anatomical results of biodegradable implants can equal those of K-wire fixation in wrist fractures.

The complications of K-wire fixation reported in this series are typical of the Karpandji technique in which the extensor pollicis tendon seems to be at risk. The number of extensor pollicis longus lesions was, however,

Table IV. Anatomical result evaluated by radiographs one year postoperatively in the two treatment groups (mean $\pm$ SD)

	K-wires	PGA rods
Anteroposterior radial angle	19.8° $\pm$ 4.8°	20.9° $\pm$ 3.0°
Lateral radial angle	2.9° $\pm$ 6.0°	3.8° $\pm$ 11.5°
Radio-ulnar index (mm)	-1.1 $\pm$ 2.5	-1.1 $\pm$ 2.7

unusually high in this series and compares poorly with our previous experience of two lesions in more than 100 wrist pinnings and with an incidence of 1.9% reported by Peyroux et al (1987).

The numerous complications in the group treated by PGA rods are all related to the degradation and resorption of the material and can be attributed to foreign-body and immune reactions to PGA (Böstman et al 1990; Santavirta et al 1990). Reactions of this type have been reported in 5% to 25% of cases so treated, depending on the anatomical location of the fracture (Böstman et al 1990).

The patients' age and the volume of PGA may both influence the appearance of these complications. A study of elbow fractures in young children treated by small 2 mm diameter PGA rods revealed no osteolysis (Hope et al 1991). The ends of the rods which protrude from the bone subcutaneously in the Kapandji pinning technique may have increased the problem of fluid accumulation in our series.

Böstman (1991a, b) interpreted osteolysis as a sign of increased intra-osseous pressure exerted by the liquid polymeric debris retained in a drill channel open only at one end and he suggested perforation of the cortex at both ends. This hypothesis is invalidated by our observation of osteolysis in 60% of our cases, in all of which the drill channels perforated both cortices.

The main theoretical advantage of biodegradable implants is the avoidance of the need for implant removal. The cost of PGA rods is more than 20 times that of K-wires, however, and the management cost and inconvenience of the late inflammatory reactions more

than offset the disadvantage of K-wire removal under local anaesthesia in the out-patient clinic.

Conclusions. This prospective randomised study showed no significant difference between the final functional and anatomical results of wrist fractures pinned with PGA rods or K-wires.

The high complication rate in patients treated by PGA rods, however, means that we cannot advocate their use for Kapandji wrist pinning.

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