

From the Department of Surgery, College of Veterinary Medicine and Small Animal Clinic MEVET, Helsinki, Finland.

The Use of Biodegradable Implants in the Fixation of Small Animal Cancellous Bone Fractures

By P. Axelson, J. Rähkä, K. Sittnikow, K. Skutnabb, M. Mero, S. Vainionpää, P. Törmälä and P. Rokkanen

Axelson, P., J. Rähkä, K. Sittnikow, K. Skutnabb, M. Mero, S. Vainionpää, P. Törmälä and P. Rokkanen: The use of biodegradable implants in the fixation of small animal cancellous bone fractures. *Acta vet. scand.* 1988, 29, 469-476. - In this study the cancellous bone fractures of 10 dogs and 2 cats were surgically treated with biodegradable implants to fixate the fractures. The implants were made of selfreinforced PGA homopolymers. The patients were allowed to walk on their operated limbs immediately after the fixation and they started to use them within one week. All patients except one used their operated limbs without lameness in 6 weeks and the twelfth case in 8 weeks, due to a postoperative periosteal infection. Radiographically, the fractures of 10 patients healed in 6 weeks and in 12 weeks in 2 cases. No other pathological reactions in the bone could be seen in the radiographs than the periosteal infection. Because the implants resolved spontaneously there was no need for a second operation to remove them.

dog and cat; orthopaedics; traumatology.

Introduction

Although the surgical treatment of fractures by internal or external metallic devices has improved during the last few decades, this method still has some disadvantages.

The elasticity factor (Young's modul) of metal is 5-10 times greater than that of the bone (Tonino *et al.* 1976, Åkeson *et al.* 1976, Paavolainen *et al.* 1978). If the metallic fixation implant is too rigid osteoporosis and decreased new bone formation will occur in the fracture site due to the lack of natural physical stimulation (micromotion) of the bone, which increases the risk of refracture after the removal of the implant (Brinker *et al.* 1984). Metallic implants will sometimes loosen before the fracture has healed, and infections around the implants

have often been reported (Cochran *et al.* 1969, Uthoff & Dubuc 1971, Slätis *et al.* 1987).

Professors Rokkanen and Törmälä and their team initiated researches to develop biodegradable implants for fracture fixations (Törmälä *et al.* 1984). The principal technique of making these implants is to melt-mould or sinter poly-glycolic acid (PGA) fibres and a matrix of the same polymer under pressure at elevated temperatures into rodshaped implants (biorods) of different diameters and lengths (Biofix[®]).

The mechanical and chemical properties of these biorods were tested by Törmälä, Rokkanen and Vainionpää and their team. They showed that the initial flexural strength of the selfreinforced PGA biorod was about 20

times greater than that of cancellous bone and was decreased to the same level in 4 weeks (Törmälä et al. 1984 and 1987).

The studies of the biodegradation and the bone compatibility of this biorod showed that the biodegradation started peripherically and was subsequently replaced by new bone. The surrounding bone tissue showed neither inflammation nor foreign body reaction (Vainionpää et al. 1986).

The first clinical study with these biorods was made by Rokkanen. Forty-four patients with displaced malleolar fractures, type Weber A or B were divided randomly into 2 groups. One was treated with conventional metallic implants and the other with biorods (Rokkanen et al. 1985).

Later on a similar study was made of Weber fractures of 56 patients with a follow up of at least 1 year. (Böstman et al. 1987). There were no differences in the healing processes between the 2 groups.

The first fracture fixation with this biodegradable implant in veterinary clinical surgery was performed by Axelson in 1986 (Axelson et al. 1988).

Materials and methods

The material in this study consisted of 10 dogs and 2 cats. They were ordinary clinical patients, each with a cancellous bone fractures presented to the clinics during a period of 1 year. fractures suitable for this study had to be simple and closed cancellous bone fractures not older than 2 days. 82% of the cancellous bone fracture cases came up to these requirements.

All the patients were under 1 year of age. The dogs had an average age of 5.5 months and the cats 4 months. The average weight of the dogs was 6.2 kg (1–12) and 1.5 kg (1–2) of the cats.

Clinical findings

The general condition of the patients was

determined at their arrival to the clinic and their condition was normalized before surgery. All cases had a fourth degree (on the scale of 0–4) lameness of one limb. The site of the fractures were painful and swollen. Clinical instability could be found in all fractures.

Radiographic findings

All patients were radiographed in sedation. At least 2 radiographs were taken in 2 perpendicular directions (ant-post and med-lat). All fracture lines were clearly visible although only 1 fracture showed complete dislocation. The rest of the fractures were angulated or slightly dislocated.

Diagnoses

The following diagnoses were made on the basis of the clinical and the radiographic findings: A fractured lateral condyle of the distal humerus of 1 dog, a fractured olecranon of 1 cat, a supracondylar fracture of the distal femur of 1 dog and 1 cat with a proximal femoral fracture, a fractured proximal tibia of 6 dogs, a fractured calcaneus of 1 dog and a fractured phalanx of 1 dog (Table 1).

The drills and the biodegradable implants (biorods) of suitable sizes were chosen on the basis of the previous radiographs (Biofix[®], Table 1).

Surgery

Operations were performed with a steril set of orthopedic instruments including drills of A-O standards. The biorods have the same diameters as the normal drills of A-O standards. A special instrument was utilized to insert the biorod into the drilled channel because the biorod would stick to the wall of the channel very quickly and it might split when hit by a hammer in an abaxial direction (Fig. 1).

Table 1. The cases used in this study.

No.	Species	Age (month)	Weight (kg)	Implant	Diagnoses
1.	Dog	8	5	small	Fract. cond. lat. os hum. dx
2.	Cat	7	2	small	Fract. oleocrani sin.
3.	Dog	8	12	medium	Fract. supracond. os fem. dx.
4.	Cat	1	1	large	Fract. supracond. os fem. dx.
5.	Dog	4	8	medium	Fract. os tibiae prox. sin.
6.	Dog	5	10	large	Fract. os tibiae prox. dx.
7.	Dog	6	4	small	Fract. os tibiae prox. dx.
8.	Dog	4	2	small	Fract. os tibiae prox. dx.
9.	Dog	6	1	mini	Fract. os tibiae prox. dx.
10.	Dog	5	8	small	Fract. os calcanei dx.
11.	Dog	5	10	mini	Fract. os phalangi I dig. 2
12.	Dog	4	2	small	Fract. os tibiae prox. sin.

Sizes of Biofix®:

Large: 4.5 mm × 70 mm

Medium: 4.5 mm × 50 mm

Small: 3.2 mm × 50 mm

Mini: 2.0 mm × 30 mm

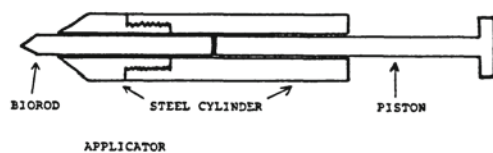


Figure 1. Schematic picture of the special instrument to insert the biorod into the channel.

The fractures were fixated after reducing the fragments. A channel was drilled crossing the fracture line in accordance with treatment standards for fracture fixation in small animal orthopaedics (Bojrab 1983, Brinker *et al.* 1983). Efforts were made to align the midpoint of the biorod in the fracture line to give equal support to both fragments. In 2 cases the fixation was secured with an osteosuture of PGA (Dexon®; 2-USP) to neutralize muscular pull (Fig. 2 a and 3 a).

Postoperative proceedings

Postoperatively the operated limb was supported by a s. c. Robert Jones bandage with-

out any splinting for 1 week. After this the patients were allowed to walk freely on their operated limbs.

Clinical and radiographic controls were made 1, 3, 6 and 12 weeks after the operation. The clinical examination included the estimation of the lameness and the swelling (edema) of the operated area. The angulation and the dislocation of the fragments were evaluated from the radiographs. Furthermore, the fracture line, the callus formation, the bone radiodensity around the implant and the visibility of the drilled channel and the outlines of the implant were estimated from the radiographs. Possible signs of degenerative joint disease in the neighbouring joint(s) were recorded.

Results

Clinical results

All patients started to use their operated limbs during the first postoperative week. Within 6 weeks all patients except 1 could

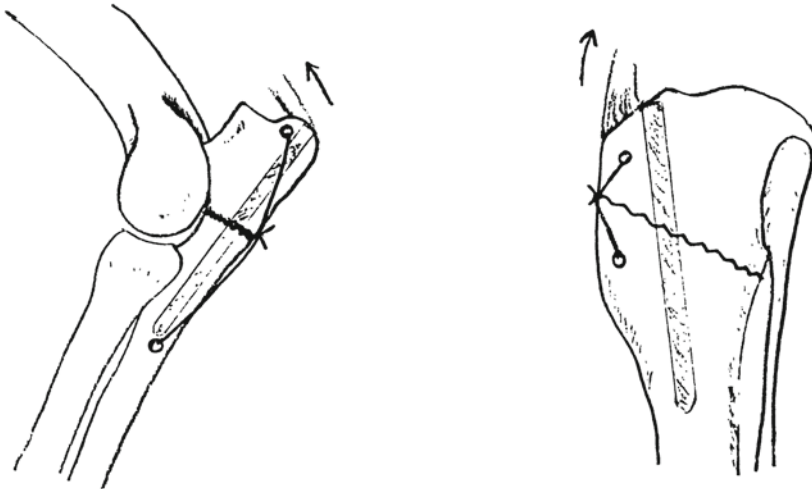


Figure 2. Schematic pictures of a fractured olecranon of a cat (a) and a fractured proximal tibia of a dog (b).

walk without lameness and the fractures were clinically healed (92%). The edema of the operated area was gone within 6 weeks after surgery in 11/12 patients (92%). The twelfth case, with a postoperative periosteal infection, showed no lameness after 8 weeks' treatment with antibiotics, but the swelling of the operated area was still prominent.

Radiographic results

Radiographically no angulation nor dislocation was seen between the fragments in 10/12 cases (83%). Two cases of proximal tibial fractures showed an angulation of 5–10 degrees between the fragments 3 weeks after the fixation. Radiographically the fracture lines disappeared in all cases between 6 and 12 weeks. Callus formation could be seen in all cases 3 weeks after the operation. The radiodensity of the bone surrounding the implants decreased during the first 3 weeks in 9/12 patients (75%) and increased in 10/12 patients (83%) even above normal bone radiodensity during the following 3 weeks. The occasional radiolucency of the drilled channels disappeared within 3 weeks. No other signs of pathological reactions in

the fracture lines or in the surrounding bone tissue could be verified than the periosteal infection mentioned above. The radiographic healing of the fractures was apparent in 6 weeks in 9/12 patients (75%) and in 12 weeks in 3/12 patients (25%). No changes indicating secondary degenerative joint disease could be seen in the nearby joints.

Discussion

The postoperative evaluations were made as required in the *Manual of Internal Fixation in Small Animals* (Brinker *et al.* 1984). The fractures fixated in this study were all closed or simple ones with only 2 fragments to minimize the risk of secondary complications. This selection was considered to be necessary because the study was the first clinical application of biodegradable implants. The operative treatment followed the adaptation technique described in the same manual with the difference that only selfreinforced PGA biodegradable rods (Biofix®) were used instead of nails and Kirschner wires made of metal.

The clinical results in this study agreed with those of similar fracture fixations made with

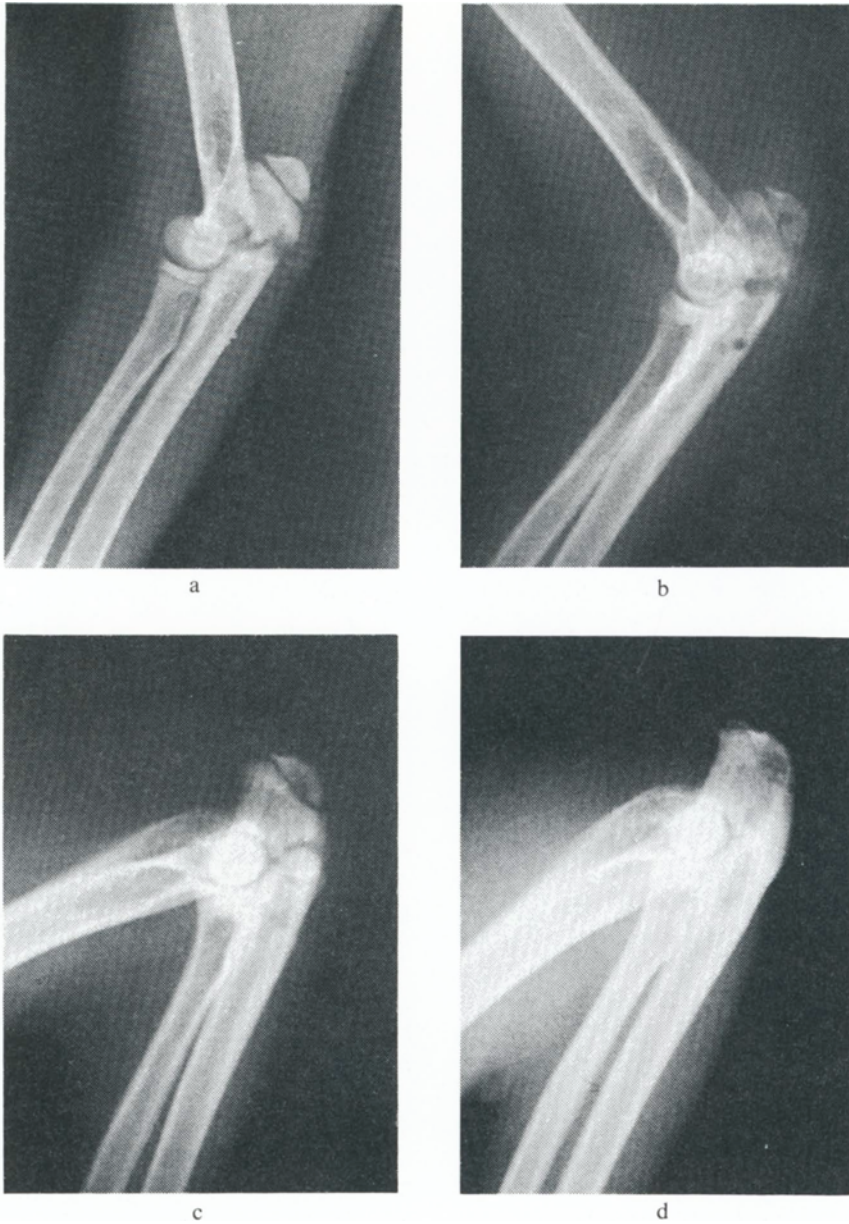


Figure 3. Radiographs of a fractured olecranon of a cat, preoperative (a), third week control, note the holes of the osteosuture (b), sixth week control (c) and twelfth week control (d).

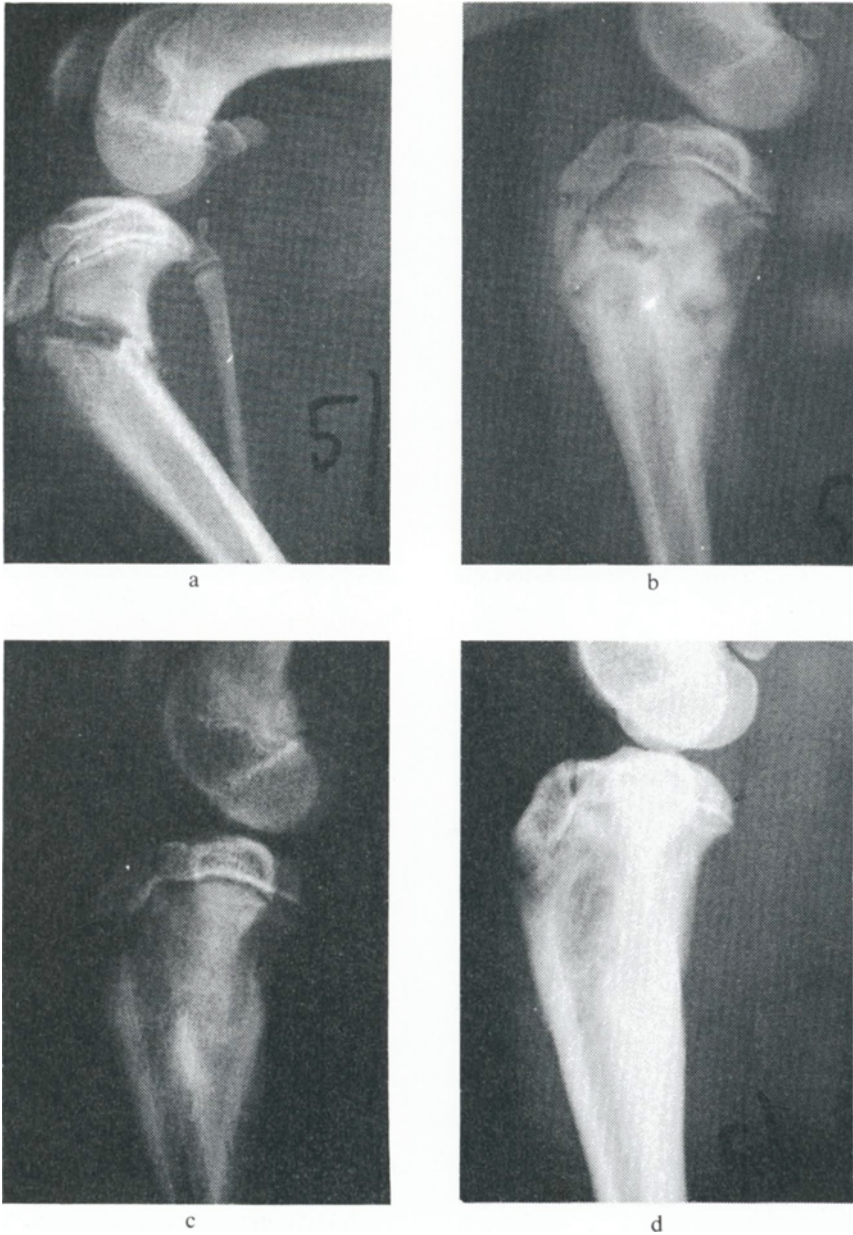


Figure 4. Radiographs of a fractured proximal tibia of a dog, preoperative (a), third week control (b), sixth week control (c) and twelfth week control (d).

metal pins explained in the handbook of Small Animal Fractures (Brinker 1978).

Radiographically, the fractures healed by secondary bone union. The callus formation and the disappearance of the fracture lines were in accordance with the terms of secondary bone healing (Brown 1981). The biodegradable implants immobilized the fragments sufficiently not to cause delayed or nonunion of the fractures (Hoesfle 1981). Despite that they allow increasing micro-movement to the fracture, which is beneficial to bone healing. This is due to the fact that the bending strength of the bone is equal to that of the biorods after four weeks in living tissue (Vainionpää 1987).

The advantage of this biodegradable implant fixation technique is that no secondary operation is needed to remove the implants as it is necessary when using metal implants (Brinker et al. 1984).

The use of biodegradable implants made of PGA is advisable in fractures which are supposed to be stable in 3 weeks and healed in 6 weeks, as in cancellous bone and physal fractures. In diaphyseal fractures this device will biodegrade too quickly but the team led by Rokkanen and Törmälä has developed a new implant made of poly-lactic acid (PLA), which will last for 12 weeks in bone tissue. This device is made in the shape of an intramedullary nail and a screw. Experimental and clinical studies are being made of these PLA implants and the results will be presented in the near future.

In this selected material biodegradable implant fixation was equally useful as the metal implant method, but further studies are needed to specify the use of biorods in different cancellous bone fractures.

Conclusions

The biodegradable implants made of polyglycolic acid homopolymers (PGA) are sui-

table for cancellous bone fracture fixations in young cats and dogs. The biodegradable implants used in this study met all the requirements of fracture fixation implants mentioned in the list made by Association for the Study of Internal Fixation (ASIF).

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Sammanfattning

Fixering av spongiösa benfrakturer hos hund och katt med hjälp av resorberbara implantater.

I dette kliniska arbete fixerades spongiösa benfrakturer med resorberbara implantater gjorda av polyglykolsyra hos 10 hundar och 2 katter. Patienterna fick omedelbart gå fritt på det opererade benet efter operationen. Alla patienter stödde på det opererade benet inom 1 vecka efter operationen. Elva av de 12 patienterna var ohalta inom 6 veckor och den tolfte, som fått en sekundär perioral infektion under operationen var ohalt efter 8 veckor. Radiologiskt läkte frakturerna hos 10 patienter inpm 6 veckor och hos 2 patienter inom 12 veckor. Radiologiskt kunde inga patologiska benreaktioner påvisas runt implantaten. Denna nye fixeringsmetod med resorberbara implantat visade sig vara användbar för behandling av spongiösa frakturer hos unge hundar och katter.

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Reprints may be requested from: Per B. Axelson, Small Animal Clinic MEVET, Ulfsvägen 25, SF-00350 Helsingfors, Finland.