POLYACETAL ROD FIXATION OF FRACTURES
IN OSTEOPOROTIC BONE

A PRELIMINARY REPORT

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Intramedullary rods manufactured from polyacetal were used to fix diaphyseal fractures in osteoporotic bone. They are pliable and can be introduced without further damage to such bone. Their low elastic modulus induces abundant callus. They can be locked with cortical bone screws without the need of jigs or radiographic control.

Nine femoral and five tibial fractures were fixed in 10 patients, all with osteoporosis; 13 united primarily; one required bone grafting. No implant broke; however, no ambulant patient weighed more than 75 kg. The rods offer a promising treatment for diaphyseal fractures in osteoporotic bone.

The management of a diaphyseal fracture in osteoporotic bone is a difficult problem. Non-operative treatment will usually achieve bony union, but often at great cost to the patient. Plaster casts may produce joint stiffness, skin breakdown and malunion and are poorly tolerated, especially by the elderly. Prolonged traction leads to loss of bone and muscle mass and to joint stiffness.

Fixation of these fractures by conventional implants presents other problems. Plates frequently fail either because the screws cannot find purchase on the thin cortical bone, or because they pull out before union occurs. External fixators loosen for similar reasons. Intramedullary nails, which perform well in the bones of young people, may shatter or perforate the cortex of a porotic tibia or femur.

Osteoporosis of the diaphyses in old people is the result of loss of endosteal bone (Jaworski, Liskova-Kiar and Ulthoff 1980), producing a thin-walled tube with an enlarged internal diameter. The ideal fixation for a fracture in such a diaphysis should confer enough stability to allow immediate full weight-bearing. A comparative study has shown that intramedullary fixation is superior to plating (Rand et al 1981). The material should be flexible enough not to damage the bone during insertion.

It should be able to withstand an estimated 100,000 cycles of stress to achieve bone union. Its elastic modulus should approach that of bone to prevent stress protection.

Polyacetal is a plastic material whose elastic modulus is one-sixth that of bone. It has a proven record of biological compatibility, as part of the ‘iso-elastic’ total hip arthroplasty (Andrew et al 1986), over 13,000 of which have been implanted. Hutzschneuper et al (1980) compared a polyacetal and metal composite plate with a stainless steel plate in an animal osteotomy model. The stiffness of the composite plate was 20% of that of the steel plate. They found that the less rigid material allowed healing, even across a gap, and produced bone of bending strength and torsional load bearing capacity similar to that produced after the steel plate. Brown, Merritt and Mayor (1980) showed that pure polyacetal plates had sufficient strength and rigidity to maintain alignment of an osteotomy in the femur of a large dog.

Brown and Mayor (1980) compared stainless steel, titanium, polyacetal and nylon rods in a rabbit fracture model; at nine weeks the polyacetal and nylon rods were associated with a progressive increase in cortical bone density and resorption of callus, whereas callus remodelling did not occur around the metal rods. Mechanical testing of the tibia at 10 weeks showed that those fixed with plastic rods were 30% stronger. At 16 weeks they were 38% stronger and had an average toughness 55% greater than those treated with metal rods. These differences were significant to a level of p < 0.001. A similar study performed on rats (Melster et al 1987) compared steel and polyacetal rods and in this experiment the nails were locked. The cross-sectional area of callus

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0301-620X/91/3096 $2.00
was greater in those femora fixed with the flexible nails. Wang et al (1985) concluded that the optimum rigidity for an intramedullary rod to stimulate external callus formation and bone healing was between 20% and 50% of the femoral bending rigidity.

In September 1985, Dr Robert Mathys of the Robert Mathys Co, Bettlach, Switzerland was asked to manufacture pure polyacetal nails. The cross-sectional design was circular with four longitudinal grooves (Fig. 1). The nails were 440 mm long and of 14, 15, 16 and 17 mm in diameter. It was decided to use them in patients with severe osteoporosis in whom conventional fixation would have a high risk of failure.

They were not used in ambulant patients who weighed more than 75 kg.

MATERIAL AND METHODS

The rods were supplied with a proximal metal screw and connector which enabled them to be used with standard AO nailing equipment. They were inserted as for open or closed femoral or tibial nailing with minimal reaming. The rod was cut to the right length with a sterile hacksaw and the distal end was rounded off with a file. When locking was required, the bone and nail were drilled with a 3.2 mm bit and tapped before inserting the screw. No jig was required and no radiographs were taken during the procedure.

We employed these techniques in the treatment of 14 closed fractures in 13 patients. The majority (10) were women; the three men were a poliomyelitis victim, a paraplegic and a 91-year-old. The average age of the women was 77 years (range 60 to 90). Nine femora and five tibiae were fixed. One nail was 14 mm diameter; five were 15 mm; four were 16 mm; and four were 17 mm in diameter; 10 were locked. Six fractures were protected by some form of supplementary external support for four to eight weeks after operation.
They have been followed for an average of two years two months (range 14 months to three years eight months).

RESULTS
Thirteen fractures united primarily. One (the first) showed no evidence of callus formation at four months; the polyacetal nail was removed, and replaced by a 95° screw-plate with bone grafting. The fracture united satisfactorily.

There were no infections and no rod broke. Union usually occurred by the formation of abundant periosteal callus (see Figs 2 and 3).

DISCUSSION
Polyacetal rods provide solutions for some difficult fracture problems. Their pliability allows them to be introduced into osteoporotic bones without further comminution. Interlocking screws can be employed in any plane without the need for jigs or radiographic control. Although the screws may loosen in the porotic bone they remain secure in the rod and do not advance or back out; they did not seem to interfere with healing. The extent and quality of callus formation is remarkable and appears to parallel that seen in animal studies.

The large diameter of the medullary cavity allows the use of large diameter rods and partially compensates for their low bending strength (Table I). However, it may be that none of the implants broke because we limited their use to people who weighed less than 75 kg.

In keeping with recent studies on cortical blood flow (Smith, Bronk and Kelly 1987), intramedullary reaming was kept to a minimum. In the first three cases, the largest diameter reamer expected to fit was simply pushed down to the canal to check medullary size. This method worked well in the femur, but the more tortuous contour of the tibia required formal reaming for a good fit.

The first nails used were radiolucent and, since they were not cannulated, they could not be used with a guide wire. The Mark II rod has a 4 mm groove to accept a guide wire (see Fig. 1) and barium sulphate has been incorporated to render it radio-opaque. Its use will be the subject of a further report.

The author acknowledges the advice and assistance of Dr Robert Mathys Snr, of the Robert Mathys Co, Bettlach, Switzerland in the design, manufacture and supply of the polyacetal nails. Dr Stephen Ruff performed the operations on six of the patients.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES