THE AO DYNAMIC HIP SCREW AND THE PUGH SLIDING NAIL IN FEMORAL HEAD FIXATION

R. H. RICHARDS, G. EVANS, J. EGAN, J. R. SHEARER

From Southampton General Hospital

We compared, under laboratory conditions, the resistance to cutting out of the AO dynamic hip screw and the Pugh sliding nail. The mean load at cut out, adjusted for bone strength, was 70% greater for the Pugh sliding nail. The reasons for this difference are discussed.

The AO dynamic hip screw is used in many centres for fixation of fractures of the neck of the femur, and excellent results have been claimed (Skinner and Powles 1986), though failure can occur by the screw backing or cutting out of the femoral head. The mode of failure is often difficult to ascertain from radiographs, but it is clear that the dynamic hip screw is less likely to perforate the head of the femur than earlier fixed devices such as the McLaughlin and Jewett nail plates (Svenningsen et al 1984). The Pugh sliding nail has some features similar to the AO dynamic hip screw, and excellent results have been claimed (Fielding 1980; Frandsen and Andersen 1981). The essential difference is that fixation of the femoral head is achieved using a trifin nail instead of a screw (Fig. 1).

We have used a quantitative biomechanical model to compare the tendency of each device to cut out of the femoral head under controlled loading.

MATERIALS AND METHODS

Twenty femoral heads obtained from patients undergoing hemiarthroplasty were preserved in 70% methyl alcohol. Five contained defects or fracture lines and were discarded. The remainder were cut to a standard length of 3 cm and 0.5 cm core samples of bone were removed using a crown drill inserted in the centre of the neck. Three heads were damaged while removing core samples and the remaining 12 were used to compare the performance of the AO dynamic hip screw and the Pugh sliding nail under load.

The core samples were tested in confined compression, using an Instron materials testing apparatus, to provide a measure of the strength of the bone in the central region of each femoral head, at the site of insertion of the fixation device. This was recorded as the CS50, the force required to compress the core specimen to 50% of its original volume.

Blocks of high density polyethylene (HDP) were used to simulate the neck and proximal shaft of the femur (Fig. 2). The upper end of each block was cut at an angle of 45° to represent the alignment of the neck. Identical blocks were used with either the dynamic hip screw or the Pugh sliding nail, and femoral heads were attached. Each implant was inserted a standard distance into a femoral head, which was aligned anatomically with the implant centrally placed. Each complete assembly was then loaded vertically in the Instron apparatus to give a shearing force.

---

R. H. Richards, FRCS, Orthopaedic Registrar
G. Evans, FRCS, Lecturer in Orthopaedics
J. Egan, BSc, DPhil, Experimental Officer, Department of Medical Engineering
J. R. Shearer, PhD, FRCS, Professor of Orthopaedics
University Department of Orthopaedics, Southampton General Hospital, Tremona Road, Southampton, Hampshire SO9 4XY, England.

Correspondence should be sent to Mr R. H. Richards.

© 1990 British Editorial Society of Bone and Joint Surgery
0301-620X/90/5141 $2.00
Using a rate of deformation of 1 cm/min, the applied load was increased until failure was indicated by the appearance of a radial crack in the articular surface of the femoral head. This failure occurred within an average of 30 sec, was associated with a sudden drop in the reading from the load cell, and appeared to be the first stage of cutting out of the implant. The value of the load at this point was recorded as the load at cut out (LCO).

There was a wide variation in bone strength on confined compression testing, so a yield-strength ratio (YSR) was used to assess the tendency of each device to cut out of the femoral heads. This was the load at cut out (LCO) divided by the CS$_{50}$ for each sample. The average fracture strength of the cores was the same for the screwed and the nailed groups, so the use of the yield-strength ratio did not bias the data in favour of either group.

**RESULTS**

The values for LCO, CS$_{50}$ and YSR for each specimen are shown in Table I. There was a highly significant difference in the yield-strength ratios of the two implants. Femoral heads mounted on Pugh sliding nails withstood loads on average 70% greater than those on AO dynamic hip screws, with mean yield-strength ratios of 4.50 and 2.64 respectively (0.01 > p > 0.001). These are equivalent to a mean load at cut out of 350 kg for the Pugh nails and 206 kg for the dynamic hip screws.

**DISCUSSION**

We found large variations in the mechanical properties of the femoral heads, but the use of the ratio LCO over CS$_{50}$ enabled us to obtain statistically significant results with relatively few specimens. Our results indicate that the AO dynamic hip screw cuts out of the femoral head more easily than the Pugh sliding nail.

The Pugh nail occupies considerably less space within the femoral head than the AO screw, the volumes of the terminal segments being about 1 cm$^3$ and 2 cm$^3$ respectively (Fig. 3). Yet the load bearing area on profile is 5% larger in the Pugh nail. An additional factor is that no extra bone was removed from the head during the insertion of the nail by hammering. Pre-drilling is
required for the AO dynamic hip screw, and this was performed on our specimens. In line with our clinical practice for osteoporotic bone, tapping was not used.

In our experiment a small amount of bone had already been removed from each femoral head for the core sample and this made it easier than usual to drive in the Pugh nail. This may have reduced the hold obtained by the nail but should not have affected the results of loading.

At operation it is possible to produce compression of the fracture site with the AO dynamic hip screw. This was neither employed nor tested in our experiment and is not important under this type of loading. It has been shown that, under clinical conditions, the use of the additional compression screw with the AO screw has no benefit in terms of fracture union (Fransden et al 1984).

Despite the clear advantages shown by the Pugh sliding nail in our test, other factors need to be taken into consideration. The Pugh nail may have a greater tendency to back out of the femoral head, and since there must be a certain amount of compaction of trabeculae around the nail during insertion, there may be more bony necrosis. We also observed, in some cases, crazing on the articular surface of the cartilage after insertion of a Pugh nail before loading was applied.

Clinical use of the Pugh sliding nail for Garden stage 3 and stage 4 fractures have reportedly given 75% to 90% union with 15% avascular necrosis (Fielding 1975; Fransden and Andersen 1981). Causes of failure have included cutting out from the femoral head and premature telescoping of the nail (Brown and Court-Brown 1979; Fransden and Andersen 1981; Nordkild, Sonne-Holm and Jensen 1985). These authors emphasise the importance of accurate reduction of the fracture with precise placement of the implant in terms of its position and penetration. Brown and Court-Brown (1979) have reported 36 failures from a series of 200, but only 11 of these failures were judged to have had acceptable reduction and positioning of the implant. Gibson and Espley (1987) reported the use of the Pugh sliding nail in 118 patients with proximal femoral fractures with only two failures attributable to the device, neither of them in the 20 Garden stage 3 and stage 4 fractures in their series.

A recent prospective study (Christie, Howie and Armour 1988) has compared sliding screw fixation and double divergent pin fixation: the sliding screw group had a significantly higher rate of nonunion but the reasons for failure were not discussed.

Our study has shown that the Pugh sliding nail is less likely to cut out of the femoral head than the AO dynamic hip screw. The optimum shape and size of implants for fixation of the femoral head still needs to be defined, and laboratory methods of investigation may provide the most precise information on some of the performance characteristics of new implants.

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


