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Holding power of different screws in the femoral head

A study in human cadaver hips

The holding power of four different bone screws was measured by a pull-out test in 40 cadaver hips from 10 females and 10 males over 70 years of age. Each femoral head was used to test a 6.5 mm cancellous bone screw and a 12.7 mm hip compression screw. The holding power was higher in screws with a long or wide thread. Generally, the holding power in bones from females was about 70 per cent of that in bones from males.

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The holding power of surgical screws in cortical bone has been studied both in cadavers (Bechtol et al. 1959, Ansell & Scales 1968, Koranyi et al. 1970) and in animals (Schatzker et al. 1975, Blümlein et al. 1977). In femoral neck fractures, however, the fixation devices rely only on the cancellous bone in the femoral head for their purchase.

Although different cancellous bone screws have been recommended for internal fixation of femoral neck fractures (Charnley 1960, Schwarz 1979, Søreide et al. 1980), few researchers have studied the holding power of screws in the femoral head (Schwarz & Newald 1981, Frandsen & Madsen 1983).

We have compared the holding power of four different screws in the cancellous bone of the femoral head.

Material and methods

The study was carried out on 40 cadaver femurs from ten females and ten males. In both groups the median age was 77 years (females 72–90, males 73–86). Except for osteoporosis, patients with known bone diseases or osteoarthrosis were excluded. The bones were stored in a refrigerator at 4°C and used within 3 days.

According to Bechtol et al. (1959), the holding power was defined as the maximum uniaxial tensile force needed to produce failure in the bone; it was measured by a pull-out test, where tension was applied along the longitudinal axis of the screw. Four different screws were compared (Table 1). Each hip was used to test the holding power of a cancellous bone screw and a hip compression screw. The right hips were used to test the two screws with the short thread and the left hips to test the screws with the long thread.

A transverse subcapital osteotomy was performed at the femoral neck. Perpendicular to the osteotomy, a hole was drilled and tapped in the central part of the femoral head. The 6.5 mm cancellous bone screw (OSTEO AG) was inserted and advanced to exactly 7 mm from the articular surface of the femoral head. The femoral head with the inserted screw was placed in a specially constructed pull-out device consisting of a pull-out mechanism and a strain gauge transducer (Figure 1) connected to a recorder (Frandsen & Madsen 1983). The pull-out force was applied intermittently until the maximum holding power was exceeded.

Then the cancellous bone screw was removed and the same hole was enlarged with a 7.9 mm reamer.

Table 1. The properties of the screws tested

Type of screw	Length of thread mm	Core diameter mm	Thread diameter mm
A1 Cancellous	15	4.5	6.5
A2 Cancellous	30	4.5	6.5
B1 Hip compression	19.1	7.9	12.7
B2 Hip compression	28.6	7.9	12.7

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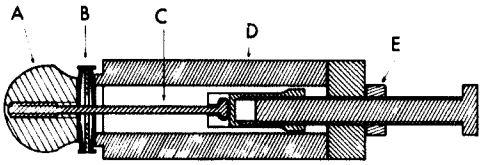

Figure 1. Diagram of the pull-out device, A) The femoral head, B) the transducer, C) the 6.5 mm cancellous bone screw, D) the outer frame of the pull-out apparatus, E) the screw by which the pull-out force is applied.

This hole was tapped and a hip compression screw (Richards) was placed with the tip of the screw 7 mm from the articular surface of the femoral head. A new pull-out test was performed as described above. The two other screws were tested in the contralateral hip.

Results

Except for the cancellous bone screw with 15 mm length of thread, the median holding power in bones from females was only about 70 per cent of that in bones from males (Table 2).

Within each sex, the cancellous bone screw with 15 mm length of thread showed significantly lower holding power compared to the other screws, between which the differences were non-significant; paired comparisons were evaluated by the Mann-Whitney rank-sum test.

Discussion

We found that the holding power of different screws in the cancellous bone of the femoral head increased both with the length of the thread and with the diameter of the thread.

However, the holding power of cancellous bone screws observed here was less than half of that reported by Schwarz & Newald (1981), who in a similar set-up used ASIF cancellous bone screws with 16 mm and 32 mm length of thread. Such discrepancies, in what should be comparable results, could better be explained by variations in methodology than by differences in the autopsied bones.

When the diameter of the thread was increased from 6.5 mm in the cancellous bone screw to 12.7 mm in the hip compression screw, a major increase in holding power was obtained, especially in bones from males (Table 2). The same observation has previously been made in an experimental study of cortical bone (Schatzker et al. 1975); four different cortical bone screws were compared, and the one with the largest diameter of thread provided the highest holding power.

Table 2. The holding power of four different screws in 40 cadaver femoral heads

Sex	Type of screw	Holding power in hundreds of Newtons			
		1. Quartile	Median	3. Quartile	Range
Females	A 1	4.3	5.1	6.4	4.2– 7.6
	A 2	5.7	8.7	12	4.5–20
	B 1	8.7	9.8	12	5.9–19
	B 2	9.2	11	14	7.0–23
Males	A 1	3.6	4.8	8.0	2.3–12
	A 2	7.3	12	17	4.7–27
	B 1	8.7	14	18	4.5–21
	B 2	12	17	19	12 –37

The holding power of a screw is a function of both the design of the individual type of screw and of the cancellous bone in which it is inserted (Hughes & Jordan 1974). This is confirmed by the wide ranges of holding power of each individual type of screw found in this study. Although a uniaxial pull-out test is a relatively simple model of the clinical situation in femoral neck fractures, it does measure one of the important parameters by which various devices for internal fixation can be compared.

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