Acta orthop. scand. *54*, 703–707, 1983

AXIAL COMPRESSION IN FEMORAL NECK OSTEOTOMIES

A Biomechanic Study in Human Cadaver Hips

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The risk of applying compression to a sliding-screw-plate osteosynthesis in the treatment of femoral neck fractures was evaluated in an experimental study of 40 femoral neck osteotomies. Ten pairs of bones from autopsied women between 70 years and 79 years of age were compared to 10 pairs of bones from autopsied women of more than 80 years of age. The compression was applied intermittently but measured continuously.

The results showed a diphasic curve. When the maximum axial compression force was reached, any attempt to apply further compression resulted in a rapid fall in pressure at the site of the osteotomy. The median of the maximum axial compression force was 971 N, ranging from 275 N to 1756N. The maximum axial compression forces were significantly lower in bones from women of more than 80 years of age compared to bones from women in the seventh decade.

The clinical implication of the study is that compression of femoral neck fractures by a sliding-screw-plate system may be hazardous in patients with brittle bone, e.g. women over 80 years of age.

Key words: axial compression; experimental study; femoral neck; osteotomy; sliding-screw-plate osteosynthesis

Accepted 24.iii.83

In the treatment of femoral neck fractures an exact reduction of the fracture forms the basis of good results (Frandsen & Andersen 1981, Garden 1961, Høgh et al. 1982, Kofoed & Alberts 1980). A good contact between the fragments of the bone can be achieved by: 1) impacting the fracture during the operation, 2) allowing the patient to bear weight on the operated leg immediately after the operation, and 3) using an osteosynthesis with compression. Impaction of the fracture and early weight-bearing are standard procedures in many orthopaedic departments. Theoretically, the application of compression across the fracture site is considered to be an advantage by many authors (Charnley 1960, Perren 1979, Schwarz 1979), but superior clinical results are still lacking.

We have previously shown that sliding-nail-plate osteosynthesis is superior to Smith-Petersen osteosynthesis in the treatment of femoral neck fractures (Frandsen & Andersen 1981). However, premature retraction of the sliding-nail followed by redisplacement of the fracture occurred in 8–9 per cent (Brown & Court-Brown 1979, Frandsen 1979). To eliminate these primary failures, a hip compression screw was chosen for internal fixation of femoral neck fractures.

The capability of the cancellous bone in the femoral head to constitute the basis for fixation in a compression osteosynthesis has been studied only by Kaessmann et al. (1972) and Schwarz & Newald (1981). Both of them recommended the use of compression in the treatment of femoral neck fractures. However, any benefit of compression across the fracture site achieved by a compression osteosynthesis, should be weighed against the implied risk: that the screw loses its grip by pulling out of the cancellous bone in the femoral head if excessive compression is applied.

The purpose of the present study was to evaluate the risk of pulling out the lag screw by applying compression to the sliding-screw-plate in the treatment of femoral neck fractures. It was done experimentally in femoral neck osteotomies by recording the compression pattern across the site of the osteotomy, and by measuring the axial compression force necessary to break down the cancellous bone taps in the femoral head.

MATERIAL AND METHODS

Elderly women constitute the major part of patients with fractures of the femoral neck. Consequently, this study was carried out on 40 femurs from 20 autopsied females, of whom 10 should be from 70 years to 79 years and 10 should be 80 years and above. In the two groups the median ages were 74 (72–77) years and 85 (82–95) years. Except for osteoporosis, patients with known bone diseases (including osteoarthritis) were excluded from the study. The bones were stored in a refrigerator at 4°C and used within 5 days.

The distal end of the femur was fixed in a vice. The guide wire was placed centrally in the neck and head of the femur in both the frontal and the axial plane, and a hole for the lag screw was reamed and tapped. Perpendicular to the femoral neck a subcapital osteotomy was performed with a saw. The lag screw (Richards Compression Hip Screw, 19.1 mm length of thread) and the plate were inserted together with a specially constructed strain gauge transducer at the site of the osteotomy (Figure 1). The tip of the lag screw was placed less than 1 cm from the articular surface of the femoral head. The cross-slotted compressing screw was tightened intermittently, i.e. a turn of 180° every minute until the maximum axial compression force was reached and exceeded. Thereafter the compressing screw was tightened every minute or every other minute.

The compression applied by the compression screw to the bone fragments was transduced to an equivalent electrical signal by the transducer shown in Figure 2. The transducer was built by two disk springs fixed by a ring. Two strain gauge elements were mounted on one of the disks with an angle of 90° between their axes (Figure 2). The strain gauge elements were connected to a constant current bridge, and the variations in the electrical signal caused by the deflection of the springs were amplified, filtered and transcribed by a Y-t writer (H. P. 7045 A). The transducer was calibrated by applying known weights to the disks in the range 10–150 kg (98 N to 1472 N).

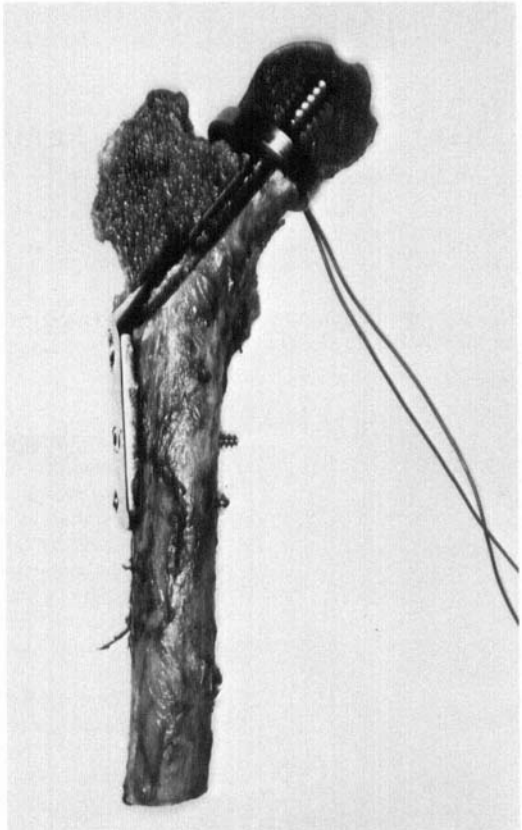

Figure 1. Cross section of an autopsied femur showing the position of the transducer and the sliding-screw-plate in the experiments.

The object of this study was to imitate the clinical situation in osteosynthesis of femoral neck fractures, and the standard equipment for hip osteosynthesis was used. With this equipment the maximum compression we could apply by the compressing screw was about 1700 N.

RESULTS

A constant finding was a diphasic curve with a gradual increase in the axial compression force as the compressing screw was tightened. When maximum axial compression force was reached, any attempt to apply further compression resulted in a rapid fall in compression (Figure 3). In

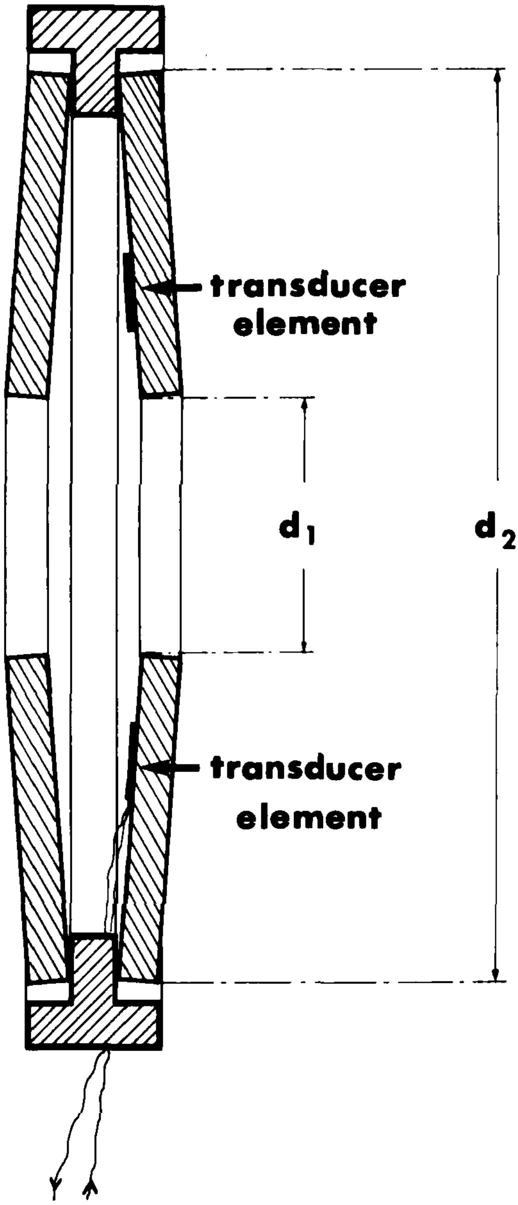

Figure 2. The transducer with the two strain gauge elements mounted.
The inner (d_1) and the outer (d_2) diameter of the disk springs are shown.

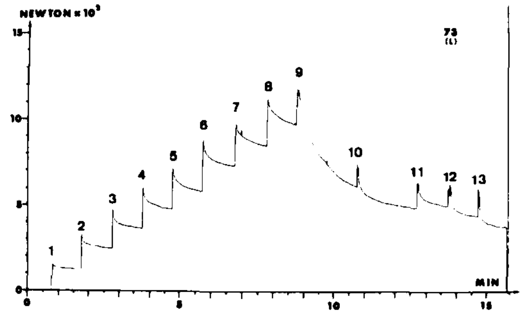

Figure 3. A typical axial compression pattern from a woman 73 years old.
The numbers refer to the consecutive radiographs taken immediately after each tightening of the compressing screw. The maximum axial compression force was exceeded after the 9th tightening of the compressing screw.

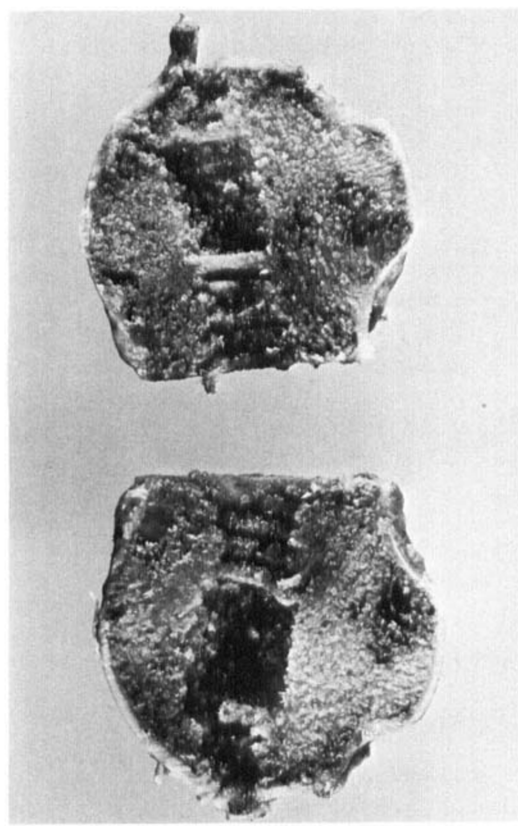

Figure 4. After the maximum axial compression force was exceeded, a cross section of the femoral head showed that the cancellous bone taps were broken at the position of the thread of the lag screw.

some cases radiographic pictures were taken between each tightening of the compressing screw. These pictures demonstrated that as long as the axial compression was increasing, the lag screw kept the same position within the femoral head,

Table 1. The maximum axial compression forces related to age in 40 femurs from 20 autopsied women

Age	1st quartile	median	3rd quartile	Range
70–79 years	883 N	1094 N	1538 N	618–1756 N
≥80 years	419 N	589 N	1018 N	275–1305 N
Total	574 N	971 N	1202 N	275–1756 N

as the distance from the tip of the lag screw to the osteochondral surface of the femoral head remained unchanged. After the maximum axial compression force was exceeded the radiographic pictures showed an increasing distance between the tip of the lag screw and the osteochondral surface of the femoral head. When afterwards the femoral head was divided along the middle of the hole of the lag screw, the cancellous bone taps were found to be broken (Figure 4).

The results are shown in Table 1. The maximum axial compression forces applied varied between 275 N and 1756 N with a median of 971 N. In five cases, all of them from women under 80 years of age, the maximum axial compression force could not be exceeded with standard operative equipment.

The median and the first quartile of the maximum axial compression force were twice as high in women from 72 years to 77 years compared to women above 80 years of age (Table 1). The maximum axial compression forces were significantly lower in bones from women 80 years and above compared to bones from women between 72 years and 77 years ($P < 0.01$, Mann-Whitney's rank sum test).

DISCUSSION

The maximum axial compression forces found in this study were much lower than those reported by Schwarz & Newald (1981), who correlated the axial compression force to the length of the thread of the screw. Using ASIF cancellous bone screws with 16 mm and 32 mm length of thread, their average maximum axial compression forces were 1800 (1393–2207) N and 2528 (1952–3364) N, respectively. Thus, their lowest maximum axial compression force was 1.43 times (1393 N/971 N) higher than the median value in this study. Although the results are not comparable since Schwarz & Newald (1981) included autopsied bones from both sexes above 60 years of age, the results differ to such an extent that differences in methodology rather than differences in the autopsied bones should be considered.

By applying axial compression forces similar to those applied in the present study, Kaessmann et al. (1972) showed that shearing and rotatory movements at the site of an osteotomy were impeded by increasing axial compression.

In this study the maximum axial compression forces were significantly lower in bones from women 80 years and above compared to bones from women in the seventh decade. Furthermore, in 25 per cent of women aged 80 years or more the maximum axial compression force was exceeded by applying a compression force of 419 N (43kp). This is in accordance with the reported reduction in bone mineral content in elderly women. In a controlled, prospective study of postmenopausal women the bone mineral content showed a linear fall reaching 3.3 per cent after 2 years of observation (Christiansen et al. 1981). Although the postmenopausal loss of bone mineral content is reported to be 10–20 per cent per decade (Lindsay et al. 1978, Smith et al. 1976), it is unknown whether the corresponding reduction in strength of the bone is even higher as indicated by the results of this study.

It would thus seem relatively safe to apply compression to a sliding-screw-plate osteosynthesis in women below as compared to above 80 years of age.

ACKNOWLEDGEMENTS

The authors wish to thank the members of the staff at the Institute of Pathology, The University Hospital, Odense for their kind cooperation. The implants were kindly supplied by Richards International, Scandinavia.

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