Stability of femoral neck fractures

A postoperative roentgen stereophotogrammetric analysis

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Using roentgen stereophotogrammetric analysis, the postoperative stability of femoral neck fractures was measured in 16 patients. During the first day after internal fixation, before weight bearing, the center of the femoral head moved on an average 1.5 mm (total translation) in six undisplaced fractures and 3.7 mm in 10 displaced fractures, which was about one third of the fracture movement during the first postoperative month. Three undisplaced fractures displayed a rotatory instability, mainly after weight bearing had begun. Five of the displaced fractures showed maximal rotatory displacement during the first postoperative day.

The recorded fracture movements before weight bearing may question the rationale of peroperative mechanical compression.

Several authors have emphasized the importance of peroperative compression of femoral neck fractures[1–4], whereas Pauwels[5] believed that normal muscle tone provides optimal compression for healing. However, the effects of muscular activity on the fracture stability in the immediate postoperative period are unknown.

We report a roentgen stereophotogrammetric analysis (RSA) of femoral head motion during the first postoperative day and the following month of weight bearing in 16 intracapsular hip fractures.

Patients and methods

Patients

Twelve women and 4 men with an average age of 74 (62–85) years. All of them had a fresh fracture of the femoral neck (Table 1), Garden[6] Stages I and II (undisplaced) in 6 patients and Stages III and IV (displaced) in 10 patients. Preoperatively, displaced fractures were treated with traction. The fractures were operated on under spinal anesthesia within 1 day after admission. No reduction of Stages I–II fractures was attempted.

Table 1. Clinical summary of 16 patients with femoral neck fractures. 1 undisplaced, 2 displaced

Case	Sex	Age	Fracture type	^{99m}Tc-MDP scintimetry (femoral head ratio)
1	F	71	1	0.7
2	F	65	1	2.4
3	F	73	1	1.6
4	F	82	1	2.0
5	F	62	1	2.5
6	M	79	1	1.4
7	M	85	2	1.0
8	F	77	2	1.3
9	M	71	2	2.6
10	F	66	2	1.3
11	F	82	2	0.7
12	F	83	2	0.8
13	F	64	2	0.9
14	M	84	2	0.9
15	F	76	2	1.2
16	F	68	2	1.5

Closed reduction of Stages III and IV fractures was performed during the operation. Two hook-pins[7] were used for internal fixation (Figure 1). The fracture fragments were not impacted at the operation.

RSA

Peroperatively, 4 to 6 0.8-mm tantalum balls were inserted on both sides of the fracture. Immediately after

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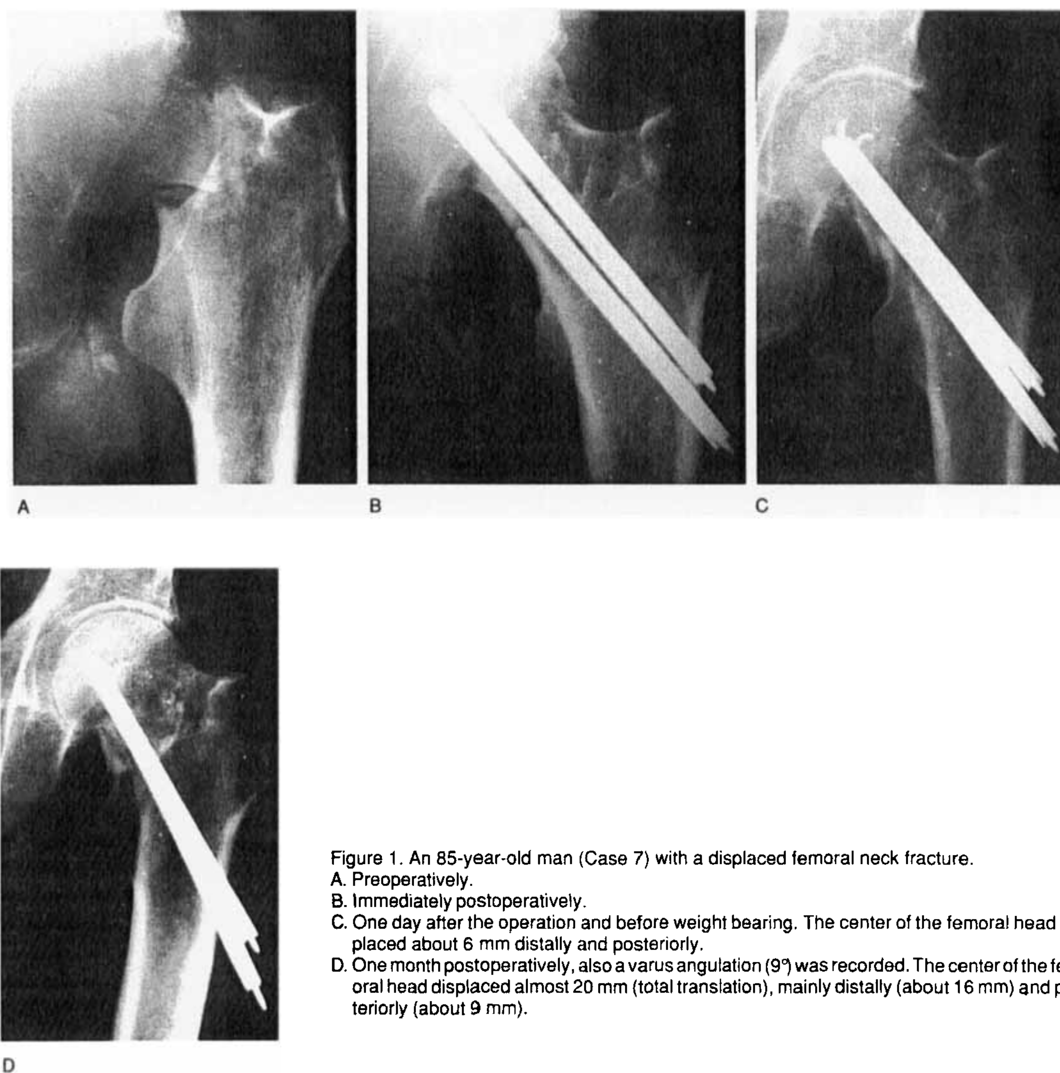

Figure 1. An 85-year-old man (Case 7) with a displaced femoral neck fracture.
A. Preoperatively.
B. Immediately postoperatively.
C. One day after the operation and before weight bearing. The center of the femoral head displaced about 6 mm distally and posteriorly.
D. One month postoperatively, also a varus angulation (9°) was recorded. The center of the femoral head displaced almost 20 mm (total translation), mainly distally (about 16 mm) and posteriorly (about 9 mm).

the operation when the patient was still anesthetized, the first RSA examination was performed[8]. The next examination was done the following day before the patient was mobilized. After this examination full weight bearing was allowed, and subsequent examinations were performed 1 week and 1 month postoperatively.

A central point in the femoral head was plotted on the radiographs of the first examination, and was transformed to all subsequent examinations by using the three-dimensional rigid body defined by the tantalum markers in the femoral head[9, 10]. By this procedure the translations of the femoral heads were measured from a standard position making comparison between the patients possible. Thus, simultaneous femoral head rotations influenced the recorded translations in a more standardized way than if the displacements had been measured more eccentrically at the position of one of the tantalum balls in the femoral head. The tantalum balls in the trochanteric region were used as a fixed reference segment.

The reproducibility of the measurements was based on 33 double examinations [11]. Significant displacements ($P < 0.05$) were 0.5 mm, 0.2 mm, and 0.9 mm, or more regarding translations along the transverse (x), longitudinal (y), and sagittal (z) axes, respectively. The corresponding smallest significant rotatory movements were 1.1°, 1.6°, and 0.7° (forward/backward rotation, retroversion/anteversion, valgus/varus rotation, respectively).

Scintimetry

The vitality of the femoral head was determined by ^{99m}TcMDP scintimetry approximately 2 weeks after the operation as described by Strömqvist [10]

Results

Translation (Figure 2)

During the first postoperative day, the average total translation of the undisplaced fractures was 1.5 (0.4–2.4) mm and during the following month of weight bearing 3.9 (0.7–7.9) mm. The corresponding values for the displaced fractures were 3.7 (0.7–8.7) mm and 11.2 (6.9–19.7) mm.

The forces acting on the undisplaced fractures before weight bearing resulted mainly in a posterior translation of the femoral head. During the following month the femoral head continued to move posterodistally.

The displaced fractures displayed a posterodistal motion of the femoral head before weight bearing, and subsequently the femoral head moved mainly distally.

Rotations (Figure 3)

During the period of observation, both fracture groups displayed rotations of the femoral heads in both directions about each of the three axes. The largest mean ab-

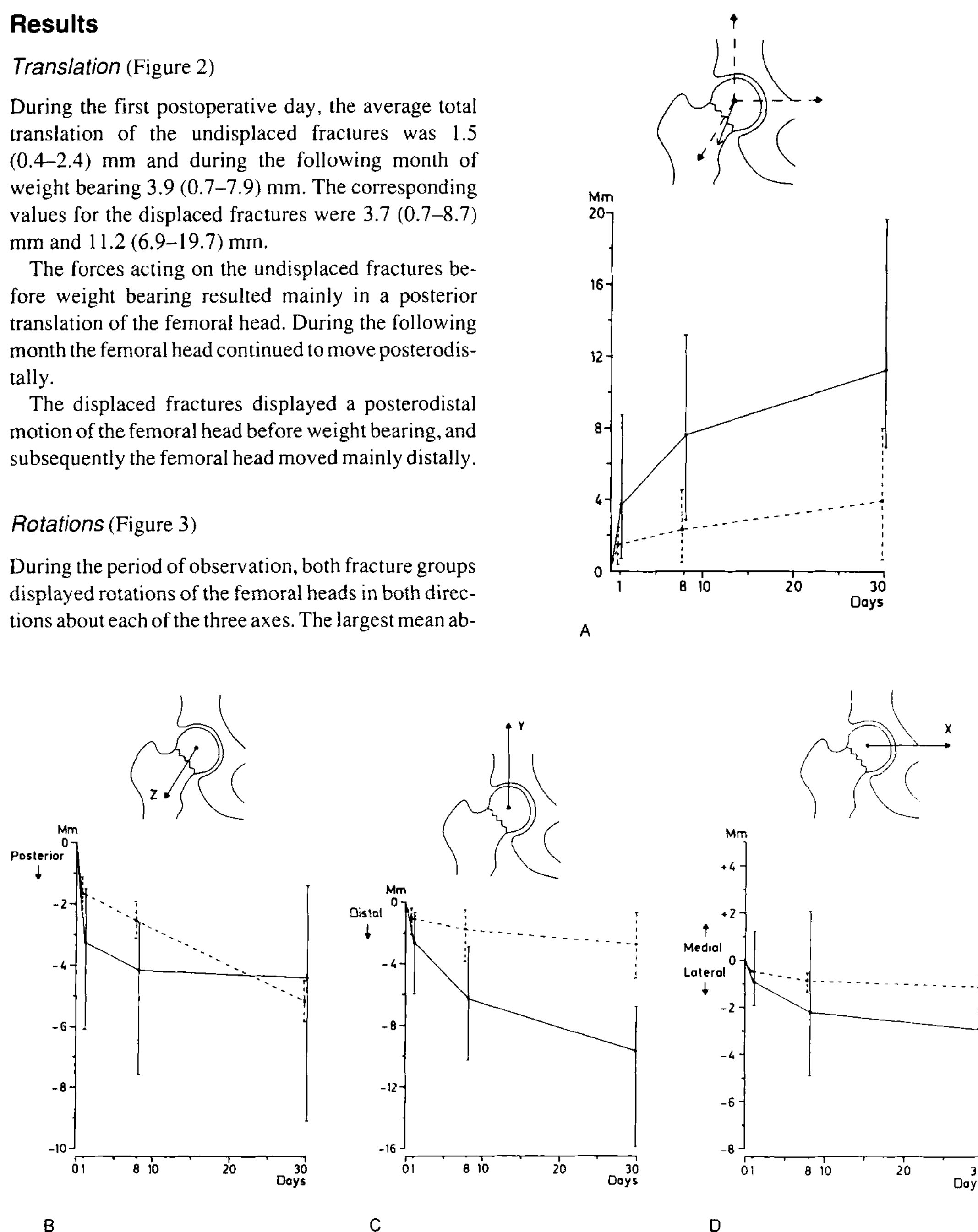

Figure 2. Translation in mm (mean and range) of 16 cases with femoral neck fractures during the first postoperative day, the first week of weight bearing, and the following 3 weeks. Displaced fractures are illustrated by an unbroken line and undisplaced fractures by a broken line.
A. Total.
B. Along the sagittal axis.
C. Along the longitudinal axis.
D. Along the transverse axis.

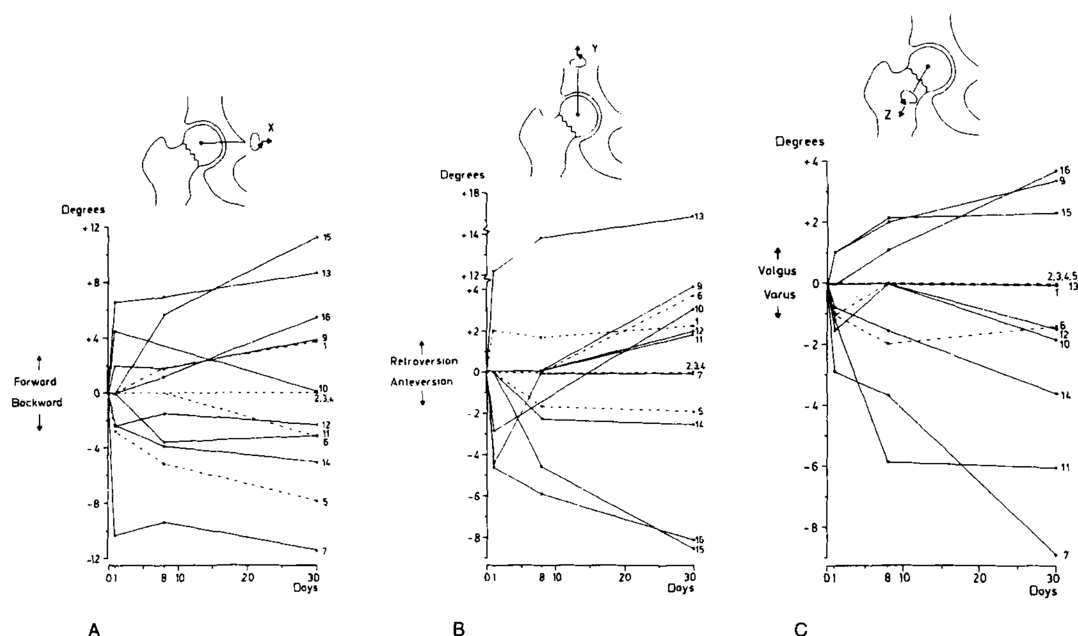

Figure 3. Rotations of the femoral heads (degrees).

A. Around the transverse axis for 15 cases with femoral neck fractures during the first postoperative day, the first week of weight bearing, and the following 3 weeks. The numbers to the right correspond to the patient numbers in Table 1. The rotations of Case 8 could not be evaluated because of loosening of one of the tantalum balls in the femoral head.
B. Around the longitudinal axis.
C. Around the sagittal axis.

solute rotations occurred around the transverse (x) axis.

Initially, the rotation of the femoral heads in the undisplaced fractures was small or insignificant. After weight bearing had begun, three of six femoral heads (Cases 1, 5, 6) rotated around the transverse and longitudinal axes. The femoral heads in five of the 10 displaced fractures (Cases 7, 9, 10, 12, 13) manifested the largest rotations around the transverse axis and before weight bearing. Three cases (Cases 7, 3, 16) showed the most pronounced rotations around the longitudinal axis during the same period. Rotations around the sagittal axis were more pronounced after the first postoperative day.

Scintimetry

In five displaced fractures with a scintimetric uptake ratio equal to or less than 1.0, the mean total translations during the first postoperative month were 13.4 (10.1–19.7) mm; and in those fractures with uptake ratios greater than or equal to 1.2, the translations were 9.1 (6.9–12.1) mm. Evaluation with the Mann-Whitney-*U* test revealed no significance.

Discussion

Peroperative compression in femoral neck fractures has been achieved by using the sliding screw plate [13] and by manual impaction[14]. Most authors in favor of peroperative compression claim that these methods result not only in an increased fracture stability[4, 15, 16],but also facilitate fracture healing[1, 2, 17]. Calandruccio and Anderson[18] had approximately the same incidence of avascular necrosis following treatment with an impaction screw-plate as compared with less stable fixation with nails and pins. According to some studies using a sliding hip screw or mallet impaction, peroperative compression may result in more nonunions[19] or decreased femoral head vitality[20]. Possibly the magnitude of the peroperative compression is of critical importance for the end result, but this was not measured in the above-mentioned studies.

In our study the undisplaced fractures displayed no or minimal movements before weight bearing, suggesting that it is unnecessary to impact these fractures at surgery as has been recommended[17]. Fracture movements occurring during weight bearing probably cannot be completely impeded by peroperative compression. Further, gentle pinning with the same type of

osteosynthesis as used in this study and without peroperative mechanical compression has been shown to not negatively affect the femoral head vitality[21]. Therefore, we believe that spontaneous compression of displaced fractures is optimal.

The importance of rotatory stability in femoral neck fractures after osteosynthesis has been stressed[15,22], but has not previously been measured in vivo. During the first postoperative day, the most pronounced rotatory instability occurred in the displaced fractures, and mainly as a forward or backward rotation of the femoral heads in combination with retroversion or anteversion. Seemingly, the osteosynthesis more efficiently counteracted varus and valgus displacements. However, weight bearing caused an impaction of the fractures into varus or valgus and also a retroversion or anteversion of the femoral head. The postoperative fracture stability probably has a multifactorial background including bone quality, fracture anatomy and displacement, type of osteosynthesis and operation, bone resorption, and perhaps also femoral-head vitality, although not demonstrated in our patients. In displaced fractures, probably the comminution, notably posteriorly, is of importance for the initial instability, whereas other factors, such as bone resorption, may cause instability of the undisplaced fractures.

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