

SIGNIFICANCE OF ENDOGENIC FACTORS IN THE LOCATION OF FRACTURES OF THE PROXIMAL FEMUR

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The significance of endogenic factors in the localization of the fractures of the proximal femur was studied in 373 patients, with 402 fractures. A statistically significant relation was found between muscular disturbances of the affected leg and trochanteric fractures, while the incidence of femoral neck fractures was high in osteoporotic but physically active individuals.

Key words: femoral neck fractures; fractures; hip

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In a previous work on bilateral non-contemporary fractures of the proximal femur (Dretakis et al. 1981) it was found that the second fracture was identical with the first one in the majority of the patients. Provided that most of the fractures of the proximal femur in the elderly resulted from a trivial injury, the high percentage of symmetry in the group of bilateral fractures, led us to the thought that endogenic factors may possibly play a role in the localization of the fractures of the proximal femur. There are a number of works on the significance of endogenic factors in the localization of the fractures of the proximal femur (Ståhl 1957, Shek 1965, Ostrüp 1970, Solomon 1973) but there are no complete and statistically documented studies on this subject.

The aim of the present work is to study the significance of endogenic factors in the localization of the fractures of the proximal femur.

PATIENTS AND METHODS

During a period of 3 years (1978–1980) 373 patients, 269 females and 104 males, were admitted to the seventh clinic of the Asclepeion Orthopaedic Hospital having sustained fractures of the upper end of the femur: 29 of the patients had fractured the other hip in the past, the total number of fractures was thus 402. The fractures were divided into two groups, 126 femoral neck fractures and 276 trochanteric fractures. The second group also included the 31 subtrochanteric fractures localized very close to the lesser trochanter. The fractures were classified into low energy fractures (fall during standing or walking), observed in 298 patients with 325 fractures, and high energy fractures, caused by severe injury, i.e. fall from steps or considerable height or resulted from a traffic accident, as in 75 patients with 77 fractures.

The following parameters were studied in each patient: sex, age, physical activity, body weight, Singh's index of osteoporosis, inclination angle, femoral neck index (thickness of the medial cortex divided by the smallest diameter of the femoral neck, Halberg & Nilsson 1977) based on the study of the other unfractured hip, neuromuscular condition and condition of the joints of the injured leg. The significance of these parameters for the localization of the fractures of the upper end of the femur was analysed statistically (χ^2 -test, t-test).

RESULTS

Sex

The sex-ratio of females to males was 2.6 (269/104). The females sustained 295 fractures, 201 trochanteric and 94 femoral neck fractures. The ratio between trochanteric and femoral neck fractures was thus 2.1 for females. The males sustained 107 fractures, 75 trochanteric and 32 femoral neck fractures (ratio 2.3).

No significant difference in the ratio trochanteric to femoral neck fractures was found between females and males ($P > 0.05$).

In the group of the 298 patients with low energy fractures, the female-male ratio was 3.5 (232/66). In the group of 75 patients with high energy fractures the female-male ratio was 0.97 (37/38). This predominance of females in the group of patients sustaining low energy fractures was found to be statistically significant ($P < 0.001$).

No significant difference was found in the ratio of trochanteric to femoral neck fractures, in the group of patients who sustained low energy fractures, between females (ratio 2.1 (175/83) and males (ratio 2.5 (48/19) ($P > 0.05$).

Nor was any significant difference found in the ratio of trochanteric to femoral neck fractures in the group of patients sustaining high energy fractures, between females (ratio 2.4; 26/11) and males (ratio 2.1; 27/13) ($P > 0.05$).

In the group of 29 patients who sustained bilateral non-contemporary fractures, the female-male ratio was 4.8 (24/5) and in 83 per cent of the cases (48/58) the fracture resulted from a low energy trauma.

Age

The age of patients with trochanteric fractures was 78 ± 11 years in the females and 75 ± 10 years in the males. The difference was statistically significant ($0.01 < P < 0.05$). In the patients with femoral neck fractures, the age was found to be 70 ± 10 in the females and 72 ± 9 in the males. The difference was not statistically significant ($P > 0.05$).

The age of patients sustaining a fracture after low energy trauma was 79 ± 9 in the females and

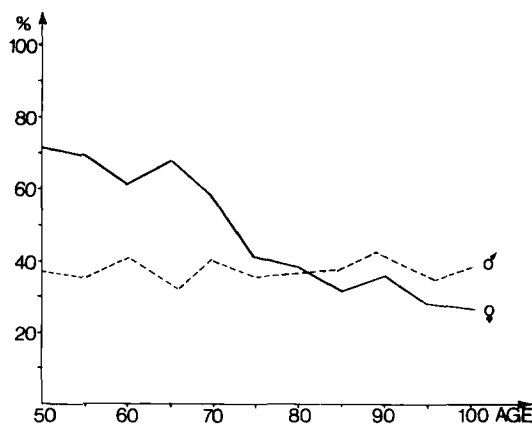


Figure 1. The percentage of femoral neck fractures in relation to age and sex.

76 ± 10 in the males with trochanteric fractures ($P > 0.05$), and 72 ± 10 in the females and 74 ± 11 years in the males with femoral neck fractures ($P > 0.05$).

The age of patients who sustained high energy trochanteric fractures was 72 ± 13 years in the females and 64 ± 14 years in the males ($P < 0.01$). The age of the patients with high energy femoral neck fractures was 60 ± 9 in the females and 62 ± 12 years in the males ($P > 0.05$).

It is also noted that in females the percentage of femoral neck fractures decreases from 72 per cent to 30 per cent from the 6th to the 9th decade of the life, while in the males it remains almost unchanged over the same period (Figure 1). In contrast, the percentage of trochanteric fractures, and especially of the comminuted ones, increases with age in females (Table 1).

Table 1. Age distribution for trochanteric fractures (females)

Age	Stable	Unstable
40-59	9	4
60-79	43	51
80-99	36	58

Physical activity

The patients were divided in two groups according to their physical activity. The first group, 152 patients, included persons living completely independently, often working and without limitation of gait. The second group, 144 patients, included moderately dependent (assistance from other persons for more than 6 h weekly), or completely dependent, individuals, living mostly indoors. Of the 152 patients with normal physical activity, 59 sustained trochanteric and 93 femoral neck fractures (ratio 0.63). Among the 144 patients with impaired physical activity, 128 sustained trochanteric and only 16 neck fractures (ratio 8). This preponderance of trochanteric fractures in patients with impaired physical activity was found to be significant ($P < 0.001$).

Body weight

In 281 out of the 373 patients, body weight was within normal limits, while 45 patients were overweight and 47 underweight.

Of the patients with normal body weight, 212 sustained trochanteric and 98 femoral neck fractures (ratio 2.2).

The 45 overweight patients sustained 31 trochanteric and 14 femoral neck fractures (ratio 2.2) and the 47 underweight patients sustained 33 trochanteric and 14 femoral neck fractures (ratio 2.4). The difference was not statistically significant ($P > 0.05$).

Osteoporosis

Based on the degree of osteoporosis, using the index method described by Singh et al. (1970), on the contralateral normal hip in patients with a unilateral fracture, 169 patients were found to have marked osteoporosis (group with osteoporosis with Singh index 1, 2, 3) and 178 patients had slight or no osteoporosis (Singh index 4, 5, 6). As demonstrated in Table 2, the percentage of femoral neck fractures in the group with osteoporosis is higher than that of the group of patients without osteoporosis ($P < 0.05$).

Table 2. Preponderance of femoral neck fractures in patients with osteoporosis

Patients with osteoporosis					
Females	139	169	→ Without	Trochanteric	97
Males	30		injury = 153	Neck	56
Patients without osteoporosis					
Females	105	178	→ Without	Trochanteric	89
Males	73		injury = 118	Neck	29

Degree of osteoporosis determined by Singh's index (1970).

Inclination angle and femoral neck index

The study of these parameters on the X-rays of the contralateral normal hip did not show any statistically significant relation to the localization of the fracture in the proximal femur. The inclination angle was found to be 131 ± 11 degrees in the females with trochanteric and 134 ± 12 degrees in the females with femoral neck fractures ($P > 0.05$), whereas in males with trochanteric fractures it was 138 ± 13 and in males with femoral neck fractures it was 135 ± 12 degrees ($P > 0.05$).

The femoral neck index (thickness of the medial cortex divided by the smallest diameter of the femoral neck (Halberg & Nilsson 1977) was found to be 0.13 ± 0.06 in females with trochanteric fractures and 0.12 ± 0.05 in females with femoral neck fractures ($P > 0.05$), while in males it was 0.13 ± 0.006 and in trochanteric and 0.12 ± 0.05 in trochanteric and femoral neck fractures, respectively ($P > 0.05$).

Condition of the neuromuscular system in the injured leg

Twenty seven patients out of the 373 included in this study were suffering from paresis due to cerebrovascular strokes, poliomyelitis and diabetes melitus. It is interesting that 24 of these 27 patients sustained trochanteric fractures and only three femoral neck fractures (ratio 8).

Condition of the hip and knee joint of the injured leg

Among the 373 patients examined, advanced

osteoarthritis was found in the fractured hip of six and in the knee joint of the same leg in 25. All six patients with osteoarthritis of the hip sustained trochanteric fractures, and 22 out of the 25 patients with osteoarthritis of the knee. It should be mentioned that all these (31) patients were included in the group with impaired physical activity.

DISCUSSION

There are several publications on the factors contributing to the fractures of the upper end of the femur. The incidence of these fractures increases with age, being higher in females (Alffram 1964, Solomon 1968, Öhman et al. 1968, Gallannaugh et al. 1976, Jensen 1980). The importance of osteoporosis in the etiology of these fractures has also been emphasized (Stewart 1955, Buhr & Cooke 1959, Bauer 1960, Stevens et al. 1962, Alffram 1964, Nordin et al. 1966, Voose & Lockwood 1965, Solomon 1968, Dälen et al. 1976, Pogrund et al. 1977, Wooton et al. 1979).

A significant age difference between females sustaining extraarticular and intraarticular hip fractures has been noted, as patients with extraarticular fractures were older (Alffram 1964, Beals 1972, Jensen 1980). Although endogenic factors like osteoporosis (Solomon 1973, Pogrund et al. 1977) and osteoarthritis of the hip (Ståhl 1957, Östrup 1970) have been linked with the localization of hip fractures, the generally accepted belief is that the magnitude and the direction of the external force are mainly responsible for the localization of these fractures. In the present work, the significance of endogenic factors in the localization of hip fractures has been studied. The mean age of the patients with trochanteric fractures was clearly higher than the mean age of the patients with neck fractures. This is in agreement with previous observations (Alffram 1964, Beals 1972, Gordon 1972, Jensen 1980). In females, the percentage of femoral neck fractures continuously decreases from the 6th to the 9th decade of life, whereas the percentage of the trochanteric fractures increases in the same period. This was also noted by Jensen (1980).

Trochanteric fractures usually occur in patients with markedly impaired physical activity, while femoral neck fractures are more common among physically active individuals.

The percentage of femoral neck fractures is higher in patients with advanced osteoporosis. This observation is in contrast to the opinion of Pogrund et al. (1977) that in osteoporotic patients extraarticular fractures of the upper end of the femur predominate. It should be mentioned that Pogrund et al. measured the degree of osteoporosis mainly on X-rays of the lumbar spine while in this study the Singh index was determined in all patients on the other unfractured hip. Neither of these methods has been proved to be sufficient, but only give some impression of the degree of osteoporosis.

The inclination angle and the femoral neck index do not seem to be related to the localization of hip fractures. Trochanteric fractures are closely related to muscular disturbances and advanced arthropathies of the hip and knee joints of the affected leg. There are few reports on the role of the muscles in the localization of the fractures of the upper femoral end. Scheck (1965) described fractures of the femoral neck following electroshock and Sinnis & Dimitsas (1977) also described fractures of the femoral neck as a result of electric current injury.

Regarding osteoarthritis of the hip and its relation to the localization of the fracture, Ståhl (1957) and Östrup (1970) found a predominance of trochanteric fractures in osteoarthritic hip. Ståhl (1957), using Smith's theory (1955) according to which trochanteric fractures are caused by intrinsic forces, i.e. contraction of the external rotators of the hip, tried to explain the rarity of femoral neck fractures in patients suffering from osteoarthritis of the fractured hip, thinking that the fixed external rotation of the leg does not allow the intrinsic forces from the external rotators muscles to cause fracture of the femoral neck.

The increased thickness of the medial side of the neck close to the attachment of the joint capsule seen in hip osteoarthritis (Lloyd-Roberts 1953) as well as the increased bone mass of the osteoarthrotic hip (Foss & Byers 1972, Carlsson et al. 1979, Roh et al. 1973) may play a role in

the rarity of femoral neck fractures in these patients. The observation, however, that the patients with osteoarthritis of the knee as well as those with parietic phenomena of the affected leg usually sustain trochanteric fractures and bearing in mind the experimental work of Pauwels (1948), related to the importance of the thigh muscles in the absorption and distribution of the stresses of the bone, led us to the following conclusions:

- A) Prerequisites for femoral neck fractures are:
Advanced osteoporosis and good muscular condition especially on the affected side. This occurs in relatively young women, showing marked osteoporosis and maintaining good muscular condition.
- B) Prerequisites for the trochanteric fractures are:
Some degree of osteoporosis and marked muscular weakness of the fractured leg. This occurs in relatively older patients living indoors, with muscular weakness, and especially parietic phenomena, or osteoarthritis of the hip or knee of the affected leg.

The muscular system therefore seems to play an important role in the aetiopathogenesis, as well as in the localization of the fractures of the upper end of the femur. Namely it determines the way the fall occurs and in addition intensifies and concentrates the bone stresses in the trochanteric region.

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