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AN EPIDEMIOLOGIC STUDY OF CERVICAL AND TROCHANTERIC FRACTURES OF THE FEMUR IN AN URBAN POPULATION

ANALYSIS OF 1,664 CASES WITH SPECIAL REFERENCE TO ETIOLOGIC FACTORS

BY

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CONTENS

I. INTRODUCTION

In the skeleton struck by severe trauma or a cancer metastasis, fracture is easily explained. In most fractures the etiology is more complex, and it is difficult to evaluate the relative importance of various etiologic factors. This investigation is an attempt at such an evaluation. A large group of patients has been chosen because the complexity of the problem makes it impossible to draw general conclusions from individual patients. Fracture of the proximal end of the femur has been chosen because virtually every case seeks medical advice and thus becomes known; and because this fracture usually necessitates prolonged hospital care, during which more information becomes available concerning the patients than is generally available concerning other fracture patients. The City of Malmö has been chosen for this investigation because it provides near-ideal conditions for an epidemiologic survey: a limited number of hospitals serve a well-defined population of relatively homogenous origin.

In a previous study fractures of the forearm in the same population were evaluated with attention to the following variables: sex, age, type of fracture, and degree of trauma. In the present investigation the region of the skeleton studied has been more limited, but the scope of the investigation has been widened by giving attention to an additional variable, the health of the probands.

Based upon the results of this investigation an etiologic classification of cervical and trochanteric fractures of the femur is proposed for use in comparison of therapeutic results, in epidemiologic studies, and in evaluation of individual patients.

II. MATERIAL, METHODS, AND DEFINITIONS

A. POPULATION AT RISK

Malmö is a center of commerce and industry in southern Scandinavia. It is the third largest city of Sweden, having 225,660 inhabitants on January 1, 1960. City authorities maintain detailed records of age, sex, mortality and migration. Hospital services are provided by one general hospital, one mental hospital and one geriatric hospital. These circumstances have made Malmö particularly suitable for previous epidemiological studies of disease, as shown by BIÖRCK, BLOMQUIST and SIEVERS (1957), SIEVERS and BLOMQUIST (1962), and SIEVERS (1963) in studies on arteriosclerotic heart disease, by BIÖRCK (1955), BIÖRCK and HALL (1955), and HALL (1961) in investigations of rheumatic disease, and by BAUER (1960), and ALFFRAM and BAUER (1962) in fracture studies. The World Health Organization has recently chosen Malmö as the site of an extensive investigation of arteriosclerotic heart disease.

1. *Hospital Facilities in Malmö.*

During the period of this investigation the population of Malmö was served by one general hospital (MGH, 1585 beds), one mental hospital (MMH, 675 beds) and one geriatric hospital (GH, 600 beds). Two small private hospitals (16 and 21 beds) were under the supervision of private physicians.

Since 1945 practically all fracture cases requiring hospital care have been referred to the Orthopedic Clinic of MGH. A few fractures occurring in patients admitted to MMH or GH were treated entirely at these hospitals. Fractures which were treated in the two small private hospitals were radiographed at MGH.

It is reasonable to conclude that, during the period of the investigation, review of the records of the radiological departments of MGH, MMH and GH and of the Orthopedic Clinic of MGH would reveal all cases of fracture of the proximal end of the femur diagnosed in Malmö.

2. *Population of Malmö in 1950—1960.*

The total population of Malmö is known for each year of the period of this investigation. *The age and sex* distribution of residents over 30 years of age is recorded for 1950, 1955 and 1960 (Table 1). From 1950 to 1960 the total population of Malmö increased by less than 2 per cent per year.

Table 1. *Population of Malmö in 1950, 1955, and 1960.*

Age groups	1950		1955		1960		Per cent women in	
	Women	Men	Women	Men	Women	Men	1950	1960
30—39	17,200	16,210	17,455	16,278	16,931	16,532	51.5	50.6
40—44	8,632	7,734	8,813	8.189	8,951	8,614	52.7	51.0
45—49	7,337	6,451	8,675	7,693	8,894	8,276	53.2	51.8
50—54	6,237	5,397	7,402	6,431	8,737	7,782	53.6	52.9
55—59	5,382	4,324	6,167	5,311	7,338	6,299	55.5	53.8
60—64	4,848	3,829	5,293	4,165	6,073	4,957	55.9	55.1
65—69	4,135	3,241	4,569	3,490	4,989	3,733	56,1	57.2
70—74	3,126	2,254	3,633	2,782	4,171	2,889	58,1	59.1
75—79	1,762	1,302	2,504	1,728	2,914	2,038	57.5	58.8
>80	1,267	770	1,732	1,170	2,513	1,497	62.2	62.7

In 1952 the Parish of S. Sallerup with 898 inhabitants was incorporated into Malmö. No other geographic or administrative changes took place.

The *natural increase in population* (the difference between the number of births and deaths) was 0.75 per cent of the total population in 1950, 0.60 per cent in 1955 and 0.49 per cent in 1960. The *net gain of migration* (the difference between the number of immigrants and emigrants) was 56 per cent of the total annual increase of population in 1950 and 68 per cent and 70 per cent in 1955 and 1960, respectively. Since 1930, 67 to 75 per cent of the net gain in population has been composed of equal numbers of women and men between 15 and 35 years of age (Generalplan för Malmö, 1959). Migration by age and sex between November 2, 1961 and November 1, 1962 is known (Statistiska uppgifter för Malmö stad, 1963). Less than 2 per cent of inhabitants over the age of 60 moved into or out of the city during that period, providing evidence of the stability of that part of the population mainly subject to fracture of the proximal end of the femur.

Between 1950 and 1960 the *absolute size* of nearly all five-year age groups increased. During the same period the *relative size of the older age groups* also increased (Table 1). This tendency to aging of the general population conformed to a general pattern observed throughout the Western World (Berg and Tillman, 1959; Buhr and Cooke 1959; and Boucher, 1959).

B. CLASSIFICATION OF FRACTURES

Differences in the prognosis of various types of fracture are well recognized. However, few studies have attempted to relate the occurrence of different types of fracture in an unselected population with age, sex, and

degree of trauma. As this was one of the purposes of this investigation, a suitable classification of fractures was needed.

COOPER (1824) was the first to describe a classification of fractures of the proximal end of the femur, distinguishing cervical fractures from trochanteric fractures upon clinical and post-mortem examination. Since the advent of diagnostic radiology, classifications have usually been based upon the radiographic appearance of the fracture.

1. *Cervical Fractures.*

A more detailed definition of cervical fractures was introduced by KOCHER (1896) and elaborated by FALTIN (1924), and ANSCHÜTZ and PORTWICH (1927) based upon the *anatomical localization* of the fracture. These authors distinguished subcapital from intermediary fractures. This classification has been used recently in experimental studies (BACKMAN, 1957; FRANKEL, 1960).

The *relative position of the fracture fragments* has also been the basis for classification, a distinction being made between abduction and adduction fractures (WALDENSTRÖM, 1924; BÖHLER, 1938; LINTON, 1944), or valgus and varus fractures (NYSTRÖM, 1938; SPOTOFT, 1944; ODÉN, 1947; HULTH, 1956).

In recent years several authors have further simplified the classification into (a) fractures without displacement (usually equivalent to impacted fractures) and (b) fractures with displacement (CLEVELAND and FIELDING, 1954; FRANKEL and PRATT, 1955; FINNEY, BEVERLY and EATON, 1959).

LÖFBERG (1924) and ODELBERG-JOHNSSON (1930) advanced the theory that the *inclination of the fracture line* on the antero-posterior radiograph was significant with regard to stability of the fracture; this has been the basis of classifications by others (HOWARD and CHRISTOPHE, 1934; NYSTRÖM, 1935; LEHMAN, 1935; PAUWELS, 1935; BÖHLER, 1938; SPOTOFT, 1944).

Impacted cervical fractures have been separated from other cervical fractures with regard to treatment and prognosis (LINTON, 1944; CARLQUIST, 1947; ODÉN, 1947; TRUETA and HARRISON, 1953; CRAWFORD, 1960). LINDGREN (1924) defined impaction as "an evident entrance of one fragment, or part of it, into the spongy substance of the other . . ." as shown radiographically, without regard to the clinical stability of the fracture. ODELBERG-JOHNSSON (1930) assumed it impossible to assess the stability of an impacted fracture at *one single* radiographic or clinical examination; and according to NICOLE (1939) radiographic examination alone cannot establish the diagnosis of impaction. LINTON (1944) stated that "from a clinical point of view a fracture which does not become dislocated when

in normal function is regarded as impacted", and suggested the word "stability" should be used instead of "impaction", emphasizing that these terms were not synonymous. According to SPOTOFT (1944), CARLQUIST (1947) and CAVE (1960) impaction is chiefly encountered in valgus fractures. Like NICOLE and LINTON, CRAWFORD (1960) and CONWELL and REYNOLDS (1961) combined the radiographic appearance and the result of clinical examination to establish a diagnosis of impaction.

2. *Trochanteric Fractures.*

FALTIN (1924) and ANSCHÜTZ and PORTWICH (1927) divided trochanteric fractures into an intertrochanteric and a pertrochanteric type. A pertrochanteric fracture was defined as a fracture within the trochanteric region lateral to the intertrochanteric line. An intertrochanteric fracture was defined as a fracture through or in the immediate vicinity of the intertrochanteric line. As this fracture passes through the base of the neck of the femur, GREVILLIUS (1938) proposed the term fractura colli femoris basalis, a term also used by MURRY and FREW (1949). CLEVELAND et al. (1959) called this fracture paratrochanteric. SPOTOFT (1944) placed such basal fractures in the cervical group but a majority of authors regard them as trochanteric fractures since they are similar to pertrochanteric from the therapeutic and prognostic point of view.

Some authors distinguish between stable and unstable trochanteric fractures (EVANS, 1951; CRAM, 1955; CLAWSON, 1957; BRENNER and GRAHAM, 1958) and others class them by degree of comminution and displacement of the fracture (HAFNER, 1951; HUDSON and GILIBERTY, 1957).

3. *Classification Used in this Study.*

The anatomical classification defined by ANSCHÜTZ and PORTWICH (1927) was adopted, but their terms medial and lateral for the two main fracture types were replaced by the terms *cervical* and *trochanteric* (STEWART, 1955) as the term lateral has so often been applied to fracture of the lateral part of the femoral neck as well as trochanteric fractures.

Fractures immediately below the head of the femur were defined as subcapital and those localized between this region and the base of the proper neck of the femur were called transcervical.

No distinction was made between different types of trochanteric fractures. Subtrochanteric fractures defined by BOYD and GRIFFIN (1949) as occurring at the level of or below the lesser trochanter, and isolated fractures of the greater or lesser trochanters, were excluded.

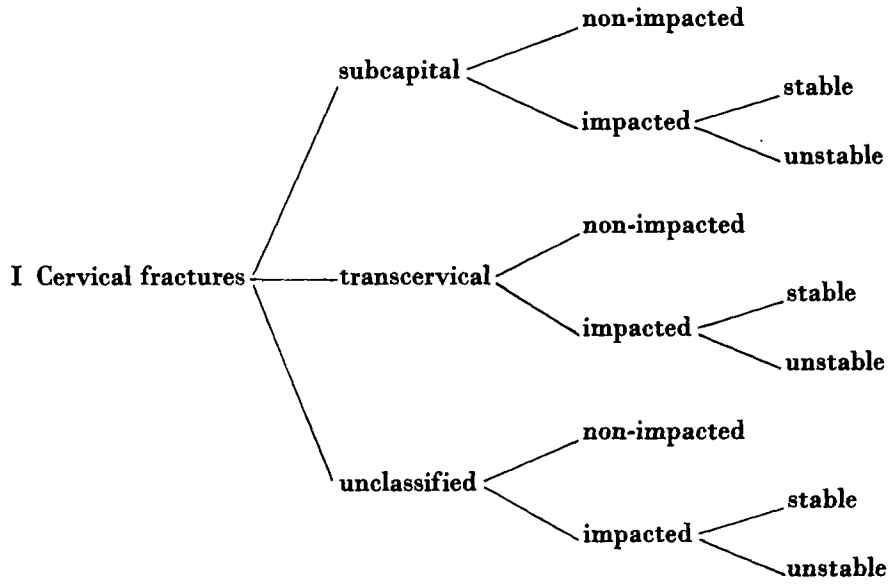
Attention was paid to the presence or absence of *impaction* as determined

from radiographs and case histories. A cervical fracture was considered impacted if the initial radiographs showed either penetration of parts of one fragment into the other or no displacement of the fragments, and active or passive movements of the hip caused little or no discomfort at the time of the initial clinical examination.

Fractures initially regarded as impacted which did not become displaced during conservative treatment were called *stable fractures*.

The trochanteric fractures were not assessed with regard to degree of comminution or stability.

The following scheme was used for the classification of fractures:



4. *Sources of Error in Classification of Fractures.*

Using modern radiographic techniques there should be little difficulty in separating cervical from trochanteric fractures. In the present series difficulty arose in only one case of mixed type, which was classified as trochanteric as it had been treated on that basis.

Irregularity of the fracture surface has been noted to cause difficulty in the separation of subcapital from transcervical fractures (Faltin, 1924; Nyström, 1938; Hulth, 1956). In this study such uncertainty was usually found in subcapital fractures where a small spike of bone was attached to the head. In view of experience with endoprosthetic replacement it seemed

reasonable to classify these as subcapital fractures as did FALTIN and HULTH.

Twenty-eight patients in this series gave a history of being able to walk on the injured leg although the first radiographs revealed displacement. A few of these actually felt their leg give way, suggesting that the fracture was stable until displacement occurred. Such fractures have been classified as non-impacted.

C. PROBANDS

1. *Selection of Probands.*

Probands were residents of Malmö who had a radiographically diagnosed cervical or trochanteric fracture of the femur during the period 1949 through 1961. Two cases with incidentally noted healed fractures without a recollection of injury were excluded from this preliminary material.

The records of the Orthopaedic clinic of MGH and the radiodiagnostic departments of MGH, MMH and GH were reviewed for case histories and radiographs. Cases at GH were found by review of all radiographs of the lower extremity done at that hospital.

Two series were distinguished —

Series A: Material from the 10 year period 1949—1958 composed of 1,124 fractures occurring in 1,101 patients, 23 of whom sustained two fractures during this period. All radiographs of these cases, initial films as well as those taken at operations, were evaluated by the author in collaboration with a radiologist at MGH[1]. Films taken at operation usually provided the best aid to classification of the fracture (CARLQUIST, 1947). The ten cases of fracture in radiographically-apparent lesions found in this series were not classified in detail. In 1,106 of the remaining 1,114 fractures, anatomical classification of fracture type was made upon films of good quality. Eight cases were classified by means of films of poorer quality or reports only. Follow-up examinations were made in Series A only.

Series B: Material from the 3 year period 1959—1961 was composed of 540 fractures in 535 patients. All films of this series were evaluated by the author using the criteria applied to series A, but fractures were classified only into cervical and trochanteric groups. Nine fractures in radiographically-apparent lesions were found.

Of the 1,664 fracture cases found during the 13 year period covered by Series A and B, 54 (46 female and 8 male) were second fractures during

[1] Dr. B. Frost, Radiodiagnostic Department (Head: Professor S. Welin), Malmö General Hospital.

this period, and 38 (31 female and 7 male) were in patients who had had a cervical or trochanteric fracture before 1949. Two of the latter group sustained two fractures during the period of study.

2. *Follow-up of Probands in Series A.*

Parish records as well as tax records in Malmö and elsewhere were consulted to identify those alive on July 1, 1960 (567 patients, 582 fractures), and determine the date of death of those deceased before July 1, 1960 (529 patients, 537 fractures).

Information about 3 patients was secured from relatives. One patient was untraceable, and one had left Sweden and could not be traced.

All traced living probands of Series A were given an appointment for a clinical examination in the Orthopaedic Clinic at MGH. Those who could not come to the clinic were examined in their homes or at the institutions where they lived. Examinations were performed by the author or one of three specially instructed medical students. 529 patients (543 fractures) of Series A were interviewed and examined in this way.

Probands who declined examination or who had moved from Malmö were sent a questionnaire (22 patients), or were interviewed by telephone (6 patients). Two mentally deteriorated patients admitted to institutions outside Malmö were not examined. Eight patients refused to cooperate.

The purpose of the interview was to collect information on previous or later fractures, the number of childbirths, and the age at menopause, and to check the reliability of available case records with regard to previous diseases. The result of the clinical after-examination will be reported elsewhere.

3. *Medical Records of Probands.*

Series A: The main sources of information were case records of the Orthopaedic Clinic of MGH. Further information was taken from records of other clinics or institutions where the patients had received treatment before or after their fractures. In about 500 cases one or more such records were studied, and data about previous disease or fracture, number of children, and treatment of the fracture were collected. In 44 female and 16 male patients the medical history before the fracture was regarded as incomplete, and in 12 women and 2 men the case records of the fracture episode itself were inadequate.

Series B: Records of the Orthopaedic Clinic of MGH and other clinics were examined to collect data about type of injury, number of births, age at menopause, blood group, and coexisting disease.

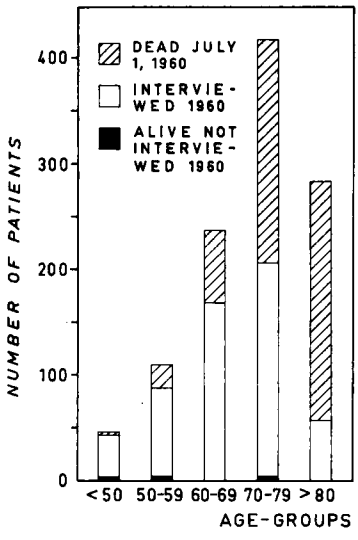


Fig. 1
Age distribution of patients in series A interviewed and not interviewed in 1960 and dead before July 1, 1960. Age at first fracture is indicated. Two patients had not been traced.

4. *Sources of Error in Identification and Follow-up of Probands.*

The film archives of MGH, MMH, and GH were the primary sources used for the collection of the cases. To rule out possible mistakes in the registration of radiographs, ward records and operating room records at the Orthopaedic Clinic were also examined.

During part of the period of investigation films of deceased patients were discarded from the archives at MMH. By reviewing case records of all patients with missing radiographs who had had pelvis, hip or femur examined radiologically at MMH this source of error was avoided. Two cases were discovered in this way.

Patients residing in Malmö who had not been radiographed or treated there were not included in the material. The insurance rules governing hospital care in Sweden render it extremely unlikely that patients normally resident in Malmö would be treated entirely in other centres. In Series A there were two such cases discovered at re-examination of known fractures.

While it is rare that a fracture of the proximal end of the femur fails to be radiographed, this could occur if the patient died soon after the fracture occurred, or if the fracture were stable and the pain so moderate that the patient did not seek medical advice. SPOTOFT (1944) believed this last alternative to be more common than is generally recognized. If this were the case, several such patients should have sought advice because of pain related to avascular necrosis. In Series A, 16 patients (1.5 per cent of the total material) with stable fracture were first diagnosed more than two weeks after the fracture incident.

Table 2. *Incidence of some coexisting diseases in Series A and B.*

	Series A	Per cent	Series B	Per cent
Rheumatoid arthritis	68/1,100	6.2	39/521	7.5
Diabetes mellitus	54/1,100	4.9	24/521	4.6
Hemiplegia	47/1,100	4.3	17/521	3.3

In older age groups, a lower proportion of patients were available for examination due to the higher death rates of these groups (Fig. 1). The percentages of patients in various age groups alive in 1960 were as follows: under 50 years 96 per cent; 50—59, 80 per cent; 60—69, 71 per cent; 70—79, 49 per cent; over 80, 20 per cent.

If interviews of the probands disclosed facts about disease unrecorded in case histories, the age distribution of the survivors could introduce a bias affecting any study of the impact of previous disease upon the etiology of fracture. For example, fractures of the distal end of the forearm were more commonly reported in those re-interviewed than in the total series. Concerning other previous diseases or conditions few cases unrecorded in the case histories were disclosed at re-interview. Thus, e. g., one patient with rheumatoid arthritis and one patient with diabetes mellitus were found. To check the reliability of case records of Series A, the incidence of some coexisting diseases in Series A was also compared with their incidence in Series B. This comparison showed no significant difference with regard to the incidence of these coexisting diseases (Table 2).

D. EVALUATION OF TRAUMA

1. *Degree of Trauma.*

In studies of fracture of the forearm (ALFFRAM and BAUER, 1962) and of the tibial shaft (BAUER et al., 1962) the degree of violence causing a fracture was assessed according to available anamnestic data. Fractures could be divided into two groups associated with moderate or severe trauma and this classification permitted resolution of the material into groups which were characterized also by age and sex distribution and type of fracture.

Therefore the data in the present study were subjected to classification according to the following definitions:

Moderate trauma — was defined as that resulting from violence equivalent to or less than a fall to the ground from the standing position. Thus trauma resulting from a fall from a chair or bed was regarded as moderate. A few

cases in which injury of any sort was denied have been included in this group. They were, however, subjected to more detailed analysis.

Severe trauma — was defined as that resulting from violence more severe than a fall from the standing position, such as a fall from standing upon a chair or a table, a fall on a stairway, and all traffic accidents.

2. *Sources of Error in Evaluation of Trauma.*

Information about the accident was collected only from the case records because it was believed that probands' recollection immediately following the injury would be more accurate than at the time of reexamination. It is evident that overlaps exist between the two groups in the classification adopted. Some traffic injuries, for example a pedestrian being knocked down by a bicycle, might have resulted in relatively mild trauma. On the other hand the forces involved in falls to the ground depend upon such factors as surface, the efficiency of reflex mechanisms, and whether there was direct violence to the hip region. BACKMAN (1957) calculated the force of impact of a fall on the hip to be as much as ten times the body weight. There is little question, however, that trauma resulting from falls from a height is still more severe.

E. DEFINITIONS AND STATISTICS[1]

The terms used in the present study were defined as follows:

Fracture case: Each separate fracture of the proximal end of the femur. A patient who sustained two fractures was regarded as two fracture cases.

Patient or Proband: A person sustaining one or more such fractures during the period studied.

Age: Age at last birthday.

Age and Sex Incidence: The annual number of fracture cases per 1,000 inhabitants per sex and age group. Age groups were generally five-year age groups. Calculations were based upon the mean population during the periods 1951—1960, 1951—1955, or 1956—1960.

Age-Specific Sex Ratio: Ratio of age and sex incidences.

Standardized Morbidity Rates: The age and sex incidence during a given period projected upon the population of Malmö in 1960.

[1] Data treated statistically under supervision of Professor C.-E. Quensel, Institute of Statistics, University of Lund.

Standard statistical methods have been used. Differences were regarded to be:

highly significant (***) when $P<0.001$,
significant (**) when $0.001<P<0.01$, and
probably significant (*) when $0.01<P<0.05$.

In the study of frequencies of, e. g., second fractures of the proximal end of the femur, the difference between the observed number (0) and the excepted number (E) was compared with the standard deviation of the observed number which equals $\sqrt{E}$. When the difference was $2 \cdot \sqrt{E}$ or more, it was said to be significant ($P< 0.05$). No more detailed statistical analysis was carried out in such comparisons.

F. PRIMARY TREATMENT OF FRACTURES IN SERIES A

An analysis of the initial treatment of cervical and trochanteric fractures is given here by a survey of the principles followed in Series A (Table 3).

1. *Cervical fractures.*

Non-impacted fractures were nailed with a three-flanged Johansson nail or multiple Nyström nails. Reduction and internal fixation were controlled radiographically. General anesthesia was almost always employed. During the period under study 91 per cent of all non-impacted cervical fractures primarily treated at MGH, MMH, and GH were operated upon. The incidence of operation was almost constant during each year of the period of study. The interval between fracture and operation varied greatly, depending upon the general condition of the patient. The mean interval was 4 days, with 75 per cent of the cases being operated within one week of the accident.

Forty-one patients with non-impacted fractures primarily treated at MGH, MMH and GH did not undergo operation. Thirty-six of these were in such poor general condition that operation was felt to be contraindicated; and 27 of these died within three months of injury. Two patients refused operation, one of whom was treated in a hip spica. In 3 cases the reason for non-operative treatment could not be deduced. Four patients were treated conservatively by private physicians in Malmö, but were radiographed at MGH or GH. Six patients received initial operative treatment in other centres.

Table 3. *Type of primary treatment in Series A.*

Fracture types	Conservative				Operative			
	Non-weight-bearing	Traction	Plaster	Not known	Nailing procedures S. Johansson[1]	Nyström[2]	McLaughlin	Other methods
Cervical non-impacted	20	19	1	4	398	30	2	1
Cervical impacted . . .	109	87	0	6	24	9	0	0
Trochanteric	32	304	0	4	1	1	50	12

[1] S. Johansson (1934)
[2] Nyström (1938)

Table 4. *Sex distribution of cervical fractures in Series A grouped according to anatomical type and stability.*

	Subcapital fractures				Transcervical fractures				Not classifiable fractures				Total cervical fractures
	Unstable	Stable	Unknown	Total	Unstable	Stable	Unknown	Total	Unstable	Stable	Unknown	Total	
Women	286	121	26	433	105	22	9	136	4	2	—	6	575
Men	42	18	3	63	47	21	2	70	2	—	—	2	135
Total	328	139	29	496	152	43	11	206	6	2	—	8	710

Impacted fractures were usually treated conservatively. All impacted fracture cases in Series A were treated at MGH, MMH or GH. Thirty-three of these cases were nailed (14 per cent). The frequency of operation in this group was higher during the last three years of the study than during the earlier years of the period (27 and 4.3 per cent, respectively). Twenty-four impacted fractures were operated upon primarily. In 14 of these there was evident angulation and in 5 there was doubt about the stability of the fracture. In 2 patients with stable fractures in good position operation was performed to shorten the period of immobilization. In 3 cases the reason for operation could not be deduced.

The remaining 9 cases were operated because of loss of position of the fractures after a period of conservative treatment.

Endoprosthetic replacement of the femoral head was not done as a primary procedure in Series A.

2. *Trochanteric Fractures.*

Trochanteric fractures in Series A were usually treated conservatively. Internal fixation was used in only 16 per cent of the cases. Operative treatment was more common during the last two years of the period than during the earlier years (33 per cent and 7.5 per cent respectively). Of 8 patients with trochanteric fractures treated outside Malmö, 4 were operated and 4 had conservative treatment.

III. RESULTS

A. RADIOGRAPHICALLY-APPARENT LESIONS OF THE PROXIMAL END OF THE FEMUR

Skeletal lesions due to primary and secondary tumours, other tumorous or cystic destructive processes, as well as osteogenesis imperfecta and Paget's disease are obvious factors predisposing to fracture. These fractures have been excluded from the present study, but will be considered in the General Discussion.

In the total material of 1,664 fracture cases, 19 such fractures were found (Table 5) in 2 of which the exact nature of the lesions was not known. Moderate trauma was recorded in 8 cases, and severe trauma in 2 cases. The remaining 9 were spontaneous fractures. The average age at fracture was 61.5 years.

B. TYPES OF FRACTURE

1. *Main Anatomical Types.*

PREVIOUS STUDIES

Remarkable differences exist in the proportions of cervical versus trochanteric fractures in series reported in the literature. Data from some representative series are shown in Table 6. A majority of authors recorded a predominance of cervical fractures ranging from 57 to 69 per cent. On the other hand, WATSON-JONES (1955) observed that trochanteric fractures "occur in elderly patients even more frequently than fractures of the femoral neck itself". STEWART (1955), FITTS JR. et al. (1959), and MANPEL et al. (1961) also found a predominance of trochanteric fractures as did the British Committee for Fractures in the Elderly (personal communication). In IBSEN's material (1951) it was calculated that trochanteric fractures were more common than cervical fractures above the age of 80, in contrast to the situation below that age.

In LÖFBERG's series from Malmö (1924) 34 per cent of female and 46 per cent of male fracture cases were trochanteric. STEWART (1955) found that 52 per cent of female, and 72 per cent of male patients had trochanteric fractures. It appears that trochanteric fractures are more common in males than in females.

Table 5. *Fractures in radiographically—apparent lesions of the proximal end of the femur.*

Code No.	Sex	Age	Fracture type	Trauma	Nature of skeletal lesion
Series A					
1045	W	34	Cervical	Moderate	Osteogenesis imperfecta
1044	W	35	Cervical	Moderate	Metastasis from sarcoma of colon
1022	W	51	Cervical	Severe	Metastasis from carcinoma of breast
831	W	68	Cervical	None	Metastasis from carcinoma of breast
340	W	82	Cervical	Severe	Paget's disease
154	M	66	Cervical	Moderate	Metastasis from carcinoma of bronchus
95	M	73	Cervical	Moderate	Metastasis from hypernephroma
94	M	77	Cervical	None	Metastasis from carcinoma of prostate
218	M	47	Trochanteric	None	Chondroblastoma
176	M	59	Trochanteric	Moderate	Metastasis from hypernephroma
Series B					
3158	W	58	Cervical	None	Metastasis from carcinoma of breast
3167	W	45	Cervical	Moderate	Metastasis from hypernephroma
4155	W	68	Cervical	None	Metastasis from carcinoma of uterine cervix
4141	W	74	Cervical	None	Not known
4066	W	61	Trochanteric	None	Not known
4065	W	62	Trochanteric	None	Myeloma
3071	W	56	Trochanteric	Moderate	Metastasis from carcinoma of breast
2016	M	73	Trochanteric	None	Metastasis from carcinoma of prostate
4005	M	80	Trochanteric	Moderate	Metastasis from carcinoma of prostate

PRESENT STUDY

In the combined Series A and B of this study, 1,024 fractures were cervical and 612 trochanteric, or 63 and 37 per cent respectively. Cervical fractures were more common in women than in men: 65 per cent of 1,241 female patients and 55 per cent of 395 male patients sustained cervical fractures(**) (Table 7).

The relative number of trochanteric fractures tended to increase during the period of this study (Table 7 and Fig. 2).

Table 6. *Survey of published series of fractures of the proximal end of the femur.*

Author	No. of cases	Type of fracture	Women: men	Cervical fractures (per cent)	Impacted or valgus (per cent of cervical fractures)	Mean age	Mortality	
							Per cent	Interval
Spotoft (1944)	512	C+T		64			17	in hospital
Linton (1944)	475	C	4.5		13	67.5	16	6 months
Duhamel (1947)....	300	C+T	3.5	62				
Boyd & Griffin (1949)	300	T	3.1			69.7	17	3 months
Ibsen (1951)	675	C+T	2.6	58	14		19	3 months
Ender (1952).....	302	C			23			
Parker (1955).....	150	T				72.5	16	3 months
Stewart (1955).....	190	C+T	2.8	43		73	32	?
Jensenius (1956)	319	C			18		12	in hospital
Wedeen et al. (1957)	938	C+T	3.5	62			11	in hospital
Murray&Young (1957)	204	C+T	1.6	45		71	30	3 months
Fitts Jr. et al. (1959)	109	C+T	4.9	41		71.5	24	6 months
Thorsøe (1960)	707	C+T	2.9	69	16			
Manpel et al. (1961) .	478	C+T	2.7	41		75.9	31	in hospital
Present series A	1,114	C+T	3.7	63	33 impacted 27 stable	72.1	15 19	3 months 6 months

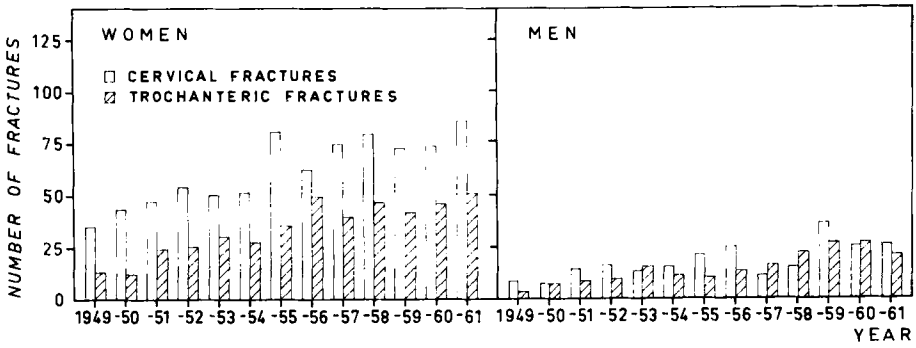


Fig. 2
Fractures in series A and B grouped according to sex, type, and year.

Table 7. *Fractures in 1949—1953, 1954—1958, and 1959—1961 grouped according to sex and type.*

Period	Women		Men		Total	
	Cervical fractures	Trochanteric fractures	Cervical fractures	Trochanteric fractures	Cervical fractures	Trochanteric fractures
1949—1953	229 (69)	104	53 (59)	37	282 (67)	141
1954—1958	346 (64)	196	82 (55)	67	428 (62)	263
1959—1961	230 (63)	136	84 (54)	72	314 (60)	208
Total	805 (65)	436	219 (55)	176	1,024 (63)	612

Bracketed figures denote per cent.

2. *Types of Cervical Fractures.*

a. Anatomical types.

PREVIOUS STUDIES

Although anatomical classifications have been widely used, there have been few reports of relative incidence of different types of fracture. In 105 cervical fractures FALTIN (1924) found 71 per cent were subcapital, while HULTH (1956) found 55 subcapital fractures in 100 cervical cases. MANPEL et al. (1961) found 26 per cent subcapital fractures in 196 cases, but did not define their method of classification. None of these authors divided their series according to age or sex.

PRESENT STUDY

In Series A 70 per cent of all cervical fractures were subcapital (Table 4, page 21). Subcapital fractures were more common in women(75 per cent) than in men (47 per cent)(***).

b. *Impaction and Stability.*

PREVIOUS STUDIES

Reports of the relative incidence of impacted (or valgus) fractures gave values ranging from 10 to 23 per cent of all cervical fractures (Table 6). It was often difficult to know whether or not these figures included fractures which displaced during conservative treatment. CRAWFORD (1960) reported 8 per cent and FLATMARK and LONE (1962) 7.5 per cent of displaced fractures.

PRESENT STUDY

At the time of admission 235 of the 710 cervical fractures (33 per cent) in Series A were judged to be impacted. For various reasons (immediate internal fixation of the fracture or lack of radiographic control) the degree of stability could not be evaluated in 40 of these cases. Eleven cases displaced during conservative treatment (5.6 per cent of the conservatively treated and radiographically controlled impacted cervical fractures).

The remaining 184 impacted fractures (26 per cent of all cervical fractures) remained stable. Seventy-five per cent of the stable cervical fractures were subcapital, 24 per cent transcervical, and 1.1 per cent could not be classified as to anatomical type. In unstable fractures the corresponding percentages were 67, 31 and 1.2, respectively. Stability was more common(*) in subcapital fractures (30 per cent) than in transcervical fractures (22 per cent). (Table 4).

Impacted fractures were equally common in men and women.

Among impacted fracture cases, 92 patients gave a history of weight-bearing on the injured leg after the probable time of fracture. Thirty-two of these had been able to walk quite a distance. 75 patients reported they were unable to bear weight after the accident. In 68 case histories there was no information about weight-bearing.

Fracture displacement under conservative treatment occurred in 4 patients who had given a history of weight-bearing prior to admission, a frequency similar to that of displacement occurring in all conservatively treated impacted cervical fractures.

The time interval between fracture and displacement ranged from 8 to 77 days, with a mean of 32 days. In one patient who had received radiotherapy for cancer of the ovary, the displacement was not noted until 190 days after the probable date of fracture. This gradual development of fracture following radiotherapy is now a recognized syndrome.

COMMENTS

The ratio of cervical to trochanteric fractures in this material was in agreement with that reported in several series but was in contrast to that of other materials. Several authors have reported a higher mean age in trochanteric fracture cases than in cervical fracture cases. This observation was also made in the material.

Differences in the age composition of the population from which the reported materials were drawn as well as selection of any kind may affect the distribution of fracture types. As the older age groups constitute a steadily increasing proportion of the population in most Western countries, and trochanteric fractures occur in patients of higher average age than do cervical fractures, an increase in the proportion of trochanteric fractures is to be expected in this material.

The distribution of subcapital and transcervical fractures in this series agreed with the findings of FALTIN (1924) and HULTH (1956) but contrasted with figures given by MANPEL et al. (1961) probably because of differences in definitions or selection of the population.

It was evident in this series that a sex-linked difference exists in the prevalence of the anatomical types of cervical fracture. In women subcapital fractures were three times more common than transcervical fractures. In men the two types were about equally common. The transcervical fracture seems to be a male fracture type. This may indicate the presence of some biologic or traumatic factor. BACKMAN (1957) found the results of experimental studies suggested that subcapital fractures occur only in association with reduced skeletal strength. This supports the idea that biologic factors partly determine the type of fracture.

The incidence of cervical fractures impacted at the time of initial examination (33 per cent) was higher in this material than has been reported in other series (Table 6). It is likely that this was due to differences in methods of classification.

Twenty-six per cent of all cervical fractures (84 per cent of those impacted) remained stable and did not require internal fixation. This figure is higher than that given in most reports but is in agreement with ENDER (1952).

In contrast to the marked sex difference found in the incidence of anatomical types of cervical fracture, no sex difference was observed in the incidence of impaction or stability.

SUMMARY

Cervical fractures were more common than trochanteric fractures in the total series, and in women. In men they were about equally

ommon. Trochanteric fractures have apparently become more common due to changes in the age distribution of the population.

Three out of 4 cervical fractures in women were subcapital, while in men subcapital and transcervical fractures were equally common.

One of every 3 cervical fractures was initially judged to be impacted, and 1 out of every 4 cervical fractures remained stable.

The occurrence of impaction or stability was unrelated to sex.

C. SEX AND AGE DISTRIBUTION

PREVIOUS STUDIES

It has long been recognized that fracture of the proximal end of the femur occurs predominantly in women (COOPER, 1824; BRUNS, 1882). The female: male sex ratio ranges from 2.6 to 4.0 in unselected series of such fractures (Table 6).

The sex ratio has been reported to be higher in cervical than in trochanteric fractures (JOHANSSON, 1934; NYSTRÖM, 1938; ODÉN, 1947; IBSEN, 1951; STEWART, 1955). This female predominance has been observed to increase with age in both types of fractures (BRUNS, 1882; NYSTRÖM, 1938; DUHAMEL, 1947). Of those quoted above only BRUNS (1882) tried to relate the sex ratio of fracture cases to that of the population at risk. In his series fractures below 50 years of age were six times more common in men while above that age such fractures were two and one half times more common in women.

The average age of unselected series of cervical and trochanteric fracture patients in the literature ranges from 70 to 76 years (Table 6).

Most authors state that patients with trochanteric fractures have a higher mean age than patients with cervical fractures (LINDGREN, 1924; CLEVELAND et al., 1951; CONWELL and REYNOLDS, 1961), but Stewart (1955) and CHRISTIANSEN (1958) found no such age difference. MCELVENNY (1957) pointed out that while subcapital fractures were uncommon below the age of 60 they became increasingly common above that age. LINTON (1944) noted that the average age of abduction fracture cases was lower than the average age of adduction fracture cases.

PRESENT STUDY

Seventy-nine per cent of *cervical fractures* occurred in women; a female : male sex ratio of 3.8 (Table 7). As there were more women than men in the population of Malmö and this predominance increased with age, the age-specific sex ratio (page 19) is a more valid measure of the relative sex incidence of these fractures. The age- specific sex ratio of cervical fracture during the period 1951—1960 was 2.7.

Table 8. *Cervical fractures in Series A grouped according to age, sex, and anatomical type.*

Age groups	Women			Men		
	Sub-capital	Trans-cervical	Unclassifiable	Sub-capital	Trans-cervical	Unclassifiable
<60	57	19	2	8	21	—
60—69	104	36	2	16	14	—
70—79	156	54	2	27	23	2
>80	116	27	—	12	12	—
Total	433	136	6	63	70	2

Table 9. *Ages of patients at time of fracture grouped according to type and sex.*

Type of fracture	Women			Men		
	No. of cases	Mean	Error of mean	No. of cases	Mean	Error of mean
Cervical (A+B) ..	805	71.7	0.38	219	68.6	0.95
Trochanteric (A+B)	436	75.2	0.52	176	69.4	1.12
Total (A+B)...	1,241	73.0	0.33	395	69.0	0.70
Cervical (A)						
Unstable.....	395	72.5	0.51	91	69.8	1.33
Stable	141	69.1	1.01	39	63.5	2.75
Subcapital	433	72.3	0.53	63	70.7	1.48
Unstable.....	286	73.1	0.59	42	69.7	1.91
Stable	117	69.4	1.16	18	72.3	2.17
Transcervical ..	136	70.7	0.92	70	65.4	1.98
Unstable.....	105	71.2	1.02	47	69.7	1.93
Stable	22	68.1	2.43	21	55.9	4.19

In cervical fracture cases, 25 per cent of the women and 20 per cent of the men were over 80 years of age, and 61 and 58 per cent, respectively, over 70 years of age (Fig. 3). Fifteen per cent of women and 22 per cent of men were below age 60, indicating a shift toward males in younger age groups. The mean age at fracture was lower(**) in men than in women (68.6 $\pm$ 0.95 and 71.7 $\pm$ 0.38 years, respectively).

In women of Series A, there was no correlation between age and the anatomical type of cervical fracture. However, the ratio of subcapital to transcervical fracture was 4.3 in females above age 80 compared to a ratio of 2.9 in females below this age. (Table 8).

In men above 60 years of age the anatomical types of cervical fracture were equally common; below that age, however, transcervical fractures prevailed(*).

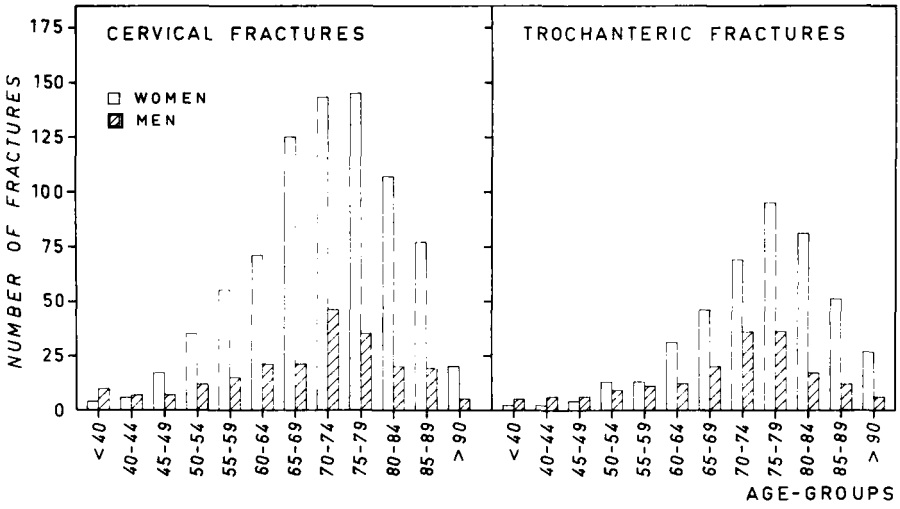


Fig. 3
Fractures in series A and B grouped according to age, sex, and type.

Table 10. *Cervical fractures in Series A grouped according to age, sex, and stability.*

Age groups	Women			Men		
	Unstable	Stable	Unclassifiable	Unstable	Stable	Unclassifiable
<60	44	28	6	18	10	1
60—69	98	39	5	19	9	2
70—79	155	47	10	35	16	1
>80	98	31	14	19	4	1
Total	395	145	35	91	39	5

The average age at fracture for all anatomical types of fracture is given in Table 9. In both sexes, subcapital fracture occurred at a somewhat higher average age than transcervical fracture. This difference was significant(*) in men, but not in women.

Stable fractures in Series A showed an increase in younger age groups when compared with the age distribution of unstable fractures (Table 10). The average age of stable fracture cases was therefore lower than that of unstable cases in women(**) as well as in men(*).

The average age of patients with stable and unstable cervical fractures was not related to anatomical type of fracture. In men, however, the average age of stable transcervical fracture cases was lower(***) than that of stable subcapital fractures.

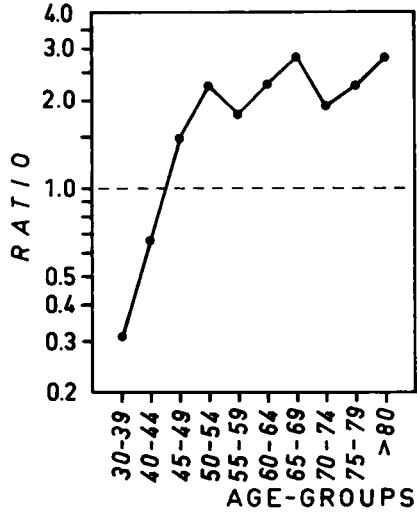


Fig. 4
Age-specific sex ratios of fractures of the proximal end of the femur in Malmö in 1951—1960.

Seventy-one per cent of the *trochanteric fractures* occurred in women; a female : male sex ratio of 2.4. The age-specific sex ratio was 2.0.

The sex distribution of trochanteric fracture patients was as follows: 37 per cent of the women and 20 per cent of the men were above age 80; 75 and 60 per cent, respectively, were above age 70. 7.8 per cent of the women and 21 per cent of the men were below age 60. The average age of trochanteric fracture cases was higher(***) in women than in men (75.2 $\pm$ 0.52 and 69.4 $\pm$ 1.12 years, respectively).

In women the average age of trochanteric fracture cases was 3.5 $\pm$ 0.65 years higher(***) than the average age of cervical fracture cases. In men the corresponding difference was 0.8 $\pm$ 1.43 years.

There was no significant change in the average age of fracture patients during the period of study.

Age-specific sex ratios of cervical and trochanteric fractures in various age groups showed that below age 45 a male predominance decreased with age, and a female predominance which then became evident remained relatively constant in age groups above 50 (Fig. 4).

COMMENTS

The female predominance of fracture of the proximal end of the femur is beyond doubt. BRUNS (1882) found a sex ratio of 2.5 above the age of 50. In Mårtensson's data it can be calculated that the age-specific sex ratio of fracture patients in Göteborg 1955—1959 was 3.2 and the data of the British Committee for Fractures in the Elderly give an age-

specific sex ratio of 2.1. In the present series the age-specific sex ratio was 2.4, about the same as reported by BRUNS.

The higher sex ratio in cervical than trochanteric fractures reported by several authors (JOHANSSON, 1934; NYSTRÖM, 1938; ODÉN, 1947; IBSEN, 1951; STEWART, 1955) was confirmed in this series, even after correction for age, and might indicate a sex-linked difference between the two types of fracture.

The increase of the female predominance with age observed by some authors (BRUNS, 1882; NYSTRÖM, 1938; DUHAMEL, 1947) could be only partly confirmed. Below age 50 the proportion of female patients increased while above that age there was no marked change in the age-specific sex ratio as shown in Figure 4.

SUMMARY

Fractures of the proximal end of the femur were about two and one half times more common in women than in men after correction for the age of the population at risk. The age-specific sex ratio was higher in cervical than in trochanteric fractures. There was no change in the age-specific sex ratio after the age of 50.

There was no definite difference in the incidence of subcapital or transcervical fractures in different age groups in women. In men below 60 transcervical fractures were more common than above that age.

The average age of women with cervical fractures was significantly lower than that of women with trochanteric fractures. In men there was no significant age difference.

Patients with stable cervical fractures had a lower average age than patients with unstable fractures.

D. TYPES OF TRAUMA ASSOCIATED WITH FRACTURES

PREVIOUS STUDIES

COOPER (1824) noted that fractures of the neck of the femur were usually a result of moderate trauma. He described two women who sustained fractures as a result of merely stumbling. More than a hundred years later APFELBACH and ARIES (1936) stated that case histories often suggested a primary fracture due to a mis-step or twist and that the fall was secondary to the fracture. Whether the fracture is due to the fall or vice versa has since been a matter of conjecture. CONWELL and REYNOLDS (1961) thought that in a majority of cases the fall was the result rather than the cause of the fracture. MCELVENNY (1957) believed this to be a rather common sequence of events. SMITH (1953) felt that while ex-

ternal forces frequently are the cause of other fractures, fractures of the neck of the femur are due to muscular forces, and reported two fracture cases occurring without a fall. However, the strength of the external rotators was estimated experimentally by BACKMAN (1957) who found that there was "very little possibility of its producing fractures" and concluded that "a fall on the hip is the most plausible and natural cause of femoral neck fractures". There are few reports in the literature of definitely non-traumatic cases of fracture of the proximal end of the femur, with the exception of march fractures in young adults (for references, see ERNST, 1963).

Some authors found a marked difference in the degree of injury reported by female patients in comparison with male patients. While a majority of females gave a history of slight or moderate injury, males on the contrary, often reported severe injury as the cause of the fracture (PELS LEUSDEN, 1902; STEWART, 1955). In experimental studies it was found that less force is generally required to cause fracture of female than of male bone specimens (MESSERER, 1880; KOLODNY, 1925; SPOTOFT, 1944; FRANKEL, 1960).

The force required to cause fractures of the type under study is greater in young adults and in middle-aged patients than in the aged (CAVE, 1960; CONWELL and REYNOLDS, 1961; MÅRTENSSON, 1962). This observation was also made by KOCHER (1896) in his experimental studies, but could not be definitely confirmed by BACKMAN (1957). STEWART (1955) found it "significant that two female patients under 50 had had violent falls at work which none over 50 had. In men, however, major accidents are equally scattered over the normal life-span".

PRESENT STUDY

Anamnestic data on the type of trauma sustained by the patients were available in 1,099 cases (99 per cent) of the 1,114 fracture cases in Series A. According to the definition given on page 18, a classification of the violence involved was made in each case.

1. *Moderate and Severe Trauma in Relation to Sex and Type of Fracture.*

The fracture cases of Series A were divided into two groups associated with severe or moderate trauma as shown in Table 11, which also lists the more common mechanisms of injury.

Of the 568 female and 131 male *cervical fracture* cases, 491 women and 67 men (87 and 52 per cent, respectively) suffered moderate trauma. A further 14 women and 1 man denied any injury so that in 89 per cent of women and 53 per cent of men cervical fractures were associated with moderate or no trauma.(***) (Table 11).

The distribution of degree of trauma was the same for subcapital and

Table 11. *Fractures in Series A grouped according to degree of trauma, sex, and main anatomical type.*

	Women		Men		Total			
	Cervical fractures	Trochanteric fractures	Cervical fractures	Trochanteric fractures	Women No.	Women Per cent	Men No.	Men Per cent
Moderate or no trauma								
No trauma	14	—	1	—	14	1.6	1	0.4
Fall on ground	487	240	67	55	727	83	122	51
Fall out of bed or chair	4	14	—	1	18	2.6	1	0.4
Severe trauma								
Fall from a height	15	14	13	8	29	3.3	21	8.8
Fall on stairs	31	17	7	9	48	5.5	16	6.7
Pedestrian knocked down in traffic	8	8	3	4	16	1.8	7	2.9
On bicycle	8	2	33	22	10	1.1	55	23
On motor bicycle	—	—	3	4	—	—	7	3.0
In automobiles	1	1	1	—	2	0.2	1	0.4
Other severe trauma	—	—	3	1	—	—	4	1.7
No data available on trauma	7	4	4	—	11	1.3	4	1.7
Total	575	300	135	104	875		239	

Table 12. *Relation between degree of trauma and anatomical type of fracture in Series A.*

Trauma	Women				Men			
	Sub-capital	Trans-cervical	Total cervical	Trochan-teric	Sub-capital	Trans-cervical	Total cervical	Trochan-teric
Moderate .	379	120	505	254	35	32	68	56
Severe ...	49	14	63	42	25	37	63	48
Not known	5	2	7	4	3	1	4	—
Total	433	136	575	300	63	70	135	104

Seven fractures with moderate trauma and one fracture with severe trauma were unclassifiable as to anatomical type.

transcervical fractures in women, while in men transcervical fractures were slightly more often associated with severe trauma. In the total series, subcapital fractures were more commonly seen(**) with moderate trauma than were transcervical fractures (Table 12). Stability in cervical fractures was unrelated to the degree of trauma.

A similar pattern of trauma was observed in the 295 female and 104 male *trochanteric fractures* in which the mechanism of injury was known. Moderate trauma was noted by 254 women and 56 men (86 and 56 per cent, respectively) of this group(***). No patient denied injury at the time of fracture.

The most common mechanism of moderate injury was a simple fall, and of severe injury a fall on stairs in women (5.6 per cent), and traffic accidents in men (29 per cent) (Table 11).

Within each sex and within the main anatomical fracture types the proportion of moderate trauma to severe trauma was constant.

2. *Moderate and Severe Trauma in Relation to Age at Fracture.*

The relation between degree of trauma and age is shown for both sexes and types of fracture in Table 13 and Figure 5. Moderate trauma was predominant in females in all age groups for both cervical and trochanteric fractures. In women, severe trauma was more often seen under age 60 than above that age(*); this difference was significant only in trochanteric fractures(*).

In men a clear relation was observed, with severe trauma predominant in both fracture types below age 70; and moderate trauma predominant above that age(***).

It was evident that there was a change in the pattern of trauma with age which was more pronounced in males.

Table 13. *Age and sex distribution of fractures of the proximal end of femur in Series A classified according to degree of trauma and anatomical type.*

	Women				Men			
	Moderate trauma		Severe trauma		Moderate trauma		Severe trauma	
Age groups	Cervical fractures	Trochanteric fractures	Cervical fractures	Trochanteric fractures	Cervical fractures	Trochanteric fractures	Cervical fractures	Trochanteric fractures
<60	64 (46)	18 (6)	13 (10)	8 (8)	5 (4)	6 (4)	22 (20)	15 (12)
60—69	126 (87)	44 (30)	15 (12)	5 (3)	13 (5)	6 (4)	17 (14)	12 (11)
70—79	187 (140)	96 (66)	21 (18)	22 (19)	33 (24)	21 (14)	17 (16)	19 (16)
>80	128 (109)	95 (79)	15 (13)	7 (7)	17 (14)	23 (21)	7 (7)	2 (1)
Total	505 (382)	253 (181)	63 (53)	42 (37)	68 (47)	56 (43)	63 (57)	48 (40)

Bracketed figures denote fractures in patients without predisposing factors.

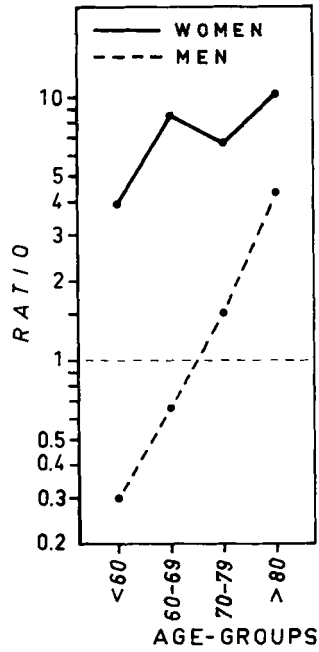


Fig. 5
Ratios moderate: severe trauma in series A grouped according to age and sex.

3. *No Trauma.*

Fifteen patients (14 women and 1 man) suffered fractures without a significant injury. All of these were cervical (2.1 per cent of cervical fractures where degree of trauma was known) (Table 14).

Eleven of these were impacted subcapital; two were subcapital non-impacted; and 2 were transcervical non-impacted fractures.

Eight patients had received radiotherapy for a pelvic malignancy. In these cases increasing local pain and a limp led to radiographic diagnosis of the fracture from 1 to 17 months after the onset of pain.

The remaining 7 female patients included 3 with coexisting invalidism (rheumatoid arthritis, severe osteoporosis, and malunion of trochanteric fracture) and 4 who had no known coexisting disease. This group of 7 cases noted sudden pain at the time of fracture, although in two cases the diagnosis was not established until 2 weeks later.

4. *Traffic Accidents.*

Fractures due to traffic accidents occurred in 28 women and 70 men (3.2 and 29 per cent) of cases of known type of injury. Motor vehicles were involved in 11 female and 19 male cases (1.3 and 8.0 per cent). Only 3 patients were passengers in cars. (Table 11).

Although the annual number of casualties in road accidents in Sweden more than doubled over the period of this study, the proportion of fractures

Table 14. *Fractures not preceded by any trauma in Series A.*

Code No.	Sex	Age	Fracture type	Onset of symptoms	Interval between onset of symptoms and diagnosis	Predisposing factors
158	M	67	SC impacted	gradual	6 months	radiotherapy
578	W	62	SC impacted	gradual	3 months	radiotherapy
696	W	74	TC non-impacted	gradual	2 months	radiotherapy
812	W	72	SC impacted	gradual	12 months	radiotherapy
877	W	62	SC impacted	gradual	15 months	radiotherapy
944	W	63	SC impacted	gradual	1 month	radiotherapy
996	W	56	SC impacted	gradual	4 months	radiotherapy
997	W	57	SC impacted	gradual	17 months	radiotherapy + rheumatoid arthritis
908	W	62	SC impacted	sudden	2 weeks	rheumatoid arthritis
309	W	86	SC impacted	sudden	2 weeks	severe osteopenia
305	W	90	TC non-impacted	sudden	none	malunion of trochanteric fracture same side
284	W	83	SC impacted	sudden	none	
749	W	71	SC non-impacted	sudden	none	
745	W	72	SC impacted	sudden	none	
985	W	57	SC non-impacted	sudden	none	

SC = subcapital and TC = transcervical.

in this material due to traffic accidents remained nearly constant (9.6 per cent in 1949—1953, 8.5 per cent in 1954—1958 and 8.7 per cent in 1959—1961) (Statistical abstract of Sweden, 1960).

Among female cases cyclists and pedestrians were equally common, but in male cases cyclists were 8 times as common as pedestrians.

COMMENTS

It has been stated that fractures of the proximal end of the femur, particularly cervical fractures, often occur without significant injury. Such a history was recorded in only 15 patients (1.4 per cent) in the total material. In 11 of these some coexisting disease probably predisposed to fracture. It was also significant that almost half of the fractures in radiographically-apparent lesions (Table 5) appeared spontaneously. The small proportion of spontaneous fractures recorded in the series supported the view that fracture of the proximal end of the femur almost always occurs in association with trauma.

The change in distribution of type of trauma with age noted by others was found in this material. While STEWART (1955) observed the frequency of major accidents to be independent of age in men, in this material the change in distribution of type of trauma with age was pronounced in men.

The pattern of trauma in cervical fractures was similar to that found in trochanteric fractures, in contrast to the observations of MORRIS (1941), NEWELL (1947), BOYD and GRIFFIN (1949), and BICK (1960).

SUMMARY

In women 9 out of 10 fractures were associated with moderate or no trauma. In men severe trauma dominated below age 70 and moderate trauma in older age groups. The increase in the proportion of moderate trauma with age was more pronounced in men than in women.

The pattern of type of trauma was similar in cervical and trochanteric fractures. After moderate trauma, subcapital fractures were more common than transcervical fractures. Recorded degree of trauma was not related to the stability of cervical fractures.

Eleven of 15 spontaneous fractures were in patients with diseases predisposing to fractures.

Fractures due to traffic accidents were uncommon in women, but accounted for 29 per cent of the cases in men.

E. MORTALITY

PREVIOUS STUDIES

In most reports, mortality refers to hospital mortality, i.e., number of deaths occurring in hospital (RENO and BURLINGTON, 1958;

FAHEY, 1949; SCHENK JR et al., 1956; CARLQUIST, 1947; FINNEY et al., 1959; MANPEL et al., 1961; JENSENIUS, 1956). Because length of hospital stay and hence mortality is influenced by administrative as well as other factors (IBSEN, 1951) comparisons of such materials are difficult (SPOTOFT, 1944). FITTS JR. et al. (1959) used mortality within 6 months of fracture or until weight-bearing was resumed as a criterion. LINTON (1944), BOYD and GEORGE (1947) and BOYD and GRIFFIN (1949) gave figures for the mortality within 3 and 6 months of fracture.

A majority of deaths occur within the first few weeks after fracture (BOYD and GEORGE, 1947; KENNEDY et al., 1957; FITTS JR. et al., 1959; MANPEL et al., 1961). FITTS JR. et al. (1959) found that life expectancy in fracture patients surviving 6 months was not appreciably less than that of the general population.

A higher mortality has been reported in patients with trochanteric than with cervical fractures (LINDGREN, 1924; NEWELL, 1947; BOYD and GRIFFIN, 1949; CLEVELAND et al., 1951; IBSEN, 1951; WEDEEN et al., 1957; FITTS JR. et al., 1959; McGOEY and EVANS, 1960) while others have been unable to confirm this (RENO and BURLINGTON, 1958; MANPEL et al., 1961).

Mortality of patients with fractures of the proximal end of the femur, particularly trochanteric fracture, has been reported higher in conservatively treated than operated cases (CLEVELAND et al., 1947; NEWELL, 1947; CARLQUIST, 1947; BICKEL and JACKSON, 1950; BEEGEL, 1958; BANKS and QUIGLEY, 1960; McGOEY and EVANS, 1960). Others have reported mortality equal in these groups (IBSEN, 1951; SCOTT, 1951; STÖREN, 1956; SCHENK JR. et al., 1956). KENNEDY et al. (1957) pointed out that the age and general condition of patients were of more importance with regard to mortality than were type of fracture or methods of treatment.

NEWELL (1947) felt the higher mortality in patients with trochanteric fractures was partly related to their higher mean age, and partly to a higher incidence of severe trauma in this group.

PRESENT STUDY

1. *Mortality of fracture patients compared with the general population.*

The mortality of the patients in Series A at intervals following the fracture was determined as described on page 16 (Fig. 6), and the prognosis quod vitam calculated using the method described by BERKSON and GAGE (1950) and used by HALL (1961). Figure 6 shows clearly that a majority of deaths occurred in the first 2 to 3 months following the fracture.

These observed post-fracture survival rates were compared with survival rates based upon the life table of Sweden adjusted to the age and sex

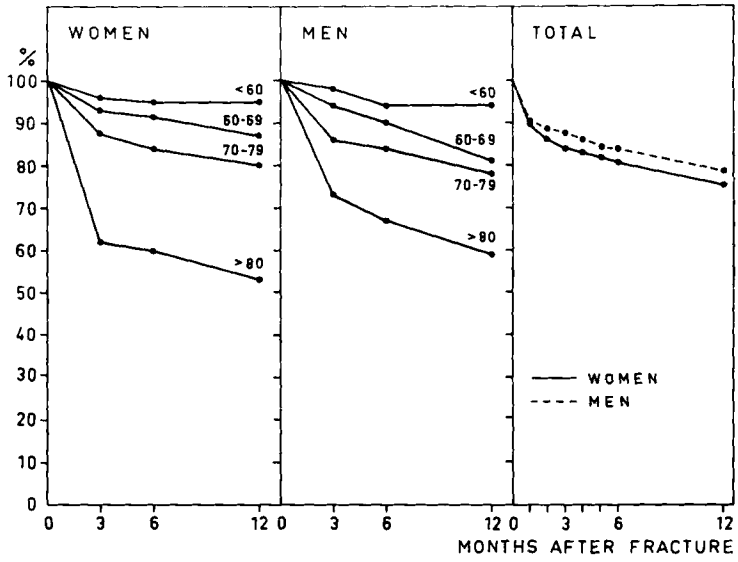


Fig. 6
Survival rates 3, 6, and 12 months after fracture in series A grouped according to age and sex.

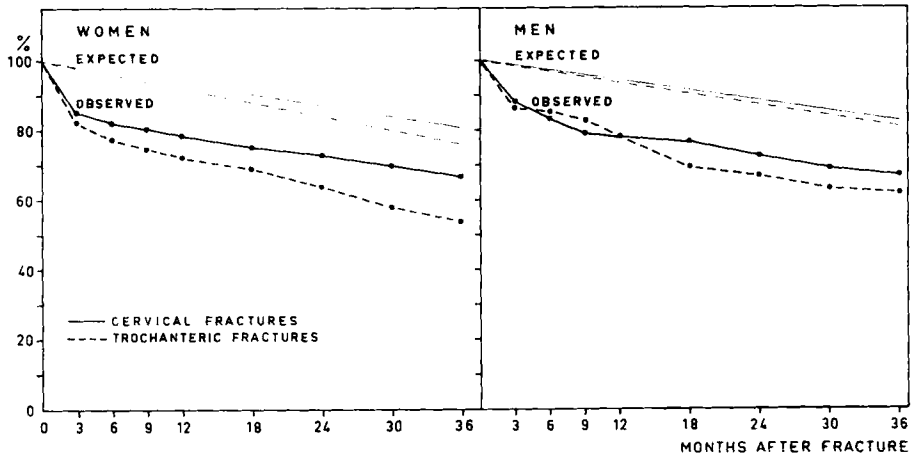


Fig. 7
Observed survival rates in series A grouped according to age, sex, and fracture type compared with expected survival rates of Swedish people of corresponding age and sex.

of the fracture patients, assuming that the life expectancy of women and men in Malmö was the same as that of women and men of equal age in the total population of Sweden.

This comparison of observed and expected survival rates showed that after the initial three months following the fracture, survival rates of fracture patients, irrespective of age, sex, or anatomical type of fracture, were similar to those of the general population (Fig. 7).

2. *Mortality in relation to age, sex, and type of fracture.*

Figure 6 shows the relationship between age and survival rate in ten-year age groups for men and women, illustrating the importance of knowing the age distribution of materials when comparisons of total mortality are being made.

To study the relation of type of fracture and sex to mortality in patients in Series A, the following method was used. Assuming there was no difference in mortality between the two main fracture types, the proportions of patients with cervical and with trochanteric fractures dead within 3 and 6 months were calculated for each sex and age group. These figures were multiplied by the observed number of patients in the corresponding age group, giving the *total number of expected deaths* for each sex and type of fracture. After correction for difference in the age distribution of the patients, mortality was found to be unrelated to sex or to the main type of fracture (Table 15).

3. *Mortality in relation to treatment.*

This material was not entirely suitable for study of the relation of mortality to method of treatment since selection of patients for operative or conservative treatment may have been based upon factors which greatly influence mortality. In several cases operation was regarded as contra-indicated because of the patients' poor general condition. In other cases operation was done to shorten the period of immobilization of such patients.

Since it was found that mortality was not related to sex or type of fracture in Series A, a comparison of mortality in patients with non-impacted cervical fractures, operated upon in 91 per cent of cases, and trochanteric fractures, operated upon in 16 per cent of cases, would give information about the effect of treatment on the three-month mortality. Assuming that there was no difference in mortality between the two series, the expected number of deaths in non-impacted cervical and in trochanteric fracture cases was calculated. A comparison between observed and expected values (Table 16) indicates that the type of treatment did not influence the three-month mortality.

There was no change in mortality rate during the period under study.

Table 15. *Observed and expected number of deaths within 3 and 6 months of fracture in Series A according to sex and type of fracture.*

Age groups	No. of fractures				No. of deaths within 3 and 6 months							
	Cervical fractures		Trochanteric fractures		Cervical fractures				Trochanteric fractures			
					Women		Men		Women		Men	
	Women	Men	Women	Men	3 months	6 months	3 months	6 months	3 months	6 months	3 months	6 months
<50	17	14	6	8	0	0	0	1	0	1	0	0
50—54	23	8	9	4	0	0	0	1	1	1	0	0
55—59	38	7	12	9	3	3	0	0	0	0	1	1
60—64	57	16	17	6	4	4	1	1	0	0	0	0
65—69	85	14	33	12	6	9	2	3	3	3	0	1
70—74	110	31	56	25	13	16	4	4	8	8	2	2
75—79	102	21	62	15	15	18	4	6	8	11	3	3
>80	143	24	105	25	45	53	5	7	36	46	8	9
Total	575	135	300	104	86	103	16	23	56	70	14	16
Per cent					15	18	12	17	19	23	13	15
Expected No. of deaths assuming no difference in mortality with type of fracture					88	106	16	21	54	67	14	18
Expected No. of deaths assuming no difference in mortality with sex					85	105	17	21	55	67	15	19

Table 16. *Observed and expected number of deaths within 3 months of non-impacted cervical or trochanteric fractures in Series A.*

Age groups	No. of fractures		No. of deaths	
	Cervical fractures	Trochanteric fractures	Cervical fractures	Trochanteric fractures
<50	12	14	0	0
50—54	22	13	0	1
55—59	25	21	2	1
60—64	46	23	4	0
65—69	70	45	8	3
70—74	91	81	14	10
75—79	94	77	15	11
>80	115	130	36	44
Total	475	404	79	70
Expected No. of deaths assuming no difference in mortality with type of treatment			76	73

Table 17. *Observed and expected number of deaths within 3 months of fracture in Series A according to sex and degree of trauma.*

Age groups	No. of fractures				No. of deaths			
	Moderate trauma		Severe trauma		Moderate trauma		Severe trauma	
	Women	Men	Women	Men	Women	Men	Women	Men
<50	18	9	3	12	0	0	0	0
50—54	24	0	8	11	1	0	0	0
55—59	41	2	9	14	3	0	0	1
60—64	62	7	11	15	4	1	0	0
65—69	108	12	9	14	9	1	0	1
70—74	147	28	17	26	19	6	1	0
75—79	136	26	25	10	20	7	2	0
>80	223	40	23	9	74	11	6	2
Total	759	124	105	111	130	26	9	4
Expected No. of deaths assuming no difference in mortality with type of trauma					124	20	15	10

Three women dead within 3 months of fracture excluded because type of trauma not known.

4. *Mortality in relation to type of trauma.*

The type of injury was known in 1,099 cases in Series A. The resulting trauma was classified as moderate in 883 cases and as severe in 216 cases. The three-month mortality in the former group was 18 per cent and in the

latter group 6.0 per cent. When adjusted for differences in age, 25 deaths were expected in the severe trauma group and 13 were observed (Table 17). One hundred forty-four deaths were expected in the moderate trauma group and 156 were observed. The three-month mortality was significantly lower(***) after severe than after moderate trauma.

COMMENTS

The mortality rates in this study 3 and 6 months following fracture were similar to a majority of corresponding figures in the literature (Table 6). BOYD and GEORGE (1947) reported mortality of 9.3 per cent within 6 months but did not state the average age of the patients. The relation between mortality and age of the patients stressed by several authors (ODEN, 1947; IBSEN, 1951; WEDEEN et al., 1957; KENNEDY et al., 1957; RENO and BURLINGTON, 1958) was demonstrated in this material.

FITTS JR. et al. (1959) found that survival rates of fracture patients living for 6 months after injury were the same as those of the general population. In this study it was found that as early as 3 months following the fracture the survival rates of the patients had become equal to those of the general population of Sweden.

The difference in mortality between patients with cervical and trochanteric fractures often reported in the literature was not confirmed. The observed differences are probably related to differences in the age composition of the series studied or length of interval between fracture and death, or possibly both factors.

In agreement with some authors, but not with others, no difference in mortality was found between conservatively treated and operated cases. The reduction in mortality of operated trochanteric fracture patients often reported may be due to selection; patients in poor general condition are conservatively treated more often than healthy patients (SCOTT, 1951). Another factor tending to reduce the reported mortality of operated cases is their shorter period of hospital care (SCHENK JR. et al., 1956; CLEVELAND et al., 1959).

NEWELL (1947) believed severe trauma was associated with increased mortality. In this series, after adjusting for age differences, mortality following severe trauma was significantly lower than following moderate trauma suggesting that the severe trauma may be sustained by healthier patients.

SUMMARY

Mortality within three months of fracture was related to the age of the patient at the time of fracture, but was not related to sex, type

of fracture, or method of treatment. A higher mortality rate was found following moderate trauma indicating that fractures caused by severe trauma occur more often in relatively healthy individuals.

F. FRACTURE INCIDENCE

1. *Age and Sex Incidence.*

To calculate the frequency of fractures, and to compare data about fracture incidence in different populations it is necessary to consider the age and sex composition of the population from which the material is drawn. The age and sex incidence, as defined on page 19, is a suitable standard of comparison.

PREVIOUS STUDIES

BRUNS (1882) attempted to correlate numbers of different kinds of fracture collected from a large group of German hospitals with the population of Germany. In this way he obtained information about the age and sex distribution of the material but not fracture incidence. STEWART (1955; 1958) related the number of fractures of the proximal end of the femur occurring during a certain period in the district of Dundee in Scotland to census data from the same area, and for the first time calculated the incidence of this fracture in women. BUHR and COOKE (1959) projected fractures treated in the Radcliffe Infirmary in Oxford from 1953 to 1957 upon the population of England and Wales to study general age and sex patterns of fracture. MÅRTENSSON (1962) has made a similar study in Göteborg, Sweden. The Committee for Fractures in the Elderly in Great Britain (personal communication) also performed a study in Oxford and Dundee collecting data on cervical and trochanteric fractures which occurred during the five-year period 1954—1958.

All of these investigations showed that the age and sex incidence of fracture of the proximal end of the femur is higher in women than in men and increases steadily with advancing age in both sexes (Fig. 8).

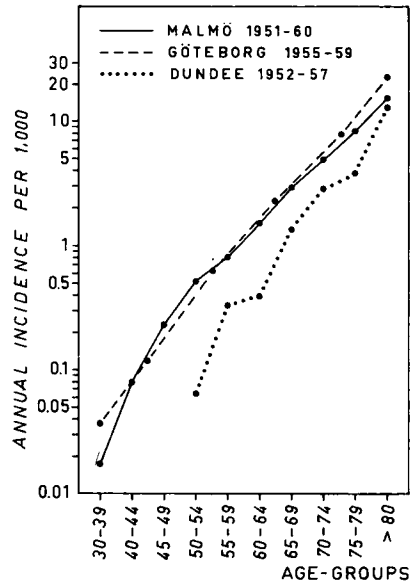


Fig. 8
Annual incidence of fractures of the proximal end of the femur in women in Malmö, Göteborg, and Dundee.

PRESENT STUDY

Projection of the average number of fracture cases in five-year age groups above age 30 upon the average population of Malmö in 1950—1960 gave values for age and sex incidence (Table 18 and Fig. 9). Below age 45 there was a slight predominance of male fracture cases in the total series but above age 45 a female predominance was evident. The rate of increase of incidence was the same in men and women after 50 years of age (Fig. 4).

The age and sex incidence pattern was similar in cervical and trochanteric fractures. In men the incidence of the two fracture types was approximately equal in each age group; the standardized morbidity rates equalling 21.0 and 17.4, respectively. In women, however, cervical fractures prevailed over the trochanteric ones in all age classes, standardized morbidity rates equalling 76.9 and 44.2, respectively.

Table 18. *Age and sex incidence of fractures of the proximal end of the femur in 1951—1960 in Malmö.*

Age groups	Cervical fractures		Trochanteric fractures		Total	
	Women	Men	Women	Men	Women	Men
30—39	0.02	0.04	0.00	0.02	0.02	0.06
40—44	0.06	0.07	0.02	0.05	0.08	0.12
45—49	0.17	0.07	0.05	0.08	0.22	0.15
50—54	0.36	0.12	0.15	0.11	0.51	0.23
55—59	0.60	0.28	0.20	0.17	0.80	0.45
60—64	1.08	0.46	0.42	0.21	1.50	0.67
65—69	2.04	0.52	0.86	0.52	2.90	1.04
70—74	3.21	1.36	1.70	1.21	4.91	2.57
75—79	5.01	1.86	3.29	1.86	8.30	3.72
>80	8.89	3.09	6.88	2.56	15.77	5.65

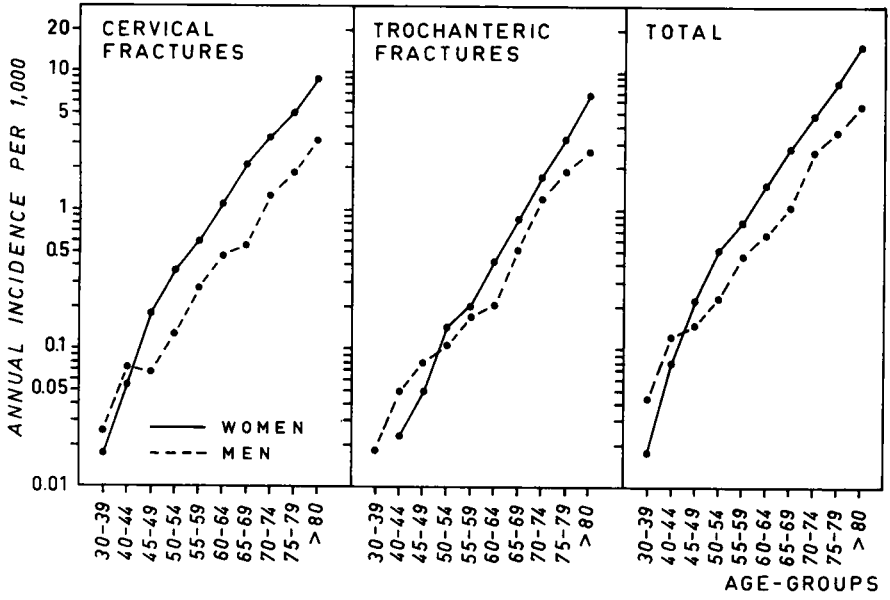


Fig. 9
Age and sex incidence of cervical and trochanteric fractures in Malmö in 1951—1960.

COMMENTS

Standardized morbidity rates calculated from the fracture incidence in 1955—1959 in Malmö were 126.7 for women and 39.8 for men, and in Göteborg 146.3 for women and 34.0 for men. These figures agreed closely, the standardized morbidity rate in women being a little higher in Göteborg than in Malmö.

Standardized morbidity rates in both sexes in Dundee and in Oxford were similar (Table 19) but were significantly lower ($P < 0.05$) than standardized morbidity rates in Malmö and Göteborg. The fracture incidence in these areas of Great Britain was about half that found in the two Swedish cities.

Standardized morbidity rates of *cervical fractures* in Malmö were higher ($P < 0.05$) than those in Dundee and Oxford (Table 20). There was no significant difference in morbidity rates of *trochanteric fractures* between Malmö and the two British cities. This trend was present in both sexes.

Apparently there are geographical differences in the incidence of fracture of the proximal end of the femur. It was further revealed that cervical fractures were responsible for this difference whereas the incidence of trochanteric fractures was about the same in the areas studied. These facts have to be considered in relation to the reported predominance of trochanteric fractures in Great Britain and in the U.S.A. which contrasted to the findings of this study (page 23).

It seems unlikely that differences in the pattern of trauma were the cause of differences in the proportion of cervical and trochanteric fractures between Swedish and the British series, as there was no evidence that type or degree of trauma had any bearing upon the main type of fracture. Differences in age composition are eliminated in the standardized morbidity rates. The difference in incidence may indicate the presence of biological differences between the populations of the two countries. In this connection it is of interest to note that MOON and URIST (1962) found among patients with osteopenia in Los Angeles that "a seemingly disproportionate number (15 per cent) were of Scandinavian stock".

SUMMARY

The age and sex incidence of fracture of the proximal end of the femur was about equal in Malmö and Göteborg. Cervical fractures

Table 19. *Standardized morbidity rates in different geographical areas.*

	Period	Women	Men
Malmö ...	1951—1960	121.1	38.4
Malmö ...	1955—1959	126.5	39.8
Göteborg .	1955—1959	146.3	34.0
Dundee ..	1953—1957	66.6	—
Dundee ..	1954—1958	61.2	25.4
Oxford ...	1954—1958	62.0	24.1

Table 20. *Standardized morbidity rates of cervical and trochanteric fractures in Malmö, Dundee, and Oxford.*

	Period	Women		Men	
		Cervical fractures	Trochanteric fractures	Cervical fractures	Trochanteric fractures
Malmö	1951—1960	76.9	44.2	21.0	17.4
Dundee	1954—1958	25.8	35.4	5.7	19.7
Oxford	1954—1958	28.6	33.3	10.4	13.8

were more common among women and men in Malmö than in Dundee and Oxford. Trochanteric fractures were about equally common in both countries.

Differences in the proportion of cervical and trochanteric fractures in geographical regions may be an index of biological differences in the population.

2. *Side involved.*

PREVIOUS STUDIES

Fracture of the proximal end of the femur has been reported to occur more often on the left than on the right (RIEDINGER, 1874; DUHAMEL, 1947; JENSENIUS, 1956). No report of right-sided predominance has been found.

HIRSCH and BRODETTI (1956) found experimentally that below age 60 the resistance of the femoral neck to compression force was the same on both sides, but above that age it could decrease considerably on one side, and stated that "this might be of clinical significance in the explanation of neck fractures", without reporting on which side this was most often observed.

VIRTAMA (1960) found higher ash weights in bones from the right than from the left extremities in active persons. In aged persons and in persons

Table 21. *Fractures in Series A grouped according to sex, side, and anatomical type.*

Type	Side	Total series		Women		Men	
		Women	Men	Moderate trauma	Severe trauma	Moderate trauma	Severe trauma
Cervical	Right	267	56	236	25	31	23
	Left	308	79	269	38	37	40
Trochanteric	Right	150	40	124	25	26	14
	Left	150	64	130	17	30	34

Table 22. *Traffic accident fractures in Series A grouped according to sex and side.*

Side	Women	Men	Total
Right....	12	23	35
Left	16	48	64
Total	28	71	99

with osteopenia only a slight difference was observed. NILSSON (to be published) was able to demonstrate in men differences in bone density between the right and left leg in vivo. A relationship between the strength of bone and its mineral or ash content has been demonstrated by VOSE and KUBALA (1959).

PRESENT STUDY

In Series A of this material 601 fractures occurred on the left side and 513 on the right side(**) (Table 21). The prevalence of the left side was significant(**) in men but not in women and was unrelated to the type of fracture. When the fractures were divided according to degree of trauma it was found that a significant left-sided predominance was present only in male fracture cases with severe trauma while in women with both types of trauma and in men with moderate trauma the difference as to side was not significant. The same result was obtained when first fractures only were considered. Further analysis showed that fractures due to accidents in traffic were significantly more common on the left side (**). Again this difference was almost exclusively due to fractures in men (Table 22).

The distribution of side of fracture in cases with moderate or no trauma was not related to the age of the patients. In the total Series A, the predominance of left-sided fractures was significant(*) below the age of 60, but not above that age.

COMMENTS

The predominance of left-sided fractures often reported was also observed in this material.

The fact that fracture due to severe trauma was significantly more common on the left side, suggested an exogenous factor, such as the Swedish Left-Hand Rule for traffic. DENCKER (1962) found, however, that femoral shaft fractures, 58 per cent of which were caused by traffic accidents, were more common on the right than on the left side.

SUMMARY

Fracture of the proximal end of the femur was more common on the left than on the right side. The difference was more pronounced below the age of 60, more pronounced in men than in women, and more pronounced after severe than after modrate trauma. These facts seem to agree with experimental findings on bone density and bone strength.

3. *Incidence of Second and Third Fractures.*

PREVIOUS STUDIES

STEWART (1957) in a study of the incidence of fractures of the proximal end of the femur in the Eastern Region of Scotland, stated that "when the appropriate bilateral cases are related to survivors from the known population the incidence is approximately twenty times that of the first fracture".

PRESENT STUDY

During the period under study there were 90 second fractures and 2 third fractures. The inverval between first and second fractures ranged from 3 months to 25 years with a mean of 6 years.

To establish whether patients who had previously sustained a fracture of proximal end of the femur had an increased fracture liability compared with the general population, the following method was used. Annual age and sex incidence of *first fractures* in 1951—1960 was determined. (Table 23). Assuming that no appreciable change in incidence occurred and that mortality in fracture patients did not differ from that of the general population of comparable age and sex, the number of persons who have suffered a hip fracture before a given age can be calculated as follows: if in a five-year age group $x - x + 5$ years the relative annual number of first fractures is $p_{x:5}$ the number of patients who have had such a fracture before age x, Px, is equal to

$$\Sigma\ 5\ p_{y:5} \text{ where } y = 0, 5, 10 \ldots\ldots\ldots\ldots x - 5.$$

These figures represent the accumulated risk of suffering a fracture prior

Table 23. *Age and sex incidence of first fractures of the proximal end of the femur in 1951-1960 in Malmö.*

Age groups	Cervical fractures		Trochanteric fractures	
	Women	Men	Women	Men
30—39	0.02	0.03	0.00	0.02
40—44	0.06	0.07	0.02	0.05
45—49	0.17	0.07	0.05	0.08
50—54	0.36	0.12	0.15	0.11
55—59	0.58	0.28	0.19	0.17
60—64	1.01	0.46	0.37	0.21
65—69	2.02	0.52	0.79	0.49
70—74	3.10	1.32	1.56	1.13
75—79	4.53	1.68	3.04	1.86
>80	8.15	2.91	6.30	2.38

to a certain age (Fig. 10). The relative number of persons in age group $x - x+5$ years who have had a fracture is $\frac{P_x + P_{x+5}}{2}$

Assuming the probability of having a second fracture to be equal to that of a first fracture the expected annual number of such fractures in the mean population of Malmö in 1951—1960 was calculated and from this the sum of expected such fractures from 1949 to 1961 (Table 24).

The calculation depended upon the assumption that the mortality of fracture patients was equal to that of the general population, and that no changes in incidence occurred. However, it has been shown that the survival rate of the fracture patients was about 15 per cent below normal in the first months following fracture. Thus, the calculated figures must be reduced by approximately 15 per cent. The reduced figures are also given in Table 24.

The expected total number of second fractures thus calculated (84) was in good agreement with the observed number (90). No difference was found between expected and observed total numbers of second fracture within each sex. However, when the material was divided according to the main type of first fracture (Table 24) it was found that the number of second fractures observed after cervical fracture (67 or 68) was higher ($P < 0.05$) than expected (53). The expected number of second fractures in women after cervical first fracture was 48 and the observed number was 56 or 57; in men the corresponding figures were 5 and 11, respectively, so that this tendency was apparent in both sexes.

The number of recurrent fractures after trochanteric fractures did not differ from that expected.

Table 24. *Observed and expected number of second fractures in 1949—1961.*

Fracture type		Sex	Calculated annual No.	Calculated No. in 1949—61	Reduced No. in 1949—61	Observed No. in 1949—1961		
First	Second					Total	A	B
Cervical	Cervical	W	2.595	33.7	28.6	32	31	1
		M	0.243	3.2	2.7	6	6	0
Cervical	Trochanteric	W	1.778	23.1	19.6	24	5	19
		M	0.198	2.6	2.2	5	3	2
Trochanteric	Cervical	W	1.416	18.4	15.6	7	5	2
		M	0.210	2.7	2.3	1	0	1
Trochanteric	Trochanteric	W	1.003	13.0	11.1	11	7	4
		M	0.176	2.3	2.0	3	2	1
Unknown	Cervical	W				1	1	0
Total		W			74.9	75	49	26
		M			9.2	15	11	4

A = opposite side. B = same side.

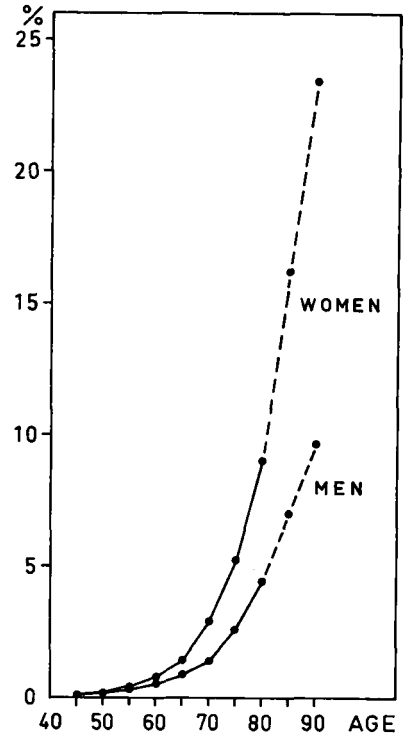


Fig. 10
Cumulative risk of sustaining at least one cervical or trochanteric fracture prior to certain ages, calculated from the age and sex incidence in 1951—1960.

COMMENTS

STEWART (1957) stated that the incidence of second fracture is about twenty times that of first fracture. In the present study no difference was found in the incidence of the first and second fractures in the total series. However, following first fractures of cervical type there was a significantly greater risk of sustaining a second fracture, which was still more pronounced when allowance was made for the observed increase in fracture incidence during the period of investigation (page 58), resulting in an overestimation of the number of expected recurrent fractures. The increased risk of fracture after cervical fractures was found in both sexes.

Patients with cervical fractures seemed more liable to sustain a second fracture than patients with a trochanteric fracture, possibly suggesting a difference in the etiology of the two fracture types. This conclusion was strengthened by observation of a sex-related difference in the incidence of cervical and trochanteric fractures (page 48) and a difference in standardized morbidity rates of cervical fractures compared with trochanteric fractures in different countries (page 50).

SUMMARY

After a cervical first fracture the risk of second fracture was increased in both sexes. After a trochanteric first fracture no such tendency was found.

The findings may be interpreted as indicating some difference in the etiology of the two types of fracture.

4. *Comparison between First and Second Fractures Regarding Type and Side.*

PREVIOUS STUDIES

STEWART (1957) stated that "a second fracture on the same side is rare". In a material of 388 patients he found 24 patients with second fractures on the opposite side but none with a second fracture on the same side. He also noted that in only two cases was the second fracture of different type and concluded that "patients who sustained fractures of the femoral neck first on one side then on the other probably exhibit the highest degree of predisposition". In an experimental study SPOTOFT (1944) obtained fractures of the same type on both sides in cadavers.

PRESENT STUDY

In the present series there were 90 second fractures (Table 24); 30 of these occurred on the same side and 60 on the opposite side, indicating a higher(***) incidence of recurrent fractures on the opposite side. In 38 cases where the first and second fractures were of cervical type,

all but one of the second fractures occurred on the opposite side. Trochanteric fracture followed a first cervical fracture in 29 patients. In 21 of these patients the second fracture occurred on the same side and in 8 on the opposite side, indicating that second fractures of trochanteric type were more common(*) on the same side following a cervical fracture. After a first fracture of trochanteric type second fractures were equally distributed as to side.

It would be reasonable to expect different types of second fracture to appear in the same proportion as first fractures provided there was no predisposition in the patient to a certain type of fracture.

Thirty-two women had the fracture sequence cervical—cervical and 24 women the sequence cervical—trochanteric. Analysis revealed no significant difference between the observed and the expected distribution of the main types of second fractures following first fractures of cervical type.

Thirty-one women with a second fracture on the opposite side showed the sequence cervical—cervical and 5 patients the sequence cervical—trochanteric, indicating that the proportion of second fractures of the same type as the first fracture was higher(*) than expected from the distribution of first fractures.

The numbers of female patients with the sequence trochanteric—cervical and trochanteric—trochanteric were 7 and 11, respectively, also indicating a high proportion of recurrent fractures of the same type as the first fracture.

The number of males with second fractures was too small for statistical analysis.

COMMENTS

In this material two fractures of cervical type seldom occurred in the same hip. In patients with a first cervical fracture, a second fracture of trochanteric type was more often seen on the previously injured side. In the total series 30 of 90 second fractures occurred on the same side. These findings, only partly agree with STEWART's (1957) statement that "a second fracture of the same side is rare".

The tendency found by STEWART (1957) for bilateral fractures in females to be of the same type was confirmed in this series.

SUMMARY

Two cervical fractures seldom occurred in the same hip. Bilateral fractures tended to be of the same type.

Table 25. *Standardized morbidity rates in 1951—1955 and 1956—1960 in Malmö.*

Period	Cervical fractures		Trochanteric fractures	
	Women	Men	Women	Men
1951—1955	75.8	18.5	39.0	11.3
1956—1960	79.0	23.0	48.8	21.3

5. *Are Fractures in the Aged Becoming More Frequent?*

PREVIOUS STUDIES

BUHR and COOKE (1959) found an increase in the frequency of fracture of the proximal end of the femur in the Oxford region which they ascribed to the changing age and sex distribution of the population. MÅRTENSSON (1962) found an increase in the incidence of fracture of the proximal end of the femur in Göteborg which could not be entirely explained by age and sex changes in the population. He did not distinguish between cervical and trochanteric fractures.

PRESENT STUDY

During the period of this study the annual number of fracture cases increased continuously (approximately trebling) over the 13 years (Fig. 2), whereas the total population increased by less than 20 per cent. The standardized morbidity rates increased from the period 1951—1955 to the period 1956—1960 (Table 25) indicating that the increase in fracture incidence could not be entirely accounted for by changes in the age and sex composition of the population. The increase was most apparent in trochanteric fractures in men.

From the age and sex fracture incidence in 1951—1960 the expected number of fractures was calculated for 1950, 1955 and 1960 as were the expected numbers of fractures in the five-year periods 1951—1955 and 1956—1960. The expected numbers in 1949—1950 and in 1961 were extrapolated from the figures of 1950, 1955 and 1960. Thus the expected numbers of fractures in 1949—1950, 1951—1955, 1956—1960 and 1961 could be compared with observed numbers in the corresponding periods (Table 26 and Fig. 11).

An increase was evident in the incidence of fractures in persons above the age of 30 during the period studied. The figures for 1949 and 1950 were considerably lower than for the rest of the period but even when these two years were excluded the trend remained. In 1961 there was no difference between the observed and the expected number of fractures.

Table 26. *Observed and expected number of fractures grouped according to period, sex, and type.*

		Women		Men		Total
		Cervical fractures	Trochanteric fractures	Cervical fractures	Trochanteric fractures	
1949—50	Observed	78	25	13	8	124
	Expected	97	52	29	24	202
			(P<0.05)	(P<0.05)	(P<0.05)	(P<0.05)
1951—55	Observed	281	141	74	48	544
	Expected	286	158	83	68	595
					(P<0.05)	(P<0.05)
1956—60	Observed	360	220	104	99	783
	Expected	350	199	99	81	729
			(P<0.05)		(P<0.05)	(P<0.05)
1961	Observed	85	49	25	20	179
	Expected	78	45	22	17	162

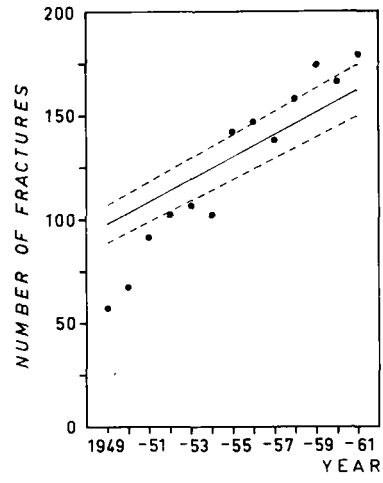


Fig. 11
Observed and expected number of fractures of the proximal end of the femur in Malmö in 1949—1961. Standard deviation in 1950, 1955, and 1960 is $= \sqrt{0.9 \cdot E}$, where E = the expected number of fractures in corresponding years.

Division of the material according to sex and fracture type (Table 26) showed that, except for the years 1949—1950, the expected incidence of cervical fracture in both sexes was similar to that observed. The observed number of trochanteric fractures in men was lower ($P < 0.05$) than expected in 1949—1950 and 1951—1955 and higher ($P < 0.05$) than expected in 1956—1960. In 1961 there was no difference. In women the observed number of trochanteric fractures was lower ($P < 0.05$) than expected in 1949—1950 and higher ($P < 0.05$) than expected in 1956—1960. In 1951—1955 and in 1961 there was no difference between observed

Table 27. *Observed and expected number of first fractures grouped according to period, sex, and type.*

		Women		Men		Total
		Cervical fractures	Trochanteric fractures	Cervical fractures	Trochanteric fractures	
1949—50	Observed	78	24	12	8	122
	Expected	92	49	28	22	191
			(P<0.05)	(P<0.05)	(P<0.05)	(P<0.05)
1951—55	Observed	270	138	74	47	529
	Expected	271	146	79	66	562
					(P<0.05)	(P<0.05)
1956—60	Observed	336	196	99	95	726
	Expected	331	183	94	78	686
					(P<0.05)	(P<0.05)
1961	Observed	80	43	25	17	165
	Expected	73	42	21	17	153

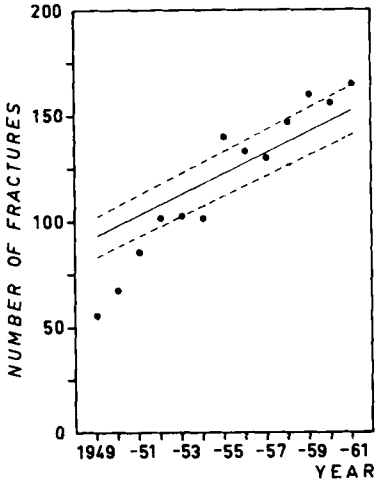


Fig. 12
Observed and expected number of first fractures of the proximal end of the femur in Malmö in 1949—1961.

and expected numbers of fractures. The increase in fracture incidence was, thus, mainly caused by trochanteric fractures.

As patients with a cervical fracture appeared to be more than normally susceptible to a second fracture of the proximal end of the femur (page 54), it was suspected that the observed increase in fracture incidence during the study was due to an increase in the number of second fractures. Accordingly, the incidence of first fracture was evaluated in the same way as were all fractures in the total material (Table 27 and Fig. 12). First fractures were less numerous ($P < 0.05$) than expected in 1949—1950 and 1951—1955

and more numerous ($P < 0.05$) than expected in 1956—1960. In 1961 there was no deviation from the expected number.

Examination of first fractures with regard to sex and main type revealed that—with the exception of the years 1949—1950 — observed values corresponded closely to expected values for cervical and trochanteric fractures in women and cervical fractures in men. Trochanteric fractures in men showed an increase during this period. The increased incidence of trochanteric fractures in women observed in the total series was related to a greater number of second fractures during the latter part of the period. Thus 3 out of 141 female trochanteric fractures in 1951—1955 were second fractures, compared to 26 out of 220 in 1956—1960 (2 of these cases were third fractures). In men, 1 out of 48 trochanteric fractures was a second fracture in 1951—1955 and 4 out of 100 in 1956—1960.

The real increase in the incidence of trochanteric fractures in men could not be explained by a higher frequency of severe trauma, e.g., traffic accidents. The ratios of severe : moderate trauma in different periods were as follows: 1949—1950, 3 : 5; 1951—1955, 25 : 23; 1956—1960, 41 : 59; and 1961, 6 : 14; indicating no difference in the relative frequency of severe trauma in the various periods.

COMMENTS

The increase in fracture incidence in this series could not be entirely explained by age and sex changes in the population at risk. MÅRTENSSON (1962) did a similar observation in Göteborg. In the present series the increase was mainly due to trochanteric fractures which are certainly less likely to escape diagnosis than cervical fractures. Therefore it is improbable that the change was due to deficient registration during the earlier part of the period. The increase could not be ascribed to a rise in the frequency of severe trauma such as traffic accidents.

SUMMARY

An increase in fracture incidence was observed in Malmö over the period between 1949 and 1961. This increase was mainly due to trochanteric fractures. The increase in female fracture cases was partly due to a higher frequency of second fractures during the latter part of the period. In men the increased fracture incidence could not be ascribed to second fractures or to a rise in the frequency of severe trauma.

6. *Expected Number of Fractures in the Future.*

PREVIOUS STUDIES

Using incidence data STEWART (1955) calculated the number of fractures expected to occur in 1965 and 1975 in the Dundee area; similarly MÅRTENSSON (1962) calculated the number of fractures expected in Göteborg in the periods 1960—1964 and 1965—1969 based upon the age and sex fracture incidence in the period 1940—1944 and 1955—1959. Both authors predicted a considerable increase in the total annual number of fractures during the next decade. The need for hospital care of these cases will increase to the same extent if no changes take place in methods of treatment.

PRESENT STUDY

City authorities in Malmö have calculated the number, age and sex distribution of the city population in 1965, 1970 and 1975. By means of age and sex fracture incidence data from the present material the number of fracture cases in 1961—1965, 1966—1970, and 1971—1975 were calculated using incidence during the five-year period 1956—1960 and ten-year period 1951—1960 as a base. Results are given in Figure 13.

It is apparent from this that the number of fractures will increase considerably. Thus between 964 and 1,038 fractures may be expected in 1966—1970 and between 1,099 and 1,182 fractures in 1971—1975 in contrast to 788 cases in 1956—1960.

Because the observed rate of increase is only partly explained by age changes in the population (page 58), it is probable that figures based upon the ten-year period are too low and that those based on the five-year period 1956—1960 should be regarded as minimum figures.

Of the 1,114 fracture cases in Series A, 991 cases (89 per cent) were admitted to the Orthopaedic Clinic of MGH. Twenty-two patients were treated as out-patients or by private physicians. One hundred and twenty-eight cases (11 per cent) sustained their fractures while patients in nursing homes or mental hospitals and 91 of these remained there for treatment. Ten patients were treated in clinics other than the Orthopaedic Clinic of MGH. It is apparent that about 90 per cent of the fracture cases required care in an acute hospital, 7.6 per cent were treated at the institutions where they lived before fracture, and 1.9 per cent were not admitted to a hospital.

During the period 1949—1958 the average length of stay in the Orthopaedic Clinic of MGH for patients with hip fractures was 91 days. If one considers only those admitted to hospital primarily because of the fracture the average period in hospital was 94 days. A majority of trochanteric fractures were treated by traction, which partly explains the comparatively

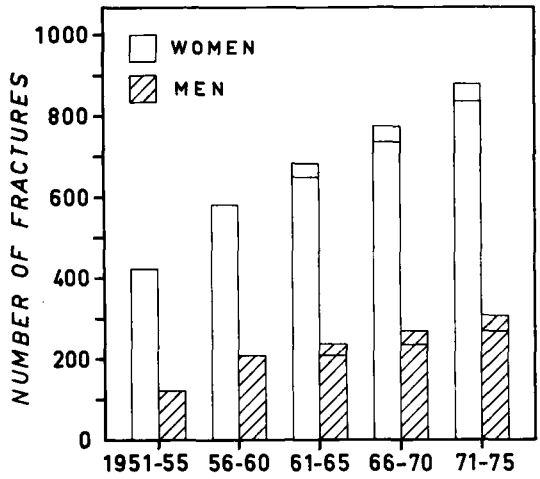


Fig. 13
Observed number of fractures of the proximal end of the femur in Malmö in 1951—1955 and 1956—1960 and calculated number in 1961—1965, 1966—1970, and 1971—1975. Calculation based upon the five-year period 1956—1960 (higher values) and the ten-year period 1951—1960 (lower values).

long stay in hospital. In the last two or three years a more active attitude was adopted regarding earlier ambulation and weight-bearing, so that the average period of treatment in 1961 at the Orthopaedic Clinic of MGH was 58 days. If this is accepted as a minimum period of hospital care for a patient treated in Malmö, the total number of hospital-care days in the years 1970 and 1975 for patients with fractures of the proximal end of the femur will be approximately 11,600 and 13,150, respectively. This assumes that only acute care is given in hospital and that 90 per cent of such fracture cases are admitted to an acute ward. In the years 1970 and 1975, approximately 32 and 36 beds, respectively, will be continuously occupied by these patients compared with 26 beds in 1961.

COMMENTS

The absolute and relative increase in the number of fractures of the upper end of the femur predicted for the immediate decades will have an impact on the need for institutional medical care. However, this increase in fracture cases cannot be immediately translated into a corresponding need for hospital beds as distinguished from nursing home beds and facilities of similar nature. Changes in the method of treatment, for example from traction to nailing, and in the policy concerning permission of weight-bearing, may influence the need for acute hospital beds. The total effect on the community, however, will probably be roughly proportional to the increase in the number of fractures. Preliminary data suggest that whereas much can be done to shorten the primary hospital stay, little can be done to shorten the entire period of institutional care needed for these often severely debilitated patients.

SUMMARY

In the years 1970 and 1975 approximately 32 and 36 acute hospital beds, respectively, will be continuously occupied by patients with fracture of the proximal end of the femur in Malmö, compared with 26 beds in 1961. The need for secondary facilities such as nursing-home beds will be proportionately increased.

G. OTHER FRACTURES

1. *Coincident Fractures.*

PREVIOUS STUDIES

Reno and Burlington (1959) and Manpel et al. (1961) found that less than 7 per cent of their patients sustained coincident fractures, but did not report the types.

PRESENT STUDY

In Series A 60 patients (5.4 per cent) had one or more coincident fractures (Table 28). Fifty-three were women and 7 were men. Fracture of the distal end of the forearm was most often found (29 patients), always occurring in women. The next largest group was fracture of the proximal end of the humerus (12 patients), and the remaining fractures were about equally distributed in other regions of the skeleton. Seventeen women and 6 men had suffered severe trauma, 6 women and 4 men sustaining their fracture in traffic accidents. Two patients with more than 2 coincident fractures had suffered very severe trauma.

COMMENTS

Practically all coincident fractures occurred in areas of cancellous bone. Although severe trauma was much more common in men as a cause of fracture of the proximal end of the femur, the majority of coincident fractures occurred in women. These facts seem to indicate that the condition of the skeleton, rather than trauma, is a dominant etiologic factor in these fractures.

SUMMARY

Coincident fractures were most frequent in women, generally as a result of moderate trauma. Practically all such fractures occurred in areas of cancellous bone.

Table 28. *Coincident fractures in Series A.*

	Women		Men		Total	
	Cervical fractures	Trochanteric fractures	Cervical fractures	Trochanteric fractures	No.	Severe trauma
Distal forearm ..	12	17	—	—	29	9
Proximal humerus	11	—	1	—	12	2
Pelvis	—	2	1	—	3	3
Elbow	3	2	—	—	5	1
Rib	1	—	2	—	3	2
Knee	1	—	1	—	2	1
Miscellaneous	3	—	—	1	4	4
Two or more bones	—	1	—	1	2	1
Total	31	22	5	2	60	23

2. *Fractures of the Distal End of the Forearm.*

PREVIOUS STUDIES

Several authors have regarded changes in the bone itself of more importance than degree of injury in the etiology of fracture of the proximal end of the femur (COOPER, 1824; FARKAS et al., 1948; RUTISHAUSER and DUFOUR, 1950; BUHR and COOKE, 1959; URIST, 1960; STEVENS et al., 1962). Such changes in bone have also been considered a major cause of fracture of the distal end of the forearm in older women (BUHR and COOKE, 1959; ALFFRAM and BAUER, 1962).

In an earlier study of material used in this investigation, BAUER (1960) found an increasing incidence of fracture of the distal end of the forearm in women from age 40 to age 60 followed 15 to 17 years later by an increasing incidence of fracture of the proximal end of the femur. He suggested that evidence of disturbed skeletal metabolism should be sought one or two decades before the increase in incidence of fracture of the proximal end of the femur.

If the occurrence of fracture of the distal end of the forearm and fracture of the proximal end of the femur is related to changes in bone metabolism resulting in decreased bone strength, patients with such fractures of the femur would have a higher incidence of forearm fracture than a similar group in the general population.

PRESENT STUDY

As case records were sometimes unreliable regarding previous minor injuries, the patients of series A (435 women and 115 men) were questioned regarding previous fracture of the forearm at their inter-

views in 1960. Twenty-eight patients (25 women and 3 men) were excluded, as mental changes made their recollection unreliable. The ages of the remaining patients at the time of their first fracture of the proximal end of the femur and at interview are shown in Table 29. This group is referred to as Series A_i.

Ninety-nine women and one man (24 per cent and 0.9 per cent, respectively, of women and men with reliable histories) had sustained a fracture of the distal end of the forearm prior to the time of interview. Available records and radiographs confirmed that 85 of these 100 fractures were the Colles type. Records were not available in the other 15 cases, but anamnestic data left little doubt as to the diagnosis. Fourteen women sustained a fracture of the distal forearm coincident with a fracture of the proximal end of the femur. Sixty-six women and one man sustained a distal forearm fracture prior to their first femur fracture.

ALFFRAM and BAUER (1962) calculated the annual incidence of distal forearm fractures in different age groups of the population of Malmö in 1953—1957. The material was estimated to constitute not less than 95 per cent of all diagnosed distal forearm fractures among residents of Malmö from 1953 through 1957.

Assuming mortality of patients with a distal forearm fracture to be similar to that of the general population, the method described on page 53 was used to calculate the number of patients between age 30 and 79 in Series A_i expected to have sustained a distal forearm fracture. The results are given in Table 29. A correction was applied for an estimated 5 per cent of forearm fractures escaping diagnosis.

Sixty-four women and one man of Series A_i between age 30 and 79 had a fracture of the distal end of the forearm before interview in 1960. The expected numbers were 32.3 and 1.5, respectively. The difference was significant ($P < 0.05$) in women but not in men. Sixty women in Series A_i had such a forearm fracture before their first fracture of the proximal end of the femur compared with the expected 36.0 ($P < 0.05$).

Three hundred and eleven women of Series A_i had their first femur fracture in association with moderate or no trauma (Series A_{im}, Table 29). Fifty-two of these patients had sustained a previous fracture of the distal end of the forearm in comparison to an expected number of 30.4 ($P < 0.05$).

The observed and expected numbers of fractures of the distal end of the forearm in five-year periods prior to first fracture of the proximal end of the femur in women are shown in Table 30. Between 0 and 4 years and 5 and 9 years there were more ($P < 0.05$) forearm fractures than expected while between 10 and 14 and 15 and 19 years prior to the femur fracture

Table 29. *Age and sex incidence of distal forearm fractures in Malmö and observed and expected number of such fractures in Series i.*

Age groups	Distal forearm fractures in 1953—1957 in Malmö. Known second fractures excluded				Age of patients in series Ai					Observed No. of patients with distal forearm fracture				
					at interview		at first fracture		at first fracture in series Aim	before interview		before first fracture Series Ai		before first fracture Series Aim
	No. of		Annual incidence											
	Wom.	Men	Wom.	Men	Wom.	Men	Wom.	Men	Women	Wom.	Men	Wom.	Men	Women
30—34	18	11	0.41	0.28	—	—	1	1	1					
35—39	12	16	0.27	0.39	—	3	—	3	—					
40—44	31	22	0.70	0.54	2	2	6	8	5					
45—49	50	18	1.15	0.47	6	5	13	4	12					
50—54	123	11	3.32	0.34	14	7	27	9	20			1 (2)	1	1
55—59	152	13	4.92	0.30	21	7	38	12	29	5	1	7 (2)		4 (1)
60—64	141	14	5.33	0.67	40	15	56	16	46	11		6		5
65—69	139	11	6.08	0.63	57	8	75	15	67	15		12 (3)		11 (3)
70—74	87	7	4.79	0.50	77	21	85	24	73	15		15 (3)		14 (1)
75—79	67	6	5.28	0.69	80	21	71	12	58	18		19 (2)		17 (2)
Total					297	89	372	104	311	64	1	60 (12)	1	52 (7)
Expected No. of distal forearm fractures										32.3	1.5	36.0	1.6	30.4

Bracketed figures denote forearm fractures sustained at the same time as the femoral neck fracture.

Table 30. *Observed and expected number of distal forearm fractures in different periods before first fracture of the proximal end of the femur in women in Series A_i.*

	Years before first fracture of the proximal end of femur			
	0—4	5—9	10—14	15—19
Observed	16	15	9	8
Expected	9.3	8.4	7.0	5.1
	($P<0.05$)	($P<0.05$)		

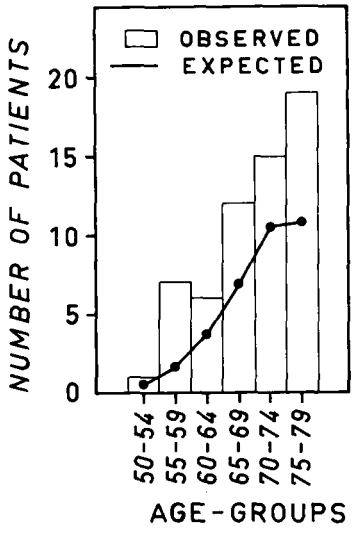


Fig. 14
Observed and expected number of patients in different age groups in series A_i with at least one distal forearm fracture prior to the first fracture of the proximal end of the femur.

the expected and observed numbers of forearm fractures were about similar.

The unexpectedly large number of previous forearm fractures in women of Series A_i was unrelated to their age at the time of femur fracture. (Fig. 14).

In Series A_i there was no relation between the proportion of cervical and trochanteric fractures and the occurrence of earlier forearm fracture.

COMMENTS

Data now available indicate that distal forearm fractures as well as fractures of the proximal end of the femur may be regarded as symptoms of age changes in the skeleton. BAUER (1960) concluded that symptoms of disturbed skeletal metabolism in women should be looked for one or two decades before the time of the hip fracture and stated that, compared with other criteria of age changes in the human skeleton, the incidence of fracture is the most revealing (BAUER, 1962).

In support of this idea it was shown in this series that in women with fracture of the proximal end of the femur distal forearm fracture was more common than expected and had occurred prior to the first hip fracture significantly more often than expected. This indicates a relationship between these two fractures, presumably due to a change in the strength of the skeleton associated either with reduced skeletal mass (osteopenia), or possibly a change in the quality of the bone apart from osteopenia (BAUER, 1962).

The data indicate that women with a distal forearm fracture have an increased risk of fracture of the proximal end of the femur in later life.

SUMMARY

Women with a fracture of the distal end of the forearm are more liable to sustain a later fracture of the proximal end of the femur than women in the general population.

H. ASSOCIATED CONDITIONS

Aside from trauma, several medical conditions are of importance in the etiology of fracture of the proximal end of the femur. Such conditions may be (1) localized changes in the bone at the site of fracture or (2) more generalized diseases leading to increased bone fragility in the entire skeleton.

COOPER (1824) gave evidence of the significant role of age changes in bone in the etiology of such fractures. This has also been suggested by more recent epidemiological studies (BRUNS, 1882; STEWART, 1955; BUHR and COOKE, 1959; BAUER, 1960). URIST (1960) and STEVENS et al. (1962), showed that osteopenia as evaluated by various radiodiagnostic methods, was more common in patients with fracture of the proximal end of the femur than in controls. VOSE et al. (1961) found experimentally that osteopenic human bones broke under loads smaller than those required to break normal bones. BAUER (1962) stated that bone fragility need not necessarily be related to osteopenia.

To examine some of the factors directly or indirectly responsible for fractures of the proximal end of the femur, it was decided to attempt evaluation of the impact of some diseases upon the liability to fracture of patients in Series A of this material. The numbers of patients suffering from the diseases studies are listed in Table 31. Several patients suffered from two or more of the diseases listed. For example, all but one of the patients who had received cortisone therapy also suffered from severe rheumatoid arthritis. Similarly a majority of patients confined to bed or

Table 31. *Associated conditions in fracture cases in Series A.*

Associated conditions	Sex		Evaluable case histories		Per cent of cases	
	Wom.	Men	Wom.	Men	Wom.	Men
Post-radiotherapy	14	1	831	223	1.7	0.4
Hemiplegia						
fracture side	32	4	863	237	3.7	1.7
opposite side	7	4	863	237	0.8	1.7
Other paresis of fractured leg	8	6	863	237	0.9	2.5
Rheumatoid arthritis	64	4	863	237	7.4	1.7
Cortisone therapy	8	—	831	223	1.0	—
Hyperthyroidism	7	—	831	223	0.8	—
Diabetes mellitus	48	5	863	237	5.6	2.1
Post gastric surgery	11	18	831	223	1.3	8.1
Non-ambulant	53	9	830	236	6.4	3.8
Parkinsonism	19	3	863	237	2.2	1.3

Table 32. *Mean ages of patients in Series A according to presence or absence of predisposing factors.*

		With predisposing factor			Without predisposing factor		
		No.	Mean	Error of mean	No.	Mean	Error of mean
Radiotherapy	Women	14	66.6	2.64	861	73.1	0.37
Hemiplegia (fracture side)	Women	32	71.2	1.41	843	73.0	0.38
Other paresis (fracture side)	Women	8	54.1	5.34	867	73.1	0.36
	Men	6	47.8	4.22	233	69.6	0.89
Rheumatoid arthritis	Women	64	66.4	1.27	811	73.5	0.38
Cortisone therapy	Women	8	57.9	2.87	867	73.1	0.37
Hyperthyroidism	Women	9	67.7	3.87	866	73.0	0.37
Diabetes mellitus	Women	48	72.5	1.08	827	73.0	0.38
Post gastric surgery	Women	11	65.3	3.62	864	73.0	0.37
	Men	18	68.6	2.14	221	69.0	0.96
Non-ambulant	Women	53	74.5	1.51	825	72.6	0.41
	Men	9	72.7	2.87	230	68.8	0.94
Parkinsonism	Women	19	75.1	1.75	856	72.9	0.37
Castration prior to 50 without radiotherapy	Women	11	65.9	2.99	850	73.2	0.36

chair had some disease as cause of their invalidism. The average ages at fracture in different disease groups are given in Table 32.

Aside from the conditions listed in Table 31 other coincident diseases

were often recorded. Cardio-vascular disease (uncomplicated hypertension and arteriosclerosis excluded), e.g., was recorded in 8.2 per cent of the cases and 1.7 per cent had a history of previous myocardial infarction. 5.3 per cent of the fracture patients were blind or had considerably reduced eyesight and 3.6 per cent were admitted to mental hospital at the time of fracture.

1. *Local Conditions.*

a. *Post-radiotherpy.*

PREVIOUS STUDIES

Radiotherapy directed toward malignancies in the pelvis, usually cancer of the uterus or ovaries, or metastatic lesions in the inguinal lymph glands sometimes causes spontaneous fracture of the neck of the femur. BAENSCH (1927) was the first to describe such fractures, and since then many reports have appeared (for reference see BONFIGLIO, 1953; KOK, 1953; BICKEL et al., 1961).

PRESENT STUDY

In Series A radiotherapy had been directed towards the pelvis prior to fracture in 14 women and one man (Table 33). Patients who had radiotherapy as treatment of osteoarthritis of the hip were not included as the dose given in these cases was small compared with that given in cases of malignancy. Cancer of the uterine cervix (7 cases) and cancer of the ovaries (3 cases) were the most common conditions receiving radiotherapy. The male patient in the group had been treated for cancer of the bladder. There was no radiographic evidence of metastatic lesions at the site of fracture in these patients.

Eight patients (7 women and 1 man) sustained fracture without a history of injury. In these cases the fracture appeared within 17 months following radiotherapy. All but one were subcapital impacted fractures. Radiotherapy must be strongly suspected as the reason for fracture in these patients. The average age of these 7 women (63.7 $\pm$ 2.97 years) was lower(**) than in the rest of the series of female cervical fracture cases.

In 7 patients moderate injury was recorded. Three of these had trochanteric fractures. None of the cervical fractures in these patients were impacted. Only 2 of these 7 patients were younger than the average female fracture patient.

The average age of the total series of radiation-treated women was lower(*) than in the rest of the series.

Table 33. *Fractures preceded by radiotherapy for various conditions.*

Code No.	Sex	Age	Fracture type	Trauma	Interval between treatment and onset of symptoms	Largest roentgen dose	Diagnosis
578	W	62	SCi	Moderate	10 months	Fractured hip	Carcinoma of uterine cervix
877	W	62	SCi	None	1 month	Fractured hip	Carcinoma of uterine cervix
997	W	57	SCi	None	4 months	Equal both hips	Carcinoma of uterine cervix
812	W	72	SCi	None	6 months	Equal both hips	Carcinoma of uterine cervix
586	W	79	TC	Moderate	13 years	Equal both hips	Carcinoma of uterine cervix
733	W	74	T	Moderate	2 weeks	Fractured hip	Carcinoma of uterine cervix
1037	W	44	T	Moderate	4 years	Equal both hips	Carcinoma of uterine cervix and corpus
723	W	72	SC	Moderate	3 months	Equal both hips	Carcinoma of uterine corpus
1047	W	71	SC	Moderate	4 months	Radium only	Carcinoma of uterine corpus
944	W	63	SCi	None	13 months	Equal both hips	Ovarian carcinoma
996	W	56	SCi	None	11 months	Fractured hip	Ovarian carcinoma
834	W	67	T	Severe	4 years	Fractured hip	Ovarian carcinoma
350	W	79	T	Moderate	1 month	Opposite hip	Melanosarcoma of vulva
696	W	74	TC	None	2 months	Fractured hip	Reticulum-cell sarcoma
158	M	67	SCi	None	Not known	Fractured hip	Carcinoma of urinary bladder

SC: subcapital; TC: transcervical; T: trochanteric; i: impacted.

b. *Neurologic conditions.*

PREVIOUS STUDIES

In a series of fracture patients with *hemiplegia* PESZCZYNSKI (1957) found that all the fractures were on the hemiplegic side. SOTO-HALL (1960) was of the opinion that fracture of the hip is an extremely common complication of hemiplegia and stated that 8 to 10 per cent of hemiplegics sustain fractures of the hip which usually occur on the hemiplegic side.

PESZCZYNSKI believed that an impaired kinesthetic sense in patients with brain damage was responsible for an increased tendency to fall and "that any changes in the bones on the hemiplegic side which might have influenced a prevalence of the fracture on the hemiplegic side must be excluded as a primary etiologic factor". However, it has been observed that disuse of a limb due to neurological disorders, injuries, or immobilization results in loss of bone substance in the affected limb (ARMSTRONG et al., 1945; ABRAMSON, 1948; SISSONS, 1952; WHEDON, 1952; GILLESPIE 1954). GILLESPIE (1954) found in experimental animals, that the bending moment at breaking point was significantly lower in bones of the affected than of the unaffected leg.

PRESENT STUDY

Hemiplegia was recorded in 47 patients of Series A (4.2 per cent). Seven of these patients had a transient paresis and only slight symptoms were found at the time of admission for their fractures. In 36 patients the fracture was on the hemiplegic side; in the remaining 11 patients it was on the normal side. In the 39 women the prevalence of fractures on the hemiplegic side was significant(***) while in the 8 men the fractures were equally distributed.

The average age of the hemiplegic patients did not differ from the average age of the rest of Series A patients. This was expected as hemiplegia is mainly a disease of old age.

Other neurologic conditions of the lower extremities were *poliomyelitis* (2 women and 5 men), *multiple sclerosis* (3 women and 2 men) and *spasticity* of varied etiology (3 women). All but one of the patients with poliomyelitis sustained their fractures on the paretic side. Nine fractures in this mixed group were cervical and 7 trochanteric type. The average age at fracture was lower(***) in both sexes than in the rest of the series. Severe trauma was recorded in 4 women and 2 men with fracture of the affected leg. In 3 of the women it was related to a transient hemiplegia.

2. *General Conditions.*

a. *Rheumatoid arthritis.*

PREVIOUS STUDIES

Rheumatoid arthritis is known to have a marked influence upon the metabolism of the skeleton (McConkey et al., 1962). Juxta-articular osteopenia can be observed radiographically in very early stages of the disease (Steinbrocker et al., 1949). Manpel et al. (1961) reported that 0.6 per cent of their patients with fracture of the proximal end of the femur suffered from rheumatoid arthritis.

PRESENT STUDY

Rheumatoid arthritis was recorded in 64 women and 4 men. After cardio-vascular disease it was the most common disease recorded in women. It was more common in younger age groups than in older ones. Below 60 years of age 15 per cent of female patients had rheumatoid arthritis, between 60 and 69 years the incidence was 11 per cent, between 70 and 79 years 7.0 per cent and above 80 years 1.6 per cent. The average age of female patients with rheumatoid arthritis was lower(***) than in the rest of the series. In these patients the distribution of moderate and severe trauma did not differ significantly from that in Series A (7.8 per cent evere trauma and 12 per cent, respectively) nor did the distribn-tion of cervical and trochanteric fractures (43 cervical and 21 trochanteric fractures). Ten patients with rheumatoid arthritis were confined to a chair (9 patients) or bed (1 patient) before fracture.

b. *Endocrinopathy.*

PREVIOUS STUDIES

Several endocrine disorders may disturb bone metabolism. Hyper-adrenocorticism in Cushing's disease and prolonged cortisone medication cause marked osteopenia and bone fragility (Reifenstein Jr, 1947; Arnoldson, 1958; Lindahl, 1961 and others). Hyperthyroidism (Williams and Morgan, 1940; Follis, 1953) and diabetes mellitus (Albright and Reifenstein, 1948; Hernberg, 1952) have a similar but less pronounced effect.

PRESENT STUDY

In Series A no patient had Cushing's disease or hyperparathyroidism.

Cortisone medication had been received by 7 women with rheumatoid arthritis and one woman with asthma. Their mean age was lower(***) than average and all the fractures were associated with moderate trauma. Cervical and trochanteric fractures were equally common.

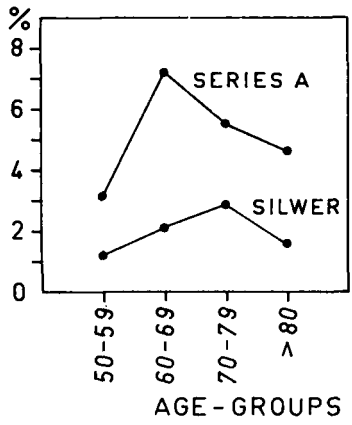


Fig. 15
Distribution of diabetes mellitus in women in series A and according to SILWER (1958).

Hyperthyroidism had been diagnosed in 9 women prior to fracture. All the fractures were caused by moderate trauma and all but one were of cervical type. Their average age did not differ from that of the rest of the series.

Diabetes mellitus had been recorded in 47 women and 5 men in Series A. One woman suffered two fractures during the ten-year period studied. In 3 women the dignosis was made during the course of fracture treatment. Twenty-one patients with diabetes recognized prior to the fracture had received insulin therapy while the remaining 31 had had only diet control. The average age at fracture of diabetic patients did not differ from that of non-diabetics nor did the distribution of moderate and severe trauma.

With the exception of diabetes, the prevalence of coexisting diseases in the present material cannot be compared with that in the general population. While no data are available on the prevalence of diabetes in the city of Malmö, SILWER (1958) published data on the incidence of diabetes mellitus in towns and rural districts of the County of Kristianstad, which is situated in the same area of Sweden as Malmö. Silwer found a higher frequency of diabetes in towns than in rural districts. It seemed reasonable to assume that incidence data from the towns of the County of Kristianstad could be compared with Series A of this material. SIEVERS et al. (1961) compared the incidence in Malmö of diabetes in patients suffering from coronary heart disease with the incidence of diabetes given by Silwer.

In making such a comparison only patients whose diabetes had been recognized before their admission for hip fracture were included. The distribution of female diabetics in this series and in Silwer's series is shown in Fig. 15. If Silwer's data are projected upon the number of fracture cases

Table 34. *Observed number of diabetics in Series A compared with expected number calculated from the incidence according to Silwer* (1958).

Age groups	Women			Men		
	No. of fractures	Expected No.	Observed No.	No. of fractures	Expected No.	Observed No.
50—59	82	0.9	3	27	0.2	1
60—69	189	4.0	13	47	0.6	1
70—79	318	9.0	18	82	1.5	3
>80	219	3.3	10	46	0.6	—
Total	808	17.2	44	202	2.9	5

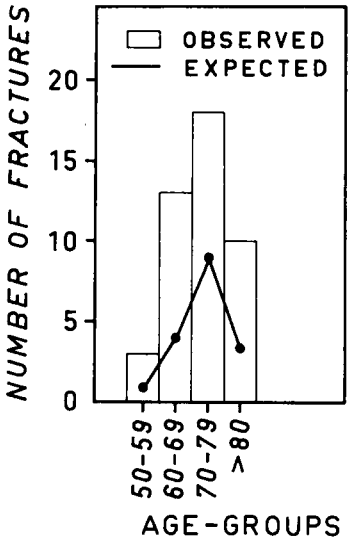


Fig. 16
Observed number of fractures in female diabetics in series A and the expected number from data given by SILWER (1958).

of corresponding age and sex and who had reliable case histories the expected number of diabetics in each sex can be calculated (Table 34 and Fig. 16). The expected number of diabetic female fracture cases was 17.2 as compared to 44 observed cases ($P < 0.05$). The ratio of observed to expected numbers was about the same in each ten-year age group (Fig. 16).

In men no difference was found between expected and observed numbers of diabetics.

The degree of trauma was not considered in the above calculations. When fractures associated with moderate trauma only were included, 15.1 women diabetics would have been expected compared with the 39 cases observed in the material ($P < 0.05$). The corresponding figures in men were 1.6 expected and 3 observed, revealing no significant difference.

Comments: When data on the incidence of diabetes mellitus in urban residents of the County of Kristianstad were applied to this material, diabetes seemed to be significantly more common in women with fractures than in the general population.

HERNBERG (1952) in post-mortem studies found a greater degree of osteopenia in diabetic subjects below the age of 65 than in non-diabetic controls while above that age there was no difference in degree of osteopenia between the two groups. In this series there was no certain difference between the relative number of diabetics in the younger and older age groups.

c. *Post gastric surgery.*

PREVIOUS STUDIES

Operations upon the gastro-intestinal tract may result in defective absorption of substances essential for normal bone metabolism. For this reason CASUCCIO (1962) included previous gastrectomy among the causes of osteopenia. MCLEAN BAIRD and OLEESKY (1957) reported 4 cases of osteomalacia after such operations. DYMLING et al. (1962) and HALL and NEALE (1963) reported several cases of osteopenia in patients following gastric operations. URIST (1960) found that the incidence of duodenal ulcers was 18 per cent in osteopenic men while in a control group it was only 9 per cent.

PRESENT STUDY

Gastric operations had been performed in 29 patients (11 women and 18 men). Subtotal gastrectomy had been done in 9 women (in 3 cases for carcinoma of the stomac) and 14 men, and gastro-enterostomy in 1 woman and 2 men. In 3 patients records of the operation could not be obtained. The distribution of moderate and severe trauma according to sex did not differ from that of the total series, nor did the average age in men. However, the average age at time of fracture of women with gastric operations was lower(*) than in the rest of the series. Earlier gastric surgery was the most common concomitant condition recorded in male patients (8.1 per cent).

d. *Immobilization.*

PREVIOUS STUDIES

Immobilization results in a loss of skeletal mass (ARMSTRONG et al., 1945; ABRAMSON, 1948; SISSONS, 1952; WHEDON, 1952; GILLESPIE, 1954) probably leading to an increased liability to fracture.

MANPEL et al. (1961) found that 21 per cent of 486 patients were not ambu-

latory prior to fracture. RENO and BURLINGTON (1958) classified 35 per cent of their 146 patients as invalids or semi-invalids but did not give definitions. In this study patients known to have been bedridden or mainly confined to a chair for months prior to the fracture were classified as non-ambulant.

PRESENT STUDY

Of all patients whose degree of mobility was known in this series 53 women and 9 men were classified as non-ambulant before the hip fracture (6.4 and 3.8 per cent, respectively). Sixteen patients had been bedridden for a long period; 34 patients had sequelae of cerebral vascular lesion (18 patients), rheumatoid arthritis (8 patients), parkinsonism (5 patients) or spastic paraplegia (3 patients) and in 3 patients some other invalidity was present (osteoarthritis, amputation, deformity due to old fracture). The remaining patients were non-ambulant because of the general debility of old age, advanced tuberculosis or carcinoma. The average age in this group was the same as that of the rest of the series. All fractures but 4 were associated with moderate trauma.

e. *Parkinsonism.*

PREVIOUS STUDIES

Patients with parkinsonism probably have a greater risk of fracture than healthy people of the same age due to reduced mobility and increased tendency to fall. MANPEL et al. (1961) and RENO and BURLINGTON (1958) found the incidence of parkinsonism in their series to be 1.0 and 1.4 per cent, respectively.

PRESENT STUDY

Parkinsonism was found in 19 women (2.2 per cent) and 3 men (1.3 per cent) in this series. The average age of these patients was the same as that of the rest of the material. With the exception of one man, moderate trauma was recorded in all of these patients.

COMMENTS

Because of a lack of data on the prevalence of diseases in the population studied it was not possible to state whether diseases known or suspected to affect the skeleton were more prevalent in this series than in the general population. Diabetes mellitus was the only disease in which age and sex incidence was known (SILWER, 1958).

The only way in which to study the impact of disease upon fracture etiology was to compare the average age at fracture, the type of trauma

and, in cases of unilateral paresis, side involvement in those patients having disease with corresponding factors in patients without disease.

The results of this study indicate that previous radiotherapy of the pelvis, hemiplegia or other paresis of a leg, rheumatoid arthritis, diabetes mellitus and prolonged cortisone medication predispose to fracture. No conclusion can be drawn from this material regarding any increased liability to fracture of the proximal end of the femur in non-ambulant patients or in patients with parkinsonism. From other reasons it seems, however, reasonable to assume such an increased liability. It can not be established whether the lower average age at fracture in female patients with previous gastric operations compared with non-operated patients was due to an increased frequency of gastric operations in women during later decades or to a greater susceptibility of the female skeleton to short-circuiting operations of the gastro-intestinal tract.

In Series A one or more of the diseases listed was known to be present in 211 women and 48 men (24 and 20 per cent, respectively). In the cases where the degree of trauma was known, 300 fractures in women (35 per cent) and 145 fractures in men (62 per cent) occurred in association with severe trauma or in association with one or more of the diseases studied.

The age and sex incidence of fractures of the proximal end of the femur associated with moderate or no trauma may be regarded as an index of fracture liability. As some conditions are known or suspected to cause skeletal changes, an index of "idiopathic" age changes of the skeleton may be found by excluding all cases of fracture with such concomitant disease (Fig. 17). It was apparent that the increase of fracture liability appeared at an earlier age in women than in men. "Idiopathic" fractures were more common in woman than in men, but with advancing age this difference tended to diminish.

SUMMARY

Several medical conditions were found to be of importance in the etiology of fracture of the proximal end of the femur.

3. *Parity.*

PREVIOUS STUDIES

During pregnancy calcium requirements are increased and although renal conservation of calcium occurs during the period of maximum fetal requirement (Goss, 1962) and during lactation, a net loss still occurs (ALBRIGHT and REIFENSTEIN, 1948).

Several authors have observed marked skeletal changes during pregnancy. ALBRIGHT and REIFENSTEIN (1948) and NORDIN and ROPER (1955) de-

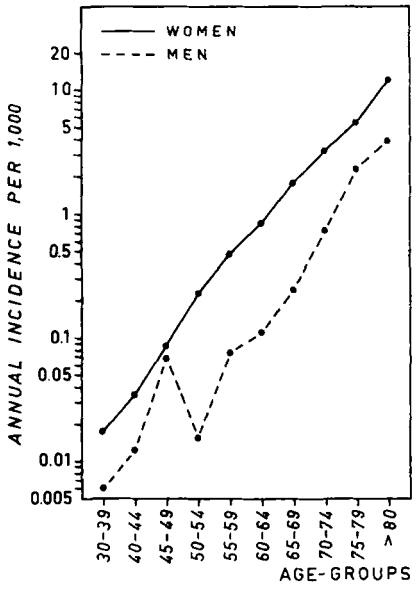


Fig. 17
Age and sex incidence of fractures of the proximal end of the femur in patients without known predisposing factors and fractures after moderate or no known trauma.

scribed severe osteopenia developing in healthy women during pregnancy. JACKSON (1958) found that premenopausal osteopenia in 11 women had occurred in connection with pregnancy and lactation, and FINLEY (1956) stated that "in elderly women, the incidence of osteoporosis in those who are multiparous is almost double that of those who are nulliparous". KESSON et al. (1946) reported that the incidence of osteopenia was significantly higher in multiparous than in nulliparous women, but DONALDSON and NASSIN (1954) could not confirm this finding.

BAYLISS et al. (1955) followed plasma-17-hydroxycorticosteroid levels in 38 women before and after delivery and found an increasing concentration up to delivery and a rapid fall in concentration after that time. In some cases the values were higher than those found in CUSHING's disease. ELLINGER et al. (1952) observed bone resorption in rats during lactation, which was most marked in cancellous bone.

No reports have been found regarding a relationship between parity and liability to fractures.

PRESENT STUDY

If parity had an influence upon liability to fracture of the proximal end of the femur, the proportion of married women would be greater among fracture patients than in the total population. The average number of children of women with fractures would also be greater than in the general population.

Table 35. *Series A + B and population of Malmö in 1950 and 1960 grouped according to age and civil status.*

Age groups	Known civil status	Unmarried		Per cent unmarried women in Malmö in	
		No.	Per cent	1950	1960
50—59	114	30	26	22	17
60—69	263	71	27	23	22
70—79	429	112	26	22	23
>80	344	75	22	24	22
Total	1,150	288	25	23	20

In Series A and B civil status was known in 1,184 of 1,205 women patients (98 per cent). Per cent unmarried in each age group and per cent unmarried women in corresponding age groups in the population of Malmö are indicated in Table 35. It is evident that the civil status of the female probands did not differ appreciably from that of the female population of Malmö.

Parity was known in 709 of the 1,205 women (59 per cent). The information was collected at the time of admission to hospital or at the time of interview in 1960. Lack of completeness of data in Series A was related to deaths occurring before the interview, and in Series B to unreliability of the case records, so that data are less complete in the older than in the younger age groups. No other systematic bias was found.

Average parity in the total series was 1.9, and in the married 2.5. The average parity was somewhat higher in women with trochanteric fractures than in women with cervical fractures, 2.1 and 1.8, respectively (Table 36).

The average age of the patients with known parity in this series was 69.4 years. A majority of these patients were born around 1885—1890. When the average parity in the female population of Sweden born in 1885, 1890, and 1895 (Table 37) was compared with that of patients in this material (Table 36), it was apparent that parity was about the same in fracture patients as in the total population.

Five hundred and ninety-nine women in whom parity was known suffered fracture in association with moderate or no trauma. The average number of children in this group was 1.9, similar to that of the total series.

No data on lactation are available.

COMMENTS

The relative numbers of married and unmarried women in this series did not differ from those of the total population of Malmö.

The average parity of female fracture patients was slightly lower than

Table 36. *Female patients in Series A and B grouped according to civil status, average parity and type of fracture.*

Civil status	No. of patients	Patients with known parity			Cervical fractures		Trochanteric fractures	
		No.	Per cent	Average parity	No.	Average parity	No.	Average parity
Married	888	525	59	2.5	351	2.4	174	2.7
Unmarried	296	179	61	0.2	130	0.2	49	0.1
Not known	21	5	24	1.0	2	1.0	3	1.0
Total	1,205	709	59	1.9	483	1.8	226	2.1

Table 37. *Average parity of Swedish women born in 1885, 1890, and 1895.*

Women born in	Average parity	Average parity per married woman
1885	2.8	3.3
1890	2.4	2.8
1895	2.1	2.4

that of women in the total population of Sweden. This was probably explained by a lower fertility rate in towns.

Parity in women with trochanteric fractures was slightly higher than in women with cervical fractures. This difference was probably related to the higher average age of patients with trochanteric fractures, as fertility decreased considerably during the last decade of the 19th century (Table 37). The literature contains many reports on childbirth and lactation as etiologic factors in osteopenia, but this study did not reveal a correlation with fracture.

SUMMARY

Parity did not influence liability to fracture of the proximal end of the femur in the patients of this series.

4. *Age at Menopause.*

PREVIOUS STUDIES

In 1940 ALBRIGHT et al. suggested that osteoporosis was one manifestation of decreased hormone production after the menopause and observed (ALBRIGHT et al., 1941) that in women with an artificial menopause the average age of onset of such skeletal changes was lower than following a physiologic menopause. REIFENSTEIN (1957) concluded that

a deficiency of anabolic hormones in aged persons was a factor leading to osteoporosis.

Many authors have included castration among the causes of osteopenia (ALBRIGHT et al., 1941; WILSON, 1953; IBARRA, 1956; BARTTER, 1957; SCHECHTER and MERVINE, 1958; URIST, 1958). URIST (1960) found a higher incidence of oophorectomy in osteopenic than in non-osteopenic women.

On the other hand DONALDSON and NASSIM (1954) concluded from a study of 94 patients with surgical castration (between age 26 and 73) that neither the time of onset nor the degree of osteopenia could be related to the age at menopause, whether natural or artificial.

As there is apparently no agreement regarding the influence of the menopause upon skeletal metabolism, an attempt was made to relate age at menopause to age at fracture in this series.

PRESENT STUDIES

At the time of interview in 1960 the patients in Series A were asked about their age at menopause. As these data were initially regarded as somewhat unreliable, the patients were classified in five-year age groups. However, as the interviews progressed it became evident that most patients had a rather distinct memory of their age at the menopause and could nearly always give a definite answer.

In Series B the age at menopause was known in 142 women. Ninety-six of these patients had cervical and 46 trochanteric fractures. The average age at menopause was 48,4 $\pm$ 0.44 years. There was no difference between the average age at menopause of the cervical and trochanteric fracture groups.

Four hundred and eight women who had sustained femoral neck fractures in association with moderate or no trauma were classified in four groups with regard to age at the physiologic or surgically induced menopause (Table 38). It was apparent that no correlation was present between age at the menopause and age at fracture.

Eleven women had undergone surgical castration before age 50 but without radiotherapy directed towards the pelvis. In these patients the average age at fracture was 65.9 $\pm$ 2.99 years which was lower than for the rest of material(*). Four out of 11 castrated women suffered severe trauma.

COMMENTS

The existence of a relationship between age changes in the human skeleton resulting in decreased bone strength, and the sex hormones is still open to discussion.

Table 38. *Women in Series A and B grouped according to mean age at fracture and age at menopause.*

Age at menopause	No.	Mean	Error of mean
<40	16	65.3	2.08
40—44	60	66.8	1.15
45—49	162	68.7	0.79
>50	170	68.5	0.62

The average age at menopause of women with fracture of the proximal end of the femur in series B was 48.4 ± 0.44 years which was essentially the same as in two control series: A series of 50 women examined radiographically at MGH in 1951 because of transient hip or low-back complaints who were clinically and radiographically reinvestigated in 1962 by DANIELSSON (1964), had an average age at menopause of 48.3 ± 0.56 years; SAMUELSON (1942) found the average age at menopause of a series of 671 women in southern Sweden to be 48,3 ± 0.13 years.

Women with surgical castration prior to age 50 probably suffered their fractures at a lower age than those without surgical castration. The higher frequency of severe trauma in these women compared with the total series may partly account for this difference in average age.

SUMMARY

No difference has been found in the average age at menopause of the female fracture cases and two control series.

The age at femoral neck fracture in women was unrelated to the age at menopause, although the average age at fracture of 11 women who had had a surgical menopause was somewhat lower.

5. *Body Weight.*

PREVIOUS STUDIES

It has been suggested that obesity is a factor predisposing to fracture of the proximal end of the femur (BACKMAN, 1957; SPAK, 1962) and that weight reduction in the elderly would reduce the risk of such fractures (FREYBERG and LEVY, 1948). STEWART (1957), on the other hand, stated that fracture patients are usually of slight build. None of these authors presented evidence to support their statements.

PRESENT STUDY

In series A and B weight of the patients had not normally been recorded. The body constitution of the examined patients in series A

Table 39. *Body weights in women: cases of fracture of the proximal end of the femur, cases of coxarthrosis and normal subjects.*

	Under-weight		Ideal weight		Over-weight		Total	Mean age
	No.	Per cent	No.	Per cent	No.	Per cent	No.	
Fracture	20	32	31	49	12	19	63	71.5
Coxarthrosis[1]	7	11	23	36	34	53	64	68.6
Normals[2]	—	12	—	49	—	39	305	all above 67

[1] Danielsson (1964)

[2] Werner and Berfenstam (1960)

was estimated by the interviewers, but more than half of the patients stated that they had gained or lost weight since the fracture. The magnitude of the gain or loss was not usually known, so that these data were of little value.

In 1963 a series of unselected patients with recent cervical or trochanteric fractures was weighed and measured. According to the definition of WERNER and BERFENSTAM (1960) female patients were divided into three groups: under-weight, ideal weight, and over-weight. Ideal weight was defined as: the body length in centimeters minus 100 $\pm$ 10 per cent, in kilograms. The results are given in Table 39 compared with results of investigations of body weight of women above age 67 in Uppsala (WERNER and BERFENSTAM, 1960), and the weights of 64 women with coxarthrosis (DANIELSSON, 1964). The distribution of female fracture patients with regard to "ideal weight" differed significantly from that of the control series(***). A greater proportion of fracture patients were below ideal body weight and a smaller proportion were above ideal body weight than ir the control series.

COMMENTS

The definition of "ideal weight" may be critisized. However, the applied method offers a basis for comparing materials. In the present series low body weight was significantly more common in female patients with fracture of the proximal end of the femur than in two control series.

MASTER et al. (1960) found body weight to decrease significantly with advancing age so that age distribution of the different series should be considered. The average age of the Uppsala series is not known but all the

probands were above age 67 so it is reasonable to assume that it was not lower than that of the fracture series. The average age of the coxarthrosis series agreed rather well with that of the fracture patients.

SUMMARY

Low body weight relative to body height was more common in female patients with fracture of the proximal end of the femur than in two control series.

I. SEASONAL VARIATION OF BIRTH DATES.

PREVIOUS STUDIES

There are reasons to suspect that changes in the skeleton are dominant factors in the etiology of fractures of the proximal end of the femur. At the moment, however, it is difficult or impossible to identify symptoms of such skeletal changes apart from fracture (BAUER, 1962).

It is well known that in some diseases there is a seasonal variation in the birth dates of the patients. A classical orthopaedic disease with such a seasonal variation is congenital dislocation of the hip (see ANDRÉN and PALMÉN, 1963). It is also well known that some kinds of intoxication (phosphorus) and some diseases (measels) suffered in early childhood result in sclerotic areas in the skeleton. Such areas of condensed bone remain unchanged or almost unchanged throughout life.

PRESENT STUDY

As influences acting in early childhood or prenatal life may thus result in persisting alterations in the skeleton, it was considered worthwhile checking whether any seasonal variation of birth dates could be demonstrated in patients with fractures of the proximal end of the femur associated with moderate or no trauma (1,058 women and 213 men). The seasonal variation of live births in Sweden from 1881 through 1890 was used as a control. The expected number of individuals in each month and difference between observed and expected number were calculated, and the results are given in Table 40 and Figure 18.

It was apparent that this material showed a clear seasonal variation of date of birth with the crest of the wave in fall and the trough in early spring. During the first 6 months of the year the observed number in the total series and in women was lower ($P < 0.05$) than expected and during the last 6 months the observed number was higher ($P < 0.05$) than exepted. In male patients no such trend was present. Similar result was obtained when the seasonal variation of live births in the district of Malmö (County of Malmöhus) from 1881 through 1890 was used as a control.

Table 40. *Observed and expected seasonal variation of birth dates of patients with fractures associated with moderate or no trauma in series A and B.*

		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Women + men	Observed	115	88	96	97	100	89	124	106	123	125	90	118	1,271
	Expected	113.0	101.6	115.2	107.1	106.8	99.3	100.0	100.4	111.7	106.3	100.4	109.2	1,271.0
	Difference	+2.0	—13.6	—19.2	—10.1	—6.8	—10.3	+24.0	+5.6	+11.3	+18.7	—10.4	+8.2	
Women	Observed	95	74	77	81	81	75	106	84	106	109	78	92	1,058
	Expected	93.5	85.0	95.9	89.1	89.0	82.1	83.3	83.1	93.2	89.0	84.0	91.0	1,058.2
	Difference	+1.5	—11.0	—18.9	—8.1	—8.0	—7.1	+22.7	+0.9	+12.8	+20.0	—6.0	+1.0	

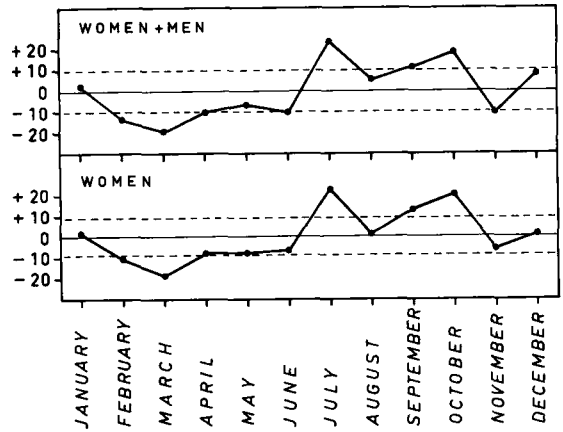


Fig. 18
Differences between observed and expected seasonal variation of dates of birth of patients in series A and B with fractures after moderate or no trauma. Random deviation = $\sqrt{n \cdot \frac{1}{12} \cdot \frac{11}{12}}$

COMMENTS

The seasonal variation of date of birth observed in this material may indicate that factors, other than hereditary factors, e.g., climatic, alimentary or hormonal influencing the child during prenatal life or early childhood are of importance in the etiology of the skeletal fragility of old age, one symptom of which can be a fracture of the proximal end of the femur associated with little or no trauma. The findings require confirmation by studies of still larger materials. Patients with distal forearm fractures should also be included in such studies.

SUMMARY

A seasonal variation of the date of birth was observed among patients with fractures of the proximal end of the femur associated with little or no trauma.

J. BLOOD GROUPS

PREVIOUS STUDIES

During recent years increasing interest has been focussed upon an association between disease and blood groups. To obtain data for blood group studies BUCKWALTER et al. (1957) studied patients with fractures of the proximal end of the femur, and found that the pattern of blood types differed from that of a series of blood donors from the same area. A significantly increased incidence of blood type A was found in the fracture series. THORSØE (1960) made a similar investigation in Copenhagen using a large series of blood-grouped residents as controls, and found no difference in blood group distribution between the total fracture series and

Table 41. *Blood group distribution of 562 patients in Series A and B and control series.*

	Cervical fractures		Trochanteric fractures		Total fractures		Controls	
Blood group	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
0	144	39.8	69	34.5	213	37.9	2,401	42.3
A	162	44.8	98	49.0	260	46.3	2,430	42.8
B	39	10.8	27	13.5	66	11.7	590	10.4
AB	17	4.7	6	3.0	23	4.1	247	4.5
Total	362	100.1	200	100.0	562	100.0	5,668	100.0

the controls. However, in cervical varus fracture cases there was a significant excess of blood group A.

BUCKWALTER et al. suspected a relationship between blood group substances and bone metabolism.

PRESENT STUDY

In Series A and B of the present study the blood group distribution in 562 patients with fractures of the proximal end of the femur associated with moderate or no trauma (43 per cent of all patients with that degree of trauma) was compared with the blood group distribution of 5,668 volonteer blood donors in the district of Malmö (County of Malmöhus) (WILLERT and WINBLAD, 1952). The results are given in Table 41. There was no significant excess of blood group A in the total fracture series nor in each of the two fracture types.

COMMENTS

In contrast to reports by BUCKWALTER et al. (1957) and THORSØE (1960) no significant excess of blood group A was present in this material.

AIRD et al. (1954) described a method for statistical calculation of significance in combined data from different regions. By studying the data given by BUCKWALTER et al. and THORSØE as well as those from Malmö (Table 42) according to that method a significant(**) excess of blood group A was found to be present in fracture patients compared with controls.

ROBERTS (1957) discussed the implication of associations observed between blood groups and disease, particularly duodenal ulcer, and suggested that blood group substances might be involved in some way, noting that many diseases with such associations "are diseases of, or closely associated with, the upper part of the gastro-intestinal tract, a region in which, in secretors, group specific substances are present in large amounts". Roberts did not rule out some hitherto unknown functions of the blood group genes which might be responsible.

Table 42. *Blood group distribution of different series of fractures of the proximal end of the femur.*

Blood group	Iowa, USA[1]		Copenhagen[2]		Malmö	
	Patients	Controls	Patients	Controls	Patients	Controls
0	410 (41.8)	2,892 (45.8)	239 (40.5)	6,082 (40.6)	213 (37.9)	2,401 (42.3)
A	441 (45.0)	2,625 (41.6)	262 (44.4)	6,545 (44.0)	260 (46.3)	2,430 (42.8)
0 + A	851	5,517	501	12,627	473	4,831

[1] BUCHWALTER et al., 1957.

[2] THORSØE, 1960. No. of controls calculated from percentages.

Bracketed figures denote percentages.

The control series were composed of young or middle-aged healthy blood donors whereas the patients with fractures of the proximal end of the femur were comparatively old. It was therefore necessary to know if blood type distributions were the same in young and middle-aged persons as in elderly persons in the same population. HART (1944) and ROBERTS (1948) found in large series of war-time blood donors a slightly lower average age of male donors of group A compared with group 0, whereas in female donors the average age was possibly lower in group 0 than in group A. BUCKWALTER et al. (1957) found it "conceivable that those persons with group A have a shorter life expectancy than group 0 and both shorter than group B". The importance of the small differences in average age noted by the above authors could not be evaluated, but must be determined by extensive observations before the observed association between blood groups and fractures of the proximal end of the femur can be definitely evaluated. So far no such investigation has been found in the literature.

SUMMARY

It seems reasonable to assume, that the increasing fracture liability of old age may be determined in part by hereditary factors.

IV. GENERAL DISCUSSION

A. ETIOLOGY OF FRACTURE OF THE PROXIMAL END OF THE FEMUR

The modern concept of fractures of the upper part of the thighbone was formulated by COOPER (1824): the fracture occurs in aged females following trivial *trauma*, sometimes as a result of *disease*, but usually because of *bone fragility*.

1. *Trauma.*

There is ample evidence that compression fractures of the vertebrae in the aged often occur without a history of trauma (GERSHON-COHEN et al., 1953). COOPER (1824) observed cases of spontaneous fracture of the proximal end of the femur, and it has been claimed that these are common. The literature contains few reports to support this view. In this investigation spontaneous fracture was rare. Only 18 cases were found. Of these 3 had a cancer metastasis or other radiographically-apparent lesion, and 8 had received radiotherapy followed by a typically insidious development of a fracture. There seems to be little doubt, therefore, that trauma is an etiologic factor in fracture of the upper end of the femur.

In the younger age groups in this study, and especially in males, severe trauma was not uncommon. In women of all age groups and in men of older age groups severe trauma was relatively rare. This age and sex pattern of trauma with fracture of the proximal end of the femur is opposite to that seen with fractures associated with severe trauma such as fracture of the shaft of the femur. Also, multiple injuries were rare in this material. Because of this it seems reasonable to exclude severe trauma as a dominant factor in the etiology of fracture of the upper end of the femur.

Aged people are reported to have an increasing tendency to fall due to conditions such as giddiness, failing eyesight, impaired muscle coordination, etc. (SHELDON, 1948; DROLLER, 1955; BOUCHER, 1959). However, it does not seem plausible that elderly people should generally sustain accidents of the type that result in fracture of the proximal end of the femur more often than active persons in younger age groups. It is also unlikely that elderly women would suffer minor accidents more than three times as often as elderly men. Similarly a sudden increase in the incidence of distal forearm fractures around the age of 50 in women but not in men (BUHR

and COOKE, 1959; ALFFRAM and BAUER, 1962) can hardly be explained by a sudden increase of the number of accidents in women but not in men.

When compared to changes occurring within bone, external factors are probably of subordinate importance in the liability of elderly persons, particularly women, to sustain fractures of the proximal end of the femur.

2. *Disease.*

In this material fracture associated with severe trauma was encountered twice as often in healthy patients as in those with one or more of the associated conditions studied. Local conditions such as cancer metastases or bone changes due to radiotherapy are obvious causes of fracture of the proximal end of the femur, but even generalized conditions associated with diabetes mellitus and contisone medication were found to be of probable etiologic significance. In the entire material 24 per cent of female and 20 per cent of male fractures occurred in patients who had one or more of the following conditions: previous radiotherapy to the pelvis, paresis of the fractured leg, rheumatoid arthritis, cortisone therapy, hyperthyroidism, diabetes mellitus, previous gastric surgery, parkinsonism or immobilisation of long duration. While it was not possible to determine the relative etiological significance of all of these conditions, the fact that as a group they were associated with a significantly higher incidence of fracture associated with moderate rather than severe trauma indicated that they were of etiological significance.

3. *Bone fragility.*

Increased liability to fracture of the proximal end of the femur may be due to local lesions or to general changes in the skeleton. Local changes caused by cancer metastases, radiation injury and similar lesions were rare in this material. A few authors have produced evidence of changes in the internal structure of the proximal end of the femur in the aged, on radiograms (APFELBACH and AIRES, 1936; RUTISHAUSER and DUFOUR, 1950; URIST, 1960) and in anatomical and histological studies (FARKAS et al., 1948; RUTISHAUSER and DUFOUR, 1950). However, for several reasons it is probable that in the aged a general loss of bone tissue is of more importance in the etiology of such fractures. In this study women with fracture of the proximal end of the femur were found to sustain more than twice as many fractures of the distal end of the forearm as women in the general population. In a previous study (ALFFRAM and BAUER, 1962) it was found that the ratio of forearm fractures occurring in cancellous bone to those occurring in cortical bone increased with age, especially in women, while the degree of violence associated with such fractures decreased with

age. Other fractures occurring in cancellous bone are also disproportionately frequent in the aged, for example, those of the proximal end of the humerus, the tibial plateau, and the bodies of the vertebrae. There can be little doubt that skeletal changes which predispose to fracture are generalized throughout the body.

Loss of bone tissue (osteopenia) is commonly believed to be associated with fracture; *indirect* evidence for this association is abundant. The incidence of osteopenia is higher in women than in men (COOKE, 1955). Although rarely seen below age 50, it is increasingly common above this age. The exact incidence of osteopenia is unknown due in part to a lack of accepted standards of definition and measurement. A progressive decrease of the total skeletal mass with advancing age has been described in a large series of human skeletons (INGALLS, 1931). Other authors have described a decrease with age of the weight per unit volume of bone (TROTTER et al., 1960; LINDAHL and LINDGREN, 1962); and in a microradiographic study of cortical bone from the human femur JOWSEY (1960) found increasing porosity in the aged. A *direct* association between osteopenia and fracture of the proximal end of the femur was claimed by STEWENS et al. (1962) based upon histologic evaluation of iliac bone biopsy and standardized radiographical measurements in fracture patients. URIST (1960) found a higher incidence of compression fracture of vertebrae and ballooning of intervertebral discs in women with fracture of the proximal end of the femur than in controls.

Changes in the quality of bone tissue have received relatively little attention. It is well known that bone in children is more resilient than in adults, as evidenced by the occurrence of greenstick fractures, but it remains only a clinical impression that bone in the elderly is more fragile. An example of an alteration in bone quality is furnished by fracture of the neck of the femur following radiotherapy to the pelvis. Such fractures are distinguished by their gradual onset over a period of days or weeks, and seem to have some features in common with fractures occurring in osteomalacia. Recent observations on an association between certain skin changes and osteopenia may have some significance with regard to changes in the quality of bone (MCCONKEY et al., 1962).

Evidence strongly suggests that fracture of the proximal end of the femur, in the absence of obvious local disease is a sign of disturbed skeletal metabolism, more prominent when the fracture is caused by moderate rather than severe trauma. The evidence that this generalized skeletal disorder can be entirely described by the term osteopenia is by no means conclusive, and for the purpose of this discussion it will be termed progressive bone fragility.

a. *Etiology of progressive bone fragility*

Previous thoughts on the etiology of age changes in bone are partly obscured by the tacit assumption that fracture is a sign of osteopenia. COOPER (1824) and subsequently ALBRIGHT and REIFENSTEIN (1948) believed that osteopenia was due to deficient bone formation. The latter authors showed that *hormonal factors* may be operative and they also showed that *pregnancy* and *lactation* may cause large calcium deficits. Against this background it is probably significant that in this study neither parity nor age at menopause were found to have any relationship to the occurrence of fracture of the proximal end of the femur.

Nutritional factors in the etiology of osteopenia have been considered by a number of authors (for references see NORDIN, 1960, and WHEDON, 1960) and occasional reports exist on the association of nutritional deficiency with fracture of the proximal end of the femur (RENO and BURLINGTON, 1958; HÖHLE, 1952). While nutritional factors were only indirectly considered in this study it is striking that the general pattern of sex, age and moderate trauma is the same in this material as in those of COOPER (1824) and BRUNS (1882) at a time when diets were probably deficient by today's standards. In as much as this material is interpreted to show that fracture of the proximal end of the femur is a late sign of a generalized skeletal disease, it is difficult to attach much etiologic importance to poor eating habits in elderly people.

Seasonal variation in the birth dates of patients with fracture of the proximal end of the femur was observed in this study. This suggests a possibility that influences operating during prenatal life or infancy may have etiologic significance with regard to skeletal fragility in the aged. Such influences may be, e.g., hormonal, alimentary or climatic in nature. Perhaps it would be profitable to study whether variations in the intake of trace elements such as copper and manganese during early life have any influence upon skeletal metabolism in adult life (for references see ASLING and HURLEY, 1963).

Heredity was suggested by FINLEY (1956) as a possible etiologic factor in osteopenia of old age and BUCKWALTER et al. (1957) and THORSØE (1960) found an association between blood group A and the occurrence of fracture of the femoral neck. In this series alone no association was found but when the three materials were combined a significant association was found, suggesting that hereditary factors may have a bearing on liability to this type of fracture.

Another factor indicating the importance of heredity is the racial difference in fracture incidence. GYEPES et al. (1962) in an American hospital

found fractures of the proximal end of the femur to be uncommon in Negroes. The finding in this study that the incidence of cervical fractures is twice as high in Sweden as in Great Britain may indicate a hereditary factor but does not excluse environmental or nutritional factors. Further studies of geographic differences in fracture incidence may perhaps unearth presently unrecognized factors in the etiology of fracture of the proximal end of the femur.

B. ETIOLOGIC CLASSIFICATION OF FRACTURE OF THE PROXIMAL END OF THE FEMUR

Anatomical classification of fractures of the proximal end of the femur are useful from a mechanical point of view in the selection of methods of treatment, and probably in assessing prognosis with regard to healing of the fracture. An anatomical classification is not sufficient, however, for evaluation of the prognosis quod vitam, or for prediction of long term functional results (ALFFRAM, 1961). Such evaluation is increasingly important now that the choice of therapy is wider than in Cooper's day, or even a decade ago. A more precise classification is needed for other reasons, too. During the course of this study it became embarrasingly apparent how difficult it can be to compare clinical material from different centers, because of lack of definitions and differences in composition. This has probably tended to hamper progress in evaluation of various types of treatment, for example open vs. closed methods in the treatment of trochanteric fractures. This lack of a suitable classification is also felt in studies aimed at prevention of fracture of the proximal end of the femur.

In his daily routine a surgeon subconsciously evaluates a patient not only with regard to the anatomical type of fracture, but also to age, degree of trauma associated with the fracture, coexisting disease, and bone fragility. In doing this he employs important etiologic factors as his parameters. The purpose of this work has been to make an analysis of these parameters. The immediate difficulty in such an analysis is that the parameters tend to overlap in most patients with fracture of the upper part of the femur. With the aid of a Venn diagram (Figure 19; FEINSTEIN, 1963) an attempt has been made to schematically evaluate the various types of overlap, to attach frequency values to them, and to propose an etiologic classification of fractures of the proximal end of the femur.

For the purpose of this discussion *disease* means every known abnormality except those described below under age. *Trauma* means a definite accident,

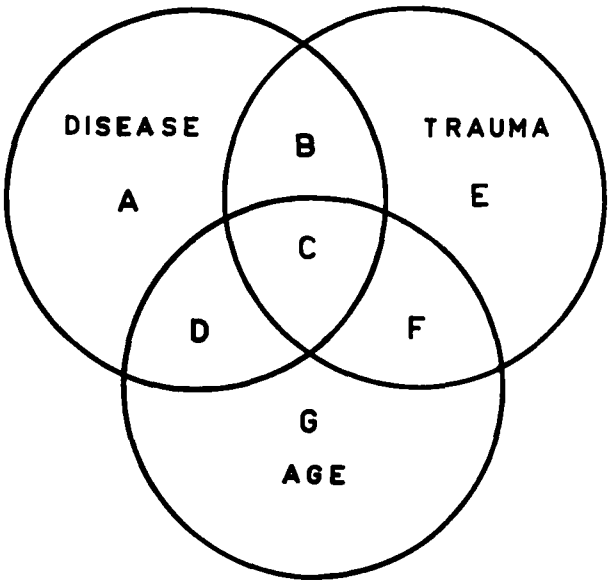


Fig. 19
Diagrammatic representation of etiologic factors in fractures of the proximal end of the femur.

however trivial. Ordinary walking or turning over in bed would not be classified as trauma. *Age* (above 70 years) has been introduced as a third variable. Ideally the third variable should have been a more direct expression for the progressive change in bone strength resulting from a decrease in bone mass and/or quality, the etiology of which is unknown, and which may be called progressive bone fragility.

The overlaps of the three circles in Fig. 19 constitute seven areas, each of which in theory is uniquely defined with regard to fracture etiology. Areas A, D, and G comprise spontaneous fractures and B, C, E, and F fractures in which trauma is a factor. Similarly areas C, D, F, and G comprise fractures in which age (or something age-dependent) is a factor and A, B, and E fractures in relatively young individuals.

This classification is based on only three questions, the answer to each of which is yes or no. The following would be examples of cases of the different groups and Table 43 shows the results of this classification.

A. Spontaneous fracture in a cancer metastasis.
B. Fracture in polio, or following cortisone medication.
C. Fracture in diabetes, and in the blind.
D. Rare and difficult to define as distinct from A and G.
E. Traffic accident or similar heavy trauma.
F. Majority of cases due to idiopathic bone changes.
G. Spontaneous fracture in very old people, extremely rare.

Table 43. *Analysis of Series A according to the Venn diagram in Fig. 39.*

	A	B	C	D	E	F	G
No. of cases	10	177	243	3	209	462	5
Mean age	60.1	59.5	77.7	74.3	58.6	80.1	80.4
Sex ratio	4.0	3.1	4.2	2.0	2.8	4.0	5/0
Moderate: severe trauma	—	4.4	7.7	—	1.8	4.5	—
Cervical: trochanteric fractures	9.0	1.8	1.5	3/0	3.0	1.5	5/0
Mortality within 3 months (per cent)	0	7.3	25	0	4.3	19	0

A through G refer to the areas in the diagram.

It is clear from Table 43 how major classes differ from each other in regard to age, sex, degree of trauma, anatomical type of fracture, and mortality. For example, in comparison to C, E comprises relatively young individuals with a high incidence of severe trauma, and cervical fractures and only one fifth the mortality rate.

F contains the majority of cases in whom progressive bone fragility is an important etiologic factor. This category has been subjected to further analysis with regard to sex, degree of trauma, and type of fracture. This analysis gives 8 categories (Table 44).

The present material is too small to allow a detailed analysis according to this second analysis. For future epidemiological studies and comparisons of materials from different sources the complete analysis may well be significant. Comparisons with work based on classification of uterine cancer or atherosclerosis show that an accepted classification provides a framework for international collaboration. The proposed classification is suitable for automatic processing of large patient materials. The proposed code defines with two letters the following characteristics: sex, age group, associated disease, degree of trauma and anatomical fracture type.

Table 44. *Analysis of Group F in Fig. 20 and Table 43 with regard to sex, trauma, and fracture type.*

Sex	Women				Men			
Trauma	Moderate		Severe		Moderate		Severe	
Fracture type	Cervical (1)	Trochanteric (2)	Cervical (3)	Trochanteric (4)	Cervical (5)	Trochanteric (6)	Cervical (7)	Trochanteric (8)
No. of cases	199	121	26	23	30	28	20	15
Mean age	80.6	81.4	78.3	77.3	79.7	80.7	75.7	75.7
Mortality within 3 months (per cent)	19	22	15	13	27	21	5.0	6.7

V. GENERAL SUMMARY[1]

METHODS

The 1,664 fractures of the proximal end of the femur occurring in the 209,473 population of the city of Malmö from 1949 through 1961 formed the material of this investigation.

Accurate census data permitted evaluation of age and sex incidence of the fractures, classified by anatomical type and degree of associated trauma. Case records, and re-examination in 1960 of 98 per cent of those surviving after fractures sustained from 1949 through 1958, furnished information concerning mortality, other fractures and associated medical conditions.

RESULTS

A. *Radiographically-Apparent Lesions.* Nineteen fractures associated with such lesions were excluded from the study but considered in the General Discussion.

B. *Types of Fracture.* In women cervical fracture was twice as common as trochanteric fracture while in men these main types were equally common. In women three of four cervical fractures were subcapital and one transcervical, while in men these types were evenly distributed. In both sexes one fourth of the cervical fractures were stable.

C. *Sex and Age Distribution.* The mean age was 73.0 ± 0.33 years in women and 69.0 ± 0.70 years in men with 86 per cent over 60 years of age. After the adjustment for differences in the age distribution of the population at risk, fracture of the proximal end of the femur was 2.4 times more common in women than in men. This ratio did not change appreciably from age 50 through 80 even though the incidence approximately doubled with each five-year increment in age.

D. *Types of Trauma.* Spontaneous fracture was recorded in 18 cases in Series A, 11 of which had either a radiographically-apparent lesion or a history of radiotherapy for a pelvic malignancy. In women moderate trauma was nine times more common than severe trauma, while in men the two types were equally common. The proportion of moderate trauma increased with age, more in men than in women. The pattern of trauma did not differ between cervical and trochanteric, or unstable and stable cervical fractures. Subcapital fracture was seen more often after moderate trauma than was transcervical fracture.

1 Alphabetical subheadings correspond to those under III Results.

E. *Mortality*. The three-month age adjusted mortality rate was unrelated to sex, main type of fracture or method of treatment (traction or nailing), but was lower after severe than after moderate trauma indicating that main factors affecting mortality were age and the general condition of the patient prior to fracture.

F. *Fracture Incidence*. Over the thirteen-year period the annual number of fractures increased due to age-shifts in the population and an increased incidence of trochanteric fractures. Cervical fractures were two times more common in Sweden than in Great Britain whereas there was no difference in the incidence of trochanteric fractures.

G. *Other Fractures*. Women with a fracture of the distal end of the forearm (Colles' fracture) are more liable to suffer fracture of the proximal end of the femur than women without a forearm fracture.

H. *Associated Conditions*. The incidence of diabetes mellitus was higher than normal in female fracture patients. In hemiplegia and poliomyelitis the fracture occurred more often in the paretic leg than in the normal leg. The ratio of moderate to severe trauma was higher in patients suffering from disease than in healthy patients. Neither parity nor the age at menopause had any effect upon fracture liability.

I. *Seasonal Variation of Birth Dates*. The seasonal variation in birth dates of female patients with fracture due to moderate trauma differed from that of the general population.

J. *Blood Groups*. Fracture patients had a higher than normal incidence of blood group A.

INTERPRETATIONS

The association of the spontaneous fractures with radiographically-apparent bone disease and previous radiotherapy and the tendency of fractures associated with severe trauma to occur in young and healthy individuals suggested that the degree of trauma as evaluated from the case histories was a valid indicator of skeletal fragility. On this basis the results of this investigation are interpreted to show that skeletal fragility is a predominant factor in the etiology of fracture of the proximal end of the femur; that bone fragility is more common in women than in men; and that it increases sharply with age. Certain medical conditions may increase bone fragility either locally or generally in the skeleton. In most cases the cause of the fragility is not known. This study has shown that hereditary as well as environmental factors may be significant.

CONCLUSION

Fracture of the proximal end of the femur is a result of the interplay of three factors — trauma, disease and non-specific skeletal fragility associated with aging. Appreciation of the relative significance of each of these factors in the etiology of the various anatomical types of this fracture should lead to a better understanding of this condition. Such understanding may in turn lead to improvements in methods of treatment and hopefully, to prevention of this disease.

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