Effect of sex and age on the ratio of cervical to trochanteric hip fracture

A meta-analysis of 16 reports on 36,451 cases

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We analyzed 15 published reports and our own data. In women, the ratio of cervical to trochanteric fractures (C/T) evolved in 3 periods. 1) Before the age of 50 years, the annual incidence of cervical fracture is close to that of trochanteric fracture. 2) Between 50 and 60 years, cervical fracture increases markedly, and the C/T ratio is well above unity at an age when the fracture incidence is still very low. 3) This imbalance progressively diminishes to reach unity in the very old, as the result of a progressive increase in trochanteric fractures. In men, cervical fractures are progressively more common with increasing age, and the C/T ratio exceeds unity after 70 years of age. In both genders, the incidence of cervical fracture is thus greater than that of trochanteric fracture during a limited period of time, in the perimenopausal period for women and in elderly men. Several hypotheses on the mechanics of falls and bone strength have been advanced, without any satisfactory explanation for the C/T sex and age changes.

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Alffram (1964), Lüthje (1983) and Zetterberg et al. (1984) noted that the age-specific women/men ratio was higher in cervical than in trochanteric fractures; Alffram remarked that this "might indicate a sex-linked difference between the two types of fractures". Indeed, the sex difference in the incidence of cervical/trochanteric fracture (C/T) had already been noted by Johansson (1934) and several authors have found that this ratio changes with age, more in women than in men (Jensen 1980, Zetterberg et al. 1984, Falch et al. 1985, Mannius et al. 1987, Sernbo et al. 1988, Caniggia and Morreale 1989, Jarnlo et al. 1989). Realizing that "a clear understanding of fracture heterogeneity might lead to new hypotheses concerning etiology" (Melton and Cummings 1987), we report an analysis of the C/T ratio based on 15 published studies and our own data.

Material and methods

Publications on hip fractures, found by Medline search, were selected if they stated the number of cervical and trochanteric fractures by sex and age classes suitable for matching. Including our own data, 16 studies were collected (Table 1). If a paper or successive papers provided samples of the same population at different periods, only the last period was used. In total, from the 16 studies, 36,451 cases of hip fracture were included from Europe (Finland, France, Italy, Norway, Sweden and UK), Israel, South Africa and the U.S.A.

Logistic regression and likelihood ratio tests were used to allow for the respective contributions of age, sex, study and the different interactions of these factors (GLIM 1987). Confidence intervals for the C/T ratio were derived from the variance-covariance matrix of the logistic regression (Swan 1983) of the saturated model (age, sex, study and all interactions). The difference in the C/T ratio between sexes is expressed on a logarithmic scale, by the odds-ratio. The C/T ratios in the different studies are shown in Table 1 by sex and age class. Data from the references in the first part of Table 1 were pooled to give an indication of the approximate age- and sex-specific hip fracture incidence rates (Table 2). The sex- and age-specific C/T ratios are shown in Figure 1, according to 2 different age classes. The level of significance was set at 0.05 and probability values are given for two-tailed tests.

Table 1. Ratio of cervical to trochanteric incidence, by sex and age group and the odds-ratio for sexes

Age (years)	Women	Men	Odds-ratio
Norway, Oslo 1978–1979 (n 2,109) (Falch 1985)			
< 50	1.7	0.8	2.2
50–59	2.3	0.9	2.5
60–69	2.2	0.8	2.6
70–79	1.9	1.6	1.2
≥ 80	1.3	1.8	0.7
Norway, Trondheim 1983–1984 (n 1,009) (Finsen and Benum1987)			
< 50	–	–	–
50–59	3.4	0.8	4.1
60–69	3.2	2.4	1.4
70–79	2.5	1.8	1.4
≥ 80	1.7	2.3	0.7
Sweden, Malmö 1949–1958 (n 1,114) (Alffram 1964)			
< 50	2.8	1.8	1.6
50–59	2.9	1.2	2.5
60–69	2.8	1.7	1.7
70–79	1.8	1.3	1.4
≥ 80	1.4	1.0	1.4
Sweden, Stockholm 1972–1981 (n 20,538) (Hedlund et al. 1987)			
< 50	1.6	1.0	1.6
50–59	2.5	0.9	2.7
60–69	2.0	1.1	1.9
70–79	1.8	1.4	1.3
≥ 80	1.2	1.5	0.8
Sweden, Lund 1986 (n 290) (Jarnlo 1989)			
< 50	–	–	–
50–59	–	1.0	–
60–69	1.7	0.7	2.4
70–79	1.9	1.1	1.6
≥ 80	1.0	1.0	1.0
Finland, National Board of Health Statistics 1980 (n 3,609) (Lüthje 1983, 1985)			
< 50	1.8	0.8	2.3
50–59	3.1	1.4	2.2
60–69	3.0	1.4	2.1
70–79	2.8	2.3	1.2
≥ 80	2.2	2.3	1.0
France, Picardy 1987 (n 1.023) (Baudoin 1993)			
< 50	2.3	1.6	1.4
50–59	1.1	0.4	2.5
60–69	3.0	1.2	2.5
70–79	1.5	0.9	1.7
≥ 80	1.1	1.3	0.9
Italy, Siena 1975–1985 (n 1,567) (Caniggia and Morreale 1989)			
< 50	–	–	–
50–59	2.6	0.8	3.1
60–69	2.4	0.9	2.7
70–79	1.3	0.9	1.4
≥ 80	0.8	0.8	1.0
Israel, Jerusalem 1957–1966 (n 537) (Levine et al. 1970)			
< 50	0.9	0.6	1.5
50–59	1.1	0.4	3.2
60–69	0.5	0.4	1.3
70–79	0.4	0.3	1.3
≥ 80	0.3	0.4	0.8
South Africa, Durban 1984–1985 (n 363) (Hammer 1988a,b)			
< 50	–	–	–
50–59	0.5	2.0	0.3
60–69	1.3	0.6	2.2
70–79	1.0	0.8	1.1
≥ 80	1.1	0.9	1.3
U.S.A., Allegheny 1961–1965 (n 182) (Niemann 1968)			
< 50	–	–	–
50–59	0.0	–	–
60–69	0.6	0.3	1.7
70–79	0.8	0.3	3.2
≥ 80	0.5	0.5	1.0
U.S.A., Rochester 1965–1974 (n 415) (Gallagher 1980)			
< 50	3.0	0.5	6.0
50–59	1.5	0.8	2.0
60–69	1.8	0.5	3.6
70–79	1.0	1.1	0.9
≥ 80	0.7	0.8	0.9
UK, Dundee 1954–1958 (n 335) (Knowelden 1964)			
35–54	1.0	0.3	3.5
55–74	0.9	0.3	3.1
≥ 75	0.5	0.3	1.8
UK, Oxford 1954–1958 (n 196) (Knowelden 1964)			
35–54	3.0	0.4	7.0
55–74	0.9	1.5	0.6
≥ 75	0.8	0.5	1.6
Sweden, Uppsala 1980–1987 (n 3,007) (Rehnberg 1990)			
55–64	2.1	1.5	1.4
65–74	1.8	1.7	1.1
75–84	1.5	1.7	0.9
≥ 85	1.3	1.8	0.7
Sweden, Lund 1978–1980 (n 161) (Jarnlo 1984)			
55–64	–	–	–
65–74	3.5	0.5	7.0
75–84	1.3	0.6	2.1
≥ 85	1.2	1.3	0.9

Results

Before 50 years of age, the annual incidence of hip fracture at both sites in men was more than twice that in women. In addition, both fractures were equally frequent in men, whereas cervical fracture was more frequent in women.

In women, during the peri- and postmenopausal periods (50–59 years), the cervical fracture incidence rose 10-fold and that of the trochanter 7-fold, with the C/T ratio reaching 2.6 between 55 and 59 years. After 60 years, the ratio of incidence rates of cervical fractures between successive age classes was steady (Table 2), whereas that of trochanteric fractures increased with age and was greater than that of cervical fractures. Consequently, the C/T ratio dropped with age to reach unity in women above 90 years. In men, the C/T ratio hovered around unity and rose to reach 1.7 above 90 years.

The logistic regression of the data referenced in the first part of Table 1 defined a conditional independent model (Everitt 1979): sex + age + study + age.sex + age.study with interaction tests between sex.age.study: P 0.9, sex.study: P 0.8, age.sex: $P < 0.001$,

Table 2. Age- and sex-specific incidence rates

Sex	Age	Incidence rate[a] per 10,000 person years			Ratio of incidence[b] age (class i):age (class i–1)	
		Cervical	Trochanteric	C/T	Cervical	Trochanteric
Women	< 50	1.0	0.6	1.7	–	–
	50–59	11	4.1	2.6	11	7.1
	60–69	31	14	2.2	2.9	3.4
	70–79	94	51	1.8	3.1	3.7
	≥ 80	281	220	1.3	3.0	4.3
Men	< 50	1.7	1.8	0.9	–	–
	50–59	6.3	6.6	1.0	3.7	3.7
	60–69	18	16	1.1	2.8	2.3
	70–79	45	31	1.4	2.6	2.0
	≥ 80	145	98	1.5	3.2	3.1

[a]The yearly incidence has been evaluated using the pooled annual number of fractures and the pooled yearly population at risk, from the references in Table 1.
[b]The increase in incidence of fractures was expressed by the ratio of specific incidence rates between successive age classes.

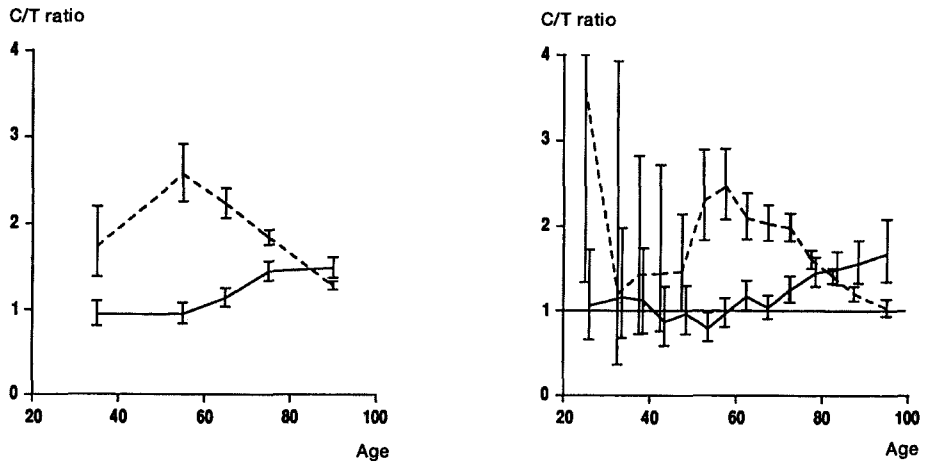
age.study: P 0.001. This indicated that in each of the 5 age classes, the difference in the C/T ratio between sexes did not depend on the study. The comparison between sexes showed that the C/T ratio in people aged 50–75 was higher in women than in men, the reverse occurring above 85 years, after the curves had intersected in the age range 75–85 .

Discussion

External causes of fracture

The circumstances of the accident may play a role in the sex and age variation of the C/T ratio. The early part of the C/T ratio curve, under 50 years, may be largely explained by relatively severe trauma. Over the

Figure 1.



Ratio of the incidence of cervical to trochanteric fractures (C/T ratio and 95% confidence interval) according to sex- and age-class at the time of fracture. — men, --- women.

Calculations based on the 6 studies from Table 1 where it was possible to obtain age groups of 5 years (France, Norway, South Africa, Sweden). The patients included in our analysis were at least 40 years old in South Africa and at least 50 years old in Sweden (Malmö) and Norway. In Sweden (Malmö) and South Africa, the patients above 80 years have been omitted, because the original data were pooled into only one age group.

age of 50 years, a greater proportion of women than men are prone to falls (Perry 1982). Sattin et al. (1990) observed this excess of risk between ages 65–84 years, and for Winner et al. (1989) this was limited to a peak in the perimenopausal period. The mechanisms and symptoms underlying this perimenopausal increase and later decrease are unclear (Bungay et al. 1980). Women and men have a tendency to fall in different circumstances: women fell more often in their home and men in their garden (Campbell et al. 1990). Brocklehurst et al. (1978) did not find an association between the type of fall and the type of fracture for people under 85 years but, over that age, trochanteric fractures were related to falls due to loss of balance and drop attacks. Melton and Cummings (1987) gave a ratio of severity of trauma (moderate:severe) of 7:1 for both types of fracture.

Age

Regardless of the type of accident, 3 factors may account for the fracture process. The first is that the fracture process at the 2 sites is different in women and men with age. The second is that the elevated C/T ratio observed in men over 80 years could correspond to that observed in women between 50 and 60 years of age. The third is that we have made a longitudinal interpretation of several cross-sectional studies where the C/T variations could be a cohort effect rather than age-related. We review these three factors.

First, the respective incidences of cervical and trochanteric fractures according to sex may be linked to the age related bone loss (osteoporosis), a primary factor associated with an increase in fracture incidence, but no argument was found in the literature. After studying the background factors in patients of both sexes with cervical and trochanteric fractures, Sernbo and Johnell (1987) concluded that the differences between the 2 sites appeared to reflect the age differences. Several authors showed that the C/T ratio decreased with age in women (Jensen 1980, Falch et al. 1985, Caniggia and Morreale 1989) and remained more constant in men. This is in agreement with results showing that women with a trochanteric fracture were older than those with a cervical fracture, while the reverse or no difference was found in men (Stewart 1955, Alffram 1964, Pogrund et al. 1977, Nilsson and Obrant 1978, Bungay et al. 1980, Zetterberg and Andersson 1982, Bohr and Schaadt 1983, Lawton et al. 1983, Zetterberg et al. 1984, Sattin et al. 1990). The fact that women were older on average when trochanteric fractures occurred implies 2 corollary ideas: the first is that in the younger age groups, cervical fractures may be more frequent than that of the trochanter, and this was verified in Figure 1; the second is that, in the older age groups, the trochanteric fracture incidence may exceed the cervical one, but this was not seen in Figure 1. As a matter of fact, the frequency of trochanteric fractures in women was never higher than that of cervical ones, even in the oldest women, although the C/T ratio decreased with age. Since bone mass declines with age, the meaning of the age difference may be that trochanteric fractures are due more to bone fragility or general disease due to age than cervical fractures are (Jarnlo et al. 1989), and are more prone than cervical fractures to occur in an osteoporotic population. This factor was supported by a prospective study in women (Aitken 1984). Moreover, in men the C/T ratio did not decrease with age; it was close to 1 before 50 years whereas, after 70 years the incidence of cervical fractures exceeded that of the trochanteric.

Secondly, in our study the higher incidence of cervical fractures than trochanteric fractures was observed in both genders during the limited period of the perimenopausal age in women and of extreme age in men. This difference may reflect the fracture threshold. We may hypothesize that men reach the fracture threshold later than women because their bone mass is initially higher and because bone loss is increased during menopause and that the fracture threshold is higher at the cervical site than at the trochanteric one. Regarding this point, Eriksson and Widhe (1988), adjusting for age, and Vega et al. (1991), not adjusting for age, showed that the bone mass density (BMD), measured at several sites of the proximal femur among women with fractures, was higher for cervical than for trochanteric fracture. Similar results were also found by Melton et al. (1986) who showed a decrease in cervical BMD with age, from 1.55 g/cm^2 at 35 years to a minimum at 79 years of 0.68 g/cm^2, whereas the intertrochanteric BMD was constant at 0.64 g/cm^2. Thus the decreasing C/T ratio of BMD could explain the decreasing C/T ratio of fracture incidence. These observations introduce a dual notion of the fracture threshold: one independent of age at the trochanteric site, and the other decreasing with age at the cervical site. No data are available for men.

The third factor is to find out whether women currently aged over 80 years had, 20 or 30 years before, similar risks for cervical and trochanteric fractures or whether this risk was higher for cervical fractures. A previously important risk factor would be much less common or some strong risk factor would now be superseding the factor that caused differential effects in younger women. We have combined in Table 1 studies performed from 1949 to 1987 and, considering the diversity of sources, no global trend could be found. The data from Sweden show that the differ-

ences observed between genders, estimated by the odds-ratio, were comparable between 1949–1958 and 1972–1981.

Various etiologic mechanisms were proposed by authors who observed a decrease over time in the C/T ratio (Elabdien et al. 1984, Zetterberg et al. 1984, Hedlund et al. 1986, Nagant de Deuxchaisnes and Devogelaer 1988, Sernbo and Johnell 1989). Most of them concluded that the bone quality, environmental factors, or the etiologic mechanism (smoking, physical demands, trauma) had changed during the period of their study, and that these risk factors were less pronounced in women. In fact, we believe that the decrease in the C/T ratio could result from the secular ageing of the population, which would lead to a greater proportion of older women and therefore to a higher proportion of those age-classes of patients with a C/T ratio close to 1. Sernbo and Johnell (1989) observed a decreased C/T over time, and showed the proportion of cervical hip fractures in women in 5 age-classes, in the 1950s and the 1980s: the 2 curves were similar. This showed that, after adjustment for sex and age, there was no longer an effect of time, although the authors did not interpret their data in this way.

Internal causes

Regardless of the effects of age, the difference in the C/T ratio may result from differences between the relative contents (Riggs et al. 1982) of cortical to trabecular bone of the cervical (75 percent cortical bone) and the trochanteric (50 percent) sites. Riggs and Melton (1983) suggested that osteoporosis in women primarily affects trabecular bone. After age-matching, Sernbo and Johnell (1987) found that trochanteric fracture patients were more prone to previous vertebral fracture, trochanteric fracture of the opposite site and fracture of the upper end of the humerus. They suggested that trochanteric fractures occurred in the bone of lower trabecular mass. Skeletal sites that derive most of their strength from this tissue are believed to be at greatest risk. According to Uitewaal et al. (1987), trabecular bone volume, trabecular surface density and the mean wall thickness were lower in trochanteric than in cervical fractures and, according to Hordon and Peacock (1990), women with trochanteric fractures had less cortical thickness.

Etiologic factors such as nutrition, physical activities, glucocorticoid use and debilitating disease are not considered in our discussion, although the etiologies of fracture in younger people differ markedly from those in the elderly and differ between the sexes also.

Our analysis of data could be influenced by the study performed in Stockholm, which accounted for 63 percent of the sample. We verified that our conclusion was not modified when this study was left out of the analysis. Nevertheless, 88 percent of our data come from northern Europe (Finland, Norway, Sweden). When compared to the studies in Italy, Jerusalem, South Africa or U.S.A. (Allegheny and Rochester), the C/T ratio seems higher in northern Europe, particularly in women. However, the series in Table 1 brings some support to our conclusions because when the C/T ratios for men and women were compared, some characteristics appear to be common to all countries. Under the age of 80 years, the C/T ratio of women is higher than that of men. Above 80 years, the C/T ratio of men is often higher than that of women, and this was observed in very different countries: Finland, France, Israel, Norway (Oslo and Trondheim), Sweden (Stockholm), U.S.A. (Rochester). The difference in the C/T ratio between men and women, expressed by the odds-ratio, followed in general a parabolic shape, women having a higher C/T ratio than men in the age range 50–70 years. This shape was observed in all series, whatever the value of the C/T ratio, for men or for women, even if it was much lower than 1, as in the Allegheny study, U.S.A., or much higher than 1, as in the Trondheim study, Norway. In addition, this evolution is present in countries with different ethnic groups: Israel (Africa, America, Asia, Europe, Israel-born), South Africa (white population).

A difference between sexes in the C/T ratio, in the 50–70-year age range, appeared clearly in each of the 16 studies that we analyzed. In men, the C/T ratio increased with age. In women, cervical fractures were more frequent than trochanteric fractures during the perimenopausal period. With increasing age, trochanteric fractures increased, whereas the C/T ratio was decreasing so that, above 90 years, fracture incidences were similar for both sites. Since the increase in hip fracture incidence is exponential and this increase is visible above 60 years, the perimenopausal predominance of the C/T ratio in women is, from a public health viewpoint, a microphenomenon. Nevertheless, to address the growing problem of hip fractures, studies to elucidate the etiology are important. Whereas many studies have concerned women, this study shows that the comparison of results from men and women of the same age can be very informative.

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