EPIDEMIOLOGY OF FRACTURES OF BONES OF THE LEG. AN INDEX OF SEVERE ACCIDENT RATE IN A DEFINED COMMUNITY (SINGAPORE)

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INTRODUCTION

The age and sex distribution of fractures of the bones of the leg in a defined community was first determined by Buhr and Cooke (1959) in their study from the Oxford District in England. In a more recent survey Knoweldon et al (1964) calculated the age and sex specific rates of fractures of the proximal, shaft and malleolar regions of the tibia and fibula from both the Dundee and Oxford Districts. In the present investigation similar determinations have been made on the mixed Asian community of Singapore.

Evaluated also, are the degree of the trauma which gave rise to the tibio-fibular shaft fractures and the amount of displacement of the latter. No attempt is made to separate the fractures into the various racial groups.

MATERIAL AND METHODS

The Population at Risk

The population of Singapore is predominantly Asian, and totals 1,445,929 people, (1957 Census) of which 75% are Chinese, 14% Malays, 9% Indians and Ceylonese, and 2% Eurasians and Europeans. The population by race, sex age is shown in Table I.

TABLE I
POPULATION OF SINGAPORE (1957).

Detailed Age Groups in Thousands	Male	Female
0 - 9	248·7	234·1
10 - 19	141·3	130·6
20 - 29	121·1	110·0
30 - 39	96·6	76·0
40 - 49	80·8	62·1
50 - 59	49·9	39·4
60 - 69	18·8	20·9
70 - 79	4·8	8·2
80 - 89	0·6	1·2

Since the General Hospital treats all fractures, and the age and sex distribution of all the Races in the Singapore Community is accurately known, ideal conditions are present not only for epidemiologic studies of leg fractures but also for all fractures.

Fracture Material

This consisted of all fractures of the leg which were diagnosed during the two years 1962-1963. Only fresh fractures were considered.

In 1963, 443 such fractures were recorded, and in 1962, 408 giving a total of 851, of which 153 or 18% were females and 698 or 82% males.

Classification of Fracture Types

I. Shaft Fractures:
They include
i) isolated fractures of shafts of either tibia or fibula
ii) fractures involving the shafts of tibia and fibula simultaneously.

II. Proximal Fractures:
These include
i) fractures of the medial or the lateral condyle (or both) of the tibia
ii) fractures of the head and neck of the fibula.

III. Distal Fractures:
They include
i) fractures of the medial malleolus
ii) fractures of the lateral malleolus
iii) fractures of both malleoli

Degree of Trauma

Two degrees were recognised, a direct high energy trauma, and an indirect low energy trauma. (Bauer, Edwards and Widmark, 1962). Trauma which resulted from motor vehicle and motor cycle accidents, falls from heights more than 3 metres, and blows from heavy objects were considered to be of the direct high energy catogory. Indirect low energy trauma were those

arising from falls either at ground level or from low heights *i.e.* less than 3 metres. *e.g.* off a chair, table or out of bed; football injuries, and accidents in which a bicycle was involved.

Hospital records permitted the evaluation of the degree of trauma in 92% of the female and 83% of all the male shaft fractures.

Incidence of Displacement

Shaft fractures were classed as being displaced and undisplaced or minimally so. A fracture is considered displaced if there is one third of a diameter or greater shift of one fragment in relation to the other, or if there is angulation or shortening.

In the present analysis, displacement could be accurately determined in 70% of all the male shaft fractures and in 92% of all the female ones.

Definition and Statistics

1. Age Specific rates. These were calculated from the population figures as the annual incidence of fractures per 100,000 males or females in each 10 or 20 year age group.
2. Age Specific sex ratio. It is the ratio of age and sex incidence (Alffram 1964). Because there are more males than females in Singapore this has been considered a more valid measure of the distribution of these fractures than the ordinary sex ratio.
3. Patients less than 20 years were called boys or girls, those from 20 through 39 years were referred to as young adults; middle age were those from 40 through 59 years, and old age from 60 years onwards.

RESULTS

Isolated Tibial Shaft Fractures

There were 190 isolated tibial shaft fractures, constituting 22·3% of the series; 161 or 84·8% were males and 29 or 15·2% were females. The male to female ratio was 5:1 (Oxford 2·5 to 1) and the age specific sex ratio was 7·3 to 1 in favour of the males. The absolute age specific incidence among the males, which throughout life exceeded those of the females, showed peaks in the 10-19 age group, in the 40 to 69 age group, with the highest one in the 70-79 age group. (Figure: 1, Table II). There were no isolated tibial shaft fractures recorded for females in the 20-49 age group. The absolute age specific incidences were maximal in childhood and in old age. (Figure: 1, Table II).

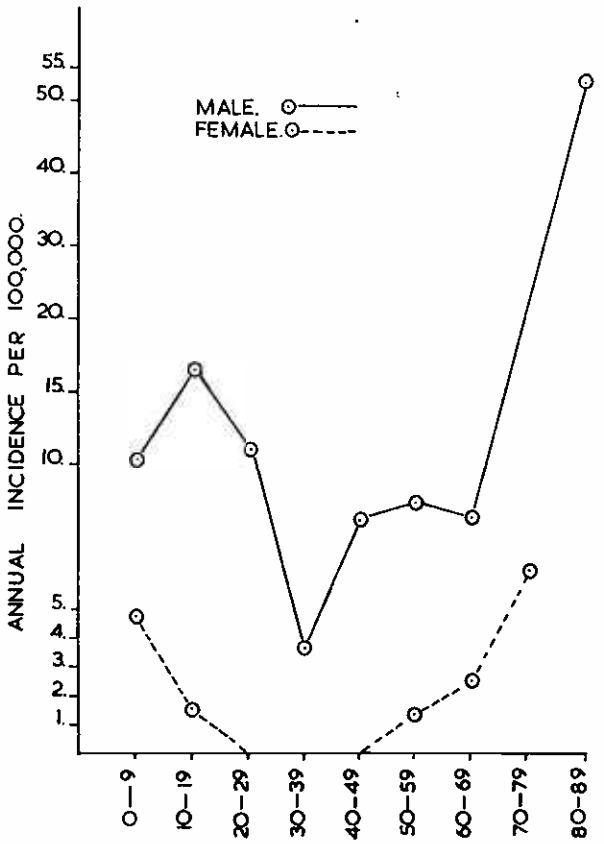

Fig. 1

Isolated Fibular Shaft Fractures

Eight of the 87 fibular shaft fractures or 9·2% were females, 79 or 90·8% were males. These made up 10·2% of the series.

The male to female ratio was 10 to 1; and the age specific sex ratio was 19·7 to 1 favouring the males.

Fibular shaft fractures were not recorded for women age above 60.

The absolute age specific rates in both sexes increased with age, and throughout life male rates exceeded the female. (Table III).

Combined Tibio-fibular Shaft Fractures

There were 336 combined tibio-fibular fractures, constituting 39·5% of all leg fractures but making up more than half (55%) of all the shaft fractures. Sixty-five or 19·6% were females and 271 or 80·4% were males. The male to female ratio was 4·3 to 1, and the age specific sex ratio was 1·4 to 1 in favour of the men.

The male incidences (which again exceeded those of the females in all age groups) exhibited a double peak, one in the 20 to 29 and the other in 50 to 69 age groups and rising sharply in old age. (Figure: 2, Table II).

TABLE II

Age	Tibial Shaft Fractures No. of Cases		Combined Tibia Fibula Shaft Fractures No. of Cases		Bimalleolar Fractures No. of Cases	
	Male	Female	Male	Females	Male	Females
0 - 9	51	22	38	17	0	0
10 - 19	46	4	54	10	10	2
20 - 29	27	0	68	1	12	0
30 - 39	7	0	32	6	14	1
40 - 49	13	0	25	5	10	2
50 - 59	9	1	28	6	8	2
60 - 69	3	1	10	9	3	3
70 - 79	5	1	16	8	1	5
80 - 89	0	0		3	0	0
	161	29	271	65	58	15

TABLE III

ISOLATED FIBULAR SHAFT FRACTURES

Age Groups		0-19	20-39	40-59	60
NO. OF CASES	MALES	12	25	30	12
	FEMALES	3	3	2	0
AGE SPECIFIC RATES	MALES	1·5	5·7	11·5	24·6
	FEMALES	0·4	0·8	1·0	-

TABLE IV

PROXIMAL TIBIAL FRACTURES

Age Groups		0 - 19	20 - 39	40 - 59	60
NO. OF CASES	MALES	5	17	17	6
	FEMALES	5	2	4	0
AGE SPECIFIC RATES	MALES	0·6	3·9	6·5	12·3
	FEMALES	0·7	0·5	2·0	-

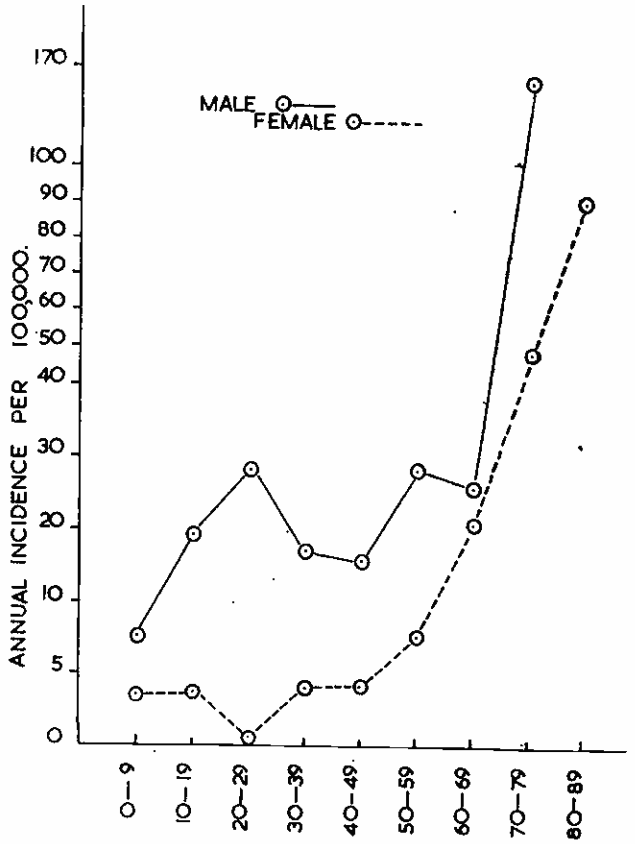

Fig. 2

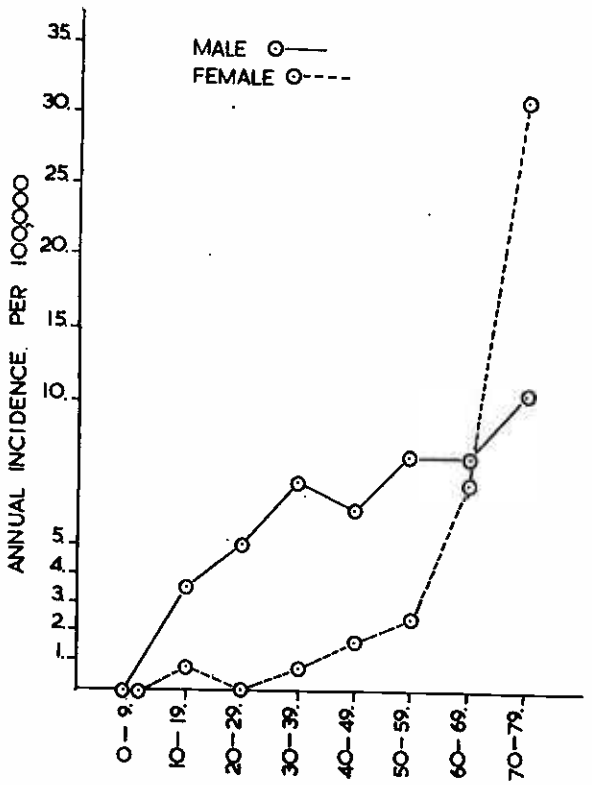

Fig. 3.

Proximal Fractures

Sixty seven or 7·9% of the series were proximal fractures. Eleven were proximal fibular fractures (8 males). Of the proximal tibial fractures 45 or 80·4% were males and 11 or 19·6% were females with a male to female ratio of 4 to 1 (Oxford 1·4 to 1). The age specific sex ratio was 7·5 to 1, again in favour of the males. No proximal tibial fractures were recorded among elderly females. In males the absolute incidences increased with age, those of the young male adults and middle age exceeded those of the female. Incidences in children were comparable. (Table: IV).

Distal Fractures

There were 171 malleolar fractures, via. 20% of the total in the series; 55 or 32·2% were medial, 43 or 25·1% were lateral and 73 or 42·7% were bimalleolar.

Bimalleolar Fractures

Fifty eight or 79·5% were males and 15 or 20·5% were females. The male to female ratio was 4 to 1 but the age specific sex ratio was only 1·1 to 1. At Oxford the sex ratio is 1·4 to 1 and is in favour of the females. The absolute incidences in both sexes increased with age, and throughout life, male incidences exceeded those of the female (except in the 70-79 group). (Figure: 3, Table II).

Lateral Malleolar Fractures

Twenty six of these fractures or 60·5% were males and 17 or 39·5% were females. The male to female ratio was 1·5 to 1 (Oxford 1·2 to 1) with the age specific sex ratio 1·3 to 1 in favour of the women. No lateral malleolar fractures were recorded among aged males. Absolute incidences were maximal and constant in young male adults and middle age men and was minimal to boys, (Table V). The absolute incidences among the females rose with age increase but were below those of the male where ever comparison could be made.

Medial Malleolar Fractures

Fifty of the 55 medial malleolar fractures *i.e.* 90·9% were males and 5 or 9·1% were females. The male to female ratio was 10 to 1 (Oxford 2·6 to 1) with the age specific sex ratio 3·7 to 1 in favour of the males. This fracture was not recorded in girls.

Age specific rates in young adults and middle age females were equal but rose in old age.

Absolute incidence among males increased with age until middle age whence it declined. In all the age specific groups rates among males exceeded those of the women. (Table: VI).

TABLE V

LATERAL MALLEOLAR FRACTURES

Age Groups		0 - 19	20 - 39	40 - 59	60
NO. OF CASES	MALES	5	13	8	0
	FEMALES	2	7	6	2
AGE SPECIFIC RATES	MALES	0.6	3.0	3.1	-
	FEMALES	0·3	1·9	3·0	3·2

TABLE VI

MEDIAL MALLEOLAR FRACTURES

Age Groups		0 - 19	20 - 39	40 - 59	60
NO. OF CASES	MALES	8	24	16	2
	FEMALES	0	2	1	2
AGE SPECIFIC RATES	MALES	1·0	5·5	6·1	4·1
	FEMALES	0	0·5	0·5	3·2

TABLE VII

Age Groups		0 - 19	20 - 39	40 - 59	60
AGE SPECIFIC RATES PER 100,000					
FEMORAL NECK	MALES	0·1	2·9	14·0	103·5
	FEMALES	0·2	0·7	4·9	74·9
PROXIMAL TIBIA	MALES	0·6	3·9	6·5	12·3
	FEMALES	0·7	0·5	2·0	0
MEDIAL MALLEOLUS	MALES	1·0	5·5	6·1	4·1
	FEMALES	0	0·5	0·5	3·2
LATERAL MALLEOLUS	MALES	0·6	3·0	3·1	0
	FEMALES	0·3	1·9	3·0	3·2
BOTH MALLEOLI	MALES	1·3	6·0	6·9	9·2
	FEMALES	0·3	0·3	2·0	13·8
HUMERAL NECK	MALES	5·4	1·2	5·0	14·4
	FEMALES	2·5	1·6	2·5	25·9
DISTAL RADIUS	MALES	28·6	17·7	23·3	53·2
	FEMALES	6·2	4·5	23·6	48·5

ALL CALCULATED FROM 1957 CENSUS.

DISCUSSION

The age and sex distribution of some of the fractures involving the leg bones *viz.* proximal tibial, isolated tibial shaft and malleolar fractures has previously been determined for the Oxford population (Buhr and Cooke, 1959). Their work forms the basis of comparison in this analysis.

In males 85%, and in women 68% of the local shaft fractures are due to severe trauma.

These percentages may be contrasted with a selected series of 173 tibial fractures (sex ratio unspecified) in which Bauer, Edwards and Widmark (1962) found 87 to be due to direct high energy trauma and the remainder due to indirect low energy trauma.

In the Singapore males the highest proportion of severe trauma fractures is in young adults, approximately 25 severe trauma fractures to every one of the moderate category; in middle age this ratio is 12·5 to 1, and in old age men there is still only 1 moderate trauma fracture to every 4 severe ones. In young adult females there are approximately 3 severe trauma fractures to every 4 moderate ones, in middle age this ratio is 4·5 to 1 and in the elderly it rises to 7 to 1. It is therefore, a complete reversal of the male trend. (Figure: 4).

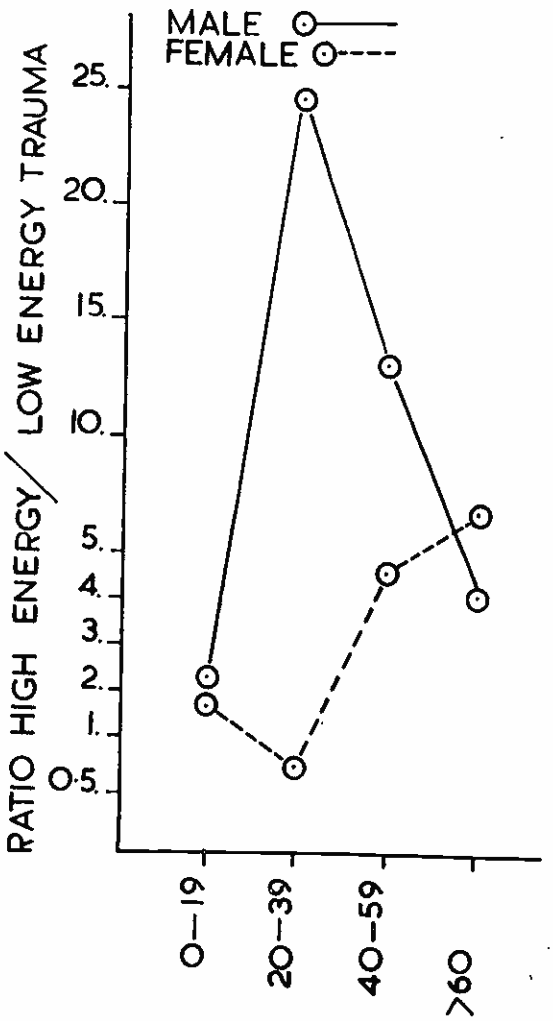

Fig. 4.

It has previously been shown that distal forearm fractures in females and femoral neck fractures of both sexes in middle age and the elderly usually follow moderate trauma because of bone fragility (Alffram, 1964; Wong, 1964). Tibio-fibular shaft fractures are therefore in direct contrast, since they are, in the main, caused by severe trauma and are therefore the product of a population's environment.

The differences in sex and age distribution of tibial shaft fractures between the Oxford and Singapore populations can thus to some extent be explained on the basis of the vast differences between the environments of these populations.

From young adult males, through middle to old age the proportion of displaced fractures increases as both the incidence of low energy trauma also increases. The behaviour of these three variables would therefore appear to be conclusive evidence for the progressive fragility of the tibio-fibular shafts among men (Figures 4 and 5).

In women, however, high energy trauma fractures rose from young adults through middle to old age, but displaced and non-displaced fractures were approximately equal in all the latter three age groups. The behaviour of the same variable in females thus contrasts markedly with the males.

Compounding occurred in 25% of the male but only 13% of all the female shaft fractures, and considering the series as a whole 23·3% were thus complicated. This may be compared with a series of 300 similar fractures analyzed at the Ratcliffe Infirmary where it was found that 30·7% were compounded. (H. T. Morgan, 1962)*

Throughout life the absolute age specific rates of compound fractures are greater among males than females but in both, surprisingly, the rates increase with rise in age. (Figure: 6).

At Oxford the sex ratio of bimalleolar fractures is 1·4 to 1 in favour of the females, the age specific incidences from 40 years onwards exceed those of the males. In Singapore the sex

* Quoted by Scott, J.C., Fractures of the Tibia and Fibula. Modern Trends in Orthopaedics (Fractures Treatment) p. 206-7 Butterworth, London, 1962.

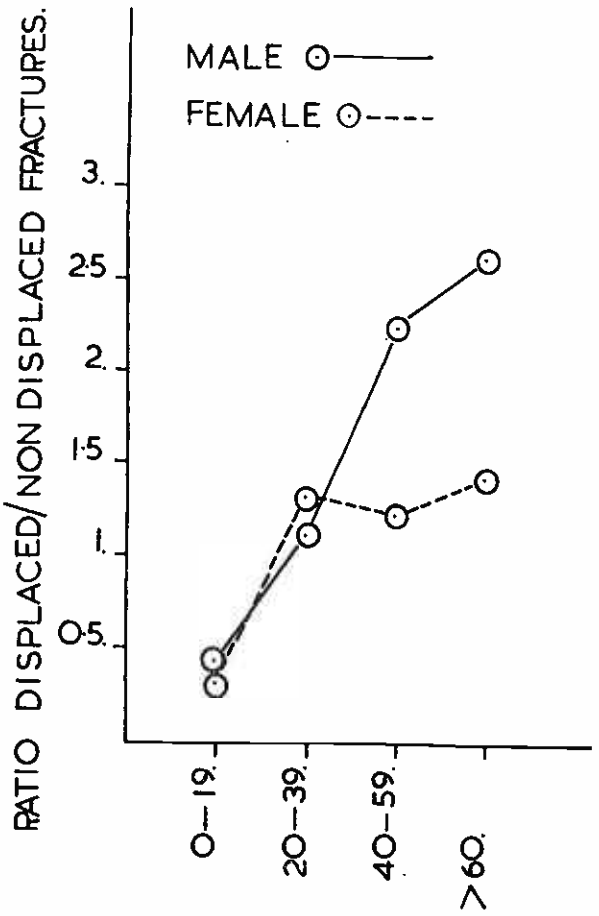

Fig. 5.

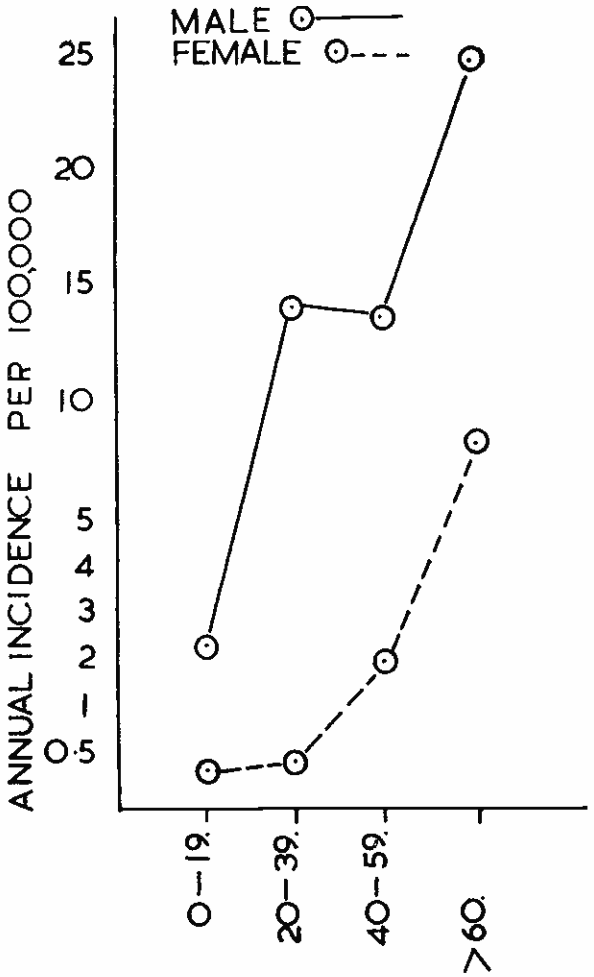

Fig. 6.

ratio is a male to female ratio of 4 to 1, and throughout life (with the exception of the 70-79 group) male incidences exceed those of their females. This reversal of the sex distribution has also previously been observed in Singapore in fractures of the femoral neck (Wong, 1964, 1966).

In Western Communities (Stewart, 1955; Buhr and Cooke 1959; Bauer, 1960; Alffram and Bauer, 1962) fractures of the cancellous extremities of long bones show a marked female predominance in middle and old age. In Singapore, however, the observation has been that more often there is an actual male predominance or that the incidences of the two sexes have been comparable at these age levels. (Table: VII).

SUMMARY

In a well defined population of approximately 1·5 million people consisting predominantly of Chinese with smaller percentages of Malays, Indians and Ceylonese, Eurasians and Europeans, the age and sex distribution of fractures of the leg bones were determined. Also evaluated were the degree of trauma which caused these fractures and the degree of displacement of the latter. The determinations were made on 851 fractures diagnosed over the 2 years period 1962-3.

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