Musculoskeletal Trauma in the Elderly

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Contents

Preface

The last 20 to 30 years have seen a massive increase in the number of fractures and other injuries in the older population. Both the fracture morphology and overall health of the patients are very different from the fractures and the patients who were seen and treated in the heady days of expanding trauma systems in the 1970s and 1980s, which were developed mainly to treat high energy trauma. We believe that it is only now that surgeons are realizing that the techniques developed to cope with high energy injuries are not always appropriate for the older patient. However, there has also been a realization that high energy injuries in younger patients and low energy injuries in older patients have a number of similarities, the main one being that an interdisciplinary approach is required to treat both types of patients. As a result, orthogeriatric units are being established in many countries.

Medical literature has failed to keep pace with the rapid expansion of musculoskeletal trauma in the older patient. Studies of fragility fractures have concentrated mainly on proximal femoral fractures, and there is still a belief that the only musculoskeletal problems in the elderly are the common fragility fractures. This is clearly not the case and we are grateful to a distinguished group of orthopaedic authors from 11 different countries who have detailed the spectrum of musculoskeletal trauma in older adults together with appropriate treatment algorithms.

We have targeted the book at both geriatricians and orthopaedic surgeons. It will become increasingly important to utilize an orthogeriatric team approach when treating elderly patients in order to optimize the functional outcomes for the patients and their families. We therefore cover both medical and surgical issues, and are fortunate to have a group of experienced international physicians and surgeons on board. We are grateful for their industry and expertise. It is our hope that this book will facilitate communication between surgeons and geriatricians and will also be a stimulus for increased clinical research in this rapidly expanding area.

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1

Epidemiology of fractures in the elderly

CHARLES M. COURT-BROWN AND KATE E. BUGLER

Fractures in the elderly are increasing in incidence very rapidly and are becoming a major socio-economic problem in most countries. A rapid rise in life expectancy has meant that there are many more patients aged ≥65 years in the population than there were only two generations ago. It is forecast that this increase in the proportion of elderly in the population will continue to increase and there is no doubt that fractures in the elderly will become a more important health issue in the next 20–30 years.

The scope of the problem is highlighted by reviewing life expectancy over the past century. In the United States, life expectancy in 1900 was 46.3 years for males and 48.3 years for females.[1] In the United Kingdom, the equivalent figures in 1911 were 49.4 and 53.1 years, respectively.[2] By 2010, the figures were 78.7 and 81.3, respectively, in the United States[1] and 78.5 and 82.5, respectively, in the United Kingdom,[2] and by 2030, it is projected that life expectancy in the United States will average 78.3 years in males and 84.2 years in females[3] with the equivalent UK figures being 83.1 years and 86.4 years.[4] It has been forecast that the population of the United States aged ≥65 years will rise from 35 million in 2000 to 71 million in 2030.[5] In 2000, the population ≥65 years represented 12.4% of the whole population and this will rise to 19.6% by 2030.[5] Table 1.1 gives figures for the proportion of the population aged ≥65 years in 1950 and 2000 in different parts of the world. It also shows projected figures for 2050.[6] It can be seen that it is projected that there will be a significant rise in the elderly population throughout the world. The increase is projected to be highest in the less developed world. The analysis of the population aged ≥80 years in the United States shows an increase from 9.3 million in 2000 to 19.5 million in 2030. These figures emphasize the scope of the problem for the next 20–30 years.

HISTORY

The analysis of skeletons over the past seven millennia has shown signs of osteoporosis, particularly in females. Fractures which were possibly osteoporotic have been found in Egyptian mummies and in skeletons from the Middle Ages in England.[7] These latter skeletons revealed healed rib and vertebral fractures, particularly in women with a lower femoral neck bone mineral density. There were no femoral neck fractures, probably due to the limited life expectancy in the Middle Ages.

Malgaigne analysed 2377 fractures in the Hôtel-Dieu, Paris, between 1806–1808 and 1830–1839.[8] He found that fractures were commonly seen in patients between 25 and 60 years of age and recorded that there were very few fractures in patients >60 years of age, but he noted that there were very few people of that age in the population. He did observe that diaphyseal fractures tended to occur in adulthood, whereas intra-articular fractures occurred in the elderly. He also stated that fractures of the ‘cervix femoris’ and ‘cervix humeri’ tended to occur in old age and that women often sustained fractures of ‘the carpal extremity of the radius’. Stimson in New York[9] and Emmet and Breck in El Paso, Texas,[10] analysed very large numbers of fractures in 1894–1903 and 1937–1956, respectively. They looked at fractures in children and adults of all ages and a comparison of their results with the prevalence of fractures in adults and children in the United Kingdom in 2000[11,12] is shown in Table 1.2. Allowing for differences in data collection, it is clear that the prevalence of fragility fractures of the proximal femur and distal radius has risen, whereas the prevalence of higher energy injuries such as fractures of the finger phalanges or the tibial and fibular diaphyses has fallen.

Table 1.1 Estimates of the prevalence of the population aged ≥65 years in different parts of the world between 1950 and 2050

Population aged ≥65 years	1950 %	2000 %	2050 %
World	5.2	6.9	15.9
North America	8.2	12.3	20.5
Europe	8.2	14.7	27.9
More developed world	7.9	14.3	25.9
Less developed world	3.9	5.1	14.3

The changing epidemiology of fractures is highlighted by a review of a study of fractures in the elderly undertaken in Dundee, Scotland, and Oxford, England, under the auspices of the Medical Research Council.[13] The Medical Research Council held a conference to discuss fractures in the elderly in 1956 and undertook a 5-year study. The medical and social changes between the 1950s and now are highlighted by the fact that they chose to study fractures in the elderly by analysing patients >35 years of age. The results of this study were compared with a prospective study of fractures in patients aged >35 years in Edinburgh, Scotland, in 2010/2011.[14] Edinburgh and Dundee are only 60 miles apart and have a very similar racial and social structure. The results highlighted the considerable changes in fracture epidemiology over a 60-year period. The overall prevalence of fractures increased by 50%, but the prevalence in males only increased by 5% compared with 85% in females. The analysis of the classic fragility fractures shows a 209% increase in the prevalence of proximal humeral fractures. This was mirrored in humeral diaphyseal fractures (129% increase), distal humeral fractures (267% increase), proximal ulnar fractures (220% increase), distal radial and ulnar fractures (39% increase), pelvic fractures (240% increase), proximal femoral fractures (186% increase), femoral diaphyseal fractures (92% increase) and distal femoral fractures (400% increase). There was an increased rate of fall related fractures in all age groups in both males and females. The study highlighted the considerable increase in fragility fractures in the last 60 years and the effect of socio-economic change on the incidence of fractures.[14]

FRACTURE INCIDENCE

Accurate analyses of fracture incidence are surprisingly difficult to find in the literature for a number of reasons.[15] In many parts of the world, there are no facilities to allow accurate analysis of what is a common medical condition. However, even in more affluent areas, little accurate information is available. In many countries, orthopaedic trauma is treated in different types of institutions, with severe trauma being treated in Level 1 trauma centres, or the equivalent, whereas less severe trauma is treated in community hospitals or by community surgeons in private practice. Thus very few large hospitals treat the whole range of orthopaedic trauma injuries and as there is very little communication between hospitals, accurate epidemiological information is hard to find. For this reason, a number of different methodologies have been used to try to assess fracture epidemiology. Not infrequently, information is gained from emergency department records. In many countries, emergency departments are mainly staffed by emergency doctors or surgeons in training who are very inexperienced in fracture diagnosis. This combined with the fact that information is not usually obtained from surgeons in private practice means that the epidemiological information is inaccurate. Surgeons have tried to obtain information by postal questionnaires asking patients if they have ever had a fracture. An analysis of the results of this method of obtaining fracture information has shown that reported fracture incidence is up to three times greater than the true incidence of fractures in the population.[15] This is because many patients may be told by paramedical professionals or others that they may have had a fracture because they have unexplainable pain.

In countries with privatized medical systems, insurance records have been used to assess fracture incidence. Again this method relies not only on the accuracy of data input but also on the prevalence of insured people in the population. The same problem occurs if only inpatient information is used. This is easier to obtain, but the data tend to be inadequate and do not represent the whole population.

The epidemiology of fractures in the elderly has unfortunately been largely ignored by orthopaedic surgeons who have concentrated mainly on high energy injuries in younger patients. Thus much of the epidemiological information has been collected by rheumatologists and other physicians whose main interest is in the diagnosis and management of osteoporosis or in the other comorbidities associated with fractures in elderly patients. Much excellent research has been done,[16,17] but understandably little information about many different types of fracture has been obtained. This problem has been complicated by the assumption that is often made that fragility fractures are simply those of the thoracolumbar spine, proximal humerus, distal radius, proximal femur and pelvis. Some comparative epidemiological data are available for these fractures, but there are many other fragility fractures in the elderly that we have very little information about. In a number of studies, fractures of the lower limb and upper limb are simply combined together and therefore little useful information is provided about many fragility fractures.

In this chapter, information about fractures in the older population has been mainly derived from two 1-year prospective studies of fracture incidence carried out in the Royal Infirmary of Edinburgh 2 years apart.[18] This is the only hospital treating a defined adult population of about 520,000. There is no private orthopaedic trauma clinic in the area. In the two 1-year studies, 13,507 consecutive non-spinal fractures were analysed in patients ≥16 years of age. Of these 4786 occurred in patients ≥65 years of age and these have been analysed to give information about the epidemiology of fractures in the elderly. Spinal fractures were not included in the analysis because comparatively few low energy spinal fractures in the elderly are actually reviewed by doctors and the epidemiology of these fractures is very difficult to determine.

Table 1.2 A comparison of fracture incidence in New York (1894–1903), El Paso, Texas (1937–1956) and Edinburgh, Scotland (2000)

	Fracture prevalence (%)		
	1894–1903[3]	1937–1956[4]	2000[5,6]
Clavicle	5.9	6.2	4.3
Scapula	0.7	0.7	0.2
Proximal humerus	5.7*	2.6	4.8
Humeral diaphysis	5.7*	2	1
Distal humerus	5.7*	5.2	2.5
Proximal ulna	1.1	21.2*	0.8
Proximal radius	9*	21.2*	3.8
Radius and ulna diaphysis	9*	21.2*	2.3
Distal radius and ulna	11.2	21.2*	22.2
Carpus	0.2	2.4	2
Metacarpus	9.7	4.2	10.5
Finger phalanges	19.3	7.6	11.2
Pelvis	0.7	2.5	1.2
Proximal femur	4.7*	6.6	8.9
Femoral diaphysis	4.7*	2.5	0.9
Distal femur	4.7*	0.6	0.4
Patella	1.7	1.8	0.8
Proximal tibia	10.4*	7.3*	1
Tibia and fibula diaphyses	10.4*	7.3*	2
Distal tibia	10.4*	7.3*	1
Ankle	10.6	8.8	7.7
Tarsus	1.5	3.5	1.6
Metatarsus	2.8	4.1	6.4
Toe phalanges	3.1	4.4	2
Others	1.5	4.6	–
Fracture numbers	8962	9379	7760

Sources: From Stimson LA. *A Practical Treatise on Fractures and Dislocations.* 4th ed. New York: Lea, 1905; Emmett JE, Breck LW. *J Bone Joint Surg (Am)* 1958; 40-A: 1169–75; Court-Brown CM, Caesar B. *Injury* 2006; 30: 691–7; Rennie L, et al. *Injury* 2007; 38: 913–22.

Note: Where it was impossible to separate the prevalence of individual fracture types in the same body area, they have each been given the cumulative prevalence and marked with an asterisk.

For the purposes of defining fracture epidemiology in older patients, data about patients aged ≥65 and ≥80 years will be presented. It is accepted that age and gender have a significant effect on fracture epidemiology, and the fracture distribution curves of the adult population ≥16 years of age show that males have a bimodal distribution with an increased incidence of fractures in young and older males, and females have a unimodal distribution with a significant increase in fracture incidence in the post-menopausal years.[15]

Analysis of fracture incidence in the 65+ population shows that the incidence of fractures rises with increasing age in both males and females. In females, there is a steady rise from 65 years of age, which accelerates in the late 70s. In males, the increased incidence of fractures occurs about one decade later (Figure 1.1).

Overall, 34.6% of all adult fractures occur in patients ≥65 years of age.[18] The analysis shows that 77% occur in females and 23% occur in males (Table 1.3). A review of the group aged ≥80 years shows that 17.4% of all adult fractures occur in this group with 80% occurring in females and 20% occurring in males. Table 1.3 shows the overall basic epidemiology of fractures in patients aged 65+ and 80+. It can be seen that fractures of the proximal humerus, distal radius and ulna and proximal femur comprise about 65% of all fractures in patients aged 65+ and about 75% in patients aged 80+. However, it is important to observe that more fractures of the proximal humerus, distal humerus, pelvis, proximal femur, femoral diaphysis, distal femur and patella occur in patients aged ≥65 years than in younger patients. More than 50% of all pelvic and proximal femoral fractures occur in patients aged ≥80 years. In the 65+ group, only fractures of the tibia and fibula, talus and toes occur as commonly in males as in females. In the 80+ group, all fractures are more commonly seen in females.

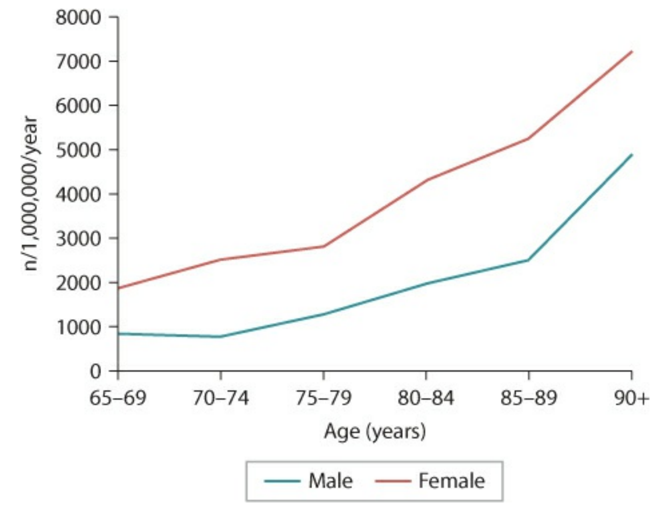

Figure 1.1 The age distribution curve for fractures in the 65+ population. (From Court-Brown CM, et al. *Bone Joint J* 2014; 96-B: 366–72.)

Tables 1.4 and 1.5 show similar epidemiological data for both males and females, but they also show the incidence of each fracture type. In males, it can be seen that only fractures of the proximal femur and femoral diaphysis are seen predominantly in patients ≥65 years of age and that overall 16.9% of male fractures occur in this age group. The data show that 7.1% of fractures in males occur in patients ≥80 years of age. In this group, 56.4% of all fractures involve the proximal humerus, distal radius or proximal femur. Only proximal femoral fractures show a predominance in patients aged ≥80 years compared with younger patients.

Table 1.3 The epidemiology of fractures in a 2-year period in patients 65+ years and 80+ years

	All patients					
	≥65 years			≥80 years		
	All fractures (%)	≥65 (%)	M/F (%)	All fractures (%)	≥80 (%)	M/F (%)
Clavicle	20.2	2.3	37/63	9.4	2.2	23/77
Scapula	34.8	0.6	26/74	15.7	0.6	7/93
Proximal humerus	58.3	12.1	21/79	24.8	10.2	20/80
Humeral diaphysis	42.3	1.1	29/71	19.2	1.0	32/68
Distal humerus	51.4	1.1	22/78	28.0	1.2	17/83
Proximal ulna	40.3	1.3	32/68	17.1	1.1	27/73
Proximal radius	12.6	1.5	17/83	2.5	0.6	14/86
Proximal radius/ulna	35.6	0.2	9/91	22.6	0.3	14/86
Radial diaphysis	18.4	0.1	40/60	13.1	0.2	20/80
Ulnar diaphysis	20.6	0.3	46/54	13.1	0.2	20/80
Radius/ulna diaphyses	21.4	0.1	17/83	10.7	0.1	33/67
Distal radius/ulna	42.9	21.7	12/88	18.1	18.2	9/91
Carpus	8.5	0.7	32/68	1.5	0.2	17/83
Metacarpus	7.5	2.4	29/71	2.5	1.6	32/68
Finger phalanges	13.4	3.9	38/62	5.4	3.1	36/64
Pelvis	69.8	3.6	23/77	52.0	5.4	19/81
Proximal femur	90.5	29.7	25/75	64.2	41.9	23/77
Femoral diaphysis	69.9	2.5	34/66	39.3	2.8	29/71
Distal femur	55.2	0.9	17/83	36.8	1.2	14/86
Patella	50.5	1.1	19/81	23.8	1.0	24/76
Proximal tibia	34.3	1.0	25/75	16.4	1.0	22/78
Tibia/fibula diaphyses	13.9	0.5	50/50	5.2	0.4	22/78
Distal tibia	17.4	0.3	19/81	5.4	0.2	20/80
Ankle	23.6	6.8	25/75	5.8	3.4	18/82
Talus	4.4	0.04	50/50	0	0	–
Calcaneus	9.2	0.2	36/64	2.5	0.1	0/100
Midfoot	13.8	0.2	33/67	1.5	0.04	0/100
Metatarsus	17.6	3.3	16/84	4.6	1.7	12/88
Toes	7.2	0.4	65/35	1.3	0.1	100/0
Total	34.6	100	23/77	17.4	100	20/80

Source: From Court-Brown CM, et al. *Bone Joint J* 2014; 96-B: 366–72.

Table 1.4 The epidemiology of male fractures in a 2-year period in patients 65+ years and 80+ years

	Males					
	≥65 years			≥80 years		
	All fractures (%)	≥65 (%)	$n/10^5$	All fractures (%)	≥80 (%)	$n/10^5$
Clavicle	10.3	3.8	49.4	3.0	2.5	61.2
Scapula	15.7	0.7	9.5	2.0	0.2	5.2
Proximal humerus	39.4	11.2	146.9	16.5	10.6	260.5
Humeral diaphysis	25.0	1.5	20.4	12.5	1.6	40.2
Distal humerus	23.8	0.9	10.7	11.9	1.0	25.0
Proximal ulna	27.4	1.8	24.1	9.6	1.4	35.5
Proximal radius	4.5	1.1	14.4	0.8	0.4	10.5
Proximal radius/ulna	9.1	0.1	1.2	9.1	0.2	5.2
Radial diaphysis	6.5	0.2	2.3	3.2	0.2	5.2
Ulnar diaphysis	13.0	0.6	7.3	2.2	0.2	5.2
Radius/ulna diaphyses	5.0	0.1	1.2	5.0	0.2	5.2
Distal radius/ulna	17.6	11.5	150.8	5.5	8.0	199.6
Carpus	6.4	1.0	13.2	0.6	0.2	4.8
Metacarpus	2.7	3.0	39.4	1.0	2.5	59.7
Finger phalanges	8.2	6.4	84.3	3.1	5.6	138.0
Pelvis	44.3	3.6	46.9	28.4	5.1	127.5
Proximal femur	85.1	33.1	434.5	54.7	47.8	1174.1
Femoral diaphysis	51.9	3.8	46.9	25.3	4.1	101.5
Distal femur	35.0	0.6	8.4	20.0	0.8	20.1
Patella	25.6	0.9	12.0	15.4	1.2	30.6
Proximal tibia	17.1	1.1	14.3	7.1	1.0	25.4
Tibia/fibula diaphyses	9.1	1.1	14.3	1.5	0.4	10.5
Distal tibia	5.1	0.3	3.5	1.7	0.2	5.2
Ankle	12.8	7.5	98.4	2.2	2.9	70.5
Talus	3.2	0.1	1.2	0	0	0
Calcaneus	4.4	0.4	4.8	0	0	0
Midfoot	8.6	0.3	3.6	0	0	0
Metatarsus	7.4	2.3	30.1	1.5	1.0	25.4
Toes	8.1	1.0	13.3	2.3	0.6	15.6
Total	16.9	100	1307.3	7.1	100	2467.4

Source: From Court-Brown CM, et al. *Bone Joint J* 2014; 96-B: 366–72.
Note: The prevalence of each fracture in the whole adult fracture population (≥16 years of age) is shown as is the prevalence in the 65+ or 80+ groups. The incidences of each fracture in the 65+ and 80+ groups are shown.

Table 1.5 shows that in females the situation is somewhat different. In females, 50.5% of all fractures occur in patients aged ≥65 years and 26.2% occur in patients ≥80 years of age. In 15 of the different fracture types listed in Table 1.5, there was a higher prevalence in patients aged ≥65 years compared with younger patients, and in patients aged ≥65 years proximal humeral, distal radial and proximal femoral fractures accounted for 66.6% of all fractures. Analysis of the 80+ group shows that 26.2% of fractures occurred in this group and in four fracture types at least 50% of the fractures occurred in patients aged 80+ years. These are fractures of the radial diaphysis, pelvis, proximal femur and femoral diaphysis.

Analysis of the incidence of fractures in 5-year intervals from 65 to 89 years and in those aged 90+ years shows that there are six patterns of fracture incidence in the older population (Figure 1.2).[18] In Type I fractures, there is a statistical correlation between increasing age and increasing fracture incidence in both males and females between 65–90 years of age. This occurs in fractures of the proximal humerus, distal radius and ulna, pelvis, proximal femur and femoral diaphysis. Type II fractures show an increasing incidence in females only. This is seen in fractures of the clavicle, distal humerus, radial diaphysis, ulnar diaphysis, distal femur and proximal tibia. In Type III fractures, there is an increased incidence in males, but not in females. This is seen in metacarpal fractures. In Type IV fractures, there is a decreasing incidence in males with increasing age. This is seen in fractures of the ankle and calcaneus. In Type V fractures, it is females who show evidence of a decreasing incidence with increasing age. This is seen in fractures of the midfoot and toes. All other fracture types have a Type VI pattern with no correlation between fracture incidence and increasing age. However, four of the fractures that showed a Type VI pattern showed evidence of increasing or decreasing incidence which failed to reach statistical significance. With an increasing population and increasing number of fractures in the elderly population, it is likely that these four fractures will need to be reclassified. Humeral diaphyseal fractures would be classified as a Type II fracture, proximal ulnar fractures would be reclassified as a Type III fracture, proximal radial fractures would become a Type IV fracture and carpal fractures would show a Type V pattern.

Table 1.5 The epidemiology of female fractures in a 2-year period in patients 65+ years and 80+ years

	Females					
	≥65 years			≥80 years		
	All fractures (%)	≥65 (%)	n/10^5	All fractures (%)	≥80 (%)	n/10^5
Clavicle	45.2	1.9	61.2	25.8	2.1	106.6
Scapula	60.5	0.6	19.8	34.2	0.7	34.6
Proximal humerus	66.8	12.3	391.5	28.7	10.2	520.3
Humeral diaphysis	59.1	1.1	33.6	25.8	0.9	45.4
Distal humerus	66.1	1.2	37.0	38.5	1.3	66.7
Proximal ulna	53.2	1.1	36.2	24.1	1.0	42.4
Proximal radius	19.8	1.6	50.0	4.1	0.6	32.0
Proximal radius/ulna	50.0	0.3	8.6	30.0	0.3	24.1
Radial diaphysis	75.0	0.2	5.1	50.0	0.2	10.5
Ulnar diaphysis	41.2	0.2	6.0	23.5	0.2	5.4
Radius/ulna diaphyses	62.5	0.1	4.3	25.0	0.1	13.2
Distal radius/ulna	53.4	24.7	787.0	23.4	20.8	1065.6
Carpus	10.0	0.6	19.8	2.2	0.3	13.3
Metacarpus	26.7	2.2	70.7	8.5	1.5	69.2
Finger phalanges	22.2	3.1	99.1	9.3	2.5	127.7
Pelvis	83.7	3.7	115.4	65.0	5.4	276.7
Proximal femur	92.4	28.6	913.0	67.7	40.4	2069.0
Femoral diaphysis	84.0	2.1	68.1	51.1	2.5	128.1
Distal femur	62.5	0.9	30.1	42.9	1.2	64.0
Patella	65.2	1.2	37.0	28.8	1.0	50.5
Proximal tibia	50.0	1.0	31.1	25.0	0.9	48.3
Tibia/fibula diaphyses	30.0	0.3	10.2	17.5	0.4	18.8
Distal tibia	39.4	0.4	11.2	12.1	0.2	10.6
Ankle	33.1	6.5	208.6	8.9	3.4	173.2
Talus	7.1	0.03	0.8	0	0	0
Calcaneus	24.1	0.2	5.9	10.3	0.2	7.9
Midfoot	28.6	0.2	5.1	4.8	0.05	2.7
Metatarsus	23.8	3.6	114.6	6.3	1.8	93.0
Toes	5.9	0.2	5.1	0	0	0
Total	50.5	100	3186.1	26.2	100	5119.8

Source: From Court-Brown CM, et al. *Bone Joint J* 2014; 96-B: 366–72.
Note: The prevalence of each fracture in the whole adult fracture population (≥16 years of age) is shown, as is the prevalence in the 65+ or 80+ groups. The incidences of each fracture in the 65+ and 80+ groups are shown.

Surgeons will not be surprised by the Type I fractures, but when considering the Type II and III patterns, they may be surprised at the increasing incidence of clavicular, radial diaphyseal, ulnar diaphyseal and proximal tibial fractures in females and metacarpal fractures in males. Further analysis of clavicular fractures shows that both distal and diaphyseal clavicular fractures increase in incidence in females with increasing age and distal clavicle fractures increase in incidence in males, giving distal clavicle fractures a Type I pattern.

Some fractures continue to increase in incidence up to the mid-70s, but then decrease in incidence, particularly in males. This is seen in ankle and calcaneal fractures. In a previous study,[11] it was stated that bimalleolar and trimalleolar ankle fractures should be considered as fragility fractures as the patients' average age was the same as that of patients presenting with distal radial fractures. Whereas the incidence of distal radial fractures increases after 80 years, the incidence of ankle fractures decreases, particularly in males. This is also seen in calcaneal fractures and presumably relates to increasing male frailty with increasing age when compared with females.

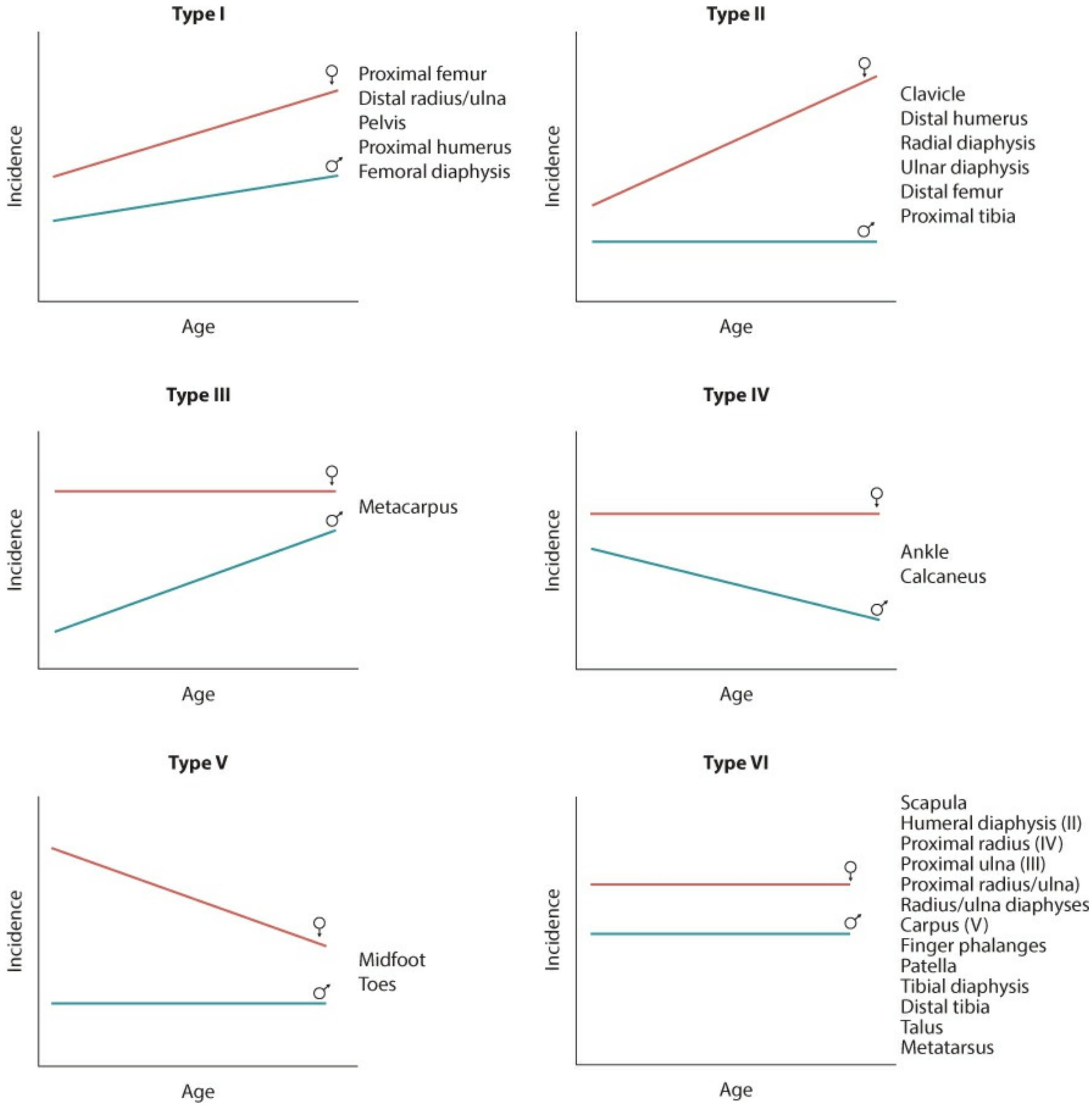

Figure 1.2 Six fracture patterns that are seen in patients aged ≥65 years. In the Type VI fractures four fracture patterns will probably change in the future. (From Court-Brown CM, et al. *Bone Joint J* 2014; 96-B: 366–72.)

CAUSES OF FRACTURE

Review of different modes of injury that cause fractures in the elderly shows that falls from a standing height have a Type I pattern[18] with increasing fracture incidence in both males and females. Falls from a low height (<6 feet) or downstairs are unusual, in that there is a positive correlation with age in males, but not in females. This again may reflect male frailty. Falls from a height, direct blows or assaults, road traffic accidents and sports related fractures showed a Type VI pattern[18] with no correlation between increasing age and fracture incidence. However, spontaneous fractures showed a Type III pattern[18] with increasing fracture incidence in males.

Falls from a standing height

It is widely accepted that falls from a standing height cause most fractures in elderly patients. Table 1.6 presents an analysis of the prevalence of falls in each fracture type and it can be seen that overall 90.8% of fractures in patients ≥65 years of age are caused by falls from a standing height. Falls cause 82.5% of fractures in males and 93.2% of fractures in females aged ≥65 years. In the 80+ group, 94.1% of fractures were caused by falls. In males, 89.5% of fractures were caused by falls and in females this rose to 95.3%. Table 1.6 shows that in 10 fracture types, at least 90% of all fractures were caused by falls in the 65+ group. This rose to 17 fracture types in the 80+ group emphasizing the importance of falls in the very elderly. The only fracture where less than 50% of fractures in the 65+ group were caused by falls was the toe fracture, where most were caused by direct blows. However, it should be noted that the prevalence of fall related fractures is less in the scapula and in the proximal tibia, tibial diaphysis, calcaneus and midfoot, than it is in other fractures. These fractures are more commonly seen in younger patients, particularly in males. Falls are discussed in detail in Chapter 12.

Table 1.6 The prevalence of fractures caused by falls from a standing height and high energy (HE) injuries is shown, as is the prevalence of open and multiple fractures

	≥65 years				≥80 years			
	Falls (%)	HE (%)	Open (%)	Multiple (%)	Falls (%)	HE (%)	Open (%)	Multiple (%)
Clavicle	83.9	5.3	0	7.4	92.3	1.9	0	4.0
Scapula	64.5	16.1	0	9.7	78.6	14.3	0	28.6
Proximal humerus	93.9	0.7	0	10.5	96.7	0.4	0	7.3
Humeral diaphysis	87.3	0	1.8	3.4	92.0	0	0	8.0
Distal humerus	96.2	1.9	0	17.8	93.3	3.3	0	10.0
Proximal ulna	88.7	1.6	6.5	18.7	96.2	0	3.8	11.5
Proximal radius	92.9	2.8	0	7.1	92.9	0	0	14.3
Proximal radius/ulna	100	0	9.1	0	100	0	14.3	0
Radial diaphysis	87.5	0	0	0	100	0	0	0
Ulnar diaphysis	61.5	7.1	7.1	7.1	83.4	0	0	16.7
Radius/ulna diaphyses	66.6	0	16.7	16.7	33.3	0	0	0
Distal radius/ulna	93.4	1.3	0.9	4.0	96.8	0.7	0.7	11.2
Carpus	100	0	0	5.9	100	0	0	0
Metacarpus	86.6	4.3	5.7	26.7	86.8	5.3	2.4	34.2
Finger phalanges	69.2	3.2	10.8	19.5	69.4	5.3	6.4	22.2
Pelvis	92.5	3.5	0	12.0	96.9	1.6	0	11.6
Proximal femur	95.7	0.4	0	5.0	95.9	0.1	0	4.1
Femoral diaphysis	84.2	0.8	0	3.6	94.1	0	0	2.9
Distal femur	95.2	0	2.4	4.8	96.4	0	0	3.6
Patella	90.6	1.9	1.9	13.2	100	0	0	12.0
Proximal tibia	68.7	18.7	2.1	12.0	65.2	26.1	0	26.1
Tibia/fibula diaphyses	68.8	31.2	43.8	25.0	85.7	14.3	42.8	14.2
Distal tibia	87.5	0	6.2	0	100	0	20.0	0
Ankle	87.3	2.8	1.5	2.8	89.7	1.3	5.1	6.4
Talus	100	0	0	0	–	0	–	–
Calcaneus	54.5	27.3	0	33.3	100	0	0	0
Midfoot	55.6	22.2	0	0	100	0	0	0
Metatarsus	89.9	3.2	0	12.6	83.7	10.0	0	20.0
Toes	31.6	0	17.6	5.9	0	0	0	0
Total	90.8	1.9	1.2	4.7	94.1	1.2	1.0	6.6

High energy fractures

In recent years, there has been considerable interest in high energy fractures[19] but virtually all studies have concentrated on younger patients. Table 1.6 shows that 1.9% of fractures in the 65+ group and 1.2% of fractures in the 80+ group were caused by high energy injuries, these being defined as road traffic accidents or falls from a height. Table 1.6 shows that in the 65+ group the fractures most likely to be caused by a high energy injury are those of the scapula, proximal tibia, tibial diaphysis, calcaneus and midfoot. In the 80+ group, fractures of the scapula, proximal tibia and tibial diaphysis had the highest likelihood of being caused by high energy injuries. In the 65+ group, 84.6% of high energy fractures were caused by a road traffic accident and 15.4% were caused by a fall from a height (>6 feet). In the 80+ group, the figures were 76.7% and 23.3%, respectively.

Analysis of the patients injured in road traffic accidents in the 65+ group showed that 57.5% of the fractures occurred in pedestrians, 18.2% in cyclists, 16.7% in vehicle occupants and 7.6% in motorcyclists. Further analysis showed that 31.8% presented with multiple fractures and 9.1% of the fractures were open. In the 80+ group, 73.9% of the fractures were in pedestrians, 17.4% in vehicle occupants and 8.7% occurred in motorcyclists. This older group were more severely injured with 76.9% of patients having multiple fractures and 15% presenting with open fractures. High energy fractures in the elderly are discussed in detail in Chapter 14.

MULTIPLE FRACTURES

Table 1.6 shows that the prevalence of multiple fractures in older patients[20] increases with age and analysis of the incidence of multiple fractures in 5-year age ranges shows that multiple fractures have a Type I pattern,[18] with increasing incidence in both males and females with increasing age. In younger patients, multiple fractures tend to occur as a result of high energy injuries, but in older patients increasing frailty means that multiple fractures can occur as a result of low energy trauma. This is the cause of the increased prevalence of multiple fractures in the group aged 80+ years. Multiple injuries are discussed in detail in Chapter 15.

OPEN FRACTURES

Table 1.6 shows that open fractures are uncommon in the elderly, but analysis of the prevalence of open fractures in the younger patients (<65 years) during a 2-year study showed that 3.2% of fractures in males were open, compared with 1.2% of fractures in females. Thus the proportion of fractures in the elderly that are open is not actually dissimilar to that in younger patients. The analysis shows that open fractures in the elderly have a Type VI distribution[18] with no correlation between increasing age and fracture incidence in patients ≥65 years of age.

Because of the rarity of open fractures in the elderly, a study was undertaken to examine the epidemiology of open fractures in the elderly over a 15-year period between 1995 and 2009.[21] During this period there were 484 open fractures in the elderly. The incidence of open fractures increased with age. In patients <65 years of age the incidence was $29.74/10^5$/year. This increased to $33.2/10^5$/year in the 65+ group and to $44.7/10^5$/year in the 80+ group. Thus despite the fact that Table 1.6 indicates that there is a low prevalence of open fractures in older patients, the incidence rises with age. The fracture distribution curves for open fractures are very different to those for closed fractures. Figure 1.3 shows the fracture distribution curves for open fractures in all age groups in males and females. It can be seen that in males the highest incidence is in the 15- to 19-year-old group where it was 53.7/10^5/year. In males, the incidence of open fractures declines in an almost linear fashion with age, so that in males aged ≥90 years the incidence is 23.2/10^5/year. In females, the 15- to 19-year-old group has a very low incidence of open fractures at 9.3/10^5/year. This gradually increases until the seventh decade of life when the incidence accelerates rising to 52.6/10^5/year in the ≥90-year-old group.

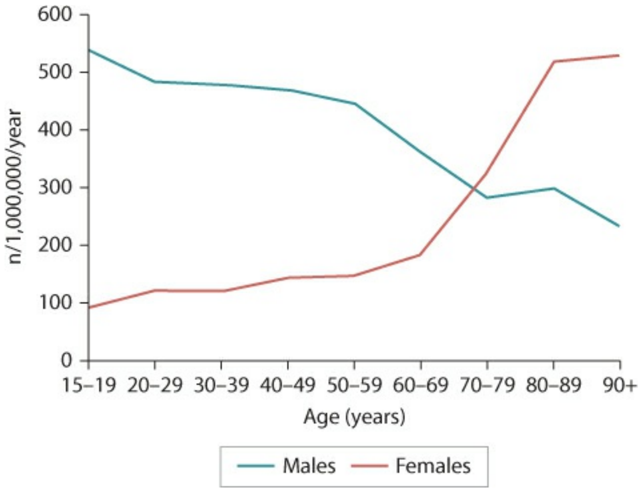

Figure 1.3 The fracture distribution curves for open fractures. (From Court-Brown CM, et al. *Injury* 2015; 46:189–94.)

The epidemiology of open fractures in the 65+ and 80+ groups is shown in Tables 1.7 and 1.8. These tables show that the incidence of many open fractures is similar in males and females, the major differences being the higher incidence of open distal radial and ankle fractures in females and a higher incidence of open finger phalangeal fractures in males. The situation is similar in both the 65+ and 80+ groups. It is important to remember that in all older patients the majority of open fractures are caused by low energy falls, but Tables 1.7 and 1.8 show that despite this there is a high prevalence of Gustilo type III[22] open fractures. This is particularly true of lower limb fractures in females. In fact, a comparison of open fractures of the tibia and fibula diaphyses in younger and older patients shows that in patients aged <65 years the incidence of open fractures was 3.4/10^5/year and 46.1% of the fractures were a Gustilo type III. In the ≥65-year-old group, the incidence was 3.3/10^5/year and 37.5% were Gustilo type III fractures. Most of the fractures in the younger patients were high energy fractures, but most of the fractures in the older group occurred as a result of simple falls. The fact that there is a high incidence of fractures in subcutaneous locations in the elderly, such as the distal radius and ulna, finger phalanges, tibia and fibula and ankle indicates that poor skin quality is probably a factor accounting for the high incidence of open fractures in the elderly.[21] It has been shown that aging alters the mechanical properties of skin and it seems likely that this accounts for the increased incidence of open fractures in elderly females which occurs about one decade after the post-menopausal increase in fracture incidence (Figure 1.3). With increasing numbers of elderly females in the population over the next few decades it seems likely that this will have significant implications for orthopaedic surgeons and plastic surgeons.

Table 1.7 The number and incidence of open fractures in males and females aged 65+ over a 15-year period. The prevalence of Gustilo III fractures is also shown

	Males ≥65 years			Females ≥65 years		
Fractures	n	n/10^6/year	GIII (%)	n	n/10^6/year	GIII (%)
Scapula	0	0	0	0	0	0
Clavicle	1	1.7	0	0	0	0
Proximal humerus	1	1.7	0	2	2.3	0
Humeral diaphysis	3	5.1	33.3	3	5.2	33.3
Distal humerus	3	5.1	33.3	3	3.4	0
Proximal radius/ulna	1	1.7	0	0	0	0
Proximal radius	0	0	0	0	0	0
Proximal ulna	5	8.5	0	10	11.5	10.0
Radial/ulna diaphyses	4	6.8	0	5	5.7	0
Radial diaphysis	1	1.7	0	0	0	0
Ulnar diaphysis	1	1.7	100	3	3.4	33.3
Distal radius/ulna	13	22.2	0	111	127.4	2.7
Carpus	0	0	0	0	0	0
Metacarpus	3	5.1	33.3	5	5.7	0
Finger phalanges	83	141.8	18.1	63	72.3	14.3
Pelvis	1	1.7	0	0	0	0
Proximal femur	0	0	0	0	0	0
Femoral diaphysis	1	1.7	0	1	1.7	0
Distal femur	0	0	0	5	5.7	60.0
Patella	2	3.4	0	3	3.4	33.3
Proximal tibia	1	1.7	0	6	6.9	66.6
Tibia/fibula diaphyses	13	22.2	7.7	35	40.2	48.6
Distal tibia	0	0	0	7	8.0	42.9
Ankle	10	17.1	30	44	50.5	56.8
Talus	0	0	0	0	0	0
Calcaneus	1	1.7	100	3	3.4	66.6
Midfoot	0	0	0	0	0	0
Metatarsus	3	5.1	33.3	4	4.6	50.0
Toes	17	29.0	11.7	3	3.4	0
Total	168	287.1	16.1	316	362.6	22.8

Source: From Court-Brown CM, et al. *Bone Joint J* 2014; 96-B: 366–72.

EPIDEMIOLOGY OF DIFFERENT FRACTURE TYPES

Clavicle

Overall fractures of the clavicle have a Type II pattern[18] meaning that in females the incidence increases with increasing age. Lateral third clavicle fractures have a Type I pattern[18] with an increasing incidence being seen in both males and females with increasing age. Review of the clavicle fractures treated in the 65+ and 80+ groups shows that lateral clavicle fractures accounted for 63.4% and 73.1%, respectively, of all clavicle fractures. The prevalence of middle third clavicle fractures was 33.9% and 25.0%, respectively. Standing falls caused most clavicle fractures in the elderly although Table 1.6 shows that clavicle fractures have the seventh highest prevalence of high energy injuries. Review of high energy clavicle fractures shows that 71.4% occurred in road traffic accidents and that 60% of these occurred in cyclists or motorcyclists. Tables 1.7 and 1.8 show that open fractures of the clavicle in the elderly are very rare and review of the multiple fractures associated with clavicle fractures in the 65+ group shows that they mainly involve the shoulder with 33.3% occurring in the scapula and 22.9% in the proximal humerus.

Table 1.8 The number and incidence of open fractures in females and females aged 65+ over a 15-year period. The prevalence of Gustilo III fractures is also shown

	Males ≥80 years			Females ≥80 years		
Fractures	n	n/10⁶/year	GIII (%)	n	n/10⁶/year	GIII (%)
Scapula	0	0	0	0	0	0
Clavicle	1	8.3	0	0	0	0
Proximal humerus	0	0	0	1	3.8	0
Humeral diaphysis	0	0	0	2	7.6	50.0
Distal humerus	0	0	0	2	7.6	0
Proximal radius/ulna	1	8.3	0	0	0	0
Proximal radius	0	0	0	0	0	0
Proximal ulna	0	0	0	4	15.1	25.0
Radial/ulna diaphyses	2	16.6	0	1	3.8	0
Radial diaphysis	0	0	0	0	0	0
Ulnar diaphysis	0	0	0	0	0	0
Distal radius/ulna	3	24.9	0	53	200.4	3.8
Carpus	0	0	0	0	0	0
Metacarpus	1	8.3	0	4	15.1	0
Finger phalanges	17	141.1	28.6	29	109.6	17.2
Pelvis	0	0	0	0	0	0
Proximal femur	0	0	0	0	0	0
Femoral diaphysis	1	8.3	0	0	0	0
Distal femur	0	0	0	3	11.3	66.6
Patella	0	0	0	2	7.6	50.0
Proximal tibia	0	0	0	3	11.3	33.3
Tibia/fibula diaphyses	3	24.9	0	15	56.7	46.7
Distal tibia	0	0	0	1	3.8	0
Ankle	3	24.9	33.3	15	56.7	73.3
Talus	0	0	0	0	0	0
Calcaneus	0	0	0	0	0	0
Midfoot	0	0	0	0	0	0
Metatarsus	0	0	0	2	7.6	50.0
Toes	3	24.9	33.3	0	0	0
Total	35	290.4	11.4	137	517.9	23.4

Source: From Court-Brown CM, et al. *Bone Joint J* 2014; 96-B: 366–72.

Scapula

The literature strongly suggests that scapula fractures result from high energy injuries and occur in young adults. However, Table 1.3 shows that over a third of scapula fractures occur in 65+ patients, this rising to 60% in females (Table 1.5). Even in elderly patients high energy injuries are important with 16% of scapula fractures in the 65+ group and 14% in the 80+ group being caused by a road traffic accident or fall from a height. This, together with increasing frailty, accounts for the fact that almost 30% of 80+ patients present with associated fractures (Table 1.6). As with clavicle fractures, the majority of fractures associated with scapula fractures are around the shoulder with 40% occurring in the proximal humerus and 30% in the clavicle. Tables 1.7 and 1.8 show that there were no open scapular fractures in the 15-year study.[21] It would seem likely that in elderly patients open scapular fractures are associated with fatal injuries.

Proximal humerus

Proximal humeral fractures are one of the classic fragility fractures[17] and have a Type I pattern.[18] Table 1.3 shows that they account for about 12% of all fractures in patients ≥65 years of age and about 10% of all fractures in the 80+ group. There is evidence that their incidence is increasing and a study of proximal humeral fractures treated in the Royal Infirmary of Edinburgh shows an increasing incidence in the whole adult population (≥16 years) from $47.2/10^5$/year in 1993 to $92.4/10^5$/year in 2010/2011.[15] The increase was seen in both males and females.

In the elderly population the overwhelming majority of these fractures follow a simple fall and Table 1.6 shows that high energy fractures are very rare. In the 2-year period that was examined, 97.2% of all proximal humeral fractures in the 65+ group followed a standing fall or a fall from a low height. The equivalent figure for the 80+ group was 99.1%. A review of the fracture morphology showed that in the 65+ group 64.8% of the fractures were AO/OTA[23] Type A extra-articular unifocal fractures, 27.3% were Type B bifocal fractures and the remaining 7.2% were Type C articular fractures. The prevalences were very similar in the 80+ group (64.6%, 25.6% and 9.7%).

There is an association between the three common fragility fractures and in the 65+ group 53.6% of patients who presented with a proximal humeral fracture and an additional fracture presented with a proximal femoral fracture and 14.3% with a distal radial fracture. Equivalent figures for the 80+ group were 61.1% and 16.6%, respectively.

Humeral diaphyseal fractures

There is a high prevalence of humeral diaphyseal fractures in the elderly. Overall, 25% of all male humeral fractures and 60% of all female humeral fractures occur in the 65+ population, and this accounts for the fact that they have a Type II pattern.[18] The majority occur as a result of a fall, but 9.1% were pathological fractures and 3.6% occurred as a result of a low fall. There were no high energy fractures. Few patients presented with associated fractures. Of those that did 50% had a distal radial fracture and 25% had a proximal femoral fracture.

Distal humerus

Table 1.3 shows that distal humeral fractures are more commonly seen in older patients than in younger patients and 66% of female distal humeral fractures occur in older patients. They have a Type II pattern[18] with the incidence of distal humeral fractures in elderly females increasing with age. The analysis shows that in the 65+ group, 58.5% had extra-articular AO/OTA[23] Type A fractures, 28.3% had partial articular Type B fractures and 13.2% had complete articular Type C fractures. As one might expect in the 80+ group, the fracture morphology was less severe with 70% having a Type A fractures, 23.3% a Type B fracture and 6.6% a Type C fracture. Periprosthetic fractures were uncommon with only 1.9% of the fractures being periprosthetic.

Virtually all distal humeral fractures in the elderly follow a fall. There was a relatively high prevalence of multiple fractures in the 65+ group. Of these 33% involved the proximal radius or ulna, 25% were metacarpal and 16.7% were proximal femoral fractures.

Proximal ulna

Table 1.3 shows that about 40% of all proximal ulna fractures occur in the older population. Analysis shows that in males the incidence rises after 75 years of age and it is therefore likely that with an increasingly elderly population proximal ulna fractures will have a Type III pattern[18] in the future. Proximal ulna fractures are mainly caused by falls and a review of the 65+ population shows that 98.1% were caused by a standing fall or a low fall with all of those in the 80+ population being so caused. Analysis of the fracture morphology in the 65+ group showed that 96.8% were AO/OTA[23] Type B unifocal olecranon fractures with the remaining 3.2% being Type A olecranon avulsion fractures. Morphology in the 80+ group was virtually identical (96.2% and 3.8%).

The subcutaneous location of the olecranon means that even low energy trauma will result in open fractures, and Tables 1.7 and 1.8 show a relatively high prevalence of open fractures in the frail 80+ group, although few are severe. There is also a high prevalence of multiple fractures and if one excludes those patients who presented with proximal radius and ulna fractures, analysis of the 65+ group shows that 33.3% presented with distal radial fractures, 22.2% with a proximal humeral fracture and 22.2% with a proximal femoral fracture.

Proximal radius

Proximal radial fractures are less commonly seen in older patients and Table 1.4 shows that they are very uncommon in older males. Review of their distribution in older males showed that they rarely occurred after the age of 80 and it is therefore likely that, in the future, they will have a Type IV pattern.[18] In the 65+ group, 68.6% were radial head fractures and 31.4% were radial neck fractures. In the 80+ group, the proportion was 50/50. Most proximal radial fractures in the older population follow a fall and open fractures are rare. In those patients aged 65+ who did not have an associated proximal ulna fracture, 23.1% had a distal radial fracture, 15.4% had a distal humeral fracture and 15.4% had a metacarpal fracture.

Proximal radius and ulna

Combined fractures of the proximal radius and ulna are worth considering separately because a previous study has shown that the fracture distribution curves for this fracture are the same as those of the proximal humerus and proximal femur, making it a fragility fracture.[11] Table 1.6 shows that all proximal radius and ulna fractures were caused by a standing fall, but there was a relatively higher prevalence of open fractures, particularly in the 80+ group, emphasizing the problems of a subcutaneous location in a frail patient.

In the AO/OTA[23] fracture classification, Type A fractures of the proximal radius and ulna are both extra-articular. In Type B fractures, one of the fractures is intra-articular, and in Type C fractures, both fractures are intra-articular. Review of the 65+ group shows that 18.2% were Type A, 36.4% were Type B and 45.5% were Type C. The equivalent figures for the 80+ group were 28.6%, 42.9% and 28.6%. No patient presented with multiple fractures.

Radius and ulna

The basic epidemiology of individual fractures of the radius and ulna and combined radial and ulna fractures is given in Tables 1.3 through 1.6. Radial diaphyseal fractures and ulnar diaphyseal fractures show an increasing incidence in older females and both have a Type II pattern,[18] although combined radius and ulna fractures have a Type VI pattern.[18] In the 65+ group, 29.6% of forearm fractures were isolated radial fractures, 51.9% were isolated ulna fractures and 18.5% were radius and ulna fractures. The fracture distribution in the 80+ group was very similar at 30.8%, 46.1% and 23.1%, respectively. Overall, 76.9% of forearm fractures resulted from a fall in the 65+ group with only 3.3% being caused by a high energy injury. The equivalent figures for the 80+ group were 78.6% and 0%.

In the 65+ group, 6.5% of the fractures were open, but Tables 1.6 through 1.8 show that it tends to be combined fractures of the proximal radius and ulna which have a higher prevalence of open fractures. However, they are relatively minor open fractures and there were no Gustilo type III[22] fractures in the 15-year study.[21] Multiple fractures are rare with only one ulna diaphyseal fracture being associated with a proximal tibial fracture and one radius and ulna fracture being associated with a proximal radius and ulna fracture.

Distal radius and ulna

Distal radial fractures are one of the classic fragility fractures,[24,25] but they are common in all ages and even in females, only 62.5% occur in the 65+ population (Table 1.5). They increase in incidence 65–90+ years giving them a Type I pattern.[18] In 65+ males, their prevalence is about the same as proximal humeral fractures and it is about one-third that of proximal femoral fractures. In 65+ females, they are twice as common as proximal humeral fractures and have almost the same prevalence as proximal femoral fractures.

The literature shows considerable variation in the incidence of distal radial fractures. In patients ≥50 years, the incidence in Texas, USA, was recorded as $78.2/10^5$/year in males and $256.9/10^5$/year in females.[24] This compares with $139.6/10^5$/year and $631.8/10^5$/year in Edinburgh, Scotland, and $141.6/10^5$/year and $676.7/10^5$/year in South Sweden.[25] It is unlikely that the incidences in Texas, Edinburgh and Sweden are so different and the reason for the differences is unknown. It would seem that the incidence of distal radial fractures is increasing and a review of the overall incidence in the whole population in Edinburgh (≥16 years of age) between 1990 and 2010/2011[15] shows that it increased from $158.3/10^5$/year to $235.9/10^5$/year with the increase being seen in both males and females.

Analysis of the severity of the distal radial fractures shows that in the 65+ group 65.6% were AO/OTA[23] Type A extra-articular fractures, 11.7% were Type B partial articular fractures and 22.7% were Type C complete articular fractures. The equivalent distribution in the 80+ group was very similar with 68.8% Type A, 11.2% Type B and 20% Type C fractures.

In most patients these fractures follow a simple fall and there are very few high energy injuries. However, the subcutaneous location of the distal radius and ulna means that in the 15-year study of open fractures, distal radial and ulna fractures had the highest incidence of all open fractures in 65+ and 80+ females. In the 65+ group, 26.2% of patients with multiple injuries had bilateral fractures, 40.5% had an associated proximal femoral fracture and 9.5% a proximal humeral fracture. The equivalent figures for the 80+ group were 25.9%, 44.4% and 11.1%.

Carpus

Table 1.3 shows that carpal fractures are unusual in 65+ patients and even in females only 10% of carpal fractures occur in this age group. Analysis showed that carpal fractures have a Type VI pattern,[18] but the declining incidence in older females indicates that in the future they may well have a Type V pattern.[18] In the 65+ group, 50% of the carpal fractures occurred in the scaphoid, 35.3% in the triquetrum, 5.9% in the pisiform and 2.9% in the lunate. In the 80+ group, all fractures were in the scaphoid (50%) or triquetrum (50%). All fractures occurred as a result of a simple fall, none were open and the only associated fractures occurred in the 65+ group with 50% of the patients having a distal radial fracture.

Metacarpus

Tables 1.4 and 1.5 show that metacarpal fractures are relatively unusual in 65+ males, but more common in 65+ females. Analysis of the incidence in males, however, shows that the incidence increases after the age of 65 and metacarpal fractures have a Type III pattern.[18] Analysis of the distribution of metacarpal fractures in the 65+ group shows that, as with younger patients, the prevalence of these fractures increases towards the ulnar border of the hand. In the 65+ group, 4.9% of the metacarpal fractures occurred in the thumb metacarpal, 5.7% in the index finger metacarpal, 10.6% in the middle finger metacarpal, 14.6% in the ring finger metacarpal and 64.2% in the little finger metacarpal. The equivalent figures for the 80+ group were very similar at 4.9%, 2.4%, 9.7%, 14.6% and 68.3%. Most metacarpal fractures followed falls, but 4–5% in each age group result from high energy injuries. Tables 1.7 and 1.8 show that there is a relatively high incidence of open fractures in the metacarpus and this increases in the 80+ group. There is a high prevalence of Gustilo type III[22] fractures compared with other fracture types, presumably because of the subcutaneous location of the finger phalanges in this frail group of patients. In the 65+ group, 16.2% of the patients had multiple metacarpal fractures, with a similar prevalence being seen in the 80+ group (17.1%).

Finger phalanges

Fractures of the finger phalanges are more commonly seen in younger patients with only 8.2% of 65+ males and 22.2% of 65+ females presenting with finger fractures (Tables 1.4 and 1.5). In both groups of patients, the thumb, ring and little fingers are more commonly involved. In the 65+ group, 18.0% of the fractures were in the thumb, 5.4% in the index finger, 11.2% in the middle finger, 22.4% in the ring finger and 38.0% in the little finger. The equivalent figures for the 80+ group were 23.1%, 6.4%, 10.3%, 24.4% and 35.9%. Tables 1.7 and 1.8 show that the incidence of open phalangeal fractures is high, particularly in males.

Falls caused fewer finger fractures than metacarpal fractures, but Table 1.6 shows that there was a relatively low prevalence of high energy injuries. However, 18.4% of finger fractures in the 65+ group and 12.5% of the 80+ group were caused by a direct blow or assault to the fingers. In the 65+ group, 14.6% of patients had multiple finger fractures, with 8.3% occurring in the 80+ group.

Pelvis

Tables 1.4 and 1.5 show that pelvic fractures are common in both elderly males and elderly females. They are acknowledged to be a fragility fracture[17,26] and they show a Type I pattern,[18] In younger patients, they tend to be high energy injuries, but in the elderly most pelvic fractures are caused by falls. Table 1.6 shows that high energy pelvic fractures do occur in the elderly, but they are rare.

Analysis of the changing incidence of pelvic fractures in Edinburgh, Scotland, between 1991 and 2010/2011[15] shows that the overall incidence has remained unchanged and this is true of males and females. However, the average age of males with pelvic fractures increased from 46 years in 1991 to 64.7 years in 2010/2011.[15] The increase in females was from 73.6 to 80.3 years. The fact that standing falls caused 28.9% of pelvic fractures in males and 73.9% in females in 1991 compared with 56.4% and 91.6% in 2010/2011 strongly indicates that, despite the overall incidence of pelvic fractures remaining unchanged, there is a declining incidence of pelvic fractures in younger patients and an increasing incidence of pelvic fractures in older patients.

Analysis of the type of pelvic fracture in the 65+ group shows that 85.6% were rami fractures, 9.2% were acetabular fractures and 5.2% involved the ilium or sacrum. The equivalent figures for the 80+ group were very similar at 86.7%, 7.1% and 6.2%. There were no open fractures. A review of the fractures associated with pelvic fractures shows that 20% were distal radial fractures, 16% were proximal humeral fractures and 12% were proximal femoral fractures. Similar figures were recorded in the 80+ group with 20% of patients having an associated proximal femoral fracture or proximal humeral fracture and 13.3% having a distal radial fracture.

Proximal femur

The epidemiology of proximal femoral fractures has been widely documented.[16,17,27,28,29,30 and 31] There are a number of studies which suggest that the incidence of proximal femoral fractures started to stabilize, or fall, after the mid-1990s, but this does not appear to be the case throughout the world. A review of studies which reported the incidence of proximal femoral fractures in patients ≥50 years of age who were either Caucasian or the results were age adjusted for the Caucasian population, showed that the incidence of proximal femoral fractures varied between $88/10^5$/year in males and $218/10^5$/year in females in Malaysia to $390/10^5$/year and $706/10^5$/year in Sweden.[15] Different studies have also showed different incidences of proximal femoral fractures in the same country in similar time periods.[15]

A review of proximal femoral fractures in Edinburgh between 1991 and 2010/2011[15] showed that overall there was no change in incidence, but the incidence in males had risen from $57.4/10^5$/year to $84/10^5$/year, and in females it had dropped from $220.8/10^5$/year to $200.4/10^5$/year. This probably reflects increasing male longevity. Further studies are clearly required to define the exact incidence of proximal femoral fractures and to see why there are differences in similar countries.

Analysis of the patients shows that in the 65+ group, 39.2% presented with a trochanteric fracture and 60.8% with a subcapital fracture. Overall, 0.5% of these fractures were periprosthetic. In the 80+ group, 41.6% were trochanteric and 58.4% were subcapital with 0.6% of the fractures being periprosthetic. Table 1.6 shows that virtually all proximal femoral fractures follow a standing fall, but in the 65+ group, 2.3% were caused by a low fall or fall downstairs and 1.4% were pathological or spontaneous. The equivalent figures for the 80+ group were 2.3% and 1.5%. None of the fractures were open and 29.3% of the 65+ patients who presented with multiple fractures had distal radial fractures with 26.8% presenting with a proximal humeral fracture.

Femoral diaphysis

There is a view among some orthopaedic surgeons that femoral diaphyseal fractures are high energy injuries. However, nowadays they are in fact a classic fragility fracture with a Type I pattern.[18] Table 1.6 shows that 84.2% of femoral fractures were caused by falls and in this older population there was only one femoral diaphyseal fracture that occurred as a result of a road traffic accident. There is no doubt that high energy femoral diaphyseal fractures do occur in younger patients, but overall the femoral diaphyseal fracture is now a fragility fracture. A review of the incidence of femoral diaphyseal fractures in Edinburgh, Scotland, between 1991 and 2010/2011[15] showed no change in incidence in males and females, but there was a significant change in the average age of the patient. In 1991 males and females with femoral fractures averaged 39.5 and 62.0 years of age, respectively, whereas in 2010/2011 the average ages were 63.4 and 75.6 years. There was also a higher prevalence of fractures from standing falls in both males and females in 2010/2011 compared with 1991.[15]

A review of the fracture morphology in the 2-year study shows that in 65+ patients 85.0% were AO/OTA[23] Type A simple fractures and 14.2% were Type B wedge fractures. Only 0.8% were Type C complex fractures in the 65+ group with no complex fractures occurring in the 80+ group. In this group, 87.5% of the fractures were Type A and 12.5% Type B. In the 65+ group, 93.6% of the fracture were either pathological or spontaneous or caused by a fall. The equivalent figure for the 80+ group was 95.6%. It should be noted that in the two patient groups 34.2% and 35.3%, respectively, of all femoral fractures were periprosthetic and it is likely that, with increasing prosthetic use in many parts of the world, the incidence of these fractures will rise in the next few decades. There were no open fractures and very few patients presented with multiple fractures.

Distal femur

Fracture of the distal femur, like femoral diaphyseal fracture, used to be assumed to be a high energy injury, but is now a fragility fracture, particularly in females. It has a Type II pattern[18] and its incidence increases with age in older females. In elderly patients, it is a low energy injury with all the patients in this study being injured in standing falls, low falls or falls downstairs. A review of the fracture morphology in the 65+ group shows that 81% were AO/OTA[23] Type A extra-articular fractures, 2.4% were Type B partial articular fractures and 16.7% were Type C complete articular fractures. The equivalent figures for the 80+ group were 85.7%, 0% and 14.3%. As with femoral diaphyseal fractures, there is a high prevalence of periprosthetic fractures with 26.2% occurring in the 65+ group and 35.7% in the 80+ group. Tables 1.7 and 1.8 show that open fractures tend to occur in females with a higher incidence being seen in the 80+ group. There was a high prevalence of Gustilo type III fractures[22] in both the 65+ and 80+ groups. Associated fractures are rare.

Patella

Table 1.3 shows that about 50% of patella fractures occur in older patients. In older females, this figure rises to 65%. In a previous study,[11] it was shown that the average age of patients who presented with patella fractures was actually higher than in those who presented with distal radial fractures and this indicated that the patella fractures should be regarded as fragility fractures. Using the AO/OTA[23] classification, 92.5% of the 65+ group presented with a Type C complete articular transverse patella fracture and all of the 80+ group presented with this fracture type. In the 65+ group, 5.7% of the patients presented with a Type A extra-articular avulsion fracture and 1.9% with a Type B partial articular vertical fracture. Virtually all were caused by a standing fall, although 3.8% of the 65+ group were caused by a direct blow. Open fractures are very rare, but as with all subcutaneous fractures, Tables 1.7 and 1.8 show that they are more commonly seen in the 80+ group. In the 65+ group, 33.3% of patients presented with associated distal radial fractures. This rose to 50% in the 80+ group.

Proximal tibia

The epidemiology of proximal tibial fractures is similar to that of distal femoral fractures in that more older females are affected than older males and they show a Type II pattern[18] with an increasing incidence in 65+ females. However, there are some differences, the main one being that there is higher prevalence of high energy fractures in the proximal tibia. Analysis of these in the 65+ group shows that 87.5% were caused by a road traffic accident and that 66.6% occurred in pedestrians. Despite this, Tables 1.7 and 1.8 show that the prevalence of open fractures is relatively low, although it rises in the 80+ group, presumably because of increased frailty.

Examination of fracture morphology also shows some differences when compared with the distal femoral fracture. In the 65+ group with proximal tibial fractures, 22.9% were AO/OTA[23] Type A extra-articular fractures, 64.6% were Type B partial articular fractures and 12.5% were Type C complete articular fractures. The figures for the 80+ group were similar at 17.4%, 69.6% and 13.0%, respectively. Analysis shows that there was a high prevalence of multiple fractures. The most common associated fractures were metacarpal and pelvic fractures in both age groups. In the 65+ group, 28.6% were metacarpal fractures and 14.3% were pelvic fractures. In the 80+ group, both fracture types occurred in 25% of patients who presented with multiple fractures.

Tibia and fibula

Tibia and fibula diaphyseal fractures are unusual, in that their incidence is falling. This is partially due to improved work-place legislation for younger patients in first world countries, but also because they are not fragility fractures and the increased incidence of fragility fractures in the older population has not had the same effect on tibial diaphyseal fractures as it has had on femoral diaphyseal and other fractures. A previous study from Edinburgh has shown that in 1991, the overall incidence of tibial fractures in the whole population was $24.4/10^5$/year. The incidence fell to $13.3/10^5$/year in 2010/2011, the reduced incidence being seen in males and females. The average age of males rose from 32.8 to 41.0 years, but in females, it fell from 60.7 to 43.6 years.[15]

Table 1.3 shows that relatively few tibial fractures occur in older patients and even in 65+ females only 30% of fractures occur in this age group. However, the fractures that do occur are associated with a high prevalence of high energy injuries and open fractures. Tables 1.7 and 1.8 show that there is a high incidence of open fractures, particularly in 80+ females, again illustrating the problems of a subcutaneous location and increasing frailty.

Table 1.6 shows that all tibial diaphyseal fractures occurred as a result of a standing fall or a high energy injury. All of the high energy injuries were road traffic accidents and 80% of these fractures occurred in pedestrians. Assessment of the fracture morphology shows that despite a high incidence of open fractures there were very few AO/OTA[23] Type C complex fractures. In the 65+ group, 56.2% were Type A simple fractures, 37.5% were Type B wedge fractures and 6.3% were Type C fractures. The equivalent figures for the 80+ group were 57.1%, 42.9% and 0%. The most common associated fracture was the proximal humerus fracture which occurred in 40% of the 65+ group.

Distal tibia

Many orthopaedic surgeons associate distal tibial fractures with high energy injuries in young patients. Tables 1.4 and 1.5 indicate that this is the case in males but 39.4% of all distal tibial fractures in females occurred in the 65+ group. As with other elderly fractures, their morphology tends to be more benign than that seen in younger patients and in the 65+ group 87.5% were AO/OTA[23] Type A extra-articular fractures and 12.5% were Type B partial articular fractures. The equivalent figures for the 80+ group were 80% and 20%. Virtually all distal tibial fractures in the elderly are caused by falls, but as with other fractures, the subcutaneous location of the distal tibia means that there is a relatively high incidence of open fractures in the 80+ group (Table 1.6). It should, however, be noted that Tables 1.7 and 1.8 show that in the 15-year study the highest incidence of open fractures was seen in 65+ females[21] and that there was also a high prevalence of Gustilo type III[22] fractures in this group. No patients presented with associated fractures.

Ankle

Ankle fractures are very common but only 23.6% of all ankle fractures occurred in patients ≥65 years of age. However, Table 1.3 shows that ankle fracture accounted for 6.8% of all fractures in the 65+ group and they were the fourth most common elderly fracture. In females, the incidence stays constant from 65+ onwards, but in males, it decreases from 75 onwards and thus the fracture has a Type IV[18] pattern. A previous study has shown that bimalleolar and trimalleolar fractures present more commonly in older patients and these ankle fracture variants should be regarded as fragility fractures.

Analysis of fracture morphology shows that in the 65+ group 25.9% were AO/OTA[23] Type A infra-syndesmotic fractures, 67.6% were Type B trans-syndesmotic fractures and 6.5% were Type C supra-syndesmotic fractures. The equivalent figures in the 80+ group were 24.4%, 74.4% and 1.3%, indicating that older patients tend to have more benign ankle fractures. In the elderly, most ankle fractures follow a fall, but despite this, like all fractures in the tibia, the subcutaneous location of the ankle means that older patients, with frailer skin, will have a higher prevalence of open fractures.[21] Tables 1.7 and 1.8 show that the incidence of open fractures is higher in females and in the 80+ group. Analysis of the fractures associated with ankle fractures in the 65+ group showed that 53.3% were in the foot with 26.7% being metatarsal fractures and 15.0% being calcaneal fractures.

Talus

Fractures of the talus very rarely occur in older patients. Only two occurred in the 2-year study. Both were lateral process fractures that followed standing falls. Neither were open and there were no associated injuries. In the 15-year study of open fractures,[21] there were no open talar fractures.

Calcaneus

Like distal tibial and talar fractures, calcaneal fractures are associated with high energy injuries in younger patients. This is undoubtedly the case, but Table 1.5 shows that 24.1% of all calcaneal fractures in females occurred in the 65+ group. As with ankle fractures, the incidence in males declines after 75 years of age giving them a Type IV fracture pattern.[18]

The epidemiology was different in the 65+ and 80+ groups. In the 65+ group, 36.4% were extra-articular and 63.6% were intra-articular. The high energy nature of the fracture morphology is confirmed by the fact that 18.2% occurred as a result of a fall from a height and 9.1% after a road traffic accident. All of the associated fractures were in the foot and 60% were ankle fractures.

In the 80+ group, all of the fractures followed standing falls, again implying patient frailty. Analysis showed that 66.6% were extra-articular and 33.3% were intra-articular. There were no associated fractures. Tables 1.7 and 1.8 show that open calcaneal fractures in the elderly are rare, but when they do occur they tend to be Gustilo type III[22] fractures.

Midfoot

Midfoot fractures, like other fractures of the foot, occur mainly in younger patients. Even in females only 28.6% occur in patients aged ≥65 years. However, in females the rate decreases after 75 years of age and consequently midfoot fractures have a Type V fracture pattern.[18] In the 65+ group, 44.4% of fractures were in the cuboid, 33.3% were cuneiform fractures and 22.2% were navicular fractures. There was only one cuneiform fracture in the 80+ group. Analysis shows that, like calcaneal fractures, there was a high prevalence of high energy injuries in the 65+ group. Further review shows that 66.6% of the high energy fractures occurred in road traffic accidents and 33.3% in falls from a height. There were no open fractures and no associated fractures. Tables 1.7 and 1.8 show that in the 15-year study, there were no open midfoot fractures.[21]

METATARSUS

Metatarsal fractures are more commonly seen in younger patients, although Table 1.5 shows that 23.8% of female metatarsal fractures occur in the 65+ group. Analysis shows that fractures are more common in the lateral metatarsals in both 65+ and 80+ patients. In the 65+ group, 2.5% occurred in the hallux metatarsal, 10.2% in the second metatarsal, 10.7% in the third metatarsal, 15.7% in the fourth metatarsal and 60.9% in the fifth metatarsal. The equivalent figures in the 80+ group were 2.0%, 14.3%, 10.2%, 16.3% and 51.1%.

Table 1.6 shows that most metatarsal fractures in the elderly occur as a result of a standing fall, but in the 65+ group and 80+ group 5.1% and 6.1%, respectively, were caused by a direct blow. There were no open fractures in the 2-year study, but review of Tables 1.7 and 1.8 shows that when open fractures occur they tend to be in older females and there is a high prevalence of Gustilo type III[22] fractures. In the 65+ group, 12.6% of patients had multiple fractures, but 44.4% of these presented with multiple metatarsal fractures and 27.8% had ankle fractures. In the 80+ group, 28.6% had other metatarsal fractures and 28.6% also had ankle fractures.

Toes

Fractures of the toes are relatively rare in older patients. None occurred in 80+ females. Overall, 64.5% were caused by direct blows or crush injuries and the only associated fractures were other toe fractures which occurred in 5.9% of the 65+ group. Table 1.5 shows that toe fractures did not occur in 80+ females and Tables 1.7 and 1.8 show that open toe fractures occur more commonly in males.

Spinal fractures

Spinal fractures were not recorded during the study period because the epidemiology of spinal fractures in the elderly is virtually impossible to assess. Grados et al.[32] analysed the prevalence of vertebral fractures in elderly French women and found that 22.8% of women, with an average age of 80.1 years, had a vertebral fracture. The prevalence and number of fractures increased with age such that 41.4% of women aged ≥85 years had vertebral fractures.

Recently, attempts have been made to assess the frequency of vertebral fractures in post-menopausal females using radiological techniques. A recent study[33] has shown that 30.7% of women ≥50 years of age had a previously undiagnosed vertebral fracture. This indicates that the incidence of vertebral fractures in women is extremely high and it suggests that vertebral fractures have a Type II pattern.[18] The incidence of vertebral fractures in older males is essentially unknown, but it is perfectly possible that vertebral fractures actually have a Type I pattern.[18]

FRACTURE PROBABILITY

The probability of the 65+ and 80+ populations having a fracture has been assessed by analysing all patients treated in the Royal Infirmary of Edinburgh over three 1-year periods between 2000 and 2011. During these periods, about 7000 fractures were treated in patients aged ≥65 years and analysis of the number of fractures and size of the 65+ and 80+ populations has allowed the calculation of fracture probabilities in males and females. Some fractures, such as those of the scapula, talus and midfoot, are so rare in the elderly that the probability of fracture could not be calculated, but Table 1.9 shows the probability of most fractures in males and females aged ≥65 and 80 years. The overall fracture probability and the probability of upper and lower limb fractures are also shown.

THE FUTURE

By extrapolating the data gained from the 2-year study in Edinburgh[18] and adding fractures that have been previously shown to be fragility fractures,[11] it is possible to list all the fractures that are liable to increase in incidence in the elderly population over the next few decades. These fractures are shown in Table 1.10. Obviously, with increasing population size, all fractures are likely to become more common, but unless there are massive socio-economic changes in the population or osteoporosis is treated more effectively, it seems likely that the fractures listed in Table 1.9 will become more common, particularly in first world countries.

Analysis of the Edinburgh figures together with an assessment of life expectancy permits the calculation of fracture risk.[18] In 65+ patients, the lifetime risk of fracture is 18.5% for males and 52.0% for females. The equivalent figures for the 80+ group are 13.3% and 34.8%. If the results of the study are extrapolated to 2030, it is likely that there will be about 393,000 non-spinal fractures in the elderly in the United Kingdom. If one simply takes the projected population of people aged ≥65 years in the United States in 2030 and compares it with the projected population of the United Kingdom, it becomes clear that there will be about 1.8 million fractures in the 65+ group in the United States in 2030. Further extrapolation of the Edinburgh data shows that the classic fragility fractures of the proximal femoral, distal radius and ulna, proximal humerus and pelvis will account for 31.8%, 20.2%, 11.7% and 4.0%, respectively, but the other fractures listed in Table 1.9 will account for 32.3% of non-spinal fractures in the elderly. It is therefore clear that fractures in the elderly are going to become a major health issue and all countries should be planning how these fractures are going to be treated in 20 years time.

Table 1.9 The probability of males and females aged ≥65 years and ≥80 years getting different types of fractures

	≥65 years		≥80 years	
	Males	Females	Males	Females
Clavicle	2147-1	1875-1	1346-1	1016-1
Proximal humerus	720-1	288-1	358-1	199-1
Humeral diaphysis	5521-1	2683-1	2861-1	1920-1
Distal humerus	10539-1	3115-1	4578-1	1620-1
Proximal radius/ulna	2273-1	1044-1	1526-1	926-1
Radius/ulna diaphyses	10539-1	6977-1	5723-1	2880-1
Distal radius/ulna	637-1	131-1	440-1	91-1
Scaphoid	16562-1	8721-1	0	10368-1
Metacarpus	3864-1	1466-1	1761-1	1127-1
Finger phalanges	1247-1	1246-1	818-1	894-1
Pelvis	5797-1	13417-1	2289-1	6480-1
Proximal femur	229-1	113-1	71-1	46-1
Femoral diaphysis	2415-1	1571-1	954-1	720-1
Distal femur	14492-1	3876-1	5723-1	1571-1
Patella	6820-1	2769-1	3815-1	1058-1
Proximal tibia	6820-1	3792-1	3270-1	2469-1
Tibia/fibula diaphyses	7729-1	6977-1	7630-1	3703-1
Distal tibia	38644-1	9180-1	22890-1	8640-1
Ankle	1026-1	535-1	1205-1	524-1
Calcaneus	12881-1	15856-1	0	12960-1
Toes	8918-1	17442-1	5723-1	51840-1
Upper limb fractures	187-1	67-1	111-1	46-1
Lower limb fractures	139-1	68-1	54-1	32-1
Overall	77-1	33-1	36-1	19-1

Table 1.10 Fractures that are likely to become more common in elderly patients

Males	Females
Distal clavicle	Clavicular diaphysis
Proximal humerus	Distal clavicle
Proximal ulna	Proximal humerus
Distal radius and ulna	Humeral diaphysis
Metacarpus	Distal humerus
Pelvis	Proximal radius and ulna
Thoracolumbar spine	Radial diaphysis
Proximal femur	Ulnar diaphysis
Femoral diaphysis	Distal radius and ulna
	Pelvis
	Thoracolumbar spine
	Proximal femur
	Femoral diaphysis
	Distal femur
	Patella
	Proximal tibia
	Bimalleolar ankle
	Trimalleolar ankle

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