

# The Epidemiology of Cycling Fractures in Adults

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## Abstract

**Objective:** To Understand the Epidemiology of Cycling Fractures. Cycling injuries are increasing in incidence but there is, as yet, very little information about which fractures are associated with cycling.

**Methods:** We have undertaken a prospective study of cycling fractures in adults over a one-year period in 2010-11. All in-patient and out-patient fractures in patients aged  $\geq 16$  years were examined.

**Results:** The results show that 3.6% of all fractures are caused by cycling and that the highest incidence in males is between 30-39 years of age with the highest incidence in females being between 50-59 years. The highest incidence in all types of cycling is in young males following road traffic accidents. Overall 86.5% of the fractures were in the upper limb and 29.3% were around the shoulder with clavicular fractures being the most common cycling fracture. The commonest lower limb fracture was the proximal femoral fracture, this usually being considered to be an osteoporotic fracture. We believe that this fracture occurs in cycling because of the use of shoes that are fixed to the pedals. There were very few foot fractures associated with cycling.

**Conclusions:** Cycling is a common cause of fractures. It is the commonest cause of fracture after road traffic accidents and the third commonest cause of fracture after sports injury. Our results demonstrate the importance of protective clothing and cycle paths.

**Keywords:** Fractures; Epidemiology; Cycling; Mountain biking; Road traffic accidents

## Introduction

Cycling is increasingly popular in many countries. In Australia it has been estimated that there was a 20.9% increase in bike trips per day between 1985/86 and 2011 in people over 9 years of age [1]. There is also evidence of a 45% increase in cycling in the Netherlands between 1980-2005, and a 91% increase in London since 2000 [2]. The overall incidence of injuries associated with cycling is difficult to determine as not all cycling accidents are reported but UK Government statistics indicate that the number of fatalities has decreased since 2005 although the numbers of cyclists that sustained injuries rose during this period with increased rates of injury being recorded in both seriously injured and slightly injured cyclists [3]. This increase is mirrored in a study of insurance claims by road users where there was a significant decrease in the frequency of claims by all road users except cyclists [4].

The types of injury that occur in cyclists have been examined in a number of studies but only in broad terms. Understandably there has been considerable interest in the frequency of head injuries particularly in relation to the debate over the use of cycle helmets. However there are other injuries that are often associated with considerable morbidity of which one of the most common is fractures. An analysis of the literature shows that there is very little information about which fractures are caused by cycling. A recent insurance study in Tasmania showed that 20.7% of claims after road traffic accidents were for fractures these being the commonest types of injury leading to a claim [4]. A recent study of injuries in top-level cyclists showed that 90.5% of fractures were upper limb fractures [5] and it is accepted that clavicular fractures commonly occur as a result of cycling accidents [5,6,7]. The prevalence of spinal fractures has also been documented [8]. However we can find no previous study of the overall epidemiology of cycling fractures.

## Materials and Methods

All in-patient and out-patient fractures presenting to the Royal Infirmary of Edinburgh during a one-year period between September

2010 and August 2011 were prospectively analysed. The Royal Infirmary of Edinburgh is the only hospital treating adult orthopaedic trauma in the City of Edinburgh, Midlothian and East Lothian and to permit accurate calculation of fracture prevalence and incidence the population examined in this study was restricted to this defined population area. The Royal Infirmary also acts as a secondary Trauma Centre for other injuries in the south of Scotland but in this study all patients treated in the hospital but resident out with the defined population area were excluded from analysis although patients injured out with our population area but resident within it were included.

The study was undertaken in adults aged  $\geq 16$  years. The population of the catchment area was calculated from Scottish government figures which show that in 2010 there were 558,220 adults aged  $\geq 16$  years in Edinburgh, East Lothian and Midlothian of which 265,971 were male and 292,249 were female [9]. Fracture incidence was defined as the number of fractures/10<sup>5</sup>/year.

The fractures recorded in the study were defined according to Orthopaedic Trauma Association (OTA) criteria [10]. They were defined according to their location with fractures of the long bones being divided into proximal, middle and distal fractures according to OTA criteria. Open fractures were classified according to the Gustilo classification [11,12].

Fractures of the proximal radius and ulna were combined as proximal forearm fractures and fractures of the distal radius and distal ulna were also combined as were fractures of the tibial and

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fibular diaphyses. Spinal fractures were recorded and analysed but it is impossible to give an accurate incidence of these fractures in the population as most spinal fractures occur in the elderly and many patients with spinal fractures are not admitted to hospital. However very few elderly osteoporotic patients will have cycling fractures and the stated incidence is probably representative of the younger cycling population.

Cycling fractures were recorded according to their precise mode of injury. They were therefore separated into fractures secondary to road traffic accidents and to those caused by recreational cycling. This latter category was separated into recreational cycling injuries and mountain biking injuries. One fracture caused by an accident with a BMX bicycle was included with the recreational cycling injury group. We have been unable to document fractures in cyclists killed as a result of road traffic accidents but fatal accidents are rare and we doubt that their inclusion would significantly alter the fracture epidemiology.

## Results

During the study year 7,100 in-patient and out-patient fractures were treated in the Royal Infirmary of Edinburgh. Of these 259 (3.6%) resulted from cycling. The average age of the patients who presented with cycling fractures was 39.3 years (16-75 years) with the average age in males and females being 38.0 and 45.3 years respectively. The gender ratio was 83/17 males/females and 11 (4.2%) of the fractures occurred in patients aged  $\geq 65$  years. The gender ratio in this group was 64/36. The age-related fracture incidence curves in males and females are shown in figure 1. The fractures occurred in 239 patients with 223 patients presenting with an isolated fracture, 13 patients with 2 fractures, 2 patients with 3 fractures and 1 patient with 4 fractures. Eleven (4.2%) of the fractures were open.

The epidemiology of all cycling fractures treated in the Royal Infirmary of Edinburgh in the one-year period is shown in table 1 which also shows the overall percentage of the different fracture types which were caused by cycling.

Overall 224 (86.5%) of all cycling fractures occurred in the upper limb, 28 (10.8%) were in the lower limb and 7 (2.7%) occurred in the spine or pelvis. Analysis of all the fractures in the study year showed that cycling accounted for 5.3% of all upper limb fractures, 1.1% of all lower limb fractures and 3.1% of all spine or pelvic fractures. There were no fractures of the humeral diaphysis, femoral diaphysis, distal femur, talus, calcaneus, mid foot or toes as a result of cycling.

Analysis of the different types of cycling fractures showed that 64.5% occurred as a result of road traffic accidents, 27.4% as a result of recreational cycling and 8.1% were caused by mountain biking.

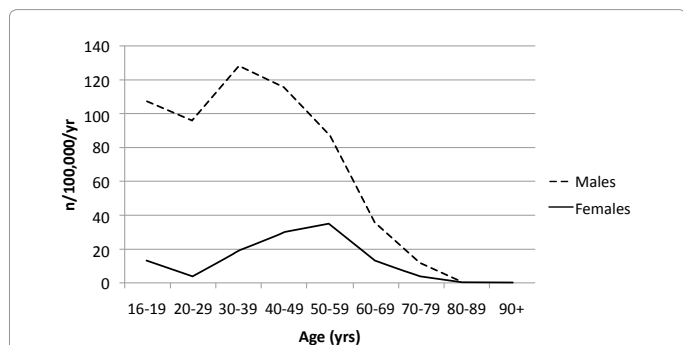


Figure 1: The age-related gender incidence curves for cyclist who present with fractures.

	Cycle fractures					All fractures
	No	(%)	n/10 <sup>5</sup> /yr	Age (yr)	M/F (%)	%
Clavicle	51	19.7	9.1	39.5	84/14	19.8
Proximal forearm	49	18.9	8.8	37.8	75/25	13.0
Distal radius/ulna	33	12.7	5.9	37.4	82/18	2.7
Metacarpus	26	10.0	4.7	36.8	85/15	3.3
Fingers	21	8.1	3.8	39.1	90/10	3.0
Proximal humerus	14	5.4	2.5	38.7	86/14	2.9
Carpus	13	5.0	2.3	33.2	85/15	6.7
Scapula	11	4.2	2.0	42.4	100/0	29.7
Proximal femur	7	2.7	1.3	48.0	86/14	0.9
Metatarsus	6	2.3	1.1	38.8	33/67	1.3
Proximal tibia	6	2.3	1.1	48.7	67/33	10.2
Distal humerus	5	1.9	0.9	37.8	100/0	10.4
Spine	5	1.9	0.9	49.0	100/0	4.8
Ankle	4	1.5	0.7	46.0	50/50	0.6
Tibia and fibula diaphyses	2	0.8	0.4	61.5	50/50	1.8
Patella	2	0.8	0.4	37.0	100/0	4.1
Pelvis	2	0.8	0.4	58.0	100/0	1.7
Distal tibia	1	0.4	0.2	38.0	100/0	2.4
Forearm diaphyses	1	0.4	0.2	50.0	100/0	1.8
Total	259	100	46.6	39.3	83/17	3.6

Table 1: The prevalence, incidence, average age and gender ratios for all fractures caused by cycling during the study year, the percentage of all fracture types caused by cycling is also shown.

The basic demographic details of the three different modes of cycling fractures are shown in table 2. Table 3 shows the prevalence of upper limb, lower limb and spine and pelvic fractures in the three different types of cycling fractures. The prevalence of the different fracture types is also shown.

A review of the cycling fractures that occurred in the older population showed that 63.6% of fractures in this age group were in the upper limb, 27.3% occurred in the lower limb and 9.1% occurred in the pelvis or spine. There was one pelvic fracture. The commonest fractures in the  $\geq 65$  year group were those of the clavicle (18.2%), and distal radius and ulna (18.2%). Only one patient (9.1%) presented with two fractures these being adjacent metacarpal fractures. Seven (63.6%) of the fractures resulted from road traffic accidents and the remaining four (36.4%) occurred in recreational cycling.

A review of the 16 patients who presented with multiple fractures as a result of cycling showed that the average age was 42.2 years, the gender ratio was 81/19 and 2 (12.5%) occurred in patients aged  $\geq 65$  years. The basic demographic characteristics of patients who presented with single and multiple fractures as a result of cycling are shown in table 4.

An analysis of the types of fracture that presented in patients with multiple fractures showed that three patients had sustained ipsilateral fractures of both their clavicle and scapula. One presented with these two fractures and one patient, who presented with three fractures, also had a distal humeral fracture. The patient who presented with four fractures had fractures of the clavicle, scapula and two adjacent thoracic vertebra.

An analysis of the 11 patients with open fractures shows that the average age was 41.0 years, the gender ratio was 91/9 and only one patient (9.1%) was  $\geq 65$  years this being a 74 year old male who presented with a Gustilo IIIb open tibial diaphyseal fracture. Seven patients (63.6%) presented with Gustilo type I open fractures, two (18.2%) with Gustilo II open fractures and one other patient presented with a Gustilo type III open fracture this being a Type IIIa open distal

radius. There were four open finger fractures, two open distal radial fractures and two open distal humeral fractures in addition to one open clavicle and one open metacarpal fracture. The only forearm diaphyseal fracture (Table 1) was a Gustilo type 1 open fracture.

### Discussion

Data regarding fractures caused by cycling is surprisingly rare. We accept that the epidemiology of cycling fractures may vary in different areas but we believe that our results will give an indication of the overall incidence of cycle fractures. Our results show that cycling caused 3.6% of all fractures presenting to a large Trauma Unit. Analysis of all fractures presenting to the Unit during the study year shows that 62.5% were caused by a fall from standing height and that sport and road traffic accidents caused 11.1% and 5.2% of all fractures. Cycling caused 46.7% of all road traffic accident fractures and 12.7% of all sport fractures.

Our data shows that cycling fractures generally occur in younger adults although figure 1 shows that the distribution in males and females is slightly different. The highest incidence of cycling fractures in males occurs between 30-39 years of age whereas in females it is between 50-59 years of age. Cycling fractures in older patients are rare but the epidemiology of fractures in patients aged  $\geq 65$  years is similar to that seen in younger patients. Table 2 shows that cycling fractures are 5.3 times more common in males than females and that the highest incidence of cycling fractures occurs in males injured in road traffic accidents.

The importance of cycling fractures in road traffic accidents cannot be overemphasized. Table 5 shows the demographic details of all road traffic accident fractures admitted to the Unit during the study year. It can be seen that most road traffic accident fractures occur in cyclists with the fewest fractures occurring in vehicle occupants. Table 5 shows that fractures in motorcyclists and vehicle drivers in particular were more serious, with a higher prevalence of open and multiple fractures, but almost 50% of all road traffic accident fractures actually occur in cyclists. We believe that this fact strengthens the argument for improved cycle paths and protective clothing. A review of sports related cycle fractures shows that cycling fractures accounted for 12.7% of all sports fractures. Only football (42.2%) and rugby (14.1%) were associated with a higher prevalence of sports related fractures.

Table 1 shows that the commonest eight fractures associated with cycling are all upper limb fractures with the commonest fractures being those of the clavicle and proximal forearm each accounting for about 20% of cycling fractures. Lower limb fractures are uncommon and in the study year the only lower limb cycling fractures that were seen were those of the proximal femur, patella, proximal tibia, tibial and fibular diaphyses, ankle and metatarsus. The foot would seem to be particularly well protected in cycle injuries as in this series only 2.3% of cycle fractures occurred in the foot, all of them being metatarsal fractures. The overall prevalence of foot fractures in the study year was 11.7% with 6.4% of road traffic accident fractures and 9.4% of sports fractures occurring in the foot. Presumably the low prevalence of foot

					Incidence (n/10 <sup>5</sup> /year)		
	N	%	M/F (%)	Age (yr)	All	Males	Females
Rta	167	64.5	81/19	40.6	29.9	56.0	11.8
Cycling	71	27.4	82/18	37.4	12.7	24.1	4.8
Mountain biking	21	8.1	100/0	34.8	3.8	8.7	----
Total	259	100	83/17	39.3	46.4	88.8	16.6

**Table 2:** The prevalence, gender ratios, average age and incidences for patients who sustained fractures as a result of the different types of cycling.

	Fracture prevalence (%)		
	Rta	Cycling	Mountain biking
Upper limb	88.0	81.7	90.4
Lower limb	8.4	16.9	9.5
Spine/pelvis	3.6	1.4	----
Clavicle	21.0	15.5	23.8
Proximal forearm	19.2	22.5	4.8
Distal radius/ulna	12.6	9.9	23.8
Metacarpus	9.6	11.3	9.5
Fingers	7.2	9.9	9.5
Proximal humerus	4.8	5.6	9.5
Carpus	5.4	5.6	----
Scapula	4.8	1.4	9.5
Proximal femur	1.8	4.2	4.8
Metatarsus	0.6	7.0	----
Proximal tibia	1.8	2.8	4.8
Distal humerus	3.0	----	----
Spine	3.0	----	----
Ankle	1.2	2.8	----
Tibia and fibula diaphyses	1.2	----	----
Patella	1.2	----	----
Pelvis	0.6	1.4	----
Distal tibia	0.6	----	----
Forearm diaphyses	0.6	----	----

**Table 3:** The prevalences of the different fracture types seen in the different cycling injuries

	Patients (%)				Age (yr)	M/F (%)
	All	Rta	Cycle	MB		
Single fractures	93.3	91.3	98.6	90.5	38.7	82/18
Multiple fractures	6.7	8.7	1.4	10.5	42.2	81/19

**Table 4:** The epidemiological details of patients who presented with single and multiple fractures

	%	Average age (yrs)	M/F (%)	Open fractures (%)	Multiple fractures (%)
Cyclist	46.7	40.2	81/19	6.0	8.6
Motorcyclist	21.7	41.0	90/10	10.3	21.3
Pedestrian	17.5	48.8	62/38	3.2	24.4
Vehicle driver	10.2	47.2	76/24	8.1	34.8
Vehicle passenger	2.2	29.6	50/50	0	16.7

**Table 5:** The basic epidemiological data for all fractures occurring as a result of a road traffic accident during the study year

fractures in cycling injuries relates to the use of protective shoe wear and to the fact that the foot is rarely run over in road traffic accidents.

It is perhaps surprising that the commonest lower limb fracture associated with cycling is the proximal femoral fracture. The proximal femoral fracture is the classic osteoporotic fracture and the average age of patients who presented with proximal femoral fractures during the study year was 80.7 years and 73% of the patients were female. Table 1 shows that the patients who had proximal femoral fractures had a slightly higher average age but we think it likely that the high prevalence of proximal femoral fractures in this group of young males relates to the use of cycle pedals which are clipped to the cyclists' shoes. The result of this is that if cyclists cannot remove their feet from their pedals they fall heavily on their hips. This has been previously reported [13-15] but we believe that the extent of the problem has not been appreciated.

Table 1 shows that cycling accounted for >10% of five different

fracture types in the study year. Overall scapular fractures are very uncommon with only 37 being treated in the Unit during the study year. Eleven (29.7%) followed cycling accidents. All occurred in males and 8 (72.7%) occurred in road traffic accidents. The fact that 7 (63.6%) patients presented with other fractures indicates that cycling fractures of the scapula are high energy injuries. A review of the type of scapular fractures shows that four (36.4%) were body fractures and that five (45.5%) were glenoid fractures. There were two (18.2%) acromion fractures as only three acromion fractures were seen in the study year 66.6% of all acromion fractures were caused by cycling.

Table 1 shows that 19.8% of all clavicle fractures in the study year resulted from cycling. It has previously been documented that clavicle fractures are the commonest fractures associated with cycling [5-7] and Aitken et al. [7] have previously reported that 26% of fractures associated with mountain biking were clavicle fractures. Analysis of the overall distribution of clavicle fractures in the study year showed that only 2.7% were in the medial third of the clavicle with 48.6% being in the middle third and 48.6% in the lateral third. A review of the cycling clavicle fractures showed that 3.9% were in the medial third, 56.8% were in the middle third and 39.2% were in the lateral third of the bone. Further analysis showed that 72.4% of middle third fractures resulted from road traffic accidents and 13.8% from mountain biking. This compares with 60% and 5% respectively in lateral third fractures suggesting that middle third fractures are higher energy injuries.

Proximal forearm fracture fractures are the second commonest cycling fracture. In this study 41 (83.7%) were proximal radial fractures of which 34 (69.4%) were radial head fractures and 7 (14.3%) were radial neck fractures. A further 5 (10.2%) were proximal ulna fractures and the remaining 3 (6.1%) were fractures of both the proximal radius and ulna. Overall 32 (65.3%) were caused by road traffic accidents, 16 (32.7%) followed recreational cycling injuries and one (2%) was caused by mountain biking.

Table 1 shows that 10.4% of distal humeral fractures in the study year were caused by cycling accidents. In the general population these are usually osteoporotic fractures and it seems likely that if they occur as a result of cycle accidents they are probably high energy injuries. In fact all five of the fractures occurred as a result of road traffic accidents and two (40%) were open fractures. In addition two (40%) of the patients had multiple fractures. Analysis of the proximal tibial fractures seen in the study year showed that 10.2% followed cycling injuries. Unlike the distal humeral fractures all the distal tibial fractures were closed isolated fractures. The average age of the patients was 48.7 years and the two oldest patients were females aged 58 and 63 years suggesting that osteopenia might be a factor in some cycling fractures. It may well be as the population ages we will see more cycling fractures in older people including more fracture types that we associated with osteopenia.

Table 3 shows the prevalence of the different fracture types seen in different types of cycling. Unsurprisingly road traffic accident related fractures have a wider spectrum with more fracture types being seen. Despite this 88% of the fractures were in the upper limb. Recreational cycling and mountain biking were associated with fewer types of fracture there being only nine different fracture types in mountain bike fractures compared with 13 in recreational cycling and 19 in road traffic accidents. The literature suggests that mountain bikers wear better protective clothing than road cyclists [6,7] and this may account for some of the differences, particularly when one considers that many mountain bike injuries are high energy injuries.

It is clear from our data that fractures around the shoulder are a particular problem for cyclists. This has been stated in previous studies [5-7] but our data indicates that overall 29.3% of cycling fractures involve the clavicle, proximal humerus or scapula. The highest rate of shoulder injuries was seen in mountain biking where 42.8% of fractures were around the shoulder. Our study shows that while fractures in bones adjacent to the shoulder, elbow and wrist comprise 66% of all cycling fractures there were no humeral diaphyseal fractures and only one forearm diaphyseal fracture. We are not sure why this is the case but it does indicate that the forces that result in cycling fractures are mainly applied to these three upper limb joints.

Our data shows that cycle fractures are relatively common. With increasing car safety and improved legislation regarding speeding and drink driving the prevalence of other types of fracture following road traffic accidents is declining. Cycling fractures are now the commonest type of fracture associated with road traffic accidents and this suggests that improved safety measures and cycle paths are required.

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**Ethics:** The local ethical committee considers that this study is audit and no formal ethical permission was required.

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