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The relative incidence of fracture non-union in the Scottish population (5.17 million): a 5-year epidemiological study

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ABSTRACT

Objectives: In the UK there are approximately 850 000 new fractures seen each year. Rates of non-union of 5–10% of fractures have been suggested, the cost to the National Health Service of treating non-union has been reported to range between £7000 and £79 000 per person yet there are little actual data available. The objective of this epidemiological study therefore is for the first time to report the rates of fracture non-union.

Design: A cross-sectional epidemiological study.

Setting: The population of Scotland.

Participants: All patient admissions to hospital in Scotland are coded according to diagnosis. These data are collected by (and were obtained from) Information Services Department Scotland. Those who have been coded for a bone non-union between 2005 and 2010 were included in the study. No patients were excluded. Population data were obtained from the Registrar General for Scotland.

Outcome measure: The number of fracture non-unions per 100 000 population of Scotland according to age, sex and anatomical distribution of non-union.

Results: 4895 non-unions were treated as inpatients in Scotland between 2005 and 2010, averaging 979 per year, with an overall incidence of 18.94 per 100 000 population per annum. The distribution according to gender was 57% male and 43% female. The overall peak incidence according to age was between 30 and 40 years. The mean population of Scotland between 2005 and 2010 was 5 169 140 people.

Conclusion: Fracture non-union in the population as a whole remains low at less than 20 per 100 000 population and peaks in the fourth decade of life. Further research is required to determine the risk of non-union per fracture according to age/sex/anatomical distribution.

ARTICLE SUMMARY

Article focus

- The cost of treating non-union is between £7000 and £79 000 per case in the UK.
- There are no population data in the literature regarding the rate of non-union; smaller site specific cohort studies suggest it to be a complication of fracture healing in up to 5–10% of cases.
- This study aims to report for the first time the rates of fracture non-union of different anatomical regions for a large population, taking into account the age and sex distribution.

Key messages

- There were almost 1000 non-unions treated in Scotland each year between 2005 and 2010 with an annual non-union incidence of 22.45 in men and 15.65 in women per 100 000 population per annum.
- The age/gender distribution was bimodal in men and unimodal in women reflecting the larger number of fractures seen with higher energy injuries in the young males and the osteoporotic fractures in the elderly.
- Non-union was more frequent in the upper than the lower limb, likely reflecting the higher incidence of fractures in the upper limb compared with the lower limb.

Strengths and limitations of this study

- This is the first study of its kind in the literature to attempt to measure the incidence of non-union in the general population.
- It is based upon a stable population of 5.17 million people.
- It can be used as a baseline to compare healthcare systems and adequacy of trauma care provision elsewhere.
- It may under represent the true incidence as it does not account for the asymptomatic non-unions (rare) which do not seek treatment or in those where the risks of surgery outweigh the benefits to the individual (also rare).
- Further research is required to look at the rate of non-union per fracture in a large population setting.

INTRODUCTION

The WHO recognise trauma as a major healthcare epidemic with over 16 000 people dying each day and injury accounting for

16% of the global burden of disease.[1] People in a low-income setting are far more likely to suffer complications from traumatic injury than those in a high-income setting; for instance, Mock *et al*[2] report a sixfold higher death rate (36% vs 6%) in the severely injured between high-income and low-income areas. Even within Europe there are major inequalities recognised in the provision of trauma care between Eastern and Western states with a 3.6-fold difference in injury-related mortality between the high-income and low-income/middle-income countries.[3] For every trauma-associated death there are many more injured and for these injured individuals non-union of the fracture is one of the major causes of morbidity and creates a significant drain on a country's resources. However, there is a paucity of data available regarding the incidence of non-union on a national scale.

In the UK, there are approximately 850 000 new fractures seen each year (based on an incidence of fresh fractures of 13.8/1000/pa[4]) of which the majority heal without difficulty.

Rates of non-union of 5–10% of fractures have been suggested, yet there are little available data for this figure. The cost to the National Health Service (NHS) of treating non-union has been reported to range between £7000 and £79 000 per person.[5–8] However, this does not take into account the morbidity and loss of earnings of the individual nor any long-term health burden, so the cost to society will be far greater than this.

Complex non-unions are best treated by a specialist limb reconstruction service. In order to plan the provision of these services, countries and health boards require data on the rates of non-union per head of population. In addition, in order to design prospective clinical research studies on non-union it is necessary to know the incidence so that realistic recruitment rates can be calculated.

The aim of this study therefore was for the first time to report the rates of fracture non-union of different anatomical regions for a large population, taking into account the age and sex distribution.

METHOD

Every patient in Scotland has a unique community health index (CHI) number. Every patient admitted into hospital in Scotland has a code attached to their CHI number when they are discharged. This individual code is derived from the Information Classification of Diseases (ICD)-10 classification and is specific for the diagnosis from that admission; it is generated by trained coders who are specialty specific in each health trust.

It is mandatory for NHS Scotland Information Services Department (ISD) to collect all the ICD-10 data for all the hospitals in Scotland. The combination of the unique patient CHI number and ICD-10 data enables them to provide age, sex and hospital-specific details for each patient treated for a non-union upon request.

Information was obtained regarding all non-unions admitted to hospital in Scotland from 2005 to 2010. Patients were coded as having a non-union if the responsible surgeon for that inpatient episode recorded the diagnosis of non-union in the patient notes or correspondence. All patients coded for non-union were included.

To assess the quality and consistency of hospital coding we checked the codes of 100 consecutive non-union patients whom had been rated for NU as inpatients in Lothian over a similar time period. 97% had been correctly coded for, those that had not been had codes for malunion or osteomyelitis (which had been present in addition to the NU).

The population data for Scotland between 2005 and 2010 were obtained from the Registrar General for Scotland who publish an annual mid-year population estimate with details of sex, age, council and the health board.

RESULTS

In total, 4895 non-unions were treated as inpatients in Scotland between 2005 and 2010, averaging 979 per year, with an overall incidence of 18.94/100 000 population per annum. The distribution according to gender was 57% male and 43% female. The overall peak incidence according to age was between 30 and 40 years. The mean population of Scotland between 2005 and 2010 was 5 169 140 people.

Overall, the actual numbers of non-unions treated were distributed fairly evenly across the ages from 15 to 75 years (table 1). The majority of non-unions occurred in the working-aged population. However, the incidence per capita demonstrated a different distribution. As expected, less than 4% of non-unions were accounted for by the paediatric population with 66% in the 15-year-olds to 60-year-olds and 30% in those older than 60 years.

5-year trend of non-union

The mean incidence of NU over the 5-year period was 22.45 in men and 15.65 in women per 100 000 population per annum. The incidence of non-union in women has remained constant over the past 5 years. In males it has fallen, with a 9.3% drop in non-union numbers despite a rise in the male population, thus the non-union incidence has fallen by 10.5% either due to a fall in the fracture incidence or improvement in overall management and healing of fractures since 2005. Non-union incidence has remained consistently higher in the male compared with the female population although with the fall in numbers of non-union in male patients the gap has narrowed (table 2).

Distribution of non-union with age and sex

Figure 1 demonstrates that the pattern of non-union varied in three age groups; the paediatric population had a very low incidence (less than 5 per 100 000 per annum) followed by a sharp rise and a plateau which

Table 1 Non-union numbers Scotland 2005–2010

Site location	0–14 years	15–29 years	30–44 years	45–59 years	60–74 years	75 years+	Total
Shoulder region (clavicle and scapula)	2	106	163	171	109	45	596
Upper arm (humerus)	10	41	93	184	228	178	734
Forearm (radius and ulna)	79	435	359	166	129	58	1226
Hand	3	120	65	37	13	3	241
Pelvis and femur	7	38	76	114	169	175	579
Lower leg (patella, tibia and fibula)	35	137	189	168	94	49	672
Ankle and foot	15	95	113	141	81	41	486
Axial skeleton	0	15	13	13	30	17	88
Multiple sites	0	4	2	3	2	1	12
Number of additional details	29	51	60	46	47	28	261
Total	180	1042	1133	1043	902	595	4895

was observed in the 20-year to 70-year age group at around 20 NU per 100 000 population per year. A second rise and further plateau was observed in the elderly at about 28/100 000 per annum.

When the data were divided into the separate sexes a different pattern was evident. In the men there was a high peak in the early adult years (25-year-olds to 29-year-olds), accounted for mostly by forearm non-union, followed by a gradual decline in incidence and a second small peak in the eighth decade due to a rise in the incidence of humeral and femur/pelvis non-unions. In the female population there was a consistently steady increase in NU incidence from childhood onwards with the female incidence overtaking that of the males in the 50-year to 60-year age group and peaking in the 75-year to 79-year age group. Similar to the male population, this peak was predominantly due to an increased incidence of humeral and femoral/pelvis non-unions.

This distribution of non-union reflected the bimodal (men) and unimodal (women) distribution of fresh fractures that has been reported with age and sex in adults.[9]

Anatomical distribution of non-union

Table 3 and figure 2A,B detail the incidence of non-union by site and age. Non-union occurred 60% more frequently in the upper than the lower limb. Five per cent of non-union patients coded had data unavailable regarding their specific anatomical site.

Table 2 A 5-year summary of non-union from 2005 to 2010

NU patient numbers				Incidence/100 000		
Year	Female	Male	Total	Female	Male	Total
2005/06	402	619	1021	15.18	25.07	19.95
2006/07	419	559	978	15.76	22.49	19.01
2007/08	420	576	996	15.74	23.04	19.27
2008/09	426	532	958	15.9	21.15	18.44
2009/10	421	521	942	15.64	20.59	18.04
5 years mean	417.6	561.4	979	15.65	22.45	18.94

Notably, the forearm had the highest NU rate overall, 2.5 times more common in males (6.68/100 000) than in females (2.79/100 000) with the majority of cases occurred in the younger population. The hand had one of the lowest rates of NU and these occurred predominantly in the young male patients (1.5/100 000) compared with female patients (0.4/100 000).

The humerus was the most frequent site of NU in women (3.54/100 000 population) and this became a greater problem with increasing age, representing the increasing number of osteopaenia-related proximal humerus fractures in the elderly. The shoulder, which was predominantly the clavicle, was affected 50% more frequently in males but with a more even distribution across the ages.

In the lower limb, NU of the femur and pelvis was more common in females, the incidence increased from the sixth decade upwards following a similar trend to that of the humerus. The highest rate of non-union in the lower limb was seen in the male leg: non-union of the tibia and fibula was the second-highest site of non-union overall, 70% more frequent than any other area of the lower limb and twice as common in men (3.4/100 000) than in women (1.8/100 000). NU of the foot and ankle was evenly distributed between the sexes and across the ages. Non-union of multiple sites and the axial skeleton was very rare.

DISCUSSION

The 5-year mean for non-union in Scotland (2005–2010) was 18.9/100 000 per annum; 22.45 in men and 15.65 in women. Although there has been a decreasing trend in male incidence a longer period of analysis is necessary to draw any significance from it. The age/gender distribution followed a trend that was similar to the fracture pattern in the Edinburgh population[6] with a bimodal male and unimodal female distribution reflecting the larger number of fractures seen with

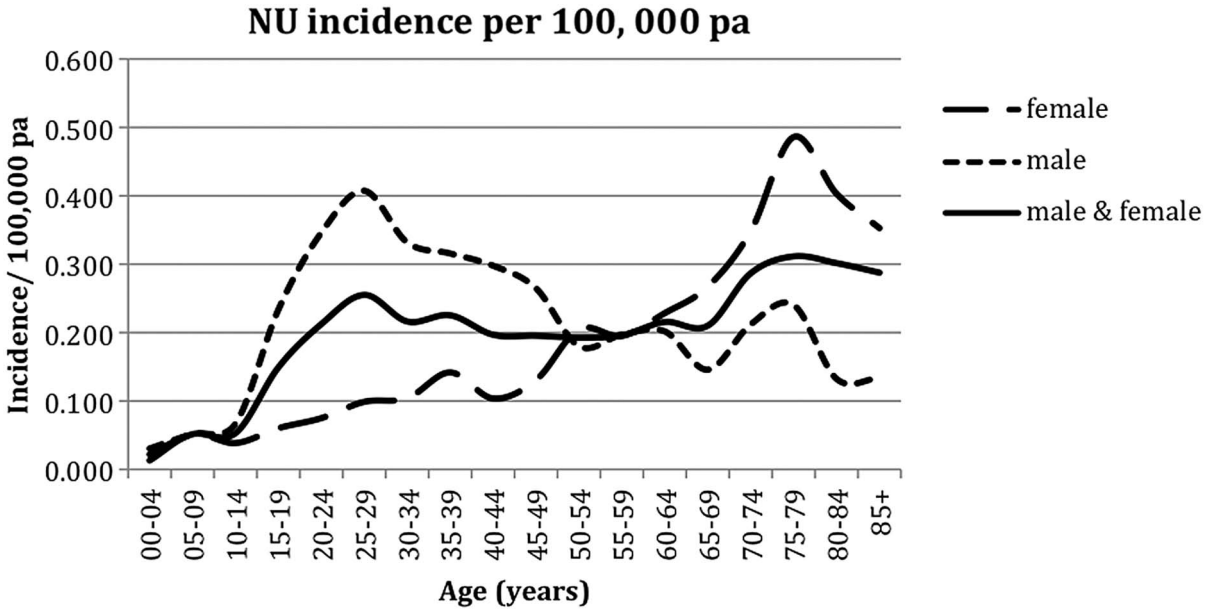

Figure 1 Incidence of non-union with age and sex.

higher energy injuries in the young males and the osteoporotic fractures in the elderly.

The most common site for non-union in men was the forearm and in women the humerus, with the upper limb having a 60% higher incidence of non-union than the lower limb likely in part due to the greater incidence of upper-limb than lower-limb fractures. In a recent epidemiology study the fracture incidence was 290/100 000 for forearms and 173/100 000 in the upper arm and shoulder compared with 199/100 000 in the pelvic/thigh region and 55/100 000 in the lower leg.[4]

This study may under-represent the numbers of NU, as in the elderly the potential for complications and the invasiveness of corrective surgery may outweigh the benefits of achieving union for the individual.

Previous estimates of fracture non-union have generally been derived from small cohorts of particular anatomical regions. The many study variables make comparison difficult although most studies of closed fracture injuries quote less than 15%[10] NU. Site-specific studies have reported 1.54/100 000 pa in the clavicle,[11] 1.1/100 000 pa in the diaphyseal humerus[12] and 1.89/100 000 pa in closed tibial fractures.[13]

At a population level, the number of non-union is potentially affected by several different factors. These include the number of fractures, the nature of the injuries (for instance, high-energy open tibial fractures compared with closed low-energy fractures[13]), the incidence of infection and importantly the access of the population to healthcare provision and adequacy of the initial fracture treatment. In addition, there will be intrinsic host factors such as diabetes and systemic agents such as non-steroidal anti-inflammatory drugs and smoking, which inhibit the repair process and would potentially, influence the incidence of non-union.

For healthcare planning and for clinical trial design, the absolute number of non-unions is required,

Table 3 Incidence of non-union by sex and anatomy

Site location	Female incidence/100 000 pa	Male incidence/100 000 pa	Total incidence/100 000 pa
Shoulder region clavicle)	1.87	2.77	2.31
Upper arm (humerus)	3.54	2.1	2.84
Forearm (radius and ulna)	2.79	6.83	4.74
Hand	0.4	1.5	0.93
Upper limb total	8.6	13.2	10.82
Pelvis and femur	2.43	2.04	2.24
Lower leg (tibia and fibula)	1.83	3.42	2.6
Ankle and foot	1.77	2	1.88
Lower limb total	6.02	7.46	6.72
Multiple sites	0.04	0.06	0.05
Axial skeleton	0.25	0.44	0.34
Total	**15.65**	**22.45**	**18.94**

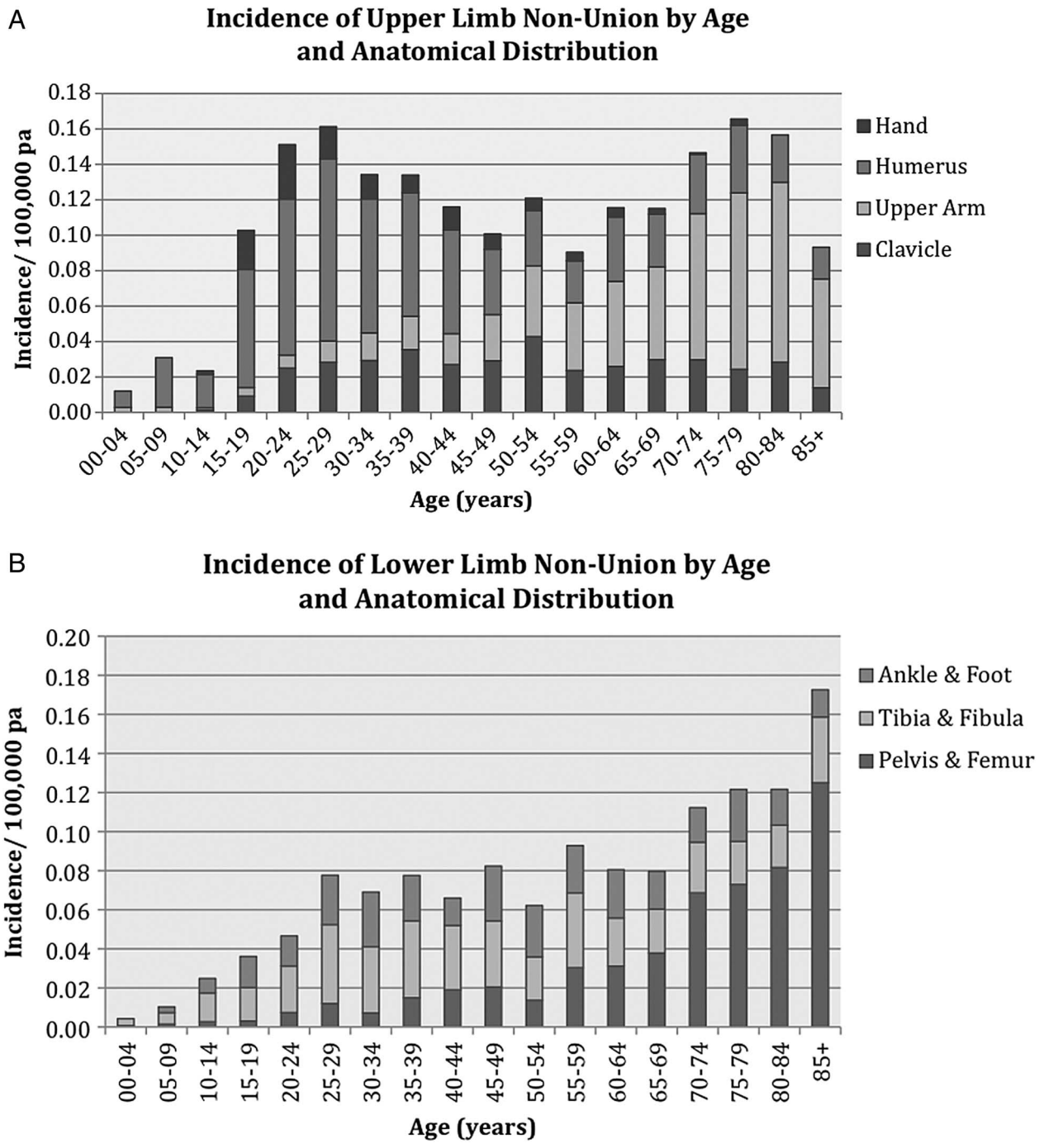

Figure 2 Distribution of non-union by site and age, (A) upper and (B) lower limb.

particularly as there is an increasing need to evaluate current and proposed new treatments for non-union.

The ISD data used in this study record all hospital episodes. As almost all non-unions are treated operatively, the ISD data are a good reflection of the number of clinically symptomatic non-unions (as was confirmed by the validation of the ISD coding carried out in our unit). Therefore, the data provided here gives realistic estimates for the number of non-unions that can be expected for each anatomical region in a given time, which will enable realistic recruitment rates to be calculated.

Our data give an overall NU incidence in Scotland of 19 per 100 000 per annum. Clearly, less than the 138/100 000

primary hip replacements[14] and 572/100 000 registered malignant neoplasms[15] but on a par with 19/100 000 revision hip replacements,[14] and 13.5/100 000 on the renal transplant waiting list in Scotland in 2009.

An estimated 25% of non-unions are complex and require referral to a specialist unit dealing with limb reconstruction, such a unit with a catchment of 2 million would see approximately 100 non-union referrals per year. This compares to the 33 primary hip replacements performed per arthroplasty surgeon and 6.7 revision hips per 'revision' arthroplasty hip surgeon in Scotland in 2009.[14]

CONCLUSION

There are very little data available in the literature regarding non-union in large numbers or populations. This study reports data that can be used as a baseline to compare against rates in other regions to assess the adequacies of trauma care provision. The pattern of non-union by age, sex and anatomical distribution in a 5.2 million Scottish population, is described with a young male bimodal and elderly female unimodal distribution and a higher incidence in the upper limb than lower limb.

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Competing interests None.

Ethics approval Ethics approval was not required for this research.

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