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Editorial

The epidemiology and outcome of open distal radial fractures

1. Introduction

Open distal radial fractures are an uncommon mode of injury in the upper limb compared to closed radial fractures. Good management is very important especially due to the diverse complications that can arise and the multi functional role of the wrist in every day activities. No literature to date has in detail investigated the epidemiology and outcome of such fractures in a large series of patients.

This aims of this were to investigate the incidence of open distal radial fractures, the types of patients, nature of injury leading to them, severity of injury, and outcome in complications with emphasis on infection rates. This information should give greater understanding about them, which may influence their management and predict outcome or complications.

2. Materials and methods

Medical records for all open distal radial fractures from an inpatient, outpatient scenario as well as operative reports and x-rays were all studied during a consecutive 12 year period (1988–2000). Basic demographic data on 132 patients and full data on 65 patients was collated prospectively. The remaining data was collected retrospectively from medical records. We are aware that prospective data is of more statistical significance than that from retrospective sources, especially as it is less susceptible to the types of bias apparent in retrospective studies. The data is continuously updated and allows the possibility for long term follow-up of large numbers of patients if required. Population data for both males and females was obtained for our catchment area in Lothian (except W Lothian) and for different age groups to calculate the age–sex incidence of such fractures.

The 132 patients forming the total study population were followed up for an average of 17.2 weeks (range 1–155 weeks). The duration of follow up for 4 patients is unknown, although the presence of complications occurring post-injury have been recorded. These patients were excluded from determining the average and range of follow up and comprised of: 2 patients which had moved outwith from the area and 2 patients, for which the review duration was unknown. 2 further

patients had died soon after 2 weeks post- injury, so their data was not used for outcome analysis but for demographic data. The epidemiological data was therefore analysed and outcome deduced for the 132 patients. Although the long term complications from these injuries is unknown.

The fractures were classified using both the Gustilo classification¹ and the AO classification.² The no of diaphyseal comminution fractures of the distal radius was also determined (Sum of A3.3, C2.3 and C3.3 fractures). The mechanism of injury was classified as: falls, falls from height (greater than 3 feet), sport, RTA pedestrian, RTA vehicle and other injuries e.g. animal bites. These were further classified as high energy e.g. falls from height, RTA and low energy injuries e.g. falls, animal bites, sport. The means of fixation and implants where applicable to stabilise the distal radial fractures were recorded. All other relevant data to include dates of injury, other injuries co-existing, site of open wound, and antibiotics administered were recorded.

Outcome was determined by recording the frequency of complications post-injury and surgery. Non-union was defined as the fractured bones failing to unite by 5 months. Mal-unions were defined as either an angle of greater than 10° dorsal angulation, an angle of greater than 15° volar angulation or more than 3 mm of radial shortening, or any combination of these. Pin site infections (PTI) were also recorded and classified as minor and major. A major PTI is one which resulted in change in the means of stabilisation of the fracture.

All the patients discharged had either regained full range of wrist movement or were happy with their injury outcome and able to lead a normal functioning lifestyle. The data was analysed where required using a paired student t-test, whereby the level of significance was taken to be 0.05.

3. Results

The 132 patients comprised of 34 males and 98 females, with an average age of 51 years (range 17–97 years). For every 100,000 population per annum during this 12 year period (1988–2000) in our catchment area of 516197 patients, the incidence of open distal radial fractures is 26 adults (13 males and 37 females during this time) with a f:m ratio of approximately 3:1. The age–sex incidence is represented in [Graph 1](#).

Graph 1 – The age–sex incidence of open distal radius fractures.

The injury mechanism was classified as: fall from height (83 patients), fall greater than 3 feet (24), sport (1), RTA pedestrian (6), RTA vehicle (14) and other injuries (4). The sport injury was from cycling and the other injuries included crush injuries (3) and an attack by a jaguar (1). Table 1 summarises the different injury mechanisms.

The frequency of injuries recorded from January till December was recorded with also a distribution of patients with falls as a cause of their injury during these months as shown in Graph 2.

According to the Gustilo classification, there were 103 of type 1 (78.0%), 24 type 2 (18.2%) and 5 type 3 (3.8%) injuries. Type 3 can be further subdivided into type 3a (4 patients), type 3b (1) and type 3c (0). The fractures according to the AO classification revealed type A (61 patients), type B (4), and type C (5). An x-ray for 1 patient was unclassified, and for 9 patients, data is unknown. Further sub-classifications are shown in Table 2.

There were 52 diaphyseal comminution fractures and the distribution with age of patients is represented in Graph 3.

The severity of injury and the fracture type occurring for our patients has been represented by Graph 4.

The wounds associated with the fracture were located either overlying the ulna (97 patients) side, radius (14) or both (1). Data for 20 patients here could not be established.

Open distal radial fractures were the only injury in 93 of our patients. The remaining patients experienced ulna shaft fractures (23 patients), dislocation of 1st metacarpal phalangeal joint (1), ankle fracture (1), scaphoid fractures (3), proximal humeral fractures (2), and radial head fractures (1) or closed fracture of opposite wrist (8).

On arrival at hospital, 109 patients following injury were administered intravenous prophylaxis antibiotics, and of the remainder 21 received no antibiotics, and 2 only post operatively. The patients also underwent some form of fixation initially to stabilise the fracture which included 93 patients receiving external fixation, 14 patients with internal fixation, 3 patients with both internal and external fixation, 20 patients with Plaster of Paris, 1 patient with manipulation and data is unknown for 1 of our patients. Some of the 93 external fixations were supplemented with plating (4 patients), and K wires (10). The 14 internal fixations were supplemented with plating (13), and screws (1).

Complications following injury were recorded and included tendon rupture- extensor pollicis longus (1 patient), ulna nerve injury (4), carpal tunnel syndrome (CTS) (17), reflex sympathetic dystrophy (RSD) (6), and compartment syndrome (CS) (1). We recorded 6 superficial wound infections. One patient had a mild superficial infection with no discharge and was successfully overcome by erythromycin. The other infections were all treated successfully with cephalosporins or erythromycin in cases of penicillin sensitivity. The pathology report for one of these patients confirms the presence of methicillin-resistant *S aureus*. Five of these patients were treated via external fixation and the remaining via Plaster of Paris. There was only 1 case of deep infection. This patient was initially subjected to plating and bone grafts to stabilise fracture but failed so a revised bone graft and a buttress plate was used. Consequently he had a deep infection after his last operation which was treated by high dose benzyl penicillin and flucloxacillin.

Split skin grafts were required for 14 of our patients with varying injury severity- 7 patients type 1, 5 type 2, 1 type 3a, and 1 type 3b. There were 13 PTI recorded, with 2 of them classified as major. In one of these, all 4 pins were infected, the external fixation had to be removed and a cast applied to stabilise the fracture. In another, the external fixation was also removed early, but both of these cases were treated with antibiotics. The patient x-rays on follow-up revealed 50 fracture mal-unions but only 4 non-unions. The non-unions comprised of 1 of the patients showing union by 6 months, 2 had required arthrodesis, and 1 patient had been recognised to have a non-union but was asymptomatic. The mal-unions occurring and age of patients has been shown in the following Graph 5:

4. Discussion

Literature searches revealed the paucity of information on the epidemiology and outcome from open distal radial fractures. To our knowledge only a single published study³ exists which looks at the treatment outcome of patients with such fractures.

From our results we find that open distal radial fractures are relatively uncommon. The overall incidence is more common in females than males and the age-sex prevalence relationship shows that such fractures have a significantly increasing incidence from the age of 40 years in females. This is seen 40 years later in males from the age of 80 years. The relationship was also reported by McQueen and Jupiter⁴ in

Table 1 – Showing injury mode of distal radial fractures and sex distribution.

Injury mechanism	No.	%	% Female
Fall	83	62.9	94
Fall height	24	18.2	45.8
Sporting	1	0.8	100
RTA pedestrian	6	4.5	50
RTA vehicle	14	10.6	21.4
Other	4	3	50

Graph 2 – Frequency of open distal radius fractures and those caused by falls for different months. Data adjusted so takes into account 30 days present in each month.

closed distal radial fractures and described the distribution as J- shaped or a post-wage earning pattern for both sexes. This contrasts with the distribution published by Buhr and Cooke⁵ where the curve was L shaped for men and J- shaped for women. The trend in women can be explained due to the increase in incidence of osteoporosis in post-menopausal women. Harvey and Cooper⁶ reported osteoporosis is a major public health issue, with fragility fractures of the hip, vertebrae, and distal radius considered the most important consequences. These lead to increased morbidity, mortality, hospital care, and dependency. The trend in males could be due to increased life expectancy of males who become vulnerable to falls and sustaining osteoporotic fractures.⁴ Bengner and Johnell⁷ reported similar findings in closed distal radial fractures in Scandinavia.

A study by Rozental et al³ found that majority of these open distal radial fractures resulted from high energy injuries. Our data however showed that only 33.3% were high energy injuries (majority comprising falls from height- 54.5%) and the remainder low energy injuries (majority comprising from falls- 94.3%). Falls in general were the most common mode of injury (62.9%) and occurred mostly in females (92.4%). More men however suffer injuries from falls from height (54.2%) and vehicle RTA (78.6%). McQueen and Jupiter⁴ also again record similar trends for closed distal radial fractures where falls (81%) were the most common injury mode and in females (85%).

The frequency of falls and months of occurrence revealed that they were increasingly common during the winter months with peak number of falls in January and a fall during the summer of months. Jacobsen et al⁸ showed in related distal forearm fractures due to falls, were more frequent in the winter ($p < 0.0001$) among Rochester men and women 35 years of age or older in 1952–89. The winter excess was

partially explained by a greater relative risk of distal forearm fractures on days with freezing rain or snow among women below 65 years of age and on days with freezing rain among older women.

Our results have shown a notable number of complications post-injury. 42.4% of our patients experienced some complication which is lower than that reported by Rozental et al³ (2/3 of patients). However we find that this rate is still significantly higher than closed fractures of the distal radius as reported by Cooney et al⁹ (31% from 565 dorsally displaced fractures managed via closed reduction or open stabilisation) and Fitoussi and Chow¹⁰ (26% in displaced intra-articular distal radial fractures treated via open reduction and internal fixation). This suggests that open fractures result in higher risk of complications with respect to closed. Although this relationship is also true for complications occurring in closed fractures of the diaphyseal humerus (2.4%, treated via Hackethal's nails), the relationship for open forearm fracture complications in children is however also lower (32.2% treated with prompt administration of parenteral antibiotics followed by debridement).^{11,12}

Open diaphyseal comminution fractures of the distal radius were found in 52 patients (39.4%). They occur more commonly as you get older with a peak about 60–69 years. They may be also common due to increase in incidence of osteoporosis especially in post-menopausal women as the bones become more brittle with this condition. However Feik et al¹³ who studied age trends on remodelling of the femoral midshaft between the sexes reported that although diaphyseal bone was not immune from age-related changes affecting other skeletal sites, due to compensatory remodelling, which was particularly evident in men, this was not reflected in increased fracture rates.

Table 2 – Frequency and average age of patients for different AO sub-classifications.

AO Group	A2.3	A3.2	A3.3	B1.1	B1.3	B3.1	C2.1	C2.2	C2.3	C3.2	C3.3
No of patients	1	30	30	1	1	2	12	3	6	20	16
% of patients	<1	23	23	<1	<1	2	9	2	5	15	12
Average age (years)	92	73	70	67	50	73	57.4	57.3	66	58	50.4

(There were 0 patients with following AO sub classifications: A1.1–A2.2, A3.1, B1.2, B2.1–B2.3, B3.2–C1.3, and C3.1.)

Graph 3 – Relationship between diaphyseal comminution fractures of distal radius and age of patients.

McQueen and Jupiter⁴ who studied closed distal radial fractures showed 39 patients (0.02%) of their patients suffered diaphyseal comminution fractures. Hence we find such fractures to be more common in open fractures than their closed counterparts. Statistical analysis using the paired students t-test revealed a value of 0.49 (0.49049).

We recorded only 6 superficial infections (4.5%) from open distal radial fractures and just a single deep infection (0.76%). In addition there were 13 PTI (9.8%). We can see that they are quite rare especially deep infection. A study by Jones¹⁴ reported in related high-energy open forearm fractures, of one case of deep infection (5.6%) of a fractured radius, showing infection in related bones is also relatively rare. Rozenal et al³ also reported 8 post operative infections in open distal radial fractures (3 were osteomyelitis-16.7%, 1 deep infection- 5.6% and 4 pin track infections- 22.2%). The higher infection rates in such patients may be attributed to a greater proportion of high-energy injuries as a cause of injury. This may be the case as only 44 patients (33.3%) involved in our study have high energy injuries. Rozenal et al³ recorded high infection rate for fractures treated with both internal and external infection and no correlation between treatment method. We however found that all of our patients with infection received external fixation, except one, stabilised with Plaster of Paris, indicating external fixation may lead to increased infection rates. This is despite several studies associating severe open fractures treated with immediate internal infection.^{1,15}

We recorded 50 mal-unions (57.9%) and just 4 non-unions (3.0%). We find that mal-unions are a common complication as shown by the large frequency in such injuries but non-unions are rare. Rozenal et al³ showed mal-unions occurring in 33.3% of their patients which is high, but non-unions were also common- 27.7%. This may be related to the energy of injury, which we know were mainly high energy in that study but mostly low energy injuries in our study. We also find that the frequency of mal-unions have increased with

increasing age, with a peak number of mal-unions for the 70–79 years interval. This may also be related to increasing incidence of osteoporosis in post-menopausal women, especially as 42 of the mal-union patients were female.

After mal-unions CTS symptoms were the most common complication recorded for 17 patients (12.9%) post injury, but are still relatively rare. Heim et al¹⁶ reported that only twelve patients (10.5%) with CTS symptoms had suffered a trauma in the recent or more distant past. Ulna nerve injury (4 patients – 3.0%), RSD (6 patients- 4.5%) and tendon rupture (1 patient – 0.76%) were also all relatively rare. Hove¹⁷ reported in his study of 532 conservatively managed distal radial fractures of 23 patients (4.2%) of carpal tunnel symptoms, but only 5 ulna nerve (0.92%) and RSD symptoms (0.92%). A relationship between injury severity and such complications could not be established as most of the injuries in our patients were of low severity – Gustilo 1 and 2. However 64.7% of our carpal tunnel symptoms, 75% of ulna nerve injury and the single tendon rupture resulted from high energy injuries. This supports Belsole and Hess¹⁸ who reported with reference to distal radial fractures, concomitant tendon, arterial, and nerve injuries often are associated with a high-energy mechanism of trauma. These injuries may complicate an already difficult fracture care plan, especially if the diagnosis of these injuries is delayed.

Open distal radial fracture were the only injury in 93 of our patients (70.5%). The commonest other injuries occurring were ulna shaft fractures (23 patients – 17.4%), and closed fracture of opposite wrist (8 patients- 6.1%). Rozenal et al³ reported other injuries apart from open distal radial fractures occurring in 14 of his patients (77.8%) which is high. This may be explained due to the majority of patients in his study resulting from high energy cause of injury, of which our study included just 44 patients (33.3%).

This study however has some limitations. Although basic demographic data on 132 patients and full data on 65 patients was collated prospectively, the remaining data was collected

Graph 4 – Frequency of patients with different injury severity and AO classification.

Graph 5 – Relationship between the no of patients with mal-unions and non-unions with age of patient.

retrospectively from medical records. Prospective data is of more statistical significance than that from retrospective sources, especially as it is less susceptible to the types of bias apparent in retrospective studies. Also, data was missing for some of the patients (as recorded) e.g. some X-rays were not located. 2 patients had died soon following their injuries so their data was used for demographic data and not outcome analysis. A larger population size may be required to show a clear relationship between the fracture type and different injury severities, which could not be established due to the small frequency of high severity injuries (e.g. Gustilo 3c).

5. Conclusion

Open fractures of the distal radius are relatively rare. They have a higher incidence in females than males over 50 years. They occur mainly from low energy injuries e.g. falls especially during the winter months, with peak in January. They commonly result in post-operative complications (42.4%) with respect to their closed counterparts (26%). Mal-unions are most common with increasing age occurring with highest frequency 70–79 age interval. Wound infections are rare especially deep infection and occur more commonly in those treated with external fixation. We also find that diaphyseal comminution fractures are common especially in the 60–69 years age interval and occur more frequently in open fractures than their closed counterparts.

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