Management of metacarpal shaft fractures

a multicentre cross-sectional study

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Aims

The aims of this study were to describe the epidemiology of metacarpal shaft fractures (MSFs), assess variation in treatment and complications following standard care, document hospital resource use, and explore factors associated with treatment modality.

Methods

A multicentre, cross-sectional retrospective study of MSFs at six centres in the UK. We collected and analyzed healthcare records, operative notes, and radiographs of adults presenting within ten days of a MSF affecting the second to fifth metacarpal between 1 August 2016 and 31 July 2017. Total emergency department (ED) attendances were used to estimate prevalence.

Results

A total of 793 patients (75% male, 25% female) with 897 MSFs were included, comprising 0.1% of 837,212 ED attendances. The annual incidence of MSF was 40 per 100,000. The median age was 27 years (IQR 21 to 41); the highest incidence was in men aged 16 to 24 years. Transverse fractures were the most common. Over 80% of all fractures were treated non-surgically, with variation across centres. Overall, 12 types of non-surgical and six types of surgical treatment were used. Fracture pattern, complexity, displacement, and age determined choice of treatment. Patients who were treated surgically required more radiographs and longer radiological and outpatient follow-up, and were more likely to be referred for therapy. Complications occurred in 5% of patients (39/793). Most patients attended planned follow-up, with 20% (160/783) failing to attend at least one or more clinic appointments.

Conclusion

MSFs are common hand injuries among young, working (economically active) men, but there is considerable heterogeneity in treatment, rehabilitation, and resource use. They are a burden on healthcare resources and society, thus further research is needed to optimize treatment.

Take home message

- Metacarpal shaft fractures (MSFs) are common injuries.
- There is considerable heterogeneity in treatments, with no consensus on acceptable deformity and indications for surgical intervention.
- There is a need for randomized trials to assess the effectiveness of surgical and non-surgical treatments for MSFs.

Introduction

Hand injuries cost the UK economy over £100 million each year,[1] and account for 20% of all fractures seen in emergency departments (EDs). Metacarpal shaft fractures (MSFs) are among the most common hand injuries,[2] reported to account for up to 31% of hand fractures.[1-4] They usually affect young adult males, with the fourth and fifth metacarpals most commonly injured.[5] They are often simple, closed injuries sustained by axial loading,

a direct blow, or torsional loading of the digit.[6]

The evidence guiding MSF treatment is limited, with no consensus on the best management. While the majority of MSFs can be managed nonoperatively,[7,8] a variety of operative techniques are also used, including Kirschner wires, interfragmentary compression screws, plates, and external fixators.[9] Despite increasing trends towards surgical fixation, no treatment modality has been demonstrated to be superior to others. Furthermore, there is continuing controversy regarding acceptable parameters of deformity.[7,9-11]

There are limited data on the epidemiology and variation in treatment following MSF. There are a limited number of single-centre studies,[12–18] and few randomized controlled trials comparing treatment methods.[19-21] The lack of high-quality, comparative, multicentre studies demonstrating superiority of any one form of treatment over another means that current management is guided by surgeon preference and local practice.

The aim of this study was to describe the epidemiology of MSF in adults, explore variations in treatment across the UK, and document secondary care resource use. The objectives were to: determine the incidence and characteristics of MSF in adults presenting to secondary care; describe treatments used and explore variation in practice; document complications following current care; document secondary care resource use; and explore associations between patient and fracture characteristics and treatment modality.

Methods

We conducted a retrospective, multicentre, cross-sectional study assessing the management of MSF in a 12-month period at six UK centres. These consisted of three tertiary level 1 trauma centres, a tertiary plastic surgery centre, a university teaching hospital, and a district general hospital.

The study was locally approved by individual institutions as an evaluation of service in line with the UK Policy Framework for Health and Social Care Research and guidance from the National Research Ethics Service.[22,23]

Adults (aged ≥ 16 years) with a radiologically confirmed MSF of the second to fifth metacarpals presenting within ten days of injury between 1 August 2016 and 31 July 2017 were identified by generating a list of the unique event key for each radiograph from the host centre's radiology department. This identified all hand radiographs taken within a specified time period. The radiographs were subsequently screened to identify those with a MSF. Where the department was not able to generate such a list, Hospital Episode Statistics (HES) codes (HE41A/HE41B/HE41C/HE41D) were used to identify patients with a primary diagnosis of hand fracture. Screening of radiographs was then undertaken to identify those with MSF (Centre A only). HES codes detail episodes (periods of care) under the care of a particular consultant at a single hospital provider in England, which includes emergency, day-case, and inpatient admissions.[24] Although they do not include patients seen in the ED who are not referred on and seen by a specialist team, MSFs were appropriately identified as all were definitively managed in specialist orthopaedic or plastic surgery clinics by the participating centres.

The shaft was defined as per the AO Foundation/Orthopaedic Trauma Association (AO/OTA) fracture classification as the part of the bone between the two end segments.[25] The end segments are defined by a square whose sides are the same length as the widest part of the epiphysis/metaphysis, as per Heim's system of squares.[25] Exclusion criteria were: fractures of the metacarpal base, neck, or head; fractures with intra-articular extension; and/or associated dislocation at the carpometacarpal joint or other adjacent joint dislocation.

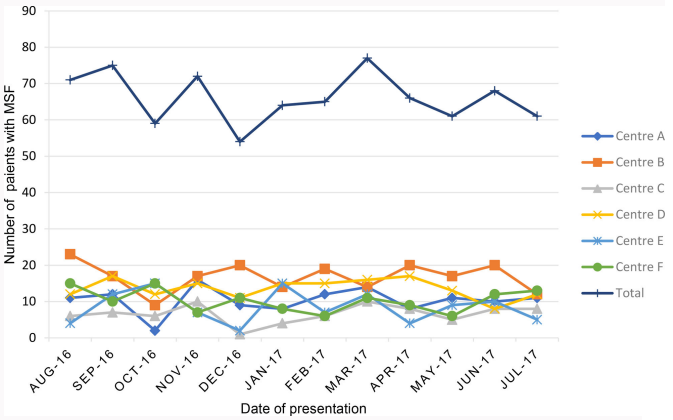

Fig. 1
Monthly distribution of metacarpal shaft fractures across centres. MSF, metacarpal shaft fracture.

Healthcare records, operative notes, and radiology imaging were reviewed to identify patient demographic details, injury details, treatment, follow-up rate and length, number of radiograph series, therapy attendances, and complications. Occupation was classified using the Office for National Statistics Standard Occupational Classification (ONS SOC).

Radiographs were reviewed by one orthopaedic or plastic surgery trainee (with a minimum five years' postgraduate experience) at each centre to assess fracture morphology and displacement. Displacement was divided into three groups: undisplaced; some displacement (defined as ≤ 30° in the fifth metacarpal, ≤ 20° in the fourth metacarpal, any visible angulation in the second and third metacarpal, and shortening of ≤ 2 mm in any metacarpal); and marked displacement (angulation or shortening greater than that described above). As there is no agreement in the literature on acceptable deformity in MSF, these broad categories were selected following review of the literature.[6,9,11,26,27] Radiological assessments were performed on initial radiographs taken as part of routine care. Angulation was measured on a lateral view, and shortening where applicable was measured as overlap of fracture fragments on the anteroposterior view. To ensure standardization of measurements, a detailed protocol was developed and distributed to participating sites. A site initiation meeting was conducted to review the protocol and demonstrate classification of fractures and radiological assessment, in order to ensure consistency in assessment across sites and minimize interobserver variability.

Statistical analysis

Quantitative variables are described using mean and SD or median and IQR, and categorical variables using frequencies and percentages. We estimated incidence rates by extrapolating mid-year population values from Office for National Statistics (ONS) data, assuming each centre serves a stable

Table I. Participant demographic and injury details.

Variable	Site						Total (n = 793)
	A (n = 124)	B (n = 202)	C (n = 79)	D (n = 163)	E (n = 102)	F (n = 123)	
Median patient age, yrs (IQR)	28 (22 to 44.5)	26 (20 to 36)	29 (23 to 43)	25 (21 to 40)	28 (20 to 44)	28 (20 to 51)	27 (21 to 41)
Patient sex, n (%)							
Female	39 (31)	49 (24)	13 (16)	43 (26)	21 (21)	31 (25)	196 (25)
Male	85 (69)	152 (76)	66 (84)	120 (74)	81 (79)	92 (75)	596 (75)
Missing*	0	1	0	0	0	0	1
Source of referral, n (%)							
Primary care	1 (1)	0	4 (5)	15 (9)	0	0	20 (3)
Secondary care	122 (98)	201 (100)	70 (89)	145 (89)	102 (100)	123 (100)	763 (96)
Other	1 (1)	1 (1)	5 (6)	3 (2)	0	0	10 (1)
Median time from injury to presentation, days (IQR)	0 (0 to 1)	0 (0 to 1)	0 (0 to 1)	0 (0 to 1)	1 (0 to 2)	0 (0 to 1)	0 (0 to 1)
Laterality of fracture, n (%)							
Left	54 (44)	61 (30)	29 (37)	57 (35)	32 (31)	38 (31)	271 (34)
Right	70 (56)	141 (70)	50 (63)	106 (65)	70 (69)	85 (69)	522 (66)
Complexity of fracture, n (%)							
Simple	113 (92)	192 (95)	56 (71)	149 (91)	92 (90)	109 (89)	711 (90)
Complex	10 (8)	10 (5)	23 (29)	14 (9)	10 (10)	14 (11)	81 (10)
Missing*	1	0	0	0	0	0	1
Degree of displacement, n (%)							
Undisplaced		137 (68)	13 (16)	48 (29)	21 (21)	47 (38)	266 (40)
Some displacement		15 (7)	17 (22)	108 (66)	58 (57)	58 (47)	256 (38)
Marked displacement		49 (24)	49 (62)	7 (4)	23 (23)	18 (15)	146 (22)
Missing*	124	1	0	0	0	0	125
Open/closed injury, n (%)							
Open	1 (1)	5 (3)	4 (5)	4 (2)	1 (1)	4 (3)	19 (2)
Closed	123 (99)	192 (97)	75 (95)	159 (98)	100 (99)	119 (97)	768 (98)
Missing*	0	5	0	0	1	0	6
Single or multiple MSF, n (%)							
Single metacarpal	114 (92)	177 (88)	64 (81)	146 (90)	89 (87)	108 (88)	698 (88)
Two metacarpals	10 (8)	22 (11)	13 (16)	17 (10)	13 (13)	12 (10)	87 (11)
Three metacarpals	0	3 (1)	2 (3)	0	0	3 (2)	8 (1)
Other injuries, n (%)							
No other injury	120 (97)	179 (89)	52 (66)	142 (87)	94 (92)	112 (91)	699 (88)
Significant hand injury†	2 (2)	14 (7)	13 (16)	8 (5)	7 (7)	8 (7)	52 (7)
Ipsilateral upper limb	0	7 (3)	2 (3)	0	1 (1)	0	10 (1)
Other injury elsewhere	2 (2)	2 (1)	8 (10)	11 (7)	0	3 (2)	26 (3)
Combination of above	0	0	4 (5)	2 (1)	0	0	6 (1)

*Denominator for percentages based on observed data only. Percentages may not sum to 100 due to rounding.
†Significant hand injury was defined as a fracture or wound requiring treatment other than associated metacarpal shaft fracture.
MSF, metacarpal shaft fracture.

population and is the only unit providing adult fracture care in the hospital's catchment area. Where patients had multiple MSFs, we selected a single digit for analysis (the most radial), allowing us to examine between-patient variability without

Table II. Reported mechanism of injury.

Injury	Site						Total (n = 793)
	A (n = 124)	B (n = 202)	C (n = 79)	D (n = 163)	E (n = 102)	F (n = 123)	
Punch injury	32 (26)	86 (48)	25 (33)	59 (37)	28 (29)	45 (37)	275 (36)
Fall from standing height	30 (24)	65 (36)	14 (18)	33 (20)	12 (12)	32 (26)	186 (24)
Sports-related	14 (11)	17 (9)	7 (9)	17 (11)	10 (10)	16 (13)	81 (11)
High-energy fall (> standing height)	26 (21)	1 (1)	3 (4)	20 (12)	15 (15)	9 (7)	74 (10)
Direct blow to hand by object	11 (9)	4 (2)	8 (11)	18 (11)	15 (15)	15 (12)	71 (9)
Road traffic accident	4 (3)	4 (2)	14 (18)	6 (4)	4 (4)	1 (1)	33 (4)
Crush injury	2 (2)	1 (1)	0	3 (2)	12 (12)	4 (3)	22 (3)
Other*	5 (4)	2 (1)	5 (7)	5 (3)	0	0	17 (2)
Insufficiency fracture	0	0	0	0	1 (1)	0	1 (0)
Missing†	0	22	3	2	5	1	33

*Other reported mechanisms included twisting-type injuries (6/17), four assaults, two knife injuries, two animal-related injuries (dog bite and kicked by horse), a circular saw injury, a drill injury, and explosion of oxygen cylinder in grasp.
†Denominator for percentages based on observed data only. All data are n (%). Percentages may not sum to 100 due to rounding.

falsely inflating our sample size. We investigated associations between characteristics of interest and treatment modality using univariable and multivariable logistic regression to obtain odds ratios (ORs), 95% CIs, and likelihood ratio test p-values. The variables most commonly associated with treatment choice, displacement, fracture complexity, open injury, patient sex, and patient age were selected for the adjusted analyses. We excluded multiple fractures, associated injuries, and occupation due to multiplicity of categorical groups. We used Stata statistical software (SE 15.1, StataCorp, USA) to analyze data.

Results

There were 837,212 ED attendances at the six centres during the study period, ranging from 67,028 to 212,149 per centre. Of 887 potentially eligible patients identified, 793 patients with 897 MSFs met the inclusion criteria, representing 0.1% of all ED attendances. Using mid-year population values from the ONS, we estimated that a population of 1,956,144 adults were served by the participating centres in 2017, yielding an incidence of 40 per 100,000/year.

There was no seasonal pattern to the incidence of MSFs (Figure 1). Almost all patients were referred from the ED, with 3% (20/793) from family practitioners and 1% (10/793) from minor injury units or local walk-in centres. Most patients, 90% (717/793) presented within three days of the initial injury, with 55% (435/793) presenting within one day.

Participant and fracture characteristics are described in Table I. Median age at time of injury was 27 years (IQR 21 to 41). The median age for males (24 years (IQR 20 to 33)), who represented 75% of all participants, was 17 years lower than that for females (41 years (IQR 27 to 60)). A mechanism of injury was reported for 760 of 793 (96%) participants. A punch injury and fall from standing height together accounted for over half of the injuries, with sports-related injuries the third most common (Table II).

There was variation in the types of non-surgical and surgical treatment between centres (Table III). The majority of MSFs were treated non-surgically, except in Centre C, a tertiary unit, where 72% (57/79) were treated surgically. Overall, 12 different types of non-surgical treatment were used, with a short hand cast such as a Barton's cast (a cast which extends from the metacarpal heads to the wrist crease)[28] being the most frequently used. Plate fixation was the most commonly used form of surgical fixation: 55% (74/134). Lag-screw fixation accounted for 14% (19/134), percutaneous wire fixation using transverse configuration 14% (19/134), intramedullary wiring 9% (12/134), 'other' which included cerclage wiring and a combination of fixation techniques 7% (9/134), and external fixation 1% (1/134). A combination of fixation techniques was often used in the case of multiple fractures.

Table IV and Table V show patient and fracture characteristics organized according to whether patients were treated non-surgically or surgically. Hand dominance was recorded in only 50% (397/793) of cases. Where recorded, the dominant hand was fractured in 68% (271/397) of participants. Almost all were simple fractures (90% (711/793)), defined as a single fracture line as per AO/OTA classification, and 97% (768/793) were closed. Of the 19 open fractures, nine were Gustilo-Anderson Type I, six were Type II or III, and four were not documented.[29] Transverse was the most common injury pattern, accounting for 34% (266/793), and multi-fragmentary the least common, at 5% (43/793).

There was evidence that fracture pattern, displacement, complexity, and patient age were associated with treatment (Table IV). While there was some evidence from univariable analyses that male patients and open fractures were more likely to be treated surgically, these associations were attenuated following adjustment for other variables. Occupation was not associated with treatment on univariable regression analysis.

There were 44 complications in 39 patients, with negligible difference in the prevalence of complications

Table III. Variation in treatment across study centres.

Variable	Site						Total (n = 793)
	A (n = 124)	B (n = 202)	C (n = 79)	D (n = 163)	E (n = 102)	F (n = 123)	
Treatment, n (%)							
Non-surgical	118 (95)	175 (87)	22 (28)	156 (96)	80 (78)	108 (88)	659 (83)
Surgical	6 (5)	27 (13)	57 (72)	7 (4)	22 (22)	15 (12)	134 (17)
Manipulation performed, n (%)							
Yes	12 (10)	33 (17)	1 (100)	16 (10)	9 (9)	8 (7)	79 (11)
No	112 (90)	164 (83)	0	138 (90)	93 (91)	113 (93)	620 (89)
Missing*	0	5	78	9	0	2	94
Anaesthetic used for manipulation, n (%)							
Local anaesthetic	0	2 (67)	0	4 (40)	5 (100)	6 (100)	17 (46)
Entonox	11 (92)	1 (33)	1 (100)	6 (60)	0	0	19 (51)
No anaesthesia	1 (8)	0	0	0	0	0	1 (3)
Missing*	0	30	0	6	4	2	42
Check radiograph performed post manipulation, n (%)							
Yes	11 (92)	26 (79)	1 (100)	16 (100)	8 (89)	8 (100)	70 (89)
No	1 (8)	7 (21)	0	0	1 (11)	0	9 (11)
Therapy referral, n (%)							
Referral made	39 (31)	68 (36)	58 (73)	23 (15)	35 (37)	39 (32)	262 (35)
No referral	85 (69)	123 (64)	21 (27)	126 (85)	59 (63)	83 (68)	497 (65)
Missing*	0	11	0	14	8	1	34

*Denominator for percentages based on observed data only. Percentages may not sum to 100 due to rounding.

between surgical and non-surgical treatment (Table VI). As complications were retrospectively collected, "restricted movement", "persistent pain", "hand weakness", "altered sensation", "cosmetic deformity" etc are qualitative descriptors derived from the healthcare records. Diagnosis of complex regional pain syndrome and malunion were documented in the healthcare records by the treating clinician. Four patients had a change of their primary treatment modality. Three non-surgically treated patients required surgery within six weeks of injury, and one surgically treated patient developed malunion requiring multiple corrective osteotomies following initial intramedullary wire fixation. Of the three patients who developed malunion requiring surgical intervention, two were open fractures associated with other significant hand injuries following polytrauma.

Patients who were treated surgically required a greater number of radiographs and longer radiological and outpatient follow-up, and were more likely to be referred for therapy than patients who were treated non-surgically (Table VII). The number of therapy sessions attended was recorded in 170 patients (87/659 non-surgically treated, 83/134 surgically treated), with a median of three (IQR 1 to 5) therapy appointments overall.

Based on 2019/2020 national tariff costs (£165 first fracture clinic appointment multi-professional, £67 follow-up fracture clinic, and £41 therapy appointment), we estimated mean outpatient treatment costs of £355 for non-surgicaly treated and £396 for surgically treated MSF.[30]

Discussion

This large multicentre study reports the epidemiology of MSFs and confirms that they are common, particularly among young men of working age. There was considerable heterogeneity in treatments, rehabilitation, and outpatient follow-up. The number of different surgical and non-surgical interventions used highlights the wide variation in management, the lack of generally agreed indications for surgical fixation, and the paucity of evidence supporting differing treatments for MSF. There were no differences in complications between surgically and non-surgically treated MSF. Fracture displacement and complexity, defined as the presence of more than one fracture line or comminution, were the only characteristics associated with treatment modality.

The estimated incidence of MSF in this study is three times greater than previously reported data from the USA.[31] Most previous studies do not report specifically on MSF but include subcapital/neck fractures, which are considerably more common, accounting for 60% to 70% of all metacarpal fractures.[4,32] This restricts comparison with our data. Of those reporting MSF, one focused on the fifth metacarpal,[4] and the second included children.[2] Sex, age distribution, and mechanism of injury are in accordance with previous studies.[3–5,32,33]

Table IV. Factors associated with surgical treatment.

Variable	Non-surgical treatment (n = 659)	Surgical treatment (n = 134)	Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)	Adjusted p-value
Fracture pattern, n (%)*					0.006
Transverse	207 (78)	59 (22)	-	-	
Spiral	178 (87)	27 (13)	0.53 (0.32 to 0.88)	1.81 (0.85 to 3.85)	
Long oblique	136 (92)	12 (8)	0.31 (0.16 to 0.60)	0.49 (0.21 to 1.14)	
Short oblique	105 (81)	25 (19)	0.84 (0.49 to 1.41)	0.99 (0.46 to 2.12)	
> 2 fragments	33 (77)	10 (23)	1.06 (0.50 to 2.28)	0.23 (0.06 to 0.93)	
Missing	0	1			
Displacement, n (%)					< 0.001
Undisplaced	258 (97)	8 (3)	-	-	
Some	228 (89)	28 (11)	3.96 (1.77 to 8.86)	3.87 (1.69 to 8.89)	
Marked	55 (38)	91 (62)	53.36 (24.48 to 116.31)	54.75 (23.92 to 125.33)	
Missing	118	7			
Fracture morphology, n (%)					< 0.001
Simple	606 (85)	105 (15)	-	-	
Complex	53 (65)	28 (35)	3.05 (1.84 to 5.04)	5.27 (2.00 to 13.87)	
Missing	0	1			
Open or closed, n (%)					0.732
Closed	644 (84)	124 (16)	-	-	
Open	9 (47)	10 (53)	5.77 (2.30 to 14.49)	1.28 (0.31 to 5.22)	
Missing	6	0			
Sex, n (%)					0.141
Female	178 (91)	18 (9)	-	-	
Male	480 (81)	116 (19)	2.39 (1.41 to 4.04)	1.72 (0.83 to 3.60)	
Missing	1	0			
Age, n (%)					0.010
Under 40 yrs	472 (81)	110 (19)	-	-	
41 to 64 yrs	116 (84)	22 (16)	0.81 (0.49 to 1.34)	1.04 (0.48 to 2.22)	
Over 65 yrs	71 (97)	2 (3)	0.12 (0.03 to 0.50)	0.09 (0.01 to 0.75)	

Number of observations included in multivariable model = 661.
*Fracture pattern was defined as per the AO/Orthopaedic Trauma Association fracture classification. Spiral, transverse, and oblique fractures have a single circumferential disruption of the diaphysis. An oblique fracture forms an angle ≥ 30° to a line perpendicular to the long axis of the bone. A long oblique fracture is defined as a fracture in which the fracture zone is greater than the diameter of the affected metacarpal shaft. A short oblique fracture is equal in length or less than the diameter of the affected metacarpal shaft. A transverse fracture forms an angle ≤ 30° to a line perpendicular to the long axis of the bone.

Despite their prevalence, there are few comparative studies of treatments for MSFs.[13,14,16-21] A recent systematic review identified no RCTs comparing surgical to non-surgical treatment for MSF, and considerable heterogeneity and bias in included studies limited meaningful comparison of treatments.[34] There are no multicentre cross-sectional studies examining treatment, resource use, or complications following standard care for MSF. Though we were unable to explore the functional impact of complications, our analysis revealed no difference in prevalence of complications between surgical and non-surgical treatment. Comparison of complications rates, and the impact of the complications encountered, requires appropriate assessment of outcomes and hand function, ideally measured through patient-reported outcome measures, which were not collected in this retrospective study due to limited available funds to support the collection of such data.

Surgically treated patients required a greater number of radiographs and outpatient attendances, and were more likely to be referred for therapy, leading to differential treatment costs. This could indicate that the overall direct cost of surgical treatment, regardless of operating theatre

Table V. Factors associated with treatment (crude analysis only).

Variable	Non-surgical treatment (n = 659)	Surgical treatment (n = 134)	Crude odds ratio (95% CI)
Laterality of fracture, n (%)			
Left	236 (87)	35 (13)	
Right	423 (81)	99 (19)	1.58 (1.04 to 2.39)
Hand dominance, n (%)			
Non-dominant hand fractured	103 (82)	23 (18)	
Dominant hand fractured	216 (80)	55 (20)	1.14 (0.66 to 1.96)
Missing	340	56	
Occupation, n (%)*			
Major Group 1	6 (60)	4 (40)	
Major Group 2	27 (79)	7 (21)	0.39 (0.09 to 1.77)
Major Group 3	19 (70)	8 (30)	0.63 (0.14 to 2.86)
Major Group 4	3 (60)	2 (40)	1 (0.11 to 8.95)
Major Group 5	40 (87)	6 (13)	0.23 (0.05 to 1.04)
Major Group 6	10 (100)	0 (0)	
Major Group 7	17 (76)	5 (24)	0.47 (0.09 to 2.36)
Major Group 8	15 (71)	6 (29)	0.6 (0.12 to 2.91)
Major Group 9	25 (63)	15 (38)	0.9 (0.22 to 3.72)
Missing	498	81	
Single or multiple metacarpal injury, n (%)			
Single metacarpal shaft	591 (85)	107 (15)	
2 metacarpal shafts	61 (70)	26 (30)	2.35 (1.42 to 3.89)
3 metacarpal shafts	7 (88)	1 (13)	0.79 (0.10 to 6.48)
Other injuries, n (%)			
Isolated metacarpal	596 (85)	103 (15)	
Significant hand injury	32 (62)	20 (38)	3.62 (1.99 to 6.57)
Ipsilateral upper limb	10 (100)	0 (0)	
Other injury elsewhere	17 (65)	9 (35)	306 (1.33 to 7.06)
Combination	4 (67)	2 (33)	2.89 (0.52 to 16.00)

*Occupation as per the Office for National Statistics Standard Occupational Classification: 1 Managers, directors and senior officials; 2 Professional occupations; 3 Associate professionals and technical occupations; 4 Administrative and secretarial; 5 Skilled trades; 6 Caring, leisure and other service; 7 Sales and customer service; 8 Process, plant & machine operatives; 9 Elementary occupations.

costs, is greater than non-surgical treatment, but this requires further investigation to quantify the direct and indirect costs of each treatment modality, and to determine if there is a cost difference and cost benefit of one over the other. Our cost estimates do not include the costs of ED treatment, radiological investigations, surgical procedures, or associated implants, splints, or casts, or lost productivity, which constitutes 75% of total hand injury costs.[35] Furthermore, MSFs were most common in men of working age, thus increasing their economic burden.

Our data showed that displacement and fracture complexity were uniformly associated with surgical treatment, with fractures displaying 'marked displacement' more likely to undergo surgical treatment than those with 'some' displacement. However, there is contention regarding acceptable parameters of deformity for MSF.[6,7,9,10] While some accept angulation of 30° in the ring and little finger,[6,36] others tolerate up to 60°,[26,37] and 'acceptable' shortening varies from 2 mm to 5 mm.[6,26,37,38] Our results support this variability given the disparity in numbers treated surgically across centres. While the majority of MSFs were treated non-surgically, 72% were treated surgically at Centre C. Nearly two-thirds of MSFs showed marked displacement and 5% were open fractures, the highest proportion of all centres (Table I). Furthermore, as a tertiary unit and major trauma centre, Centre C may have received cases of greater complexity through trauma or tertiary referrals, compounding the severity of MSFs seen. In addition, they also had a higher proportion of men. Though sex was not associated with treatment on adjusted analyses (Table III), this requires exploration in larger

Table VI. Complications by treatment modality.

	Treatment modality		
Type of complication	**Non-surgical (n = 19)**	**Surgical (n = 25)**	**Total (n = 44)**
Persistent pain > 6 weeks	5	4	9
Restricted movement > 6 weeks	2	7	9
Malunion accepted	3	2	5
Malunion requiring surgery	1	2	3
Infection	0	4	4
Cosmetic deformity	2	1	3
Altered sensation	2	1	3
Hand weakness > 6 weeks	3	0	3
Removal of metalwork other than pre-planned removal of Kirschner wires	0	2	2
Plate failure	0	1	1
CRPS	1	0	1
Other	0	1	1

n = number of complications.
CRPS, complex regional pain syndrome.

Table VII. Rehabilitation and outpatient care according to treatment modality.

Variable	**Treatment modality**		
	Non-surgical (n = 659)	**Surgical (n = 134)**	**Total (n = 793)**
Therapy referral, n (%)			
Referral made	156 (25)	106 (82)	262 (35)
No referral	474 (75)	23 (18)	497 (65)
Missing*	29	5	34
Number of therapy sessions			
Cases with data available, n	87	83	170
Median (IQR)	2 (1 to 4)	3 (2 to 5)	3 (1 to 5)
Median number of radiograph sets (IQR)	1 (1 to 2)	2 (1 to 3)	1 (1 to 2)
Median days from injury to final radiograph (IQR)	1 (0 to 12)	6 (1 to 29)	2 (0 to 14)
Outpatient follow-up, n (%)			
Yes (local)	642 (97)	128 (96)	770 (97)
Yes (elsewhere)	9 (1)	0	9 (1)
No (follow-up arranged)	8 (1)	6 (4)	14 (2)
Median number of fracture clinic appointments (IQR)	2 (1 to 2)	2 (1 to 3)	2 (1 to 2)
Missing*	17	6	23
Median length of follow-up, days (IQR)	18 (3 to 29)	49.5 (29 to 92)	21 (4 to 36)
Missing*	3	0	3
Fracture clinic attendance, n (%)			
Did not attend ≥ 1 appointment	119 (18)	41 (31)	160 (20)
Attended all appointments	530 (82)	93 (69)	623 (80)
Missing*	10	0	10

*Denominator for percentages based on observed data only. Percentages may not sum to 100 due to rounding.

randomized studies. In contrast to previous literature which advocated surgical fixation for multiple or open fractures,[7,26] this association was attenuated in the adjusted analysis.

The large sample size, specific focus on MSF, and multiplicity of sites in our study provides a more robust assessment of MSF than previous studies. We included a broad mix of centres with a wide geographical spread to account for regional variations in prevalence and standard care.

As study centres were not randomly selected, though aiming to be representative, we may have included naturally conservative centres with higher rates of non-surgical intervention. Therefore, the picture is an indication rather than confirmatatory of patterns of care across the country. However, the study sample includes all patients presenting to the centre, as MSFs are treated in the acute hospital setting in the UK, hence the data are comprehensive for the catchment areas studied. There were few surgically treated patients overall, limiting the numbers available for adjusted analyses in regression models. We relied on the accuracy of healthcare records and were unable to explore associations between occupation and treatment modality due to poor documentation. Reporting of complications may be inconsistent, as they were retrospectively collected using qualitative descriptors such as "persistent pain", "weakness", or "altered sensation" from medical notes, and we did not account for treatments received prior to fracture clinic.

Our study demonstrates heterogeneity in treatment of MSF of the finger digits, supporting the need for randomized trials to assess the effectiveness of surgical and non-surgical treatments. It also provides essential information to improve the efficient design and implementation of future studies. First, the heterogeneity in practice supports the need for a study to compare treatment methods, while the examination of resource use helps to quantify the burden of MSF on healthcare services, thereby strengthening future grant applications. Second, defining the epidemiology highlights the size and characteristics of the eligible patient pool available for recruitment. It also informs likely recruitment rates and the number of sites required in a future trial. Lastly, information regarding routine attendances and timing of radiographs will help determine planned follow-ups. However, most patients were not routinely seen beyond three to four weeks, therefore longer follow-up in this cohort must be balanced against the ability to retain and engage patients in studies. Though our data supports the inclusion of all fracture patterns in a future trial, as no one pattern was preferentially treated one way or another, acceptable thresholds of deformity for MSF need to be identified to inform selection criteria for future studies and aid surgical decision-making.

References

1. **Dias JJ**, **Garcia-Elias M**. Hand injury costs. *Injury*. 2006;37(11):1071–1077.
2. **Stanton JS**, **Dias JJ**, **Burke FD**. Fractures of the tubular bones of the hand. *J Hand Surg Eur Vol*. 2007;32(6):626–636.
3. **Chung KC**, **Spilson SV**. The frequency and epidemiology of hand and forearm fractures in the United States. *J Hand Surg Am*. 2001;26(5):908–915.
4. **Gudmundsen TE**, **Borgen L**. Fractures of the fifth metacarpal. *Acta Radiol*. 2009;50(3):296–300.
5. **de Jonge JJ**, **Kingma J**, **van der Lei B**, **Klasen HJ**. Fractures of the metacarpals. A retrospective analysis of incidence and aetiology and a review of the English-language literature. *Injury*. 1994;25(6):365–369.
6. **Day C**, **Stern P**. Fractures of the metacarpals and phalanges. In: *Green's Operative Hand Surgery*. Vol 1. Elsevier Science, 2017: 231–277.
7. **Diaz-Garcia R**, **Waljee JF**. Current management of metacarpal fractures. *Hand Clin*. 2013;29(4):507–518.
8. **Giddins GEB**. The non-operative management of hand fractures. *J Hand Surg Eur Vol*. 2015;40(1):33–41.
9. **Kollitz KM**, **Hammert WC**, **Vedder NB**, **Huang JI**. Metacarpal fractures: treatment and complications. *Hand (N Y)*. 2014;9(1):16–23.
10. **Retrouvey H**, **Morzycki A**, **Wang AMQ**, **Canadian Plastic Surgery Research Collaborative**, **Binhammer P**. Are we over treating hand fractures? Current practice of single metacarpal fractures. *Plast Surg (Oakv)*. 2018;26(3):148–153.
11. **Wong VW**, **Higgins JP**. Evidence-based medicine: management of metacarpal fractures. *Plast Reconstr Surg*. 2017;140(1):140e–151e.
12. **Biz C**, **Iacobellis C**. Comparison of percutaneous intramedullary Kirschner wire and interfragmentary screw fixation of displaced extra-articular metacarpal fractures. *Acta Biomed*. 2014;85(3):252–264.
13. **Braakman M**. Is anatomical reduction of fractures of the fourth and fifth metacarpals useful? *Acta Orthop Belg*. 1997;63(2):106–109.
14. **Gulabi D**, **Avci CC**, **Cecen GS**, **Bekler HI**, **Saglam F**, **Merih E**. A comparison of the functional and radiological results of Paris plaster cast and ulnar gutter splint in the conservative treatment of fractures of the fifth metacarpal. *Eur J Orthop Surg Traumatol*. 2014;24(7):1167–1173.
15. **Küntscher MV**, **Schäfer DJ**, **Germann G**. Frakturen der mittelhand. indikationen und behandlungsoptionen. [Metacarpal fractures: treatment indications and options. Results of a multicenter study]. *Chirurg*. 2003;74:1018–1025. . [Article in German].
16. **Ozer K**, **Gillani S**, **Williams A**, **Peterson SL**, **Morgan S**. Comparison of intramedullary nailing versus plate-screw fixation of extra-articular metacarpal fractures. *J Hand Surg Am*. 2008;33(10):1724–1731.
17. **Sletten IN**, **Nordsletten L**, **Husby T**, **Ødegaard RA**, **Hellund JC**, **Kvernmo HD**. Isolated, extra-articular neck and shaft fractures of the 4th and 5th metacarpals: a comparison of transverse and bouquet (intramedullary) pinning in 67 patients. *J Hand Surg Eur Vol*. 2012;37(5):387–395.
18. **Tavassoli J**, **Ruland RT**, **Hogan CJ**, **Cannon DL**. Three cast techniques for the treatment of extra-articular metacarpal fractures. Comparison of short-term outcomes and final fracture alignments. *J Bone Joint Surg Am*. 2005;87-A(10):2196–2201.
19. **Konradsen L**, **Nielsen PT**, **Albrecht-Beste E**. Functional treatment of metacarpal fractures 100 randomized cases with or without fixation. *Acta Orthop Scand*. 1990;61(6):531–534.
20. **McMahon PJ**, **Woods DA**, **Burge PD**. Initial treatment of closed metacarpal fractures. A controlled comparison of compression glove and splintage. *J Hand Surg Br*. 1994;19(5):597–600.
21. **Pandey R**, **Soni N**, **Bhayana H**, **Malhotra R**, **Pankaj A**, **Arora SS**. Hand function outcome in closed small bone fractures treated by open reduction and internal fixation by mini plate or closed crossed pinning: a randomized controlled trail. *Musculoskelet Surg*. 2019;103(1):99–105.
22. **No authors listed**. UK Policy Framework For Health And Social Care Research. NHS Health Research Authority. https://www.hra.nhs.uk/planning-and-improving-research/policies-standards-legislation/uk-policy-framework-health-social-care-research/uk-policy-framework-health-and-social-care-research (date last accessed 24 July 2024).
23. **NHS Health Research Authority Research Ethics Service**. Defining Research. 2007. https://www.pi.nhs.uk/data/consent/NRES_leaflet_Defining_Research.pdf (date last accessed 24 July 2024).
24. **NHS Digital**. Hospital Episode Statistics (HES). https://digital.nhs.uk/data-and-information/data-tools-and-services/data-services/hospital-episode-statistics#further-information (date last accessed 24 July 2024).
25. **Meinberg EG**, **Agel J**, **Roberts CS**, **Karam MD**, **Kellam JF**. Fracture and Dislocation Classification Compendium-2018. *J Orthop Trauma*. 2018;32 Suppl 1:S1–S170.
26. **Kozin SH**, **Thoder JJ**, **Lieberman G**. Operative treatment of metacarpal and phalangeal shaft fractures. *J Am Acad Orthop Surg*. 2000;8(2):111–121.
27. **Strauch RJ**, **Rosenwasser MP**, **Lunt JG**. Metacarpal shaft fractures: the effect of shortening on the extensor tendon mechanism. *J Hand Surg Am*. 1998;23(3):519–523.

28. **Barton NJ**. Use of a hand plaster for fractures of the shaft of the fifth metacarpal. *J Hand Surg Br*. 2005;30(1):99.
29. **Gustilo RB**, **Anderson JT**. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: retrospective and prospective analyses. *The Journal of bone and joint surgery American volume*. 1976;58(4):453–458.
30. **NHS England**. NHS Improvement 2019/20 National Tariff Payment System: National Prices and Prices for Emergency Care Services 2019/20. https://www.england.nhs.uk/publication/past-national-tariffs-documents-and-policies/ (date last accessed 24 July 2024).
31. **Nakashian MN**, **Pointer L**, **Owens BD**, **Wolf JM**. Incidence of metacarpal fractures in the US population. *Hand (N Y)*. 2012;7(4):426–430.
32. **Laugharne E**, **Bhavsar D**, **Rajaratnam V**. The distribution of hand fractures: a British perspective. *Eur J Plast Surg*. 2013;36(6):367–370.
33. **van Onselen EBH**, **Karim RB**, **Hage JJ**, **Ritt MJPF**. Prevalence and distribution of hand fractures. *J Hand Surg Br*. 2003;28(5):491–495.
34. **Taha RHM**, **Grindlay D**, **Deshmukh S**, **Montgomery A**, **Davis TRC**, **Karantana A**. A systematic review of treatment interventions for metacarpal shaft fractures in adults. *Hand (N Y)*. 2022;17(5):869–878.
35. **de Putter CE**, **van Beeck EF**, **Polinder S**, **et al**. Healthcare costs and productivity costs of hand and wrist injuries by external cause: A population-based study in working-age adults in the period 2008-2012. *Injury*. 2016;47(7):1478–1482.
36. **Diao E**. Metacarpal fixation. *Hand Clin*. 1997;13(4):557–571.
37. **Orbay J**. Intramedullary nailing of metacarpal shaft fractures. *Tech Hand Up Extrem Surg*. 2005;9(2):69–73.
38. **Dreyfuss D**, **Allon R**, **Izacson N**, **Hutt D**. A comparison of locking plates and intramedullary pinning for fixation of metacarpal shaft fractures. *Hand (N Y)*. 2019;14(1):27–33.

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Data sharing

The data that support the findings for this study are available to other researchers from the corresponding author upon reasonable request.

Ethical review statement

The study was locally approved by individual institutions as an evaluation of service in line with UK Policy Framework for Health and Social Care Research and guidance from the National Research Ethics Service, and thus ethical approval was not required.

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