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Talbot, C., Davis, N., Majid, I. et al. (4 more authors) (2018) Fractures of the femoral shaft in children: national epidemiology and treatment trends in England following activation of major trauma networks. Bone and Joint Journal , 100B (1). pp. 109-118. ISSN 2049-4394

https://doi.org/10.1302/0301-620X.100B1.BJJ-2016-1315.R3

Title: Paediatric Femoral Shaft Fractures: National epidemiology and treatment trends in England following activation of Major Trauma Networks

Abstract

To describe the epidemiology of closed isolated femoral shaft fractures in children, and compare treatments used in Major Trauma Centres (MTCs) and Trauma units (TUs) in England.

National Data was obtained from the Trauma and Audit Research Network (TARN) for all isolated femoral shaft fractures in children aged 0 to 15 years between 2012 and 2015. Age, gender, season fracture occurred, non-accidental injury, injury mechanism, hospital trauma status, length of stay (LOS) and treatment type were recorded.

1852 closed isolated femoral shaft fractures were identified. The overall average annual incidence was 5.82 per 100,000 children (95% CI, 5.20 to 6.44). The age of peak incidence was 2 years for both boys and girls, this decreased with increasing age. Children aged 4 to 6 years treated in MTCs were more likely to be managed with open reduction internal fixation when compared to children treated in TUs (OR 3.20; 95% CI 1.12 to 9.14; p=0.03). Median hospital LOS was significantly less in MTCs compared to TUs for children aged 18 months to 3 years treated in both a spica (p=0.005) and traction (p=0.0004).

This study highlights the current national trends in closed isolated paediatric femoral shaft fracture management following activation of major trauma networks. Future studies focussing on the reasons for differences identified may help achieve more consistency in the management of these injuries across the trauma networks.

Level III evidence.

Introduction

In 2012 Major Trauma Networks (MTNs) were activated in England to improve the management and organisation of trauma care. Seriously injured children are defined as having major trauma injuries and are subsequently diverted away from their regional Trauma Units (TUs) and triaged to Major Trauma Centres (MTCs)[1]. ~~TUs are linked to MTCs, with whom they work with closely to ensure that optimal standards of care are provided for children with traumatic injures[2].~~ In contrast to TUs, MTCs have a comprehensive level of specialist care required to treat serious and/or life threatening injuries[2]. Injury is the most frequent cause of death and disability in children and young people after the first year of life[3]. Femoral shaft fractures in children are one of the most common consequences of traumatic injury requiring inpatient care[4,5].

~~Closed isolated femoral shaft fractures are classified as a moderately severe trauma and as such are treated at both MTCs and TUs.~~ There is no overall consensus about which is the most appropriate type of hospital to treat this injury. MTCs may be the best treating hospital if specialist surgery is required. Maintaining treatment and care at TUs enables children to be managed closer to home, with less disruption to safeguarding processes, if this is indicated.

Despite isolated femoral shaft fractures being a common injury, we identified only one study of children's femoral shaft fracture epidemiology in England[6]. This study focused on a regional population in the West Midlands, England and was conducted from 1991 to 2001, prior to the activation of MTNs ~~major trauma networks~~. This national study of paediatric femoral shaft fracture epidemiology was undertaken to provide an update and inform MTNs of safe and effective pathways for these children and accident prevention efforts.

Patients and methods

Under the terms and conditions of a data sharing agreement, anonymised data was obtained from Trauma and Audit Research Network (TARN). The data include submissions from 138 TUs and 27 MTCs. The 27 MTCs included data from 5 specialist children's MTCs, 11 children and adult MTCs, 11 adult only MTCs within the children's Major Trauma Network[7].

During the study period from April 1st, 2012 and March 31st 2015 we identified 2021 closed isolated femoral shaft fractures in children aged 0 to 15 years coded by TARN using the abbreviated injury score[8].

A secondary validation of diagnosis codes for femoral fracture was undertaken. For cases to be included in the study, both SJ and CT had to agree that the cases met the study inclusion criteria. The validation involved a review of radiology reports, operative notes, discharge summaries and the injury description fields within the TARN database.

Inclusion Criteria: Children aged (0 to 15 years) with a closed femoral shaft fracture; injury sustained through trauma; isolated injury (no other injuries identified).

Exclusion Criteria: Femoral neck, intertrochanteric, distal femoral physeal, intra-articular fractures, and slipped capital femoral epiphysis; open, pathological or periprosthetic fractures; children with injuries in addition to their femoral fracture; insufficient injury detail to determine the precise location of the fracture; bilateral femoral fractures.

Paediatric fractures sustained and managed outside of England, and children with missing data fields relating to treatment were not included in the data analysis when comparing treatment used in MTCs and TUs. (Figure 1)

Demographic data included: age, gender, season fracture occurred, non-accidental injury (NAI), injury mechanism, hospital trauma status (MTC versus TU), length of stay (LOS) and treatment type.

Age was categorised as: infancy (<18 months), toddlers (18 months to 3 years), pre-school (4 to 6 years), school age (7 to 11 years), adolescence (>11 years).

Season of fracture was categorised as; Autumn (22nd September to 20th December), Winter (21st December to 19th March) Spring (20th March to 20th June) Summer (21th June to 21st September).

Children were grouped into 6 categories according to cause of injury: road traffic collision (RTC), fall of <2 metres, fall of >2 metres, crush, blow and other.

Pavlik harness, traction (including gallows, Thomas splint, skin, and skeletal traction), hip spica (early or delayed following initial traction), above knee plaster of Paris (AKPOP) cast, open reduction internal fixation (ORIF), intra-medullary nailing (rigid and flexible nails), circular frame, and external fixator were treatments documented within the TARN database. Early spica treatment was defined as application of spica within 48hours of admission, delayed >48hours.[9]

Definitive treatment was defined as the treatment in which the patient had up to the day of discharge from the treating hospital. All patients were initially treated with 'traction', for many this was not definitive. Analysis was based on the definitive treatment undertaken. All patients were discharged home or to a home with carers. Two patients had a change of treatment following discharge; both changing from traction to spica. No other patients within this study were recorded as being readmitted for change in femoral fracture treatment following discharge from hospital. A patient was only categorised into the traction group if this was the only treatment the patient received during their hospital stay and was recorded as the only treatment used until discharge from hospital, and were not readmitted for change in treatment. A patient would not be categorised into the traction group if initially placed into traction (any form) prior to being placed into a spica (early or delayed), or having another operative procedure to manage their fracture during their admission. For purposes of analysis all forms of traction, used definitively, were placed into the 'traction' group. Verification of definitive treatment was undertaken and involved a review of all TARN descriptive data documented for each individual patient. This ensured all patients treated with traction were coded correctly as the definitive treatment.

Mid-year population estimates for 2012 to 2015 were obtained from the Office for National Statistics[10]. These were used as denominators to calculate the national annual incidence of paediatric closed isolated femoral shaft fractures[6].

Statistical Analysis

For the purpose of analysis when comparing treatment types and hospital LOS between MTCs and TUs, centres holding MTC status for adults and/or children were considered MTCs. Bilateral femoral fractures in an individual were excluded. The Chi-squared or Fisher exact test was used to determine differences between definitive treatment at MTCs and TUs for different age groups. The Bonett-Price test was used to assess any difference in LOS following a particular treatment in a specified age group between MTCs and TUs[11]. A p value < 0.05 was considered statistically significant. Stata® version 14 was used to perform all statistical analysis.

Results

During 2012 to 2015, 1852 closed isolated femoral shaft fractures were recorded, 1358 (73.3%) in males and 494 (26.7%) in females; a ratio of 2.75:1. There were no mortalities. 68 patients (3.7%, [95% CI, 2.8-4.8]) were recorded as having an NAI, 62 (91.2%) of which occurred in children less than 2 years.

Incidence

The overall mean annual incidence was 5.82 per 100,000 children (95% CI, 5.2-6.44), 8.33 (95% CI, 7.43-9.24) in boys and 3.18 (95% CI, 2.40-3.96) in girls. (Table 1) The age of peak incidence was 2 years for both boys and girls, this decreased with increasing age. (Figure 2)

Mechanism

Figure 3 shows the distribution of injury mechanism for all closed isolated femoral shaft fractures according to age. A fall <2 metres was the most common injury mechanism across all age categories.

Seasonal Variation

Closed isolated femoral shaft fractures ~~shaft~~ occurred most frequently in the summer. Over the 3 years (2012 to 2015) 560 (30.2%) of femoral fractures were sustained in the summer, compared to 395 (21.3%) of femoral fractures in the winter. (Figure 4)

Major Trauma Pathway and activity

Of the 1852 closed isolated femoral shaft fractures, 1181 (63.7%) were treated solely in TUs, and 543 (29.3%) solely in MTCs. 128 (6.9%) of children with femoral fractures were transferred between hospitals within the major trauma networks, of which 80 (4.3%) were transfers from TUs to MTCs. (Figure 5) 1206 and 646 femoral fractures were treated definitively in TUs and MTCs, respectively (a rate of 23.9 fractures per MTC and 8.7 fractures per TU involved in the study). Over the period of three years there was a decrease in the total number of closed isolated femoral shaft fractures recorded (Goodness of fit; p=0.540). (Figure 6) There was also a corresponding decrease in the number of femoral fractures treated at TUs and increase in the number of femoral fractures treated at the MTCs (p=0.0011).

Treatment trends between MTCs and TUs

Of the 1852 closed isolated femoral shaft fractures identified, known treatments were documented in 1397 cases (75.4%). Table 2 demonstrates the number of closed isolated femoral shaft fractures definitively treated, categorised by age and treatment modality. Spica treatment was the most frequent mode of treatment in children aged between 0 to 6 years. (Figure 7) Children aged 4-6 were more likely to undergo ORIF in MTCs when compared with TUs (OR 3.20; 95% CI 1.12 to 9.14). This finding was statistically significant. (Table 3)

Hospital LOS between MTCs and TUs

The median LOS for children aged 18 months to 3 years treated in a spica was 2 days less for children managed in MTCs compared to TUs (p<0.005). In the same age group, the median LOS when using traction was 5 days less, in the MTCs compared to TUs, (p<0.0004). (Table 4) Differences in LOS at MTCs and TUs for those treated in spica (early and delayed) are shown in Tables 5 and 6. ~~The pre-operative median LOS for delayed spica application was longer in MTCs compared to TUs (p=0.023). (Table 5) Moreover, a significant differences were found between median LOS in MTCs and TUs for delayed spica treatment in the 18 month to 3 years group (p=0.0314) and 4-6 years group (p=0.045). (Table 6)~~

Discussion

This study provides up to date epidemiological information based on 1852 closed isolated femoral shaft fractures over a 3 year period in children managed within the major trauma networks in England. We have identified only one study of national paediatric femoral shaft fracture epidemiology[12]. The study was conducted in Sweden and due to differences in demographics, environmental and socioeconomic factors it is difficult to apply these findings to an English population. Other studies of paediatric femoral fracture epidemiology have derived their populations from states in America[13-15], a county in Sweden[16], a hospital in South Africa[17], a region in England[6], and an urban population in Denmark[18]. To our knowledge this is the first national review of the management of paediatric femoral fractures following the activation of MTNs in England.

The average annual incidence of closed isolated paediatric femoral shaft fractures was 5.82 per 100,000 children. This is lower than several previously reported studies[6,12]. Heideken et al.[12] report a higher average annual incidence of 16.4 fractures per 100,000 children. The Swedish study is comparable in terms of fracture site, but includes children with open fractures and associated injuries. This may contribute to the higher incidence seen in femoral shaft fractures overall.

~~Isolated femoral shaft fractures in children are assigned an Injury Severity Score (ISS) of 9 which automatically triggers the TARN inclusion criteria.~~ Annually, TARN validates trauma data by asking all MTCs and TUs to compare submissions against Hospital Episode Statistics (HES) data. Over the study period, the range of completeness of trauma data for MTCs was 91.5% to 100+% and for TUs 59.8 to 69.2%. We were unable to obtain data completeness figures specifically for closed isolated femoral fractures. Due to the variability in the data completeness within the trauma networks ~~on the whole~~, there is potential to miss cases ~~is present~~ and an underestimation of the femoral fracture incidence may have been reported in this study. One explanation for the difference between MTCs and TUs data completeness may be due to the Best Practice Tariff (BPT)[2], exclusively allocated to MTCs for achieving trauma standards, which may incentivise ~~provide more of an incentive for~~ MTCs to submit data compared to TUs. ~~Therefore,~~ We recommend a review of current data collection practices, especially in the TUs to help improve data completeness.

The predominance of boys (73%) with isolated femoral shaft fractures ~~in our study~~ is a consistent finding with several previously reported studies[6,12,18], and ought to be considered in accident prevention strategies. In addition, boys had a peak incidence of femoral shaft fracture at the age of 2 years (Figure 2). The increased number of boys with femoral shaft fractures relates to their known increased injury risk taking behaviour compared to girls[19,20]. Despite this, the difference in risk with gender is still the subject of debate, as yet there is limited evidence to support any particular explanation.

Falls less than 2 metres were the most common injury mechanism for all age categories, but this was most pronounced in the 18 months to 3 year age category (Figure 3). This category of injury mechanism is predefined within the TARN database which does not allow for the differentiation of the exact height fallen. However, most falls in toddlers represent a low energy impact which can result in spiral femoral shaft fractures[13]. Furthermore, toddlers have less well developed protective reflexes and may have unprotected falls which are more likely to result in a lower limb fracture. Older children have more developed motor skills and are more likely to fall on an outstretched arm[13,18].

This study found NAI to be a suspected cause of femoral fracture in 3.8% of children. This is higher than the West Midlands based study[6] in which non-accidental injury accounted for 1.17% of fractures. The increase in suspected cases of NAI may be ~~as~~ a result of high profile child abuse cases and changes in legislation since the publication of the West Midlands based study[21,22]. Furthermore, there has been a recent increase in referrals to children's social care departments[23].

The impact of activating MTNs is demonstrated in this study by the decrease in femoral fractures managed at TUs and corresponding increase (triage) of femoral fractures to the MTCs over the three years studied (Figure 6). Additionally, 6.9% of children with femoral fractures underwent inter-hospital transfers within the MTNs in England. The retention of 93.4% (n=1126) children with femoral fractures triaged and treated in a TU ~~and then treated definitively in a TU~~, may reflect the ongoing confidence and ability of TUs in managing this type of injury.

The use of traction, including the Thomas splint, is described and remains a technique of definitive isolated femoral fracture management within the United Kingdom and other European countries[24-27]. This study showed Thomas splint traction to be the most common form of traction treatment employed as definitive in the 18 month – 6 years age groups within England. (Table 2)

Traction at home reduces the LOS for patient and families in hospital and allows ongoing management at home. The Royal College of Nursing[27], have produced guidance on traction at home, including patient selection, preparation and care at home. It is imperative, that those undergoing treatment at home are managed correctly, in line with national guidance. A recent Cochrane review[28] of the interventions used for children with femoral shaft fractures found there to be insufficient evidence to conclude that one non-surgical method of treatment is superior to another. We recommend a national collaborative study to determine the outcomes of paediatric femoral shaft fractures comparing all non-operative treatment modalities.

Overall there were no statistically significant differences in the treatment modalities used between MTCs and TUs in children of all age groups, except for ORIF in 4-6 year olds (p=0.03). (Table 2). We found LOS to be comparable between MTCs and TUs for the majority of ages and treatments. However, children aged between 18 months and 3 years managed in a spica or traction had a significantly shorter LOS in MTCs compared to TUs. Furthermore, the overall LOS for delayed spica application in children between 18 months to 6 years was shorter in MTCs compared to TUs (p=0.025 and p=0.042). The enhanced rehabilitation standards required for MTCs, including seven day trauma rehabilitation cover and musculoskeletal specialist therapists may help to facilitate earlier discharge for children managed with either spica or traction[29]. Additionally, the difference in LOS between MTCs and TUs may be due to variations in the estimation of bone healing by clinicians, which may result in an earlier discharge from MTCs. Previous studies have identified a lack of consensus in the assessment of long bone fracture healing among orthopaedic surgeons[30] and the definition of fracture healing in orthopaedic literature[31]. This which may have a bearing on when a child, especially treated in traction, is discharged from hospital. The number of femoral fractures treated per MTC compared to TU per unit time is also greater, which may lead to increased confidence in discharging children earlier from hospital when treated in traction (for those managed with home traction).

There are several limitations of the study. The data obtained does not provide a date of fracture union. However, all patients had data relating to readmission for change in treatment. Specifically, in the traction group, only two patients were readmitted for change of treatment following discharge from hospital. Moreover, 79% (n=215) patients treated definitively in traction were discharged following removal of traction; not being placed into a spica nor undergoing further treatment. 21% (n=56) continued traction out of hospital; 32.1% (n=18) were treated in Tobruk splint.[24]

LOS is the only outcome used in this study. Further research, using both quantitative and qualitative outcomes, would help to assess the impact of the major trauma network in England for patients with an isolated closed femoral shaft fracture. In clinical practice the choice of treatment would be influenced by the configuration of the fracture, age of child and weight[3]. Data relating to weight was not available at the time of the study, but has since been incorporated into the TARN database. Future work, including age, weight and fracture configuration, when assessing treatment trends, would improve the clinical relevance. MTCs were defined as those hospitals with major trauma status, for adults and/or children. We recognise not all defined MTCs in the study were MTCs for paediatric patients, and this is a limitation.

Finally, 24.5% (n=455) of femoral fractures had unknown data fields / missing data regarding treatment undertaken. There is a need for improvement in data inputting within the major trauma networks, in particular through simplifying the data entering process and education to all data inputters. Heideken et al.[12] also reported similar findings with 26.4% (n=1317) of data missing in their national study.

Conclusion

This is the only national study of closed isolated paediatric femoral shaft epidemiology and treatment trends and follows the activation of MTNs in England. Treatment of femoral fractures is comparable between MTCs and TUs for the majority of children which may impact on future trauma pathway planning. Our study shows that accident prevention should focus on falls in children aged between 18 months and 3 years. We would recommend that future studies focus on understanding the reasons for differences in treatment and LOS identified in this study, and believe this may help achieve more consistency in the management of paediatric femoral fractures and optimise patient experience across the MTNs.

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Tables:

Table 1: Mean annual incidence rates per 100000 population for closed isolated paediatric femoral shaft fractures according to age and gender. [95% Confidence Intervals]

	Age / years																
Gender	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Combined ages
Male	5.92 [2.68-9.15]	16.2 [8.95-23.5]	35.6 [30.3-40.9]	19.2 [9.40-29.0]	10.4 [2.71-18.1]	6.55 [2.63-10.5]	5.76 [3.00-8.53]	4.09 [3.05-5.13]	4.36 [1.98-10.7]	3.93 [2.85-5.36]	3.88 [1.67-6.10]	4.80 [3.18-6.42]	3.85 [0.28-7.43]	4.31 [1.21-7.40]	2.63 [0.17-5.09]	1.75 [0.59-4.00]	8.33 [7.43-9.24]
Female	7.02 [2.15-11.9]	7.76 [1.66-13.9]	9.21 [7.12-11.3]	5.63 [3.27-7.99]	3.44 [5.25-1.64]	2.67 [0.63-4.72]	2.71 [1.64-3.78]	2.14 [1.85-2.44]	1.32 [0.61-2.02]	1.93 [0.97-2.90]	1.26 [0.83-3.36]	1.87 [0.30-4.05]	1.27 [0.28-2.26]	0.56 [0.08-1.05]	0.99 [0.44-2.43]	1.07 [0.58-1.57]	3.18 [2.40-3.96]
Overall	6.45 [2.45-10.5]	12.1 [8.39-15.8]	22.7 [19.8-25.7]	12.6 [8.38-16.8]	7.02 [2.19-11.9]	4.66 [2.08-7.24]	4.27 [2.34-6.20]	3.14 [2.50-3.78]	2.87 [0.64-6.38]	2.95 [1.29-4.61]	2.61 [1.67-3.54]	3.37 [1.81-4.93]	2.60 [1.21-3.99]	2.48 [0.67-4.29]	1.83 [0.10-3.77]	1.42 [0.40-3.25]	5.82 [5.20-6.44]

Table 2: Number of closed isolated femoral shaft fractures definitively treated, categorised by age and treatment modality (AKPOP – above knee plaster of Paris, ORIF – open reduction internal fixation)

		Centre	Age category <18months	18months - 3 years	4 - 6 years	7 - 11 years	>11 years
Spica		MTC	32	145	31	3	0
	Early		10	35	9	1	0
	Delayed		22	108	21	2	0
	Unknown		0	2	1	0	0
		TU	47	322	64	10	0
	Early		7	41	6	2	0
	Delayed		36	272	46	8	0
	Unknown		4	9	2	0	0
Traction		MTC	16	59	21	5	0
	Skin (Gallows)		12	4	0	0	0
	Skin (other)		0	1	1	0	0
	Skeletal		0	0	0	0	0
	Thomas splint		2	42	20	5	0
	Unknown		2	12	0	0	0
		TU	28	108	28	6	0
	Skin (Gallows)		22	7	0	0	0
	Skin (other)		0	21	4	1	0
	Skeletal		0	2	0	1	0
	Thomas splint		3	49	14	4	0
	Unknown		3	29	10	0	0
IM Nailing		MTC	0	4	27	48	55
	Rigid		0	0	0	14	36
	Flexible		0	4	27	34	19
	Unknown		0	0	0	0	0
		TU	0	0	49	61	65
	Rigid		0	0	3	6	30
	Flexible		0	0	41	54	26
	Unknown		0	0	5	1	9
ORIF		MTC	0	1	10	27	23
		TU	0	0	6	29	37
AK POP		MTC	1	4	0	1	0
		TU	0	6	5	4	1
External fixator		MTC	0	0	0	1	2
		TU	0	0	1	1	0
Circular frame		MTC	0	0	0	0	1
		TU	0	0	0	0	0
Pavlik Harness		MTC	1	0	0	0	0
		TU	1	0	0	0	0

Table 3: Difference between treatment modalities undertaken at MTCs and TUs for differing age groups for closed isolated femoral shaft fractures, presented as odds ratios (95% confidence intervals and p values given; chi-square test used unless marked * denoting the use of fisher exact test).

Age	Spica	Traction	IM nailing	ORIF
< 18 months	OR 1.10 [95% CI 0.52 – 2.30] p=0.81	OR 0.81 [95% CI 0.38 – 1.72] p=0.58	-	-
18 months – 3 years	OR 0.75 [95% CI 0.53 – 1.08] p=0.12	OR 1.16 [95% CI 0.80 – 1.69] p=0.42	-	-
4 – 6 years	OR 0.74 [95% CI 0.43 – 1.28] p=0.28	OR 1.38 [95% CI 0.73 – 2.61] p=0.32	OR 0.91 [95% CI 0.52 – 1.62] p=0.76	OR 3.20 [95% CI 1.12 – 9.14] p=0.03*
7- 11 years	OR 0.36 [95% CI 0.10 – 1.34] p=0.15*	OR 1.06 [95% CI 0.31 – 3.59] p=0.99*	OR 1.13 [95% CI 0.64 – 1.99] p=0.68	OR 1.26 [95% CI 0.68 – 2.34] p=0.47
Over 11 years	-	-	OR 1.24 [95% CI 0.67 – 2.29] p=0.50	OR 0.71 [95% CI 0.36 – 1.39] p=0.28

- Groups in which no data or insufficient data was present to allow for comparison.

Treatment of fractures with Pavlik harness, above knee POP, external fixator or circular frame had insufficient data to allow for comparison.

Table 4: Comparison of median length of stay (days) and (inter-quartile range) between MTCs and TUs for different age and treatment categories for closed isolated femoral shaft fractures (p values using the Bonett-Price test)

Age	Above knee POP	Spica	Traction	IM nailing	ORIF
<18 months	-	5 (4-8) vs 6 (4-10) (p=0.43)	16 (12.5-19) vs 19 (14-22) (p=0.18)	-	-
18 months – 3 years	7.5 (4-14) vs 17.5 (5-26) (p=0.15)	6 (4-10) vs 8 (4-13) (p=0.005)	17 (14-23) vs 23 (20-29) (p=0.0004)	-	-
4 – 6 years	-	11 (4-17) vs 10 (5-16) (p=0.73)	19 (16-27) vs 26 (14-33.5) (p=0.064)	5 (4-9) vs 7 (4-11) (p=0.14)	7 (5-9) vs 7 (5-10) (p=0.99)
7- 11 years	-	11(3-30) vs 19 (7-28) (p=0.60)	17.5 (15-23) vs 52 (50-59) (p=0.007)	6 (4-8) vs 6 (4-9) (p=0.99)	7 (4-9) vs 6 (4-8) (p=0.39)
Over 11 years	-	-	-	6 (4-9) vs 5 (4-9) (p=0.17)	5 (4-8) vs 5 (4-8) (p=0.99)

- Groups in which no data or insufficient data was present to allow for comparison.

Treatment of fractures with Pavlik harness, external fixator or circular frame had insufficient data to allow for comparison.

Table 5: Comparison of pre and post-operative median length of stay (days) and (inter-quartile range) between MTCs and TUs for different age and treatment categories for closed isolated femoral shaft fractures (p values using the Bonett-Price test)

Age	Spica		IM Nailing		ORIF	
	Pre-Op	**Post-Op**	**Pre-Op**	**Post-Op**	**Pre-Op**	**Post-Op**
<18 months	3 (2-7) vs 5.5 (3-9) (p=0.041)	1 (1-2) vs 1 (0-2) (p=0.999)	-	-	-	-
18 months – 3 year	5 (3-9) vs 6 (3-12) (p=0.042)	1 (1-2) vs 1 (0-1) (p=0.999)	-	-	-	-
4 – 6 years	8.5 (2-16) vs 8 (4-13) (p=0.87)	1 (1-3) vs 1 (1-1) (p=0.999)	1 (1-2) vs 1 (1-6) (p=0.20)	3 (2-5) vs 3 (2-5) (p=0.99)	2 (1-2) vs 3 (2-7) (p=0.66)	3.5 (2-5) vs 3 (3-5) (p=0.79)
7- 11 years	6 (1-11) vs 14 (3-19) (p=0.35)	1 (0-2) vs 2.5 (2-16) (p=0.80)	1 (1- 3) vs 6 (4-9) (p=0.99)	4 (3-5) vs 4 (2-6) (p=0.99)	1 (1-3) vs 2 (1-5) (p=0.09)	5 (3-6) vs 4 (3-5) (p=0.22)
Over 11 years	-	-	2 (1-3) vs 1 (1-2) (p=0.006)	4 (3-6) vs 4(3-6) (p=0.99)	1 (1-2) vs 1 (1-2) (p=0.99)	4 (3-6) vs 3 (3-6) (p=0.06)

- Groups in which no data or insufficient data was present to allow for comparison.

Treatment of fractures with Pavlik harness, external fixator, and circular frame had insufficient data to allow for comparison.

Table 6: Comparison of pre, post-operative and overall median length of stay (days) and (inter-quartile range) between MTCs and TUs for different age categories for closed isolated femoral shaft fractures using early and delayed spica treatment (p values using the Bonett-Price test)

Age	Early Spica (< 48 hours)			Delayed Spica (>48 hours)		
	Pre-Op	**Post-Op**	**Overall**	**Pre-Op**	**Post-Op**	**Overall**
<18 months	2 (1-2) vs 2 (1-2) (p=0.079)	2 (1-2) vs 2 (1-5) (p=0.99)	3 (3-4) vs 3 (3-6) (p=0.99)	5 (3-8) vs 6 (3-9) (p=0.55)	1 (1-1) vs 1 (0-1) (p=0.99)	6 (5-9) vs 7 (5-10) (p=0.52)
18 months – 3 year	2 (1-2) vs 2 (1-2) (p=0.99)	2 (1-3) vs 2 (1-3) (p=0.99)	3 (3-4) vs 3(3-4) (p=0.99)	6 (4-11) vs 7.5 (4-13) (p=0.09)	1 (1-1) vs 1 (0-1) (p=0.99)	7 (5-12) vs 9 (5-14) (p=0.025)
4 – 6 years	2 (1-2) vs 2 (1-2) (p=0.99)	2 (1-3) vs 2 (1-10) (p=0.99)	3 (3-4) vs 3 (3-11) (p=0.99)	15 (8-16) vs 9 (4-15.5) (p=0.006)	1 (0-2) vs 1 (1-1) (p=0.99)	15(11-21) vs 10 (5.5-17) (p=0.042)
7- 11 years	-	-	-	16.5 (11-22) vs 20 (14-28.5) (p=0.73)	4 (0-8) vs 2 (1.5-3.5) (p=0.74)	20.5 (11-30) vs 22 (14.5-36.5) (p=0.93)
Over 11 years	-	-	-	-	-	-

Figures:

Figure 1. Schematic to show inclusion / exclusion process.

Figure 2. Mean annual incidence of closed isolated paediatric femoral shaft fractures by age (years).

Figure 3. Distribution of injury mechanism according to age.

Figure 4. Graphical representation of seasonal variation for closed isolated femoral shaft fractures.

Figure 5. Graphical representation of the Major Trauma Pathway and differences between years.

Figure 6. Closed isolated femoral shaft fracture treated in MTCs and TUs between 2012 and 2015.

Figure 7. Graphical representation of the four most common treatments for isolated closed femoral fractures used in each age group.