Childhood metatarsal shaft fractures: treatment outcomes and relative indications for surgical intervention

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Abstract

Purpose Although the epidemiology of childhood metatarsal fractures is known, the appropriate treatment has not been elucidated. This study was undertaken to ascertain the outcomes of both non-operative and surgical treatment of these common childhood injuries and to discern any indications for treatment.

Methods A retrospective review was performed of all children identified from 2006 to 2007 with a metatarsal fracture by the ICD-9 code, 825.25. After dividing the cohort into groups by age in years (0–5, 6–10, 11–15, 16 and older), we collected demographics, mechanism of injury, and associated injuries, as well as clinical information concerning metatarsal involvement, treatment, complications, return to activities/sports, and residual pain. Radiographic information was also collected, including fracture location, displacement, comminution, and union.

Results We identified 337 children that met the criteria. The mean age was 10.5 years (range 1.8–20.6). Only ten children had surgery. Only age, multiplicity of metatarsal fracture, and fracture translation was statistically different between the non-surgical and surgical cohorts. None of the patients under the age of 12 years underwent surgical intervention ($p = 0.005$). Evidence of multiple metatarsal

fractures was seen in only 28 % of the non-surgical group compared to 70 % of the surgical group ($p = 0.009$). The amount of fragment translation significantly correlated with a decision for surgery ($p = 0.001$), but not angulation. Logistic regression demonstrated that, for every year of age, the likelihood for surgery increased by 32 % and that children were 6.6 times more likely to have surgery if they had multiple metatarsal fractures. Complete union was achieved in 84.6 %, with no difference in treatment groups regarding the time of release to full activities, and of the 50 delayed unions, only two required subsequent operative interventions. Return to sports took longer in the operative group, with a mean of 4.0 compared to 2.1 months ($p < 0.001$). Only 14 children complained of residual post-treatment pain and all of those cases had been treated without surgery. The presence of post-treatment pain did not correlate with the mechanism of injury or the amount of displacement.

Conclusion Each metatarsal injury pattern is unique and surgeons should utilize their clinical judgment to determine appropriate treatment; however, there appears to be some relative indications for surgical treatment. Whereas open and articular fractures may be absolute indications for surgery, the relative indications for surgical intervention in metatarsal shaft fractures appear to be adolescent age and multiple fractures. Successful non-surgical management may consist of a short-leg walking cast for a mean of 4 weeks and activity restrictions for an additional month. However, children should be followed to radiographic union, since 15.4 % may have a delayed union and 4.3 % have short-term residual problems related to the injury.

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Introduction

Metatarsal fractures are common in the pediatric population, accounting for close to 60 % of all pediatric foot fractures [1]. The epidemiology of metatarsal fractures in children has been well established [2, 3]. It has been shown that the fracture pattern and severity of injury vary according to age and mechanism of injury [4]. This association can further be correlated with both osseous development and the age-related levels of activity [3].

Despite having a good understanding of the epidemiology, no investigation has previously evaluated the fracture-specific treatment for childhood metatarsal fractures. This study was undertaken in order to determine if the best treatment for these fractures could be determined based on patient age and fracture pattern. More specifically, we wanted to determine if relative indications could be established that would delineate when surgical intervention should be considered in the treatment of these common injuries.

Patients and methods

Clinical and radiographic review

After Institutional Review Board approval was obtained, a retrospective chart and radiographic review was performed for all consecutive children treated for a metatarsal fracture during a 2-year period from 2006 to 2007. The inclusion criterion was based on the ICD-9 code, 825.25. Exclusion criteria included those children found to have an open fracture, Lisfranc fracture, or insufficient clinical or radiographic data. The overall cohort was then divided into age-based groups for data collection. These groups included an infant and toddler group aged 0–5 years, child group aged 6–10 years, pre-teen and early adolescent group aged 11–15 years, and an older group of those aged 16 years and greater.

Each child's age, gender, side affected, mechanism of injury, associated injuries, metatarsal involvement, treatment, length of treatment, and return to activities were recorded. Pre- and post-treatment radiographic data were reviewed. Measurements including angulation, translation, and distraction of the bone fragments were performed and recorded, along with the location of the fracture. A qualitative analysis of fracture displacement and comminution was also noted during radiographic review. Final follow-up X-rays were used to assess fracture union, defined by complete resolution of the fracture line and three out of four intact cortices on orthogonal views. Delayed union was defined as any fracture not achieving union in the first 3 months, but before 6 months. Six months without union was defined as a non-union.

Statistics

Upon completion of the chart and radiographic review, the mean age, multiplicity of fractures, length of treatment, time to return to activities, and percentage with good union were calculated. The Statistical Package for the Social Sciences (SPSS, Inc., Chicago, IL) was utilized for the data analysis. Analysis of variance was utilized to detect differences in age and fracture translation between surgical and non-surgical groups. Chi-square was utilized to evaluate differences in the distribution of patients with/without multiple fractures between surgical and non-surgical groups. Multivariate logistic regression was carried out to determine significant predictors of surgical intervention and the resultant odds ratios were calculated. Alpha was set at $p < 0.05$ to declare significance.

Results

There were 337 consecutive children that met the inclusion and exclusion criteria for this study. The mean age at the time of injury for the surgical and non-surgical groups was 10.5 years (range 1.8–20.6). Of the entire study group, only ten children underwent surgical intervention, with a mean age of 14.3 years (range 12–16.3). The surgical and non-surgical groups were not statistically different regarding gender, mechanism of injury, associated injuries, or metatarsal involvement (Table 1).

The epidemiology of fractures based on age is summarized in Table 2. The 5 years old and under age group had isolated first metatarsal fractures 50.7 % of the time. The 6–10 years old age group began a shift away from that

Table 1 Demographics and treatment of the study cohort

	Non-operative (<i>n</i> = 327)	Operative (<i>n</i> = 10)
Age (years)	10.4 (range 1–21)	14.3 (range 12–16.3)
Gender	216 Males 111 Females	5 Males 5 Females
Mechanism	115 Twisting foot/ankle 48 Fall/trip (standing) 43 Jumping 24 Fall (height) 19 Jumping/twisting 16 Dropping heavy object 15 Kicking 13 Undocumented 12 Skateboarding 8 Other 7 Motor vehicle accident 7 Jammed foot	4 Skateboarding 4 Motor vehicle accident 2 Fall/trip (standing)

Table 2 Age stratified frequencies of specific metatarsal fractures

Fractures	Frequency per age group				Total
	0–5 years	6–10 years	11–15 years	16+ years	
1	36	11	12	1	60
2	0	2	5	1	8
3	4	4	3	3	14
4	0	2	4	2	8
5	1	33	101	13	148
1, 2	2	4	1	1	8
1, 2, 3	2	2	3	0	7
1, 2, 3, 4	4	0	2	0	6
1, 2, 3, 4, 5	0	1	1	0	2
1, 3	1	0	0	0	1
1, 3, 4, 5	0	0	0	1	1
2, 3	4	2	2	1	9
2, 3, 4	8	12	9	7	36
2, 3, 4, 5	2	3	4	1	10
2, 3, 5	0	1	0	0	1
3, 4	2	2	3	1	8
3, 4, 5	4	0	4	0	8
4, 5	1	0	1	0	2
Total	71	79	155	32	337

injury, with only 14 % isolated first metatarsal fractures, but with 41.8 % isolated fifth metatarsal fractures and 15.2 % combined second, third, and fourth fractures. The 11–15 years old age group had 65.2 % isolated fifth metatarsal fractures, compared to the 16 years old and over age group, with 40.6 %. Furthermore, the 16 years old and over age group had 21.9 % combined second, third, and fourth fractures.

The non-surgical group consisted of 293 children treated in a cast for a mean of 4.3 weeks, 25 treated in a post-op/hard-soled shoe or CAM walker for a mean 3.4 weeks, and nine others who were treated with activity restriction or a splint. There was no significant difference found between the metatarsal fractured and choice of immobilization. Of those treated with a cast, 188 were made weight-bearing as tolerated (WBAT), 57 were made non-weight-bearing (NWB), 35 were transitioned from NWB to WBAT after 1–4 weeks, ten were partial weight-bearing (PWB), and three were transitioned from PWB to WBAT. Twenty-one of the patients who were treated with a post-op shoe were allowed to be WBAT, two were NWB, and one was PWB.

In regards to the compliance of treatment, we had six children that had some level of non-compliance noted in their charts. These children either began playing sports or participating in physical education before they were officially released, began weight-bearing sooner than recommended, or removed their cast at home. In general, these

children were followed for a longer period of time than those who followed recommendations.

Treatment in the surgical group consisted of closed reduction and percutaneous pinning in three children and open reduction internal fixation in the remaining seven children (Fig. 1). No child under the age of 12 years required surgery ($p = 0.005$). Logistic regression demonstrated that, for every year of age, the likelihood for surgery increased by 32 %.

Evidence of multiple metatarsal fractures was seen in only 28 % of the non-surgical group compared to 70 % of the surgical group ($p = 0.009$). Logistic regression demonstrated that children were 6.6 times more likely to have surgery if they had multiple metatarsal fractures.

The average amount of translation was 84 % in the surgical group compared to the non-surgical group, which averaged 28 % translation. The amount of fragment translation significantly correlated with a decision for surgery ($p = 0.001$), but not fracture angulation. Complete union was achieved in 84.6 %, with no difference in treatment groups regarding the time of release to full activities, and of the 50 delayed unions (seen only in the non-operative group), only two required subsequent operative interventions. Both children underwent an open reduction and internal fixation of their fifth metatarsal due to delayed union of their metadiaphyseal fracture. A third child was treated for loss of reduction of their second and third metatarsals (Fig. 2).

Fig. 1 Case example of a patient treated operatively: **a** initial treatment AP, **b** final follow-up AP

Fig. 2 Case example of non-operative treatment that required subsequent operative treatment: **a** presentation AP radiograph, **b** 4 weeks post-casting AP radiograph, **c** intra-operative AP view using fluoroscopy, **d** 3 months from initial injury AP radiograph

Return to sports took longer in the operative group, with a mean of 4.0 months compared to 2.1 months ($p < 0.001$). Persistent post-treatment pain was noted in 14 patients (4.33 %) in the non-surgical group and none of the patients in the surgical group ($p = 0.523$). The presence of post-treatment pain did not correlate with the mechanism of injury or amount of displacement. These children with pain and six others that were unable to return to sports activities due to non-pain-related issues associated with their injury were followed for a mean 7.3 months, until resolution of their symptoms. This was only a month longer than the follow-up for the entire cohort, which was followed for a mean of 6.25 months (range 0–48.7), whether treated with or without surgery.

Discussion

Owen et al. [2] reported on metatarsal fractures in children. They found that the highest rate of fracture in childhood involved the fifth metatarsal (45 %) and the lowest rate of fracture was the first metatarsal (22 %). Singer et al. [3], took another look at the epidemiology and stratified their results by age. They had similar findings in regards to the frequency of metatarsal fracture, and confirmed that children under the age of 5 years were more likely to have first metatarsal fractures in contrast to those more than 5 years old, who were more likely to have fifth

metatarsal fractures. Furthermore, they found that the second, third, and fourth metatarsals were more frequently associated with other metatarsal fractures.

This current study agreed with these past epidemiology findings. For children under the age of 5 years, the frequency of isolated first metatarsal fractures was 51 %. In contrast, the older population demonstrated fifth metatarsal fracture frequency, depending on the age group, as high as 65 %. Across all age groups, the next most common fracture finding was a specific combination of second, third, and fourth metatarsal fractures.

The purpose of this study was to go beyond epidemiology and determine the best treatment for these common injuries. Each metatarsal injury pattern is unique and it is difficult to apply a general rule to any one fracture. At our institution, only 2.97 % of all feet with a closed metatarsal shaft fracture underwent any surgical intervention as the primary treatment. Once the open fractures and major ligamentous injuries are excluded, there seemed to be very little indication for surgical treatment in our population based on a retrospective analysis of surgeon preferences.

From our data, we were able to determine the following trends in treatment: an increase in child age (greater than age 12 years), the multiplicity of metatarsal fractures, and the amount of translation appeared to incline surgeons to treat the child with surgery. However, there were patients of older age, with multiple fractures, and with significant translation that were treated successfully (union and

Fig. 3 Case example of a non-operatively treated patient with significant translation at presentation: **a** initial treatment AP, **b** final follow-up AP

asymptomatic) without surgery (Fig. 3). Specifically, there were seven children with greater than 50 % translation, the most translation being 82 % in the non-operative group. Although the follow-up of this patient group is limited to their immediate return to sports, we did not have a large cohort of children (only 20 out of 337, or 5.9 %) with residual issues at their final follow-up, whether treated conservatively or with surgery.

We believe that this large cohort of children with metatarsal fractures demonstrates plausible relative indications for the treatment of these fractures among this age group. Treatment for closed metatarsal shaft fractures in childhood should consist of attempted closed management in a cast, with operative intervention reserved for cases with delayed union or severe translation in multiple fractures during adolescence. Based on our data of non-surgical treatment, successful management can consist of a short-leg walking cast for mean of 4 weeks and activity restrictions for an additional month if evidence of healing was

noted on X-ray at the time of cast removal. However, children should be followed to radiographic union, since 15.4 % had a delayed union in this study.

There are three main limitations of this study. The primary limitation is the fact that indications for surgery were subjectively derived by the treating surgeon. Given the paramount limitation of being a retrospective study, we have no method of accurately defining the reasons for surgical intervention. That and the limited number of surgical cases make it difficult to identify absolute surgical indications, and, yet, our data does suggest that the aforementioned statistically significant variables can be utilized as relative indications. The other limitation of this study is the short follow-up. The nature of treating childhood fractures is that most heal well and return to activity without returning to see a physician, especially if there are no residual symptoms. However, it should be noted that all children were doing well at final follow-up and released to sports activities without symptoms.

As with many childhood fractures that are closed and do not involve the articular surfaces, the approach to metatarsal fractures should take into account fracture location, the number of fractures, and the age of the patient, especially as those relate to the ability for the child to remodel the fracture. It appears that most childhood metatarsal shaft fractures can be successfully treated without surgery, even those with significant translation or angulation.

Conflict of interest None of the authors received financial support for this study.

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