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ORIGINAL PAPER

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Casting versus surgical fixation for grade IIIA open tibial diaphysial fractures in children: effect on the rate of infection and the need for secondary surgical procedures to promote bone union

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Abstract We evaluated 39 grade IIIA open tibial fractures presenting in children younger than 13 years of age, to determine if the mode of fracture stabilization (casting vs. surgical fixation) was related to the rate of infection or the need for secondary surgical procedures to promote bone union. All fractures had wound debridement in the operating room. Thirty patients had manipulation and casting, and nine surgical internal or external fixation. There were two cases of infection in the cast-treated group and two in the surgical fixation group (P=0.17). None of the fractures required a secondary surgical procedure to promote bone union. Three of the fractures treated by manipulation and casting displaced; two required re-manipulation and casting and one was converted to external fixation. In two cases the applied external fixator had to be re-aligned. Our results suggest that manipulation and casting is a reliable treatment for open tibial fractures in children.

Résumé Nous avons évalué 39 fractures tibiales ouvertes niveau IIIA survenues chez des enfants de moins de 13 ans, pour déterminer si le mode de stabilisation de la fracture (plâtre contre fixation chirurgicale) a été en rapport avec le taux d'infection ou la nécessité d'interventions chirurgicales secondaires pour obtenir la consolidation. Toutes les fractures avaient un parage en salle d'opération. Trente malades avaient une réduction suivie d'un plâtre, et neuf une fixation chirurgicale interne ou externe. Il y avait deux cas d'infection dans le groupe traité par plâtre et deux dans le groupe fixation chirurgicale (P=0,17). Aucun des fractures n'a nécessité une intervention chirurgicale. Trois fractures traitées par plâtre se sont déplacées, avec nouvelle réduction et plâtre pour deux, et utilisation d'un fixateur externe pour la troisième. Dans deux cas les fixateurs externes ont du être réalignés. Nos résultats suggèrent que le traitement orthopédique par réduction et plâtre est un traitement fiable pour les fractures tibiales ouvertes chez les enfants.

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Introduction

It is generally recommended that surgical fixation is performed for open fractures, to improve stability and thus reduce the risk of infection and delayed or non-union. Surgical fixation also allows easier management of open traumatic wounds that may require multiple wound debridement or plastic reconstruction procedures. However, in children, there have been reports of successful management of open tibial fractures by manipulation and casting rather than surgical fixation [1–3, 5–7].

There seems to be an agreement that low-energy, Gustilo [4] grade I fractures can be treated with casting, and that grade IIIB tibial fractures which require plastic procedures to achieve periosteal coverage should be treated by surgical fixation. However, there is no consensus with regard to the management of grade IIIA injuries, that is high-energy or very contaminated open tibial fractures where periosteal coverage is adequate. The aim of this study was to determine the outcome of grade IIIA open tibial diaphysial fractures treated with manipulation and casting and compare their outcome with that of those having surgical fixation with regard to infection rates and the need for secondary surgical procedures to promote bone union.

Methods

We retrospectively reviewed 39 cases of grade IIIA [4] open tibial diaphysial fractures in children up to the age of 13 years, presenting to seven hospitals in the northwest of England and identified from the hospitals' information system via a computer search. They were all treated between January 1992 to January 2001, although the exact number of years examined varied amongst hospitals. The principle of early surgical treatment, antibiotic prophylaxis, thorough wound cleansing and debridement was applied in all patients. Further management with casting or surgical fixation was at the discretion of the surgeon. There was no specific protocol to guide choice between casting and surgical fixation, and the decision was taken by the consultant in charge of the patient's care.

The patients' records and, where necessary, radiographs were reviewed and recorded on a pre-designed form. As this was a retrospective study, follow-up of all index patients was achieved.

All patients were followed up until there was clinical and radiological evidence of complete bony union. Superficial infection was defined as the presence of cellulitis or pus involving the soft tissue area of the wound without clinical or radiological features of osteomyelitis but requiring antibiotic treatment or surgical intervention. Deep infection was defined as the development of osteomyelitis, diagnosed clinically (development of chronic discharging sinus) or radiologically, that required surgical bone debridement. A positive microbiological culture was not considered essential for the diagnosis of superficial or deep infection. Both superficial and deep pin site infections were excluded, as these are a recognized complication of external fixator devices. Secondary surgical procedures were defined as those that were performed for inadequate radiological and clinical bony union. All fractures included in the study were diaphysial.

The fractures included in the study were divided into two groups, those having manipulation and casting and those where surgical fixation with plating or external fixation was used. The two groups were then compared with regard to overall and deep infection rates as well as the rates of secondary procedures to promote bone union. Fisher's exact test was used for statistical comparison. An intention to treat analysis was performed. Statistical significance was established at the $P<0.05$ level.

Results

Thirty-nine grade IIIA open tibial diaphysial fractures in children aged 13 years or younger were reviewed. The patients' demographics and management are summarized in Tables 1 and 2. Of the nine fractures treated by surgical fixation, six had an external fixator and three, plating. There were two (7%) cases of superficial infection in the casting group and two (22%) in the surgical fixation group, but this difference was not statistically significant ($P=0.17$). The characteristics of the patients developing an infection are shown in Table 3. There were no cases of deep infection, and none of the patients required a further surgical procedure to promote bone union. One patient with external fixation developed pin site infections, two months after injury and one month after external fixation removal, which required surgical debridement. Of the fractures treated initially with manipulation and casting, two, in a 4-year-old and a 12-year-old, required re-manipulation and casting for displacement, 10 and 14 days respectively following the initial reduction. A comminuted fracture in a 14-year-old treated initially with manipulation and casting was re-manipulated for displacement 2 days

Table 1 Demographics of the casting and surgical fixation groups of open tibial fractures

Parameter	Manipulation (n=30)	External or internal fixation (n=9)
Sex		
Male	16	6
Female	14	3
Age (years)	7 (range 3–13)	5 (range 4–11)
Mechanism of injury		
Walker hit by car	26	8
Fall from height	2	1
On motorbike hit by car	1	0
Simple fall	1	0
Fracture pattern		
Spiral	1	2
Comminuted	10	5
Transverse	11	1
Oblique	8	1

Table 2 Management of the casting and surgical fixation groups of open tibial fractures

Parameter	Manipulation (n=30)	External or internal fixation (n=9)
Time to surgery (hrs)	5.1 (2.1–24.0)	6.1 (3–15.4)
Time to initial antibiotics		
Average	76 min	72 min
Range	Range (6–422 mins)	Range (20–564 mins)
Length of antibiotic administration		
<48 h	6	3
48 h to 7 days	13	6
>7 days	11	0
Method of skin closure		
Initial closure	2	0
Delayed closure	6	2
Granulation	20	6
Partial closure	1	0
Skin grafting	1	1

Time to initial antibiotics and time to surgery are referenced to Accident and Emergency arrival time

Table 3 Characteristics of patients that developed a superficial infection

Characteristic	Case 1	Case 2	Case 3	Case 4
Age (years)	4	11	5	8
Sex	Male	Male	Male	Female
Fracture type	Spiral	Comminuted	Comminuted	Transverse
Time to initial antbiotics (min)	564	20	422	92
Antibiotic duration (days)	5	7	9	33
Type of surgery	External fixation	External fixation	Casting	Casting
Time to surgery (h)	15.4	3	3.3	4.2
Skin closure	Granulation	Delayed	Granulation	Granulatione

Time to initial antibiotics and time to surgery are referenced to arrival time at Accident and Emergency

following the initial reduction and then converted to external fixation after 14 days. In two cases where external fixation after was used, this had to be re-aligned as the achieved position was not considered satisfactory. One patient required fasciotomies for compartment syndrome. This was a 6-year-old walker hit by a car, with a comminuted fracture. The wound was surgically cleaned and the fracture stabilised with an external fixator 6 h and 20 min after injury but at 46 h the child developed compartment syndrome and was treated by fasciotomies.

Discussion

In treating open tibial fractures in adults, rigid surgical stabilization is recommended to reduce the risk of infection and encourage bone healing. There have been reports in the literature of open tibial fractures in children, successfully treated with wound debridement and immobilization in a cast [1–3, 5–7].

Bartlett et al. [1] studied 23 open tibial fractures in children aged 3.5–14.5 years, eight of which were grade IIIA. All fractures were stabilised with an external fixator and healed between 8 and 26 weeks, with no deep infections, growth arrests or mal-unions. In a review of 38 open tibial fractures by Song et al. [7], the average time to union was 21 weeks. Although there were no cases of non-union in children younger than 11 years, there was an 8% risk of deep infection or non-union in those older than 11 years. Jones et al. [5] retrospectively reviewed 91 open tibial fractures in children younger than 13 years, 6 of which were grade IIIA. Sixteen fractures were treated with an external fixator and 75 by manipulation and casting, with an average time to union of 15.5 weeks in the former and 10.4 weeks in the latter group. There were deep infections but one delayed union and one non-union were encountered. In another retrospective review, Cullen et al. [2] studied 83 open tibial diaphyseal and metaphysial fractures, 13 of which were grade IIIA and 6 grade IIIB. Thirty-two were managed in a cast, 40 with transcutaneous fixation using two Steinman pins and cast immobilization, nine with external and two with internal fixation. Of the grade III fractures, seven were managed with cast, five with transcutaneous pin fixation, six with external and one with internal fixation. Overall, there were two superficial infections, 18 delayed unions and one non-union. There was one superficial infection in the grade IIIA group. Although the number of delayed and non-unions amongst grade IIIA fractures was not stated, it was reported that the average time to union was not related to the severity of soft tissue injury, being 13 weeks in grade I and 15 weeks in grade II and III fractures. Grimard et al. [3] looked at 90 open tibial fractures, 14 of which were grade IIIA. Forty were stabilised in a cast, 31 with external and 18 with internal fixation. Of the grade IIIA, two fractures were stabilised with casting, six with external and five with internal fixation. Overall, there were six superficial infections, ten delayed unions and seven non-unions. Amongst the grade IIIA fractures there were no infections but there were two delayed unions and three non-unions. The average time to union for IIIA fractures was 6.2 months. Children over 12 years of age had a higher risk of problems with bone union than those under six years.

Previous studies mainly looked at heterogeneous populations combining different fracture grades and including children of adolescent age. We feel that for grade I and II open tibial fractures, immobilization in a cast is the optimum choice as these are low-energy injuries that are mostly inherently stable. At the opposite extreme, surgical fixation is the method of choice for grade IIIB and IIIC fractures, to allow easier care of the wounds and protect the repaired vasculature. The aim of this study was to look at grade IIIA open tibial fractures, the management of which is more controversial.

In this study, there were only four cases of superficial infection and no cases of deep infection. In the two cases of superficial infection, there was a significant delay to initial antibiotic treatment which may well have contributed to this complication. The low rate of superficial infection observed in our study, together with the absence of any deep infections or any cases where further surgery was needed to promote bone union, supports casting as a valid management option for open tibial fractures in children whose fractures have a high potential for union.

A potential limitation of this study is the relatively small numbers of patients examined. This is unavoidable, given the low incidence of these fractures in the paediatric population. Nevertheless, our series seems to be the largest series of grade IIIA open tibial fractures in children. We do not comment on mal-union rates between the two groups, because that would require standardised radiographs which were not available for this retrospective study. The mode of treatment was not randomised but was decided by the consultant which introduces a potential bias. It could be

argued that the more severe fractures were subjectively chosen to be treated with surgical fixation rather that casting, hence the failure to show any significant difference in infection and union problems between the two groups.

In summary, there is a low rate of complications in grade IIIA open tibial diaphysial fractures in children below 13 years of age. We feel that, despite the limitations of this study, our results suggest that manipulation and casting is the best option for stabilization of open tibial diaphysial fractures in children.

References

1. Bartlett CS, Weiner LS, Yang EC (1997) Treatment of type II and type III open tibia fractures in children. J Orthop Trauma 11 (5):357–362
2. Cullen MC, Roy DR, Crawford AH, Assenmacher J, Levy MS, Wen D (1996) Open fracture of the tibia in children. J Bone Joint Surg Am 78(7):1039–1047
3. Grimard G, Naudie D, Laberge LC, Hamdy RC (1996) Open fractures of the tibia in children. Clin Orthop Relat Res 332:62–70
4. Gustilo RB, Merkow RL, Templeman D (1990) The management of open fractures. J Bone Joint Surg Am 72(2):299–304
5. Jones BG, Duncan RD (2003) Open tibial fractures in children under 13 years of age–10 years experience. Injury 34(10):776–780
6. Kreder HJ, Armstrong P (1995) A review of open tibia fractures in children. J Pediatr Orthop 15(4):482–488
7. Song KM, Sangeorzan B, Benirschke S, Browne R (1996) Open fractures of the tibia in children. J Pediatr Orthop 16(5): 635–639