Treatment of femur fractures in children with cerebral palsy

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Abstract

Purpose Children with cerebral palsy may have low bone density stemming from various etiologies and are, thereby, at risk for fractures. The treatment of femur fractures in children with cerebral palsy may need to be tailored to address the management of spastic muscle tone and multiple medical co-morbidities.

Methods Our study is a retrospective review that evaluates the treatment of 47 femur fractures in children with cerebral palsy in both ambulatory and non-ambulatory patients.

Results Thirty-two fractures in non-ambulators were treated non-operatively, 11 of which resulted in malunions and five developed pressure sores. Six fractures in non-ambulators were treated operatively, one of which resulted in a malunion. In ambulators, five fractures were treated non-operatively; one of these fractures lost reduction after 2 weeks and required surgical intervention. One of four fractures in ambulators treated operatively developed a malunion.

Conclusion Our study results suggest that femur fractures in children with cerebral palsy can be treated non-operatively; however, because of the high risk of malunion in

this patient population, fracture alignment needs to be followed closely during healing. Careful attention during casting is necessary to prevent pressure sores. Strong consideration should be given to initial operative treatment in ambulatory patients in order to preserve function.

Keywords Cerebral palsy · Femur fracture · Treatment

Introduction

In children with cerebral palsy, the management of femur fractures is often more complicated than in neurologically normal children. Many children with cerebral palsy have spastic muscle tone which can cause an increase in shortening or malunion at the fracture site [1, 2]. Some children with cerebral palsy have other medical co-morbidities, such as loss of the gag reflex or gastrointestinal reflux, which make lying supine for a prolonged time both dangerous and difficult to tolerate secondary to the development of pneumonia. In addition, children who are non-verbal are harder to monitor for cast sores or neurovascular changes [3, 4]. Thus, the treatment of fractures in children with cerebral palsy must consider methods which reduce prolonged bed rest, including casting or splinting allowing return to an upright position, or surgical intervention. In addition, children with cerebral palsy often have decreased bone density, which, during immobilization, can result in an additional fracture at a new site, at the same site, or even in the opposite extremity [5, 6].

In 1966, McIvor and Samilson [1] reviewed 134 fractures in 92 patients with cerebral palsy, 69 of which occurred in the femur. They found that preexisting contracture of contiguous joints was the factor most

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consistently associated with fractures. All 69 femur fractures in the series were treated non-operatively. Treatment included 27 patients in spica casts and eight patients treated with skeletal traction. These authors reported a high rate of malunion: 65% overall and an 85% rate of malunion in the distal femur [1].

Additional reports of the treatment of femur fractures involving muscle spasticity have occurred in the setting of children with traumatic brain injuries. Since the brain injury can resolve over time and patients can resume walking, aggressive surgical treatment of displaced fractures is advocated [7, 8]. However, children with cerebral palsy have a static brain injury, and may not gain ambulatory function over time. The purpose of our study was to examine whether or not the same surgically aggressive approach to the treatment of femur fractures used in children with traumatic brain injuries should be applied to children with cerebral palsy. Our study retrospectively examines the results of both surgical and non-surgical management in patients with cerebral palsy to determine outcomes of treatment and possible complications, so as to better define which patients need aggressive surgical management.

Materials and methods

The medical records at The Johns Hopkins Hospital were searched for children with diagnoses of femur fractures and cerebral palsy. Patients were identified by ICD-9 and CPT codes. All patients were less than 20 years old and carried a diagnosis of cerebral palsy.

The charts and radiographs were retrospectively reviewed for patient demographics, treatment method, complications, and end results of treatment. Radiographic union was determined by the presence of at least three cortices or more of bridging callus on both anteroposterior and lateral radiographs of the femur. Malunion was defined as more than 2 cm of shortening, angulation greater than 30° in the sagittal plane or 10° in the frontal plane, or more than 10° of rotation. Up to 10° of varus/valgus angulation or flexion/extension angulation was accepted for distal femur fractures.

Results

Thirty-six patients with 47 fractures met the inclusion criteria: 21 boys, 15 girls. Nine patients sustained more than one femur fracture: seven patients sustained two fractures and two patients sustained three fractures. Seven patients had spastic diplegia, 28 had spastic quadriplegia,

and one patient had spastic hemiplegia. Nine patients were ambulators and 27 were non-ambulators.

All of the fractures were closed injuries. No fractures were determined to be caused by abuse and no fractures occurred during physical therapy. One fracture was sustained during a motor vehicle accident. The remaining 46 fractures were the results of minimal trauma. Of these 46 fractures, seven fractures occurred less than 6 weeks after orthopedic procedures. Four of these seven fractures occurred in the subtrochanteric region, following varus derotation osteotomies (Fig. 1) and two occurred following hardware removal. One fracture occurred following a distal femoral derotational osteotomy. The most common mechanism of injury involved transfers of the patient out of a wheelchair.

There were 22 right-sided and 25 left-sided femur fractures. No patient sustained simultaneous bilateral fractures. The distal femoral shaft was the most common fracture location. There were 25 distal shaft, seven supracondylar, eight proximal shaft, and seven midshaft femur fractures (Table 1). Thirty-five fractures were displaced and 12 were non-displaced. There were 19 transverse, 11 spiral, 11 oblique, four plastic deformation, and two buckle fractures.

Ten fractures were treated operatively and 37 fractures were treated non-operatively (Table 2). All 12 non-displaced fractures were treated non-operatively. Nine of the fractures occurred in ambulators and 38 fractures occurred in non-ambulatory patients (Table 3).

Five of nine fractures in ambulators were treated non-operatively. There was one treatment failure (20%) in this group: the patient sustained a midshaft femur fracture and was treated with immediate spica cast application. The fracture lost reduction after 2 weeks and the patient

Fig. 1 Fracture through a blade plate 6 months following surgical intervention after a fall from bed. The initial osteotomy had been performed 2 years prior to the fracture

Table 1 Fracture type in ambulators and non-ambulators

	Proximal	Midshaft	Distal/supracondylar
Ambulators			
Displaced	3	1	3
Non-displaced	1	0	2
Non-ambulators			
Displaced	4	5	19
Non-displaced	0	1	8

Table 2 Comparison of treatment (non-operative or operative) and ambulatory status

	Operative	Non-operative
Non-ambulatory	6	32
Ambulatory	4	5

underwent operative fixation with an intramedullary nail. The other four fractures in this group healed without any complications.

Four of nine fractures in ambulators were treated operatively. The procedures included percutaneous pinning (one patient), plate fixation (one patient), blade plate fixation (one patient), and hip screw fixation (one patient). One fracture (16.7%) developed a malunion. The malunion occurred in a supracondylar femur fracture treated with percutaneous pinning with K-wires. One patient (16.7%) developed a medical complication, post-operative pneumonia.

Thirty-two of the 38 fractures in non-ambulators were treated non-operatively. There were no nonunions but there were 11 malunions (34.3%), based on our specified criteria. Eight of these malunions occurred in fractures of the distal femur (Fig. 2). There were no reported difficulties in seating, comfort, or care due to a malunion. Five patients developed cast-related pressure sores or ulcers that required dressing changes.

One of the non-ambulatory patients had sustained a midshaft femur fracture and underwent non-operative treatment consisting of 3 weeks of skeletal traction followed by spica cast application. The child tolerated the traction and the fracture healed in anatomic alignment. This fracture was the only one in this series treated with skeletal traction.

Six of the 38 fractures in non-ambulators were treated operatively. Procedures included percutaneous pinning (one patient), plate fixation (one patient), external fixation (two patients), and intramedullary nailing (two patients). One of six (16.7%) patients developed a malunion with 4.0 cm of shortening following treatment of a distal femur shaft fracture with percutaneous pins and a long leg cast. One patient developed a pressure ulcer following plate fixation and spica cast application. Two of six (33%)

patients had postoperative medical complications; one patient developed pneumonia while another developed bacteremia (Table 4).

Of the distal and supracondylar fractures, the malunion rate was 31% (10/32). Fractures that occurred in the proximal and midshaft regions had a malunion rate of 27% (4/15). Thus, there was a slightly greater risk of malunion of the distal fractures, but malunions occurred at fractures along the entire femur.

Discussion

The child with cerebral palsy and a femur fracture presents a treatment challenge, as consideration must be given to medical comorbidities, low ambulatory potential, spasticity, and osteopenia. In a previous study at our institution, we found that age at the time of fracture and the use of seizure medications predicted fractures more than any other patient characteristics [5].

The experience of treating femur fractures in children with spasticity in the current literature primarily comes from studies of children with traumatic brain injury. In addition to spasticity, these children can have problems with skin breakdown and a need for improved pulmonary toilet. Because of these factors, femur fractures in these children have been shown to require different management from those in children without head trauma, as operative treatment may facilitate the other needs of the head-injured child [7–11]. The goal of treatment in these patients is an anatomic union, as the child should recover from the head injury and ambulate again.

Studies on the treatment of femur fractures in head-injured children have shown that spasticity can have a negative effect on fracture management [8]. Glenn et al. [9] reported that five of 15 (33%) head-injured children with femur fractures treated by traction and spica cast application developed malunions, compared to none of eight fractures treated with intramedullary nailing. Fry et al. reported that 12 of 29 (41%) femur fractures, in head-injured children treated with skeletal traction, developed more than 2 cm of shortening. Three fractures required delayed operative treatment due to unacceptable alignment [7].

Kregor et al. reported a retrospective series of patients less than 10 years of age with head injury and femur fracture treated with plate fixation. Fourteen out of 15 fractures healed in anatomic alignment, supporting the treatment methodology [10].

Porat et al. reviewed seven femur fractures in head-injured children with spasticity or decerebrate posturing. The patients were treated with external fixation and healed with good alignment, length, and without infection. The

Table 3 Outcomes of the femur fracture treatment

Case	Ambulatory status	Location	Fracture displacement	Treatment	Malunion	Other complications
1a	None	Midshaft	Yes	Spica cast	Yes	No
1b	None	Distal	Yes	Percutaneous pins	Yes	Pneumonia
2	None	Distal	Yes	Intramedullary nail	No	None
3a	None	Distal	Yes	Long leg cast	Yes	None
3b	None	Distal	No	Long leg cast	No	Cast sores
4a	None	Distal	No	Long leg cast	No	None
4b	None	Distal	Yes	External fixator	No	None
5	None	Distal	Yes	Long leg cast	No	None
6	Community	Supracondylar	Yes	Percutaneous pins	Yes	None
7	None	Midshaft	Yes	Spica cast	No	None
8	None	Midshaft	Yes	External fixator	No	None
9	Community	Proximal	No	Spica cast	Yes	Loss reduction
10a	None	Supracondylar	No	Long leg cast	No	None
10b	None	Supracondylar	No	Long leg cast	Yes	None
10c	None	Distal	No	Brace	No	None
11	None	Distal	Yes	Long leg cast	No	None
12	Household	Midshaft	Yes	ORIF	No	Pneumonia
13a	None	Midshaft	Yes	Spica cast	Yes	No
13b	None	Midshaft	Yes	Intramedullary nail	No	Bacteremia
14	Household	Distal	No	Long leg cast	No	No
15	None	Distal	No	Long leg cast	No	No
16	None	Distal	No	Long leg cast	No	Cast sores
17	None	Distal	Yes	Long leg cast	No	No
18a	None	Proximal	Yes	ORIF, spica cast	No	Cast sores
18b	None	Distal	Yes	Cylinder cast	Yes	No
18c	None	Supra-condylar	Yes	Posterior splint	Yes	No
19	None	Midshaft	No	3 weeks traction, then spica cast	No	No
20	Community	Proximal	Yes	ORIF	No	No
21a	None	Proximal	Yes	Spica cast	No	Cast sores
21b	None	Distal	Yes	Spica cast	No	No
22	None	Distal	No	Long leg cast	No	No
23	Household	Proximal	Yes	ORIF	No	None
24a	None	Supracondylar	Yes	Long leg cast	Yes	No
24b	None	Supracondylar	Yes	Long leg cast	No	No
25	None	Distal	Yes	Long leg cast	Yes	Cast sores
26	None	Distal	Yes	Spica cast	No	Fracture in cast/cast sores
27	None	Distal	Yes	Spica cast	No	No
28	Household	Proximal	Yes	Spica cast	No	No
29a	None	Distal	Yes	Spica cast	No	No
29b	None	Distal	Yes	Long leg cast	No	No
30	None	Proximal	Yes	Spica cast	No	No
31	None	Proximal	Yes	Spica cast	Yes	No
32	None	Distal	Yes	Spica cast	Yes	No
33	Community	Distal	No	Long leg cast	No	No
34	Non-ambulator	Supracondylar	Yes	Long leg cast	Yes	No
35	Non-ambulator	Distal	Yes	Long leg cast	No	No
36	Household	Distal	Yes	Long leg cast	No	No

ORIF open reduction internal fixation

Fig. 2 **a, b** Initial injury films, anteroposterior and lateral views, of the distal femur fracture in a non-ambulator with cerebral palsy subtype spastic quadripareisis. **c, d** Fracture 6 weeks post-injury

authors concluded that external fixation was the optimal treatment for a fractured femur in the head-injured child who exhibits spasticity or seizures [11].

In a critical appraisal of the literature, Wright examined 15 studies that compared the results of two or more forms of treatment for femoral shaft fractures in children without cerebral palsy. Children who underwent treatment with early spica cast application had an angulatory malunion (greater than 10°) rate of 8% (range 0–19%), and 3% (range 0–25%) of patients developed a limb-length discrepancy greater than 2 cm [12].

Our retrospective study shows that the femur fractures in children with cerebral palsy are at increased risk of developing a malunion. Supracondylar fractures were the pattern with the highest malunion rate, with 5/6 fractures

Table 4 Complications by treatment and fracture type in non-ambulators

	Proximal	Midshaft	Distal/supracondylar
Surgical/displaced	1/1 (w)	1/2 (i)	2#/3 (m, i)
Surgical/non-displaced	0	0	0
Non-op./displaced	2/3 (m, w)	2/3 (2m)	7#/16 (5m, 2w)
Non-op./non-displaced	0	0/1	3/8 (1m, 2w)

m malunion; *w* wound problem; *i* medical issue; # single patient with more than one complication

going on to malunion. The incidence of malunion in fractures treated operatively was 20% (2/10) and was even higher in fractures treated non-operatively at 32% (12/37). These rates are higher than those reported in the studies reviewed by Wright [12], who studied normal children, but are not as high as the rates reported for traumatic brain-injured children or the rates reported by McIvor and Samilson 30 years ago for children with cerebral palsy [1].

The risk of malunion should not mandate that all femur fractures in children with cerebral palsy be treated operatively. The clinical result of a malunion in a non-ambulator may be negligible. An ambulator may be more functionally affected by a femoral malunion and ambulatory ability should be considered when determining treatment.

Other complications from treatment include cast sores and medical complications. Meticulous cast technique must be used when treating these children, as some will be unable to verbalize cast tightness or discomfort.

Many patients with cerebral palsy have diminished bone density. The etiology of diminished bone density in these patients is multifactorial. Ambulatory status has been shown to be the factor that best correlates with bone mineral density [12, 13]. The diminished bone mineral density in the femur is also associated with an increasing severity of neurologic involvement, increasing feeding difficulty, the use of anticonvulsants, and lower triceps skinfold *z*-scores [14]. The osteopenia in this patient population was evident in this study, as most of the fractures occurred following low-energy mechanisms and by the number that occurred following other orthopedic procedures. Family members and medical personnel must be careful when transferring children with cerebral palsy in the postoperative period, as transfers were found to be the most common mechanism of fracture. Furthermore, activity restrictions should be considered following the removal of hardware in patients.

The study would have been improved by utilizing a greater sample size of ambulators, which would have allowed a meaningful statistical analysis comparing ambulatory to non-ambulatory patients. However, the smaller number of ambulators in this study likely reflects

the increased bone mineral density and decreased fracture rate in these patients relative to non-ambulators. In addition, direct measures of sitting comfort may have shown that excessive malunion can be harmful in non-ambulators.

The results of this paper suggest that, as in head-injured patients, patients with cerebral palsy are at risk of developing a malunion of a femur fracture. The malunion may not cause as many functional problems in non-ambulatory patients, but should be of concern in ambulators. Strong consideration should be given towards operative treatment in ambulators based on fracture displacement and alignment. Patients with cerebral palsy are very challenging to pediatric orthopedists. The osteopenia that likely resulted in the fracture can make achieving fixation difficult and the gracile nature of the femur can make some surgical fixation more difficult to utilize. The chance to medically optimize the patient in terms of nutritional status and tone management is not available because of the unpredictable nature of trauma. Although there can be many complications in this group, aggressive management seems optimal, allowing non-ambulatory patients to be positioned in a sitting posture to maintain health and providing adequate alignment to ambulatory children to maintain function.

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