Immediate Spica Casting of Pediatric Femoral Fractures in the Operating Room Versus the Emergency Department

Comparison of Reduction, Complications, and Hospital Charges

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Background: Immediate spica casting for pediatric femur fractures is well described as a standard treatment in the literature. The purpose of this study is to evaluate the application of a spica cast in the emergency department (ED) versus the operating room (OR) with regard to quality of reduction, complications, and hospital charges at an academic institution.

Methods: An institutional review board-approved retrospective review identified 100 children aged 6 months to 5 years between January 2003 and October 2008 with an isolated femur fracture treated with a hip spica cast. Patients were compared based on the setting of spica cast application.

Results: There were 79 patients in the ED cohort and 21 patients in the OR cohort. There were no significant differences in age, weight, sex, fracture pattern, prereduction shortening, injury mechanism, duration of spica treatment, time to heal, or length of follow-up between cohorts. There were no significant differences in the rate of loss of reduction requiring revision casting or operative treatment (6.3% vs. 4.8%), the need for cast wedging (8.9% vs. 14.3%), or minor skin breakdown (12.7% vs. 14.3%). There were no sedation or anesthetic complications in either group. There were no significant differences in the quality of reduction or the rate of complications between the 2 groups. Spica casting in the OR delayed the time from presentation to cast placement as compared with the ED cohort (11.5 h vs. 3.8 h, $P < 0.0001$) and lengthened the hospital stay (30.5 h vs. 16.9 h, $P = 0.0002$). The average hospital charges of spica cast application in the OR was 3 times higher than the cost of casting in the ED ($15,983 vs. $5150, $P < 0.0001$).

Conclusions: Immediate spica casting in the ED and OR provide similar results in terms of reduction and complications. With the significantly higher hospital charges for spica casting in the OR, alternative settings should be considered.

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None of the authors received financial support for this study.

No funding was received by the NIH, Wellcome Trust, or Howard Hughes Medical Institute (HHMI).

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Level of Evidence: III—Retrospective comparative study.

Key Words: pediatric femur fracture, spica casting, emergency room, sedation, operating room

(*J Pediatr Orthop* 2010;30:813–817)

Femoral shaft fractures are one of the most common lower extremity fractures in children and because almost all require hospital admission, they are one of the most expensive injuries to treat in childhood.[1] Immediate spica cast application is an established treatment for isolated closed femur fractures.[2–13] Dameron and Thompson[14] demonstrated that this technique avoids the lengthy hospital stay necessary for traction and delayed spica casting.[1]

Spica cast application in the emergency department (ED) has been documented with favorable results in multiple studies.[3,11,12,15] The cost of spica cast treatment has been analyzed in comparison to other forms of treatment, such as hospital traction, intramedullary fixation, and external fixation.[10,16–19] The purpose of this study was to determine the difference in the quality of fracture reduction, complications, and the initial hospital charges of spica cast treatment at an academic institution when the cast is applied in the ED as compared with the operating room (OR). Our hypothesis was that rate of loss of reduction and other cast complications would be lower in the OR cohort with attending surgeon supervised spica cast application, justifying the higher hospital charges.

METHODS

After institutional review board approval, a retrospective chart review was performed to identify all pediatric femoral shaft fractures in patients aged 6 months to 5 years treated at a single tertiary-referral children's hospital between January 1, 2003 and October 1, 2008. Patients with skeletal dysplasia, pathologic fracture, neuromuscular disorders, multisystem injuries complicating care, or incomplete radiographs were excluded. One hundred patients were identified and divided into 2 groups for comparison based on whether the spica cast application occurred in the emergency room or OR. The ED group (ED cohort) was composed of 79 patients and the OR group (OR cohort) was composed of 21 patients.

All children were initially seen and assessed by an ED physician. After the diagnosis of a femoral shaft fracture was made, the patient was evaluated by a junior orthopaedic resident and the determination of the need for spica cast application was made with the attending orthopaedic surgeon. The decision to perform the spica cast application in the OR versus the ED was based on several factors—discretion of the attending orthopaedic surgeon, OR availability, availability of emergency room sedation personnel, time of day, and general anesthesia safety criteria including time of last meal.

If ED placement was decided, conscious sedation was administered in the form of intravenous ketamine or midazolam and a one-and-a-half or double-leg fiberglass hip spica cast was placed by the junior orthopaedic resident using mini-fluoroscopy. Plain radiographs were not routinely obtained after the cast hardened if the fluoroscopy images were adequate. The technique was based on those described earlier in the literature.[3,11,15]

If OR placement was decided, the patient was placed in 5 pounds of Buck's traction, a long-leg splint, or no immobilization based upon the child's size, until the OR was available. General anesthesia was administered and a one-and-a-half or double-leg fiberglass hip spica cast was placed by the attending orthopaedic surgeon and an assisting resident and/or cast technician, similarly as mentioned above. The reduction was confirmed using biplanar fluoroscopy and wedged if necessary to improve alignment. Plain radiographs were not routinely obtained after the cast hardened if the fluoroscopy images were adequate.

A one-and-a-half spica cast was used if the child was large enough to allow for adequate perineal care without excessive encroachment of the bar connecting the legs. Otherwise, double-leg fiberglass spica casts were used and this tended to be necessary in children below 12 months of age. In both treatment groups, the patient's family received cast-care teaching before discharge. Patients undergoing evaluation for nonaccidental trauma (NAT) were admitted to the general pediatric service and discharged when appropriate.

All patients were followed clinically and radiographically through fracture healing by an operative or nonoperative pediatric orthopaedic attending. The casts were removed after 4 to 6 weeks when there was abundant fracture callus, representing radiographic union. Clinical union was confirmed after the cast was removed and the patient demonstrated no tenderness to palpation. Patients were allowed to bear weight as tolerated and return to normal activities.

Hospital electronic medical records and paper charts were reviewed for each patient. Routine femur fractures were discharged within a 23-hour observation period. For patients undergoing a NAT evaluation, any additional hospitalization beyond the first 24 hours was considered to be related to the NAT evaluation. Radiographs were reviewed by 2 observers blinded as to the setting of spica application. Final angulation and shortening measurements were obtained at or near the time of spica cast removal. Clinical outcomes were evaluated by documentation in the medical record describing limb-length discrepancy or malrotation at final follow-up. Although acceptable reduction criteria varies depending on the author, we used the same criteria as Cassinelli et al[3,20] in their large series of emergency room spica casting. Acceptable angulation for patients below 2 years of age was 30 degrees in the sagittal or coronal planes and 15 mm of shortening. Acceptable angulation for patients aged 2 to 5 years was 15 degrees in the coronal plane, 20 degrees in the sagittal plane, and 20 mm of shortening.

Complications were stratified into 2 categories—major (loss of reduction requiring re-reduction or alternative fixation, sedation, or anesthetic complications), or minor (soiling of the cast requiring cast change, subsequent cast wedging to improve alignment, or skin irritation/breakdown).

Hospital billing records were obtained for each patient. These included charges for the emergency room, medications, laboratory, radiography, sedation, operating and recovery room, anesthesia, and hospital room charges. The following charges not related to the care of the femur fracture were excluded: radiographs of contralateral or upper extremities, other imaging modalities, advanced laboratory tests, and skeletal surveys. All physician professional charges were also excluded. Subsequent hospitalizations, procedures, and outpatient clinic charges were not included.

Statistical analysis was performed to compare the 2 cohorts. Wilcoxon rank sum test was used to compare continuous variables and the χ^2 or Fisher exact tests were used for categorical variables. A P value less than 0.05 was used to indicate statistical significance.

RESULTS

There were 67 males and 33 females in the study group. All patients had spica cast application within 24 hours of presentation. There was no significant difference in age, weight, sex, fracture pattern, prereduction shortening, injury mechanism, duration of spica treatment, time to heal, or length of follow-up between cohorts (Table 1). There was a significant difference in the mean time from ED arrival to cast placement between cohorts (ED was 3.8 h and OR was 11.5 h, $P < 0.0001$). The length of stay excluding the NAT evaluation was significantly longer for the OR cohort (30.5 h vs. 16.9 h, $P = 0.0002$).

Clinical outcomes were noted at final follow-up, a mean of 20 weeks in the ED cohort and 16 weeks in the OR cohort ($P = 0.45$). There was no significant difference in leg-length discrepancy of at least 2 cm in the ED cohort, 4 of 79 (5.1%) versus the OR cohort, 1 of 21 (4.8%). Clinically apparent angular deformity was noted in 2 of 79 (2.5%) of the ED cohort versus 0 of 21 (0%) of the OR cohort, however, these deformities were asymptomatic. In the OR cohort, 2 of 21 (9.5%) had clinically apparent rotational deformities, not affecting function versus 0 of 79 (0%) in the ED cohort.

TABLE 1. Comparison of Demographics, Fracture Characteristics, and Treatment

	ED Cohort	OR Cohort	*P*
Patient			
Total patients	79	21	
No. male	52 (65.8%)	15 (71.4%)	
Average age at injury (y)	2.4	2.9	0.15
Average weight (kg)	13.7	15.1	0.27
NAT workup	22 (27.9%)	5 (23.8%)	0.71
% of high-energy mechanism*	47 (59.5%)	13 (61.9%)	0.96
Fracture location and shortening			
Proximal 1/3	8 (10.1%)	2 (9.5%)	0.74
Middle 1/3	65 (82.3%)	16 (76.2%)	0.75
Distal 1/3	6 (7.6%)	3 (14.3%)	0.59
Nondisplaced fractures	10 (12.7%)	1 (4.8%)	0.52
Average prereduction fracture shortening (mm)	10	11	0.80
Treatment			
Average time from ED admission to spica application (h)	3.8	11.5	< 0.0001
Average length of sedation/anesthesia for spica application (min)	40	51	0.007
Length of stay excluding NAT workup (h)	16.8	30.5	0.0002
Average duration of spica treatment (wk)	5.9	6.2	0.10
Average duration of follow-up (wk)	20.5	15.9	0.82
Average time to healing (wk)	6.6	7.4	0.21
Average initial hospital charges	$5150	$15983	< 0.0001

*High-energy mechanisms were classified as those not resulting from a twisting injury or a fall from standing height.

ED indicates emergency department; NAT, nonaccidental trauma; OR, operating room.

Quality of reduction was assessed on radiographs obtained at the time of spica removal and were evaluated as described earlier. Radiographic acceptability was stratified and compared based on patient age and is presented in Table 2. There were no significant differences in acceptable reductions between cohorts in both the below 2 years and the 2 to 5 years age groups.

TABLE 2. Comparison of Acceptable Radiographic Reduction With Healed Fracture

	ED Cohort	OR Cohort	*P*
Age < 2 y	n = 27	n = 5	
Varus/valgus angulation (> 30 degrees)	0 (0%)	0 (0%)	—
Anterior/posterior angulation (> 30 degrees)	2 (7.4%)	1 (20%)	0.96
Shortening (> 15 mm)	1 (3.7%)	1 (20%)	0.71
Overall unacceptable reduction*	3 (11.1%)	2 (40%)	0.34
Age 2 to 5 y	n = 52	n = 16	
Varus/valgus angulation (> 15 degrees)	6 (11.5%)	1 (6.2%)	0.89
Anterior/posterior angulation (> 20 degrees)	4 (7.7%)	0 (0%)	0.59
Shortening (> 20 mm)	10 (19.2%)	4 (25%)	0.88
Overall unacceptable reduction*	16 (30.8%)	5 (31.3%)	0.78

*Defined as failing at least 1 of the 3 radiographic parameters for acceptable reduction.

ED indicates emergency department; OR, operating room.

TABLE 3. Comparison of Complications

	ED Cohort (n = 79)	OR Cohort (n = 21)	*P*
Major			
Loss of reduction requiring revision casting or internal fixation in OR	5 (6.3%)	1 (4.8%)	0.80
Anesthetic complications	0	0	—
Malunion (according to radiographic criteria)	19 (24.1%)	7 (33.3%)	0.67
Minor			
Skin breakdown	10 (12.7%)	3 (14.3%)	0.87
Subsequent wedging to improve alignment	7 (8.9%)	3 (14.3%)	0.23
Cast soiling requiring cast change	5 (6.3%)	0	—
Cast breakage requiring revision cast	1 (1.3%)	0	—
Overall need for revision casting or internal fixation in OR	11 (13.9%)	1 (4.7%)	0.44
Total number of spica-related complications	47	14	
Overall patients with spica-related complications	33 (41.8%)	11 (52.4%)	0.62

ED indicates emergency department; OR, operating room.

The complications associated with treatment are summarized in Table 3. There were no significant differences in complications between the 2 groups. All skin complications resolved with cast modification and/or local wound care, without the need for rehospitalization. The 5 patients in the ED cohort who had loss of reduction were all treated with revision spica cast application under general anesthesia in the OR to achieve acceptable alignment. The single loss of reduction in the OR cohort was a subtrochanteric femur fracture in a 3-year-old patient that drifted into malalignment at 1-week follow-up (55 degrees varus and 21 degrees apex anterior angulation) and was treated with open reduction and plate fixation.

Total actual charges were compiled and compared between cohorts, excluding physician professional charges. The mean hospital charges for spica application in the OR was 3 times that of the cost for application in the emergency room ($15,983 ± $3587 vs. $5150 ± $1694, $P < 0.0001$).

DISCUSSION

This study is a comparative analysis of pediatric femur fractures treated with immediate spica casting in either the ED or OR at an academic institution. To our knowledge, this is the first study that directly compares the setting of spica cast application, particularly with regard to quality of reduction, complications, and hospital charges. Several earlier studies show favorable results of hip spica placement in the ED, but either lack a comparison group or use other types of treatment

including internal fixation as the comparison.[3,11,12,15] Infante et al[11] reported on 175 patients treated with immediate hip spica casting in either the ED or OR with acceptable results. The decision to perform the reduction in the ED or OR was based on the patient's weight. No cost analysis was performed and there was no comparison between groups based on the setting of spica cast application. Multiple other studies document successful treatment with spica cast application in the OR, however they lack a comparison group or compare other types of treatment methods.[4,5,7,9,21,22]

In this study, review of hospital billing records allowed charge comparison between the 2 cohorts. The OR cohort mean hospital charges of $15,983 were substantially greater than the ED cohort mean charges of $5150. Our study provides data to support the conclusions of Cassinelli et al[3] that spica casting in the emergency room setting decreases unnecessary OR expenses. Newton and Mubarak[17] compared the cost of various treatments of pediatric femur fractures at their institution and found that early spica casting had lowest cost ($5497) compared with other treatments. Although not specifically stated in their report, it seemed that all spica casting was performed in the OR under general anesthesia. In our study, hospital charges were nearly 3 times greater than they reported. Their study was conducted during 1990, and we assume that our series reflects more current billing trends with increased hospital costs. Coyte et al[16] presented cost analysis data comparing spica casting with external fixation for pediatric femur fractures and reported the cost of spica casting to be $5970, including inpatient and outpatient charges. All spica casting in their series was performed under general anesthesia in the OR. Their lower cost of OR spica casting may also reflect their earlier study period (1993 to 1994), and potentially the lower costs in the Canadian healthcare system.

Our complication rates were comparable to similar studies and there were no significant differences in the complications between the cohorts. In the ED cohort, 5 of the 79 (6.3%) patients had loss of reduction requiring revision, slightly lower than Cassinelli et al[3] reported in their series of spica casts applied in the emergency room (8.9%). Seven of the 79 (8.9%) patients in the ED cohort and 3 of the 21 (14.3%) in the OR cohort required cast wedging to improve alignment. These rates are similar to those reported by Martinez et al[23] (8%) and Irani et al[15] (12%). In this study, we report no difference in leg-length discrepency between cohorts.

The comparison of acceptable radiographic reduction yielded similar results between the 2 cohorts and are comparable with those reported by Cassinelli et al.[3] The number of patients in the OR cohort below 2 years of age was small (n = 5) and limits analysis of data in that subgroup. However, the ED cohort of patients below 2 years of age (n = 27) nearly uniformly met radiographic criteria for acceptability. With regard to patients aged 2 to 5 years, length was more difficult to maintain. Ten of the 52 (19%) patients in the ED cohort and 4 of 16 (25%) in the OR cohort had radiographic shortening greater than 2 cm at the time of spica cast removal. Martinez et al[23] reported a higher percentage of unacceptable (> 2 cm) shortening in their series of immediate hip spica casting (43%). Buehler et al[24] had a similar rate (18%) as our study, however, they defined unacceptable shortening as greater than 2.5 cm.

Although spica cast placement in the ED showed similar outcomes as placement in the OR, this method of treatment is not without potential problems. First and foremost, at our teaching institution, the casts are placed by junior orthopaedic surgery residents with limited untrained assistance. Our residents are trained in spica cast application by attending pediatric orthopaedic surgeons at the beginning of each academic year. Safety and proper cast application is ensured by senior resident assistance in the ED as necessary. As stated in other studies, careful attention to detail is critical and experienced assistance during cast application is of paramount importance.[5,7] An additional difficulty at a high-volume ED is the availability of the emergency room attending physician to supervise the sedation portion of the procedure for an extended period.

At our institution, we are performing a cost analysis of using a nonsterile sedation room for closed reductions with a dedicated sedation team, similar to that used for endoscopy. An advantage of this approach is to prevent overloading our OR time with cases which could be performed efficiently in alternative settings. Another consideration is having an on-call cast technician available for assisting with spica cast application in the emergency room setting. Both of these options may be cost-effective alternatives to spica cast placement in the OR.

This study has several limitations. The potential for selection bias has been introduced because of the retrospective and nonrandomized nature of this study. All of the patients in our study are below 6 years of age. This reflects our practice of favoring internal fixation of femur fractures in older children and prevents this study from being generalized to the older population. The number of patients in our ED cohort (n = 79) was much larger than the OR cohort (n = 21). This reflects our institutional practice of performing spica cast application in the emergency room for isolated pediatric femur fractures unless operative time is immediately available or ED sedation is unavailable. Given the relatively small number of patients in the OR cohort, this study may be underpowered to detect statistically significant differences between the treatment cohorts. For example, the rate of revision casting or internal fixation was almost 3 times greater in the ED cohort (13.9%) as compared with the OR cohort (4.7%), but the difference was not statistically significant ($P = 0.44$) and this may reflect a lack of adequate power in the study. In addition, our study only presents short-term follow-up, precluding any determination of long-term outcomes, specifically with respect to limb-length inequality. A difficulty in obtaining long-term follow-up for an injury with uniformly excellent outcomes is the reluctance of parents to return with their children to

see a physician when the child is asymptomatic.[3] Our entire patient population was below 6 years of age and based upon the long-term results of Irani et al,[15] we speculate that at least partial correction of the leg-length discrepancy may occur because of femoral overgrowth. From a cost analysis standpoint, our study only presents initial hospital charges. We did not analyze actual reimbursement, indirect costs of missed school or work (for the parents), physician costs, or additional costs for repeat reduction.

We have analyzed the impact of secondary procedures (revision casting or internal fixation) on the overall charges for the duration of treatment with the use of average charges for the 2 cohorts. Within the ED cohort, 79 patients had primary casting with average charges of $5150. Eleven patients in the ED cohort required revision casting under anesthesia in the OR. Using the average charges for OR casting ($15,983), the total charges of the initial and revision treatment in the ED cohort would be $406,850 with average charges of $7375 per patient for the duration of treatment. Within the OR cohort, 21 patients had primary casting with average charges of $15,983. One patient in the OR cohort required a revision (open reduction internal fixation) under anesthesia in the OR. Using the average charges for OR casting ($15,983) as a surrogate for this surgical procedure, the total charges of the initial and revision treatment in the OR cohort would be $351,626 with an average charge of $16,744 per patient for the duration of treatment. Despite the lack of charge data for the revision casting or internal fixation, it seems the charges remain much greater in the OR cohort even when considering the cost of secondary procedures in the ED cohort.

In summary, our study provides support for immediate spica casting of femur fractures in children aged 6 months to 5 years, either in the ED or OR, with similar short-term results. Spica cast application in the ED results in dramatically fewer hospital charges, as it avoids the expenses related to use of the OR. Closed treatment of femoral shaft fractures may be performed in alternative settings, such as sedation rooms. These alternatives should be considered and further investigation into their cost effectiveness is warranted.

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