Long leg splinting for pediatric femur fractures

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ABSTRACT

Background: Pediatric femur fractures are frequently encountered injuries frequently treated with spica casting. Spica casting may, however, be expensive and burdensome to patients. A possible alternative is a long leg splint. **Methods:** Patients aged 6 months to 5 years old who were treated for a femoral shaft fracture with a long leg splint extending above the waist were matched with a patient treated with a spica cast. **Results:** At the time of healing, the alignment in the spica cast group was only significantly better than the alignment of the splint group with respect to coronal angulation.

1. Introduction

Pediatric femur fractures are frequently encountered injuries.[1–3] For patients aged 6 months to 5 years old the most common treatment for fractures with < 2 cm of shortening is spica casting.[4–6] Multiple studies have demonstrated the effectiveness of this technique in terms of union and long term functional outcomes.[7–10].

It has been noted, however, that spica casts represent a significant burden to parents.[11] Routine transportation and hygiene for patients with spica casts can be extremely difficult; it has been shown that parents in dual income households need to take an average of 3 weeks off from work to care for their child.[11] Single leg spica casts can decrease some of the mobility and hygiene problems associated with double leg spica casts, but remain cumbersome and difficult to care for.[12,13] Furthermore, at most centers spica casts are applied in the operating room under general anesthesia, increasing healthcare costs and exposing children to the potential complications associated with anesthesia.[14].

A possible alternative to spica casting is a long leg splint extending onto the flank. Such a splint can be applied quickly and easily in the emergency department or clinic rather than the operating room. Furthermore, it has the potential to be less cumbersome for patients and their parents than a single or double leg spica cast. To this point, however, there are no studies investigating the effectiveness of long leg splints at maintaining reduction and promoting healing of pediatric femur fractures.

This study compares spica casting to long leg splinting for the

treatment of femur fractures in children aged 6 months to 5 years old with respect to union rates, complications and radiographic alignment.

2. Methods

2.1. Patient selection

Following IRB approval (Advocate Healthcare IRB #6543, Ann & Robert H. Lurie Children's Hospital IRB #2017-787), all patients aged 6 months to 5 years old who were treated for a femoral shaft fracture at a high volume children's hospital from 1/1/2000–12/31/2015 were identified using an electronic data warehouse search. At this hospital such patients are routinely treated with a long leg plaster splint extending from their foot to their flank which is applied at their first clinic visit. Patients were excluded if they had an open fracture, were initially treated surgically or had incomplete radiographic imaging (complete imaging defined as orthogonal femoral radiographs at the time of injury, the time of initial splinting and at the time of radiographic union).

Each of the patients thus identified were matched for age (within 1 year of age) and fracture pattern with a patient treated at a second high volume children's hospital during the same period. At the second site these patients are routinely treated with a spica cast applied in the operating room. Once again, patients were excluded if they had an open fracture, were initially treated surgically or had incomplete radiographic imaging as defined above.

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2.2. Data collection

For each patient included in the study basic demographic data was collected, including gender, age at time of injury, and fracture pattern. Outcomes measures collected included complications, rate of splint or cast revision, rate of conversion to operative management, union rate and time to union. Union was defined as a combination of pain free weightbearing without cast or splint and radiographic union (bridging callous across 4 cortices on orthogonal radiographs). Time to union was defined as the time from injury until the patient's first clinic visit in which they demonstrated fracture union as defined above.

Additionally, orthogonal femoral films were collected from three time points: 1) at the time of presentation, 2) at the time of initial splinting or casting, and 3) at the time of union. For each set of films coronal angulation, coronal translation (defined as distance translated/width of femur at level of fracture), sagittal angulation, and shortening were measured. These were converted to absolute values for analysis.

2.3. Statistics

Quantitative variables were compared using a Student's t-test, with a significance set at < 0.05 . Categorical data was compared using a Fisher's exact test. Statistical analysis was completed with JMP Pro v13 software.

2.4. Funding

This study did not receive any funding from internal or external sources. The authors have no conflicts of interest to declare.

3. Results

3.1. Demographics

79 patients with femur fractures treated with long leg splinting were identified as described above. Of these, 44 were excluded for inadequate clinical data or radiographs. An additional 9 patients were excluded given a lack of an appropriate matched control. In total, there were 26 patients treated with long leg splinting and 26 matched controls treated with spica casts available for final analysis.

The average age of patients in the splint group was 2.68 years old, while the average age of patients in the spica cast group was 2.49 years old ($p = 0.55$). 85% of patients in the splint group were male compared to 88% of patients in the spica cast group ($p = 1.0$). In each group 92% of patients had spiral fractures and 8% of patients had transverse fractures.

There was a significant difference in time until treatment between the splint group and the spica cast group. The splint group had their splints applied in clinic an average of 11.1 days after injury, while the spica cast group had their casts applied in the operating room 0.7 days after injury, usually shortly after presentation ($p < 0.001$). Table 1 contains a summary of demographic data.

3.2. Outcomes

On presentation, there were no significant differences between the

Table 1
Demographics.

	Splint (N = 26)	Cast (N = 26)	p-value
Gender (% male)	85%	89%	> 0.99
Age (years)	2.68	2.49	0.55
Spiral (%)	92%	92%	> 0.99
Transverse (%)	8%	8%	> 0.99
Time to Treatment (days)	11.08	0.69	< 0.01

splint and spica cast groups with respect to any of the alignment parameters (coronal angulation, coronal translation, sagittal angulation, shortening). Following initial reduction and stabilization the spica cast group had significantly better alignment than the splint group with respect to coronal angulation ($p = 0.07$), sagittal plane angulation ($p = 0.03$) and coronal translation ($p = 0.01$), but no difference with respect to shortening ($p = 0.11$). At the time of healing, however, the alignment in the spica cast group was only significantly better than the alignment of the splint group with respect to coronal angulation (5.3° v 8.6° , $p = 0.04$); there were no significant differences in coronal translation, sagittal plane angulation or shortening.

One patient in the splinting group was converted to a spica cast for unacceptable alignment in the splint, while one patient in the spica cast group was converted to open reduction internal fixation for unacceptable alignment in the cast. Otherwise all patients in both groups went on to unite with their original treatment modality. There was no significant difference in time to union between the splinting and spica casting groups (44.6 days v 40.8, $p = 0.28$). These results are summarized in Table 2.

4. Discussion

Currently, the standard of care for femoral shaft fractures in patients aged 6 months to 5 years old with < 2 cm of shortening is spica casting.[4–6] This has been shown to be an effective treatment method, with high rates of union and low rates of significant malunion at time of final healing.[7–10]. Furthermore, spica casting is associated with lower costs than traction or operative fixation of these fractures.[15–17].

Even so, spica casting remains an imperfect treatment modality. Hughes, for example, found that patients with spica casts had significant mobility issues and required substantial care from their parents. Working parents were forced to take an average of 3 weeks off of work to care for their children while being treated with spica casts.[11] These issues are somewhat improved with single leg casts as compared to double leg casts, but remain prominent.[12, 13] A further improvement, so called “walking casts”, may allow children to mobilize themselves during healing process, but are prone to breakage if not properly reinforced.[18] Additionally, spica casts have also been shown to have relatively high rates of skin breakdown due to the challenges of properly padding the casts and subsequently keeping them dry.[13] Finally, spica casts are usually applied in the operating room under general anesthesia, costing an average of \$15,983 per patient.[14] There is evidence that application in the emergency department is possible in centers with appropriate staff and resources, but this strategy has not been universally adopted.[19].

Long leg splinting is a potential alternative treatment for pediatric femur fractures which might avoid some of the care difficulties and costs associated with spica casting. To our knowledge this is the first study comparing radiographic outcomes of long leg splinting to spica casting for these fractures.

We found that spica casting improved fracture alignment at the time of initial treatment compared to splinting. At final healing, however, spica casting only outperformed splinting with respect to coronal angulation, suggesting some loss of reduction with time in the cast; furthermore, the absolute difference in coronal angulation between the groups, 8.6° v 5.3° , raises the question of whether this difference is clinically significant. There were no differences between the groups with respect to need for conversion to alternate treatment, union rate or time to union.

These results suggest that long leg splinting may be a reasonable alternative to spica casting for pediatric femur fractures. This may be an especially useful technique in regions and hospitals where resources, anesthesia availability and operating room space are limited.

There are multiple weaknesses in this study. For one, the splinting cohort and the spica casting cohort were gathered from different centers, possibly introducing a confounding variable. Furthermore, this

Table 2

Outcomes.

Alignment		Splint (N = 26)	Cast (N = 26)	p-value
Presentation	Sagittal Angulation (deg)	8.15	6.88	0.56
	Coronal Angulation (deg)	9.42	5.50	0.18
	Shortening (mm)	8.50	12.40	0.09
	Coronal Translation (%)	33%	23%	0.24
Post-splinting v casting	Sagittal Angulation (deg)	7.88	4.16	0.03
	Coronal Angulation (deg)	8.33	4.08	< 0.01
	Shortening (mm)	8.42	11.80	0.11
	Coronal Translation (%)	29%	10%	0.01
Union	Sagittal Angulation (deg)	8.96	7.96	0.63
	Coronal Angulation (deg)	8.64	5.32	0.04
	Shortening (mm)	9.08	11.70	0.22
	Coronal Translation (%)	32%	18%	0.10
	Secondary Procedure (%)	4%	4%	> 0.99
	Time to Union (days)	44.58	40.83	0.28

study did not assess patient reported outcomes. Therefore, we cannot comment on whether splinting actually made patient care easier during the healing process. It is also possible that long leg splinting provides less stability to the fracture site than spica casting, resulting in increased patient discomfort prior to union. In infants, for example, there is some evidence that pavlik harness treatment of femur fractures results in more pain during healing than spica cast treatment.[20] Further studies are needed to assess the effect of long leg splinting on patient comfort and ease of care.

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