The treatment of femoral shaft fractures in children: a systematic overview and critical appraisal of the literature

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OBJECTIVE: Through a critical systematic overview of the literature on the treatment of pediatric femoral shaft fractures to determine if any method of treatment can be recommended over others.

DATA SOURCES: A MEDLINE search was performed for all cohort and randomized clinical trials for the years 1966 to 1996.

STUDY SELECTION: Of 1217 identified articles, 15 cohort studies (where 2 or more treatments were compared in the same study) reported the treatment of children with femoral fractures.

DATA EXTRACTION: Information was abstracted and articles rated for quality blind to author, institution and journal.

DATA SYNTHESIS: Children having early application of a hip spica cast had an average hospital stay of 11 days (range from 5 to 29 days), average charges of $5784 (range from $590 to $11 800), average rates of limb-length discrepancy (greater than 2 cm) of 3% (range from 0 to 25%), angulatory malunion rates (greater than 10°) of 8% (range from 0 to 19%), and rotational malunion rates (greater than 10°) of 13% (range from 0 to 5%). The costs and malunion rates of early application of a hip spica cast were lower than for traction. Internal fixation (including intramedullary nails) had low angulatory malunion rates compared with early application of a hip spica cast but higher over-lengthening rates (greater than 2 cm) of 25% (range from 5% to 100%) and mean rotational malunion rates (greater than 10°) of 25% (range from 11% to 32%).

CONCLUSION: Early application of a hip spica cast had lower costs and malunion rates than traction.

OBJECTIF : Déterminer, au moyen d’une recension systématique critique des articles publiés sur le traitement des fractures du corps du fémur chez les enfants, s’il est possible de recommander une méthode privilégiée de traitement.

SOURCES DE DONNÉES : On a effectué, dans MEDLINE, une recherche portant sur toutes les études cliniques randomisées et de cohortes réalisées au cours des années 1966 à 1996.

SÉLECTION D’ÉTUDES : Sur 1217 articles repérés, 15 études de cohorte (où l’on a comparé deux traitements ou plus dans le contexte de la même étude) comportaient un rapport sur le traitement de fractures du fémur chez les enfants.

EXTRACTION DES DONNÉES : On a résumé l’information et évalué la qualité des articles sans en connaître l’auteur, l’établissement et le journal.

SYNTHÈSE DES DONNÉES : Les enfants auxquels on a posé rapidement un spica de la hanche sont demeurés à l’hôpital 11 jours en moyenne (intervalle de 5 à 29 jours), les frais ont atteint en moyenne 5784 $ (inter-

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valle de 590 $ à 11 800 $), la différence moyenne entre la longueur des membres (plus de 2 cm) a atteint 3 % (plage de 0 % à 25 %), les taux de cals vicieux angulaires (plus de 10°) se sont établis à 8 % (intervalle de 0 % à 19 %), et ceux des cals vicieux rotatoires (plus de 10°), à 13 % (intervalle de 0 % à 5 %). Les coûts et les taux de cals vicieux découlant de la pose rapide d'un spica de la hanche ont été moins élevés que dans le cas d'une traction. La réduction interne (y compris la pose de clous intramédullaires) a produit de faibles taux de cals vicieux angulaires avec la pose rapide d'un spica de la hanche, mais des taux d'allongement excessif (plus de 2 cm) plus élevés de 25 % (intervalle de 5 % à 100 %) et des taux moyens de cals vicieux rotatoires (plus de 10°) de 25 % (intervalle de 11 % à 32 %).

CONCLUSION : La pose rapide d'un spica de la hanche entraîne des coûts et des taux de cals vicieux moins élevés qu'une traction.

Femoral shaft fractures are one of the commonest fractures of the lower extremity in children and the commonest requiring hospital admission.[1] Because almost all femoral shaft fractures require hospital admission, they are one of the most expensive injuries to treat in childhood.[2] The options for treatment of femoral shaft fractures in children include skeletal or skin traction (with or without the delayed application of either a hip spica or a cast brace), early (or immediate) application of a hip spica cast, external fixation and internal fixation, including the insertion of intramedullary nails (both traditional intramedullary nails or multiple flexible intramedullary nails).[1,3] Although recommended treatment options vary according to age, even within the same age group recommendations are often variable and conflicting.[1] The purpose of this study was to critically appraise the literature on the treatment of femoral shaft fractures in children.

METHODS

The relevant literature on the treatment of femoral shaft fractures in children was identified using a MEDLINE search for the years 1966 to 1996.[4–7] The database was searched using the key words "femoral fracture," limiting to English language and human, and including 3 age groups, preschool (birth to 5 years), child (6 to 12 years) and adolescent (13 to 18 years). In addition to the MEDLINE search, articles mentioned in the reference lists or known to the author were retrieved. All articles that compared 2 or more treatments of femoral fractures in children (randomized clinical trials or cohort studies) were eligible. Case reports or case series (evaluation of a single form of treatment) were not included because of the methodologic difficulties of comparing different patient populations, different treatment regimens and different methods of evaluation among centres.[8] Articles were also excluded for the following reasons: they reported exclusively on either the injuries associated with femoral fractures or the complications of treatment; they focused primarily on adults (patients over the age of 16 years); they reported on the treatment of fractures of the hip or distal femoral growth plate; they did not report the outcomes of treatment; they included fewer than 10 patients; they reported on the treatment of pathologic fractures; or they investigated the etiology, imaging or pathophysiology of femoral fractures. No randomized controlled clinical trials were identified and, thus, all identified studies were cohort studies (either retrospective or prospective) where 2 (or more) forms of treatment were compared in the same centre. These studies, if well performed, would constitute Level III information on the relative therapeutic efficacy of treatments for femoral fractures. (Well performed randomized clinical trials constitute Level I information.[9])

The following information about the effectiveness and outcomes of treatments for femoral shaft fracture was abstracted from each article: time in hospital (days), duration of immobilization (days), malunion rates (limb-length discrepancy, malangulation and malrotation), average cost (or charges), and complications. When possible, average rates for outcomes across studies were determined.

The quality of the studies, graded blindly by removing all identifying information (authors and institutions) from the articles, was judged in 2 ways. First, studies were evaluated using a standard assessment of individual study quality.[4] Articles were graded on 15 criteria and received a total score between 0 and 15.[4] Second, strategies used to reduce bias were catalogued. Feinstein[8] has described 4 main types of bias that threaten the validity of comparative studies: susceptibility bias, performance bias, detection bias and transfer bias. The following strategies used to minimize bias were noted: susceptibility bias, including standardized inclusion and exclusion criteria, comparison and adjustment for important differences in prognostic variables between the 2 treatment groups, and an unbiased method of treatment allocation; proficiency bias, including explicit description and standardization of the intervention, description and adjustment for cointerventions; detection bias, including clear specification for the primary outcome and blinded (to the treatment group) evaluation of the outcome; and transfer bias, including complete assessment of patients at a consistent time.

In addition to the assessment of strategies to reduce bias, articles were

Table I

Criteria by Which the 15 Cohort Studies Were Included in the Critical Evaluation of the Treatment of Femoral Shaft Fractures in Children

Series	Inclusion and exclusion criteria	Assessment of prognostic factors	Treatment was explicit	Treatment was standardized	Treatment choice was explained	Adjustment for cointerventions	Blinded assessment	Similar assessment times	Functional sssessment	Statistical analysis
Allen et al[10]	No	No	EHS: Yes Traction: No	No	Yes	No	No	No	No	No
Barford and Christensen[11]	Yes	Yes	No	No	Yes	No	No	No	Yes (but not formal)	No
Burton and Fordyce,[12]	Yes	Yes	No	No	Yes	No	No	No	Yes (but not formal)	No
Curtis et al[13]	Yes	Yes	Yes	Yes	No	No	No	No	Yes (but not formal)	Yes
Fry et al[14]	Yes	No	No	No	No	No	No	No	Yes (but not formal)	No
Henderson et al[15]	Yes	No	Yes	No	Yes	No	No	No	No	No
Herndon et al[16]	Yes	Yes	No	No	No	No	No	No	Yes (but not formal)	Yes
Kirby et al[17]	Yes	Yes	No	No	Yes	No	No	No	No	No
Miller et al[18]	No	Yes	Yes	Yes	No	No	No	No	No	No
Mohan[19]	Yes	No	Yes	No	No	No	No	No	Yes (but not formal)	No
Neer and Cadman[20]	Yes	No	No	No	No	No	No	No	No	No
Parvinen et al[21]	Yes	No	No	No	No	No	No	No	No	No
Reeves et al[22]	Yes	No	No	No	No	No	No	No	No	No
Schonk[23]	Yes	No	No	No	Yes	No	No	No	No	No
Ziv and Rang[24]	Yes	No	No	Yes	Yes	No	No	No	No	No

EHS = early application of hip spica.

evaluated to determine if all (rather than just 1 or more) aspects of malunion were reported, if composite malunion rates were provided, if complications were reported and if childrens' function (in addition to malunion rates) was assessed.

RESULTS

Of the 1217 articles retrieved in the literature search, 1202 (99%) were excluded; 279 (23%) dealt only with the complications or associated injuries of femoral fractures, 239 (20%) dealt principally with adults, 193 (16%) evaluated the treatment of hip or femoral growth-plate fractures, 163 (13%) were case reports or case series, 126 (10%) considered etiology, imaging or pathophysiology of femoral fractures, 128 (10%) considered pathologic or iatrogenic fractures (such as fractures after limb lengthening), and 74 (6%) discussed the treatment of femoral fractures but did not provide results (e.g., editorials or reviews). The remaining 15 studies compared the results of 2 or more forms of treatment for femoral shaft fractures in children.

Of the 15 studies, 8 considered children of different age groups, 3 considered only adolescents, 2 considered children of different age groups but only head injured children, and 2 did not provide age criteria (Tables I and II).[10–24] Of the 15 studies, 6 compared traction of different types, with immediate or early application of a hip spica cast (including "pontoon" casts), 8 compared nonoperative treatment (early application of a hip spica cast or traction) with internal fixation (plates and nails), and 1 compared traction, early application of hip spica cast, and internal fixation (Table III).[10–24]

Thirteen of the 15 studies had specified inclusion and exclusion criteria; the upper age limit of eligibility varied from 10 to 17 years (some used open physes as eligibility criteria); the lower age limit varied from birth to 2 years (except for 3 studies that considered only "adolescents" and used lower age limits of 9, 10 and 11 years). Of the 15 studies, 6 compared the treatment groups for baseline prognostic factors (which might affect the outcome in addition to the treatment), such as age, sex, fracture type and associated injuries, but no study adjusted for differences in prognostic factors among groups. Treatments were explicitly described (such that all details of treatment would allow reproduction of the regimen) in 5 of the studies. The following reasons for the choice of treatment (other than surgeon's preference) were provided in 7 of the studies: patients admitted to hospital in alternate weeks; different time periods; different hospitals; or patients who failed nonoperative treatment and underwent internal fixation. Cointerventions, such as physiotherapy, were described incompletely in all studies. The final assessment was performed blind to treatment allocation in none of the studies. Patients were assessed at different treatment times in all studies. Physical function, in addition to malunion, was assessed in 6 of the studies, but standardized outcome assessments were used in none of the studies (Tables I and II).

The method of assessment for length discrepancy was clinical in 7

Table II

Inclusion and Exclusion Criteria, Method of Allocating Treatment and Determining Outcome for the 15 Cohort Studies

Series	Inclusion and exclusion criteria	Method of treatment allocation	Method of outcome determination			Follow-up, %
			LLD	Rotation	Alignment	
Allan et al[10]	Not stated	Different time periods	Radiologic	Clinical	Radiologic	EHS, 97
Barford and Christensen[11]	Incl: < 15 yr Excl: Bilateral fractures, DDH, pathologic fractures, premature infant death	Failure of nonoperative treatment with ORIF	Clinical	Clinical	Radiologic	97
Burton and Fordyce[12]	Incl: 2–10 yr	Alternate weeks	Clinical	Clinical	Radiologic	46
Curtis et al[13]	Incl: Isolated shaft fractures 2–10 yr	"Surgeon's preference"	CT, scanogram	Clinical	Radiologic	48
Fry et al[14]	Incl: All fractures with head injury	Not stated				100
Henderson et al[15]	Incl: < 10 yr Excl: Subtrochanteric fractures, pathological	Different time periods	Clinical	Clinical	Radiologic	34
Herndon et al[16]	Incl: All 11–16 yr (open plates) Excl: Closed physes, proximal/distal fractures, pathologic fractures	Not stated		Not performed	Radiologic	86
Kirby et al[17]	Incl: 10–15 yr (open plates) Excl: Skeletal dysplasia	2 different hospitals	Clinical	Clinical	Radiologic	93
Miller at al[18]	Not stated	Not stated			Radiologic	100
Mohan[19]	Incl: < 12 yr	Not stated			Radiologic	100
Neer and Cadman[20]	Incl: All 6 mo–12 yr Excl: Birth fractures, hip and distal femoral factures, pathologic fractures	Not stated	Clinical	Clinical	Radiologic	72
Parvinen et al[21]	Incl: 1–15 yr	Not stated	Not performed	Radiologic	Not performed	27
Reeves et al[22]	Incl: All 9–17 yr Excl: Pathologic fractures, death	"Surgeon's preference"	Clinical	Clinical	Radiologic	100
Schonk[23]	Incl: < 13 yr	ORIF for open or multiple fractures, serious displacement, failed conservative treatment	Radiologic	Radiologic	Radiologic	92
Ziv and Rang[24]	Incl: < 16 yr with head injury Excl: Death, recovery < 3 d	Failure of skin traction leading to skeletal traction or ORIF	Clinical		Radiologic	98

LLD = limb-length discrepancy, DDH = developmental dysplasia of the hip, ORIF = open reduction and internal fixation, EHS = early application of hip spica.

Table III

Comparison of the Types of Treatment of Femoral Shaft Fractures in Children Through 15 Studies Drawn From the Literature That Met the Study Criteria

		Outcomes									
				Malunion rate							
				LLD		Angulation		Malrotation			
Series	Compared treatments (no. of patients)	Time in hospital, d	Time immobilized, d	Type	%	Type	%	Type	%	Average cost or charges, $	Complications
Allan et al[10]	1. Early hip spica (32)	5.4	47			Varus–valgus < 5° Varus–valgus ≥ 10° Ant.–post. < 10° Ant.–post. 10°–15°	90 10 87 13			590	No delayed or nonunion. All “fully active and without residual disability within 4 mo following cast removal”
	2. Traction (15)	31								2 514	Not followed; “acceptable results when carefully applied”
Barford and Christensen[11]	1. “Nonoperative” (91) (traction, cast or bed rest)			Short ≥ 1 cm Long ≥ 1 cm	9 14	Ant Valgus	? ?				Time till normal walking, 2 mo. Limp, 5%. Pain, 7%. Muscular atrophy, 13%
	2. ORIF (23) (plate in 19, Parham bend in 4)			Long ≥ 1 cm	87	Ant Valgus	? ?				Death, 4%. Time till normal walking, 3.4 mo. Limp, 39%. Pain, 17%. Muscular atrophy, 39%
Burton and Fordyce[12]	1. Skin traction/ Thomas splints (42)	43	38.9	Equal Long < 1.25 cm Short < 1.25 cm Short 1.6–2.5 cm	52 14 29 5	None Varus 1°–10° Varus 11°–20° Valgus 1°–10° Ant. bow. 1°–10° Ant. bow. 11°–20° Ant. bow. > 20° Post. bow. 1°–10°	36 10 10 7 14 14 5 5		36		Pain 21%. Limp, 12%. Intoe, 5%. Limited knee motion to 90°, 2%
	2. Hip spica cast, (42)	9.6	41	Equal Short < 1.25 cm Short 1.6–2.5 cm	67 31 2	None Varus 1°–10° Valgus 1°–10° Ant. bow. 1°–10° Ant. bow. 11°–20° Ant. bow. > 20°	57 14 2 31 7 2		38		Pain, 12%. Limp, 17%. Intoe, 2%
Curtis et al[13]	1. 90–90 traction with distal femoral pin followed by hip spica (12)			Short 2.9 cm Long 3.0 cm	8 8	Varus > 10° Post. > 10°	8 8			20 000	Pain, 8%. Knee flexion contracture > 20%, 43%. Fracture, 10%. Delayed union, 5%

	2. "Pontoon cast": distal femoral pin incorporated into hip spica (31)			Long 2.6 cm (1/12)*	8	Varus > 10° Valgus > 10° Post. > 10°	3 3 3			5 800	Pain, 16%. Knee fixed flexion, 3%. Readmission for manipulation, 10%. Pin-tract infection, 3%. Cast sore, 3%. Delayed union, 10%
Fry et al[14]	1. Traction (skeletal and skin) and hip spica (29)			Short > 3 cm	28				3 (1/36)*		Osteomyelitis, 3%. Needed ORIF, 17%. Internal knee derangement, 7%
	2. EHS (4)			Short 3.6 cm	25						None
	3. ORIF (9)			"All did well"							None
Henderson et al[15]	1. Early hip spica (26)	5.5	55.3	Short ≤ 1.5 cm	100	Varus > 10° Ant. > 10° Post. > 10°	19 12 8			1 545 (excluding surgeon's fees and cost of complication)	Fractured pin (for "pontoon cast"), 4%. Cast syndrome, 4%. Readmission for flexion contracture, 4%
	2. 90–90 skeletal traction and hip spica (50)	22.4								5 301	Readmission for flexion contracture, 16%
Herndon et al[16]	1. Traction with hip spica or cast brace (19)	28		Short > 2 cm	21	Varus–valgus > 10° Ant. > 10°	16 11				Pressure sores, 5%. External fixator for shortening, 5%. Pin-traction infection, 5%
	2. Intramedullary nail (Küntscher, Ender, Rush) (20)	17									
Kirby et al[17]	2. Skeletal traction and hip spica (13)	30.5	76	Short > 1 cm Long 1 cm Equal	23 8 69	Varus–valgus < 3% Valgus 5°–8° Varus 6°–9° Post. 15° Ant. 22°	69 15 23 8 8	Rotation > 10°	23		Flexion < 20°, 8%. Patellar dislocation, 8%
	2. Intramedullary nail (13)	20.6		Short ≤ 0.5 cm Equal	15 85	Straight	100	Rotation > 20° Rotation 5°–15°	15 23		Flexion lacking 10°, 15. Inhospital fractures needing hip spica, 8%. Trochanteric plate growth arrest, 8%
Miller et al[18]	1. 90–90 skeletal traction and hip spica (35)	23	40			Varus > 10° Valgus > 10° Post. > 10°	23 6 23			18 307	Readmission for physiotherapy, 20%. Knee flexion contracture > 20°, 49%
	2. "Pontoon cast" (distal femoral pin incorporated into hip spica) (21)	7	40			Varus > 10°	3 (1/35)*	External rotation > 10°	3 (1/35)*	4 963	Pin-tract infection, 5%. Pin fracture, 5%

Mohan[19]	1. Skin traction (Bryant and balanced) (39)			"Good" result (able to squat, no limp, minimal angulation, and LLD < 1 cm), 90%. "Fair" result, 10%							Skin irritation, 7% (1/15)*
	2. Early hip spica (24)			"Good" result, 75%. "Fair" result (5°–10° angulation, LLD < 2 cm), 17%. "Poor" result (limp, unable to squat, angulation > 10°, LLD > 2 cm), 8%							
Neer and Cadman[20]	1. Closed treatment (84), hip spica (34), traction (50) (skin [47], skeletal [3])			Short < 2.5 cm Short	11 4	No angulatory or rotational malunion "permanently noticeable"					None
	2. ORIF (16)			Overgrowth	69						Loss of fixation, 19%. Infection, 13%. Refracture, 6%
Parvinen et al[21]	1. Traction (skeletal and skin) and cast (33)							> 10°	36		"None of the patients had any symptoms and none were in need of corrective osteotomy"
	2. ORIF (19)							> 10°	32		
Reeves et al[22]	1. ORIF (49), rod (33/52 fractures), plate (19/52 fractures)	15								8 078 (charges)	Broken plate, 2%. Bent rod, 2%. Transient peroneal nerve palsy, 2%. Urinary retention, 2%
	2. 90–90 traction/hip spica (41)	29	51	Malunion (defined as > 10° frontal, > 30° sagittal or 10° rotation), 12%						11 800 (charges)	Delayed union, 10%. "GI disturbance", 10%. Psychosis, 5%. Refracture, 2%
Schonk[23]	1. ORIF (plate in 6, Küntscher nail in 11) (19)	42		< 1 cm 1–2 cm > 2 cm	58 37 5			Anteversion ≤ 10° Anteversion 10°–20°	89 11		
	2. Traction (73)	56		< 1 cm 1–2 cm > 2 cm	78 19 3			Anteversion < 10° Anteversion 11°–20° Anteversion > 20°	88 11 1		
Ziv and Rang[24]	1. Traction (skin and skeletal) (34)			Short > 1 cm	18	> 10° or short > 1 cm	18				
	2. ORIF (Küntscher rod, Rush rod, plate) (21)			Short > 1 cm Long > 1.5 cm	5 5	> 10° or short > 1 cm	14				Infection, 60% (3/5 plates)

studies, radiographic in 3 studies, not specified in 4 studies, and not performed in 1 study. Rotational deformity was assessed clinically in 8 studies, radiographically in 2 studies, not specified in 4 studies, and not performed in 1 study. Limb alignment was evaluated by means of radiographs in 13 studies, not specified in 1 study, and not performed in 1 study. Follow-up of patients ranged from zero (for 1 of 2 treatment groups) to 100%. The mean quality score of the studies was 4.1 with a possible score of 15 (range 1 to 7, standard deviation = 1.9).[4]

The results of treatments were divided into 3 groups: early or immediate (including pins and plaster) application of hip spica cast; traction (including skin or skeletal traction) with or without application of a hip spica cast; and internal fixation (Tables III and IV). (The treatments were not separated into more specific groups because the study results were reported in the above groupings.) Mean limb-length discrepancy (more than 2 cm) ranged from 3% in the early hip spica cast group to 25% in the internal fixation group. Mean angulatory varus or valgus malunion rates (more than 10°) ranged from 0 for internal fixation to 16% for traction. Mean anterior or posterior malunion rates (more than 10°) ranged from 0 for internal fixation to 16% for traction. Mean malrotation rates (more than 10°) ranged from 13% for early application of a hip spica cast to 25% for internal fixation.

Two studies provided composite malunion rates. Mohan[19] classified the results of treatment as "good" (able to squat, no limp, minimal angulation, limb-length discrepancy less than 1 cm), "fair" (5° to 10° angulation, limb-length discrepancy less than 2 cm), or "poor"" (limp, unable to squt, angulation more than 10°, limb-length discrepancy more than 2 cm). Skin traction provided 90% (35 of 39) good and 10% (4 of 39) fair results. Early application of a hip spica cast provided 75% (18 of 24) good, 17% (4 of 24) fair and 8% (2 fo 24) poor results. Reeves and colleagues[22] defined "malunion" as more than 10° frontal, more than 30° sagittal, and more than 10° rotational deformity. Internal fixation had a zero malunion rate and skeletal traction provided a 12% (5 of 41) malunion rate.

The mean hospital stay ranged from 11 days for early application of a hip spica cast to 34 days for traction. The reported cost (or charges) for treatment ranged from $5784 for early application of a hip spica cast to $10 410 for traction.

Discussion

Randomized clinical trials provide the strongest evidence for clinical efficacy.[9,25,26] None of the identified studies comparing 2 or more treatments for femoral shaft fractures were randomized clinical trials. The majority were case series that reviewed the results of a single form of treatment, usually in a single centre. The use of case studies to make implications about treatment effectiveness necessitates the use of historical controls. The comparability of treatment groups and the assessment of the outcome differ so much between centres that the use of case series in making inferences about treatment effectiveness is quite uncertain.[8] Therefore, although many case series have been published, their inclusion in any meta-analysis is usually not recommended. In the absence of randomized trials, treatment decisions should be based on the results of cohort studies in which 2 or more treatments are compared within the same study. Of the 178 clinical studies identified for possible inclusion in this study, 15 cohort studies (either retrospective or prospective) compared 2 forms of treatment within the same institution.

Several trends were noted in the reported results. Early application of a hip spica was associated with the shortest length of hospital stay and the lowest costs. Lower cost has been the basis for many hospitals substituting early application of hip spica casts in favour of traction. In addition, early or immediate application of hip spica casts was associated with lower rates of limb-length discrepancy and lower average rates of angulatory and rotational malunion compared with traction. This finding does not confirm the general impression that early application of a hip spica results in higher rates of malunion than traction.[1] Patients who underwent internal fixation, when compared with early application of a hip spica had

Table IV

Results of Treatment

Outcome measure	Treatment, mean (and range): Early application of hip spica	Traction with or without spica	Internal fixation
LLD ≥ 2 cm, %	3 (0–25)	10 (0–28)	25 (5–100)
Varus or valgus > 10°, %	9 (3–19)	16 (8–29)	0
Anterior or posterior angulation > 10°, %	8 (0–19)	16 (8–23)	0
Malrotation > 10°, %	13 (0–25)	21 (3–36)	25 (11–32)
Hospital stay, d	11 (5–29)	34 (22–40)	24 (5–42)
Immobilization, d	45 (40–51)	39 (39–39)	—
Cost or charges, $	5 784 (590–11 800)	10 410 (2 514–18 307)	8 708

LLD = limb-length discrepancy.

lower rates of angulatory malunion but much higher rates of limb-length discrepancy (due to over-lengthening) and rotational malunion. Because the studies analysed did not provide results for different types of internal fixation, the specific rates of malunion for flexible intramedullary nails are unknown. However, the high rates of over-lengthening and rotational malunion with internal fixation emphasize the need to consider all types of malunion (angulatory, rotational, shortening and over-lengthening) in future comparisons of different treatments.

This systematic overview of the literature revealed methodologic problems with the reviewed studies. In the absence of randomization, a cohort study requires that the 2 treatment groups are similar in every way except the treatment allocated.[8] Of the 15 cohort studies, 14 provided a clear description of the inclusion and exclusion criteria of the patients but none adjusted for baseline differences. Thus, differences noted in outcomes between 2 treatments may have been due to differences in prognostic factors. Outcomes used to evaluate treatments were inconsistent between studies, and in none of the studies was the outcome of treatment ascertained blind to the treatment intervention.

In addition to the previously discussed methodologic limitations, there were specific issues relevant to the care of children, relating mainly to the choice of treatment and evaluation of the outcome, which should be considered in any future study evaluating femoral shaft fractures in children. First, none of the reviewed studies formally assessed patient-based outcomes, such as function or behavioural disturbances.[27] Because malunion and loss of motion may have an impact on a child's function, this may be an additional important outcome to determine.[28] Second, many studies selectively reported only 1 type of malunion, such as limb-length discrepancy. Because different forms of treatment are associated with varying types of malunion with different long-term implications,[29–31] all aspects of deformity should be reported to allow comparison between treatments. Third, the methods of evaluating malunion were inconsistent, having been performed both clinically and radiographically.

Conclusions

Early application of a hip spica cast was associated with a shorter duration of hospital stay and low rates of malunion compared with traction. Internal fixation gave low rates of angulatory malunion compared with early hip spica casting but high rates of over-lengthening. The preferred treatment for children with femoral fracture will await the results of randomized clinical trials.

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