Prevalence of Abusive Fractures of the Hands, Feet, Spine, or Pelvis on Skeletal Survey

Perhaps ''Uncommon'' Is More Common Than Suggested

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Objective: Recently, it has been suggested that views of the hands, feet, spine, and pelvis should be omitted from routine skeletal surveys (SSs) because these fractures are rarely identified by SS. Our objective was to describe the prevalence of fractures to the hands, feet, spine, or pelvis among SSs obtained for children in a large, multicenter population who underwent consultation for physical abuse.

Methods: This was a retrospective secondary analysis of data from the Examining Siblings To Recognize Abuse research network, a consortium of 20 US child abuse teams who collected data for all children younger than 10 years who underwent consultation for concerns of physical abuse. This secondary analysis included data only from index children and excluded data from siblings and contacts. Consulting child abuse physicians reported the number of fractures identified and those that were detected by SS.

Results: Among 2049 initial SSs, 471 (23.0%) showed at least 1 previously unknown fracture including 49 (10.4%) that showed a fracture to the hands, feet, spine, or pelvis. In 10 cases, the SS identified at least 1 fracture of the hands, feet, spine, or pelvis when no other fractures were identified.

Conclusions: A significant number of occult, abusive fractures would have been missed if SSs had omitted or deferred views of the hands, feet, spine, and pelvis. Given the risks associated with missed abuse, these views should be routinely included in the radiographic SS.

Key Words: physical abuse, fractures, skeletal survey

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Physical abuse is an important source of morbidity and mortality in childhood.[1,2] Serious, irreversible outcomes are common among children who present with obvious symptoms, but a subset of children have relatively good outcomes, perhaps because abuse is recognized early, when symptoms are subtle.[3,4] Because abuse is thought to be an escalating phenomenon, the recognition of subtle, early signs of abuse is important in preventing mortality and serious, irreversible outcomes.[5–8]

The skeletal survey (SS) has been used for decades to diagnose occult fractures in children with concerns for abuse and has a robust literature supporting its utility,[9–13] especially in children younger than 24 months (2 years), in whom the American Academy of Pediatrics (AAP) considers the SS "mandatory" for children with concerns of physical abuse.[10,14] The AAP and the American College of Radiology (ACR) have published guidelines for the performance of the SS, which recommend at least 19 views including lateral views of the spine, anteroposterior views of the pelvis, and separate views of the hands and feet.[14,15] Recently, Karmazyn and colleagues[16] reviewed 930 SSs performed in a single center between 2003 and 2009 and found that only 10 children had fractures identified in the hands, feet, spine, or pelvis and suggested that special views of these areas might be omitted to decrease radiation exposure to young children.[16]

Because fractures of the hands, feet, spine, or pelvis are relatively specific for abuse,[17] the identification of these fractures in children with concern for abuse has the potential to dramatically affect the outcome of a child being evaluated for concerns of abuse. We sought determine the incidence of fractures to the hands, feet, spine, or pelvis in a large, multicenter population of children evaluated with concerns for physical abuse.

METHODS

This is a retrospective, secondary analysis of data obtained by the Examining Siblings to Recognize Abuse (ExSTRA) research network, the complete methods of which have been described elsewhere.[18] Briefly, 20 centers enrolled all children younger than 10 years who received subspecialty evaluation to determine the likelihood of abuse. Subjects were eligible for inclusion regardless of the source of the referral or site of evaluation (intensive care unit, inpatient floor, emergency department, or outpatient clinic) or the ultimate level of concern for abuse. Although the core analysis of the network dealt with siblings and contact children, this secondary analysis deals only with index children and does not include data from siblings or contacts of children evaluated with concern for abuse. All participating centers and the data coordinating center obtained approval with waiver of informed consent from their local institutional review board.

Although data were collected before the existence of board-certified child abuse pediatricians, each participating center had a dedicated child protection team, including at least 1 member of the Helfer Society, an honor society of child abuse physicians. All centers conducted SSs according to the guidelines published by the AAP and ACR.[14,19] All SSs were read by pediatric radiologists with experience reading SSs. The ultimate determination of whether a fracture was present was made by

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TABLE 1. Characteristics of Identified Fractures

	Subjects (n = 2890), n (%)
No. fractures	
1	737 (25.5)
2	197 (6.8)
3–5	147 (5.1)
6–10	79 (2.7)
>10	48 (1.7)
Ages of fractures	
All acute	480 (16.6)
All healing	198 (6.9)
Acute and healing	148 (5.1)
Unclear or skull only	382 (13.2)
Type	
Skull	458 (15.8)
Long bone	533 (18.4)
Ribs	250 (8.7)
CML	135 (4.7)
Clavicle	66 (2.3)
Hands/feet	40 (1.4)
Spine	22 (0.8)
Pelvis	8 (0.3)
Other*	21 (0.7)

*Other fractures include mandible (n = 7), scapula (n = 8), sternum (n = 2), and nasal bone (n = 6)

CML indicates classic metaphyseal lesion.

the responsible child abuse physician after review of any available testing, clinical information, and specialty consultation.

Data were entered prospectively for children younger than 120 months (10 years) who were referred for evaluation of possible physical abuse. Missed subjects were identified by monthly audits, and their data were entered retrospectively. Each participating center enrolled more than 90% of eligible patients based on the monthly audits. At the time of disposition (child abuse physician sign off, discharge, or death), the responsible child abuse physician entered data about the presenting symptoms of the child, findings on physical examination, and all testing that was undertaken to screen for abuse and any injuries identified.

Child abuse physicians submitted free-text descriptions of all identified injuries, including fractures. Child abuse physicians were also asked prospectively to designate children's fractures as skull, ribs, long bones, hands/feet, and/or "other." Classic metaphyseal lesions were designated separately from other fractures of long bones. For this analysis, one investigator (D.M.L.) reviewed the complete records of all children who were identified as having "other" fractures to determine the number of fractures to the spine or pelvis. The complete database was searched for the following terms to ensure that fractures described in free text were correctly coded: "metacarpal," "metatarsal," "phalan*," "C1-C7" inclusive, "T1-T9" inclusive, "L1-L4" inclusive, "spine," "pelvi*," and "sacr*," where * represents a wildcard.

RESULTS

Between January 15, 2010, and April 30, 2011, the ExSTRA research network enrolled 2890 children who were evaluated for concerns of physical abuse. The demographics and injuries identified in the overall sample have been published previously.[18] Among all subjects, fractures were identified by SSs and/or other imaging modalities (such as dedicated plain films or computed tomography) in 1208 (41.8%), with the most common fracture types being long-bone, skull, and rib fractures. Characteristics of identified fractures are listed in Table 1.

Initial SSs were completed in 2049 subjects (70.9%) overall and were significantly more common among the 1975 subjects younger than 24 months, where they were obtained in 88.6% of cases (odds ratio [OR], 16.2; 95% confidence interval [CI], 13.1–19.6). Among all SSs, 471 (23.0%) showed a previously unknown fracture, with these fractures more likely to be found in subjects younger than 24 months than in older subjects (23.8% vs 18.1%; OR, 1.42; 95% CI, 1.03–1.97).

Fractures of the hands, feet, spine, or pelvis were identified in 16 subjects by imaging other than the SS (such as dedicated plain films). Including subjects older than 24 months, SSs showed fractures of the hands or feet in 33 subjects, spine fractures in 16, and pelvic fractures in 3. At least one of these fractures was found by SS in 49 subjects (2.4% of all subjects who had SS, 2.1% of subjects <24 months old with SS; Table 2).

TABLE 2. Fractures Identified by Skeletal Survey

	All Subjects, n = 2890 (2049 [70.9%] With SS, 471 [23.0%] With Facture[s] on SS)		Subjects < 24 mo, n = 1975 (67.3%) (1750 [88.6%] With SS, 417 [23.8%] With Fracture[s] on SS)	
Fracture	Total No. Identified Subjects (fx)*	No. Identified by SS Subjects (fx)*	Total No. Identified Subjects (fx)*	No. Identified by SS Subjects (fx)*
Hand/feet	40 (74)	34 (68)	31 (60)	27 (56)
Hand	15 (20)	14 (19)	10 (13)	9 (12)
Foot	21 (35)	17 (31)	18 (31)	15 (28)
Unclear†	7 (19)	6 (18)	5 (16)	5 (16)
Spine	22 (38)	16 (29)	14 (21)	10 (15)
Pelvis	8 (10)	3 (3)	4 (4)	2 (2)
Total†	65 (122)	49 (100)	46 (85)	37 (73)

*In some cases with multiple fractures, descriptions of fractures included phrases such as "multiple vertebral body fractures" or "multiple fractures to metacarpals." In such cases, the number of fractures of the given type was counted as 2. Fracture totals may therefore be underestimates.

†Several subjects were noted to have fractures of the hands and/or feet, but there was insufficient detail to determine whether the fracture was to the hand or foot (eg, "healing fracture to proximal fourth digit" or "phalanx").

fx indicates Fractures.

Among all 65 subjects with fractures of the hands, feet, spine, or pelvis, 21 (32.3%) had no other fractures identified, including 10 children in whom the SS was the first or only test to identify these fractures. For these 21 subjects, 6 had fractures that were all acute, 4 had fractures that were all healing, 1 (a patient with 2 thoracic vertebral body fractures) had fractures that were both acute and healing, and the remaining 10 had fractures where the age was unclear or could not be determined.

Clinical signs of injury were noted by investigators in 15 (23.1%) of 65 subjects with fractures of the hands, feet, spine, or pelvis. Clinical signs included bruising, swelling, or abrasion over the fracture site; decreased use of the affected extremity and (in the case of spinal fractures) weakness of the lower extremities; or priapism and (in the case of pelvic fractures) signs of sexual abuse or injury to the genitalia.

DISCUSSION

The SS is the most widely studied screening test for physical abuse in children and has the potential to make a profound impact on the perceived likelihood of abuse. Although long-bone, skull, and rib fractures are the most common abusive fractures, fractures in the hands, feet, spine, and pelvis are relatively specific for abuse, especially in a child without a history of trauma to these regions of the body. We feel our data support current recommendations to include these views in SS protocols.

The proportion of SSs in subjects younger than 2 years old that identified fractures of the hands, feet, spine, or pelvis in our population (37 of 1750 surveys; 2.1%; 95% CI, 1.5%–2.9%) is slightly larger than the proportion identified by Karmazyn et al[16] (1.1%; 95% CI, 0.5%–2.0%), although the difference did not reach statistical significance. More important than the difference in the point estimates, however, is the context in which these numbers are interpreted. In our sample, more than 10% of SSs that identified a previously unknown fracture included fractures of the hands, feet, spine, or pelvis, meaning that these fractures were an important part of the information added by SSs.

Although the majority of subjects with fractures to the hands, feet, spine, or pelvis had other fractures, we do not feel that this decreases the importance of these fractures. Because interventions to protect abused children frequently involve litigious or adversarial debates about the likelihood of abuse, each identified injury that serves to increase the consensus around abuse likelihood can improve the ability to protect the abused child. Furthermore, additional fractures can improve the ability to demonstrate the chronic or severe nature of abuse and serve to help identify the abuser or argue for more appropriate protection or sentencing. Because an important fraction of children with fractures to the hands, feet, spine, or pelvis did not have other fractures, a strategy of limiting imaging to those children with other fractures would miss some fractures while still subjecting a majority of children to imaging.

Ultimately, as is often the case in medicine, interpretation of these results will depend on the number of films that one is willing to undertake to identify a case of abuse. In the early 1980s, 2 landmark articles established the utility of the SS. In a series by Merten et al,[9] occult fractures were identified in nearly 14% of SSs, whereas in a series by Ellerstein and Norris[11] the following year the rate was only 2.4%. Ironically, the former article concluded that fractures were rare on SS, and the number of surveys should be curtailed, whereas the latter concluded that the SS had a favorable cost-benefit ratio. Recently, the authors of a study of the "pan-scan" in adult trauma patients could not agree even among themselves whether their results supported or discouraged routine computed tomography.[20]

Weighing the risks of the radiation associated with these films and the risk of missing a case of physical abuse, we feel that SSs should continue to include dedicated films of the hands, feet, spine, and pelvis according to the recommendations of the AAP and ACR.

Limitations

Our study is subject to several limitations. The ultimate determination of whether a fracture was present rested with the child abuse physician responsible for the care of the patient, who nevertheless benefited from consultation with a radiologist experienced in interpretation of SSs. However, we did not review the primary images for subjects with or without fractures identified. It is possible that fractures were missed or that findings coded as fractures would not be considered fractures on independent review. We feel that these results represent real-world conditions likely to be faced by clinicians who order SSs. Of 796 follow-up SSs performed, only one showed that a finding concerning for hand, foot, spine, or pelvis fracture was not, in fact, a fracture (1 subject had questionable periosteal reaction around a metacarpal that was not present with no additional signs of fracture on follow-up SS).

Because all participating centers were referral centers for children with concerns of abuse, it is possible that our cohort of children undergoing subspecialty consultation with concerns of physical abuse may have been artificially inflated. If some children underwent a (presumably negative) SS without undergoing a child abuse consultation, these SSs would not have been included in the sample. Also, if children with higher likelihood or more severe abuse were more likely to be transferred and more likely to have these fractures identified, this would increase the proportion we identified.

In their article, Karmazyn et al[16] noted that all subjects with isolated fractures of the hands, feet, spine, or pelvis had other signs of abuse. We did not specifically determine which children had other signs of abuse because we presume that the vast majority of children undergoing SS for abusive fractures had some other indicators of abuse.

We included subjects older than 2 years, where spine and pelvis fractures were relatively more common. It is possible that older children are more likely to have these fractures or that clinicians might be more likely to identify these fractures clinically without routine SS.

CONCLUSIONS

Fractures of the hands, feet, spine, or pelvis are identified in a relatively small portion of all SSs obtained in the course of subspecialty evaluation of potential physical abuse but represent an important fraction of the previously unknown fractures identified by SS. Omitting views of the hands, feet, spine, or pelvis from the SS would result in missing some cases of physical abuse.

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