

## Practice Point

# The medical assessment of fractures in suspected child maltreatment: Infants and young children with skeletal injury

Laurel Chauvin-Kimoff, Claire Allard-Dansereau, Margaret Colbourne

Canadian Paediatric Society, Child and Youth Maltreatment Section, Ottawa, Ontario

**Correspondence:** Canadian Paediatric Society, 100-2305 St Laurent Blvd, Ottawa, Ontario K1G 4J8. E-mail [info@cps.ca](mailto:info@cps.ca), website [www.cps.ca](http://www.cps.ca)

### Abstract

Fractures are common injuries in childhood. While most fractures are caused by accidental trauma, inflicted trauma (maltreatment) is a serious and potentially unrecognized cause of fractures, particularly in infants and young children. This practice point identifies the clinical features that prompt concern for inflicted skeletal injury and outlines a management approach based on current literature and published guidelines, including the clinician's duty to report suspicion of child abuse to child welfare authorities. This document does not address isolated skull fractures.

**Keywords:** *Child abuse; Children; Fracture; Maltreatment; Physical abuse*

Fractures are found in 11% to 30% of infants and children evaluated for possible physical abuse (1–3). In this practice point, fractures occurring as a result of maltreatment or abuse are referred to as ‘inflicted’. Many inflicted fractures are clinically unsuspected, largely because they occur in the pre-verbal, non-ambulatory age group (4–6). In cases of child maltreatment, the history may also be incomplete, misleading or unknown by the presenting caregiver. No specific fracture type is pathognomonic for inflicted injury (7,8). Fracture patterns in both maltreatment and accidental circumstances are often specific to age or development level. Therefore, understanding the typical spectrum of injuries that children sustain as they mature is important.

This practice point addresses the following questions in the context of current published recommendations on child maltreatment:

- When fractures are identified in infants and children, what features should raise concern for inflicted injury?
- In the context of suspected child maltreatment, what should the medical assessment include?
- What assessments should be performed to evaluate for other medical conditions or other possible injuries?

### DIFFERENTIATING INFLECTED FROM ACCIDENTAL FRACTURES

The process of bone growth and mineralization is most dynamic during childhood. Knowledge of the common mechanisms for any given fracture type, combined with relevant clinical information, can guide the clinician as to the plausibility of reported injury mechanisms (Figure 1) (9,10). A recent systematic review of paediatric studies compared fractures due to abuse with fractures from other causes. It found that fracture site and type, with the developmental stage of the child, are helpful toward determining the likelihood of inflicted trauma (7).

#### Age of the child

**Young age is a key discriminator for inflicted skeletal trauma (1,2,4,7,11).** Accidental fractures are uncommon in children <18 months of age (11). Overall, 25% to 56% of all fractures in children <1 year of age are due to abuse (7).

#### Patterns of skeletal injury

Numerous studies have highlighted the significant association between multiple fractures and physical abuse (1,7,11). The relationship is particularly pertinent when fractures of different ages or old fractures for which medical care was not previously

<p><b>Historical:</b></p> <ul style="list-style-type: none"> <li>• No history of trauma/unwitnessed injury</li> <li>• History incompatible with age/developmental stage OR with injury</li> <li>• History changes with repetition</li> <li>• Delay in seeking medical attention</li> </ul> <p><b>Clinical:</b></p> <ul style="list-style-type: none"> <li>• Age &lt; 1 year</li> <li>• High-risk fractures: <ul style="list-style-type: none"> <li>◦ Rib fractures</li> <li>◦ Metaphyseal fractures</li> <li>◦ Humerus fracture &lt; 18 months</li> <li>◦ Femur fracture in a non-ambulatory child</li> </ul> </li> <li>• Multiple fractures</li> <li>• Fractures of different ages</li> <li>• Presence of other injuries</li> </ul>
--

**Figure 1.** Red flags for inflicted trauma in a young child with fracture(s)

sought are found. For hospitalized children with three or more fractures, abuse is the underlying etiology in almost 70% of those <36 months of age and in 85% of infants (1).

Rib fractures are uncommon in infants and young children, occurring only rarely with serious trauma (e.g., a motor vehicle accident) or underlying bone disorders (12,13). In the absence of overt trauma, rib fractures have the strongest association with inflicted injury (7,13,14). Rib fractures due to maltreatment are typically multiple, may be unilateral or bilateral and have been reported at all locations along the rib (7).

Children <18 months of age rarely sustain humeral fractures. Accidental humeral fractures typically occur after a fall and are more often supracondylar injuries. This location contrasts with inflicted humeral fractures, which are more likely to be spiral or oblique and midshaft or proximally located (7,15).

When a child is able to cruise or walk, accidental femur fractures may occur with a short fall, (generally < 1.5 m [5 feet]) stumble or tumble (10,16,17). These fractures may be of any type, including spiral or oblique, transverse or 'buckle'. A fall while in the arms of a caregiver is recognized as a possible accidental cause of such fractures (10). Femur fractures from inflicted trauma are primarily seen in very young, non-ambulatory children.

Classic metaphyseal fractures at the end of developing long bones are generally unique to the infant population and have high specificity for maltreatment (6,18). Scapular, spinous process and sternal fractures are uncommon accidental fractures and considered suspicious for inflicted injury.

### Presence of other injuries

The clinician must be alert to subtle findings of additional injury, such as bruising or oral trauma, particularly in young

infants. Bruises, especially on the child's trunk, ears and neck, may be a marker for inflicted trauma (19–21).

When children sustain minor accidental trauma, injuries are usually localized to one body region. Intracranial and abdominal injuries are uncommon with such minor incidents and generally occur only after significant, verifiable events, such as a motor vehicle collision, crush injury or a fall from a significant height (10,16,22). **When another serious injury accompanies skeletal injury, significant traumatic forces should be clear in the history.**

### Medical conditions predisposing to skeletal injury

Child abuse is far more common than bone disorders. A 2008 report identified the major causes of fractures in children <3 years of age hospitalized in the USA to be falls (50.4%), child abuse (12%) and motor vehicle accidents (11%) (1). **Underlying metabolic or bone disorders were identified in <1% of children.** Nevertheless, the clinician must consider the possibility of pre-existing medical conditions associated with bone fragility, and radiographic abnormalities must be interpreted carefully to avoid misinterpretation (Figure 2) (5,6,8).

### HISTORY

The medical assessment begins with a detailed inquiry as to the onset and progression of symptoms related to the child's presentation and carefully documents the circumstances around events leading to the injury. The history should include all recent and remote traumatic events and any known medical conditions. Note the child's dietary history and, in breastfed infants, significant maternal dietary restrictions.

Review the child's birth and past medical history, including premature birth, birth trauma or other previous injuries.

- |  |
|--|
| <ul style="list-style-type: none"> <li>i. Trauma           <ul style="list-style-type: none"> <li>1. Birth-related</li> <li>2. Accidental</li> <li>3. Inflicted</li> </ul> </li> <li>ii. Genetic bone disorder           <ul style="list-style-type: none"> <li>4. Osteogenesis imperfecta</li> <li>5. Menkes disease</li> <li>6. Infantile cortical hyperostosis</li> <li>7. Hypophosphatasia</li> </ul> </li> <li>iii. Nutritional/metabolic disorder           <ul style="list-style-type: none"> <li>8. Vitamin D deficiency rickets</li> <li>9. Osteopenia of prematurity</li> <li>10. Copper deficiency</li> <li>11. Chronic renal insufficiency</li> <li>12. Scurvy</li> </ul> </li> <li>iv. Infection           <ul style="list-style-type: none"> <li>13. Osteomyelitis</li> <li>14. Congenital syphilis</li> </ul> </li> <li>v. Toxicity           <ul style="list-style-type: none"> <li>15. Hypervitaminosis A</li> <li>16. Methotrexate toxicity</li> </ul> </li> <li>vi. Neoplastic disorder           <ul style="list-style-type: none"> <li>17. Leukemia</li> <li>18. Langerhans cell histiocytosis</li> </ul> </li> </ul> |
|--|

**Figure 2.** Differential diagnosis of skeletal injury in young children

Document prior and current medication use, including vitamin supplements, notably vitamin D. Growth and developmental milestones, particularly gross motor abilities, may be helpful in evaluating the plausibility of reported injury mechanisms.

The family history should include consanguinity, known metabolic abnormalities, fractures in related family members, hearing impairment, connective tissue disorders and dental hypoplasia.

## PHYSICAL EXAMINATION

Any infant or child presenting with a skeletal injury of unclear cause must have a thorough physical examination. Documentation should include:

- General appearance, vital signs and growth parameters (including head circumference).
- Skin assessment: Expose all areas. Document any bruising, scarring, skin laxity.
- Head:
  - Head shape, fontanel size, dysmorphic features, areas of soft-tissue swelling.
  - Eye exam: Sclera colour (blue sclera may be a normal finding in the first year of life) scleral or retinal haemorrhage.
  - Dentition and oral injury, including frenula tears.
- Chest/abdomen: Distension, tenderness, hepatosplenomegaly.

- Musculoskeletal: All limbs and joints, noting deformity, swelling, tenderness, limitations in range of motion, joint laxity or congenital abnormalities.

Ask for an indirect ophthalmological examination by an ophthalmologist in all children with a head injury concerning for inflicted trauma.

## LABORATORY EVALUATION

Recommended investigations include:

- Complete blood count
- Renal and liver function tests
- Serum calcium, phosphate and alkaline phosphatase
- Urinalysis
- When clinically indicated:
  - parathyroid hormone, 25-hydroxy-vitamin D
  - serum copper, ceruloplasmin

If the child has evidence of multisystem trauma or concern for an underlying medical condition, additional medical testing may be indicated (5,6).

## RADIOLOGIC EVALUATION

The skeletal survey (SS) is the cornerstone of radiographic investigation for fractures of unclear cause because it provides

valuable information about bone health and may identify occult skeletal injury. SS is recommended for any child <2 years of age when there is concern for physical maltreatment (2,3,6,23,24). While the yield for positive findings decreases past age 2 years, the clinician should consider imaging children between 2 and 5 years of age when there is a strong likelihood of occult inflicted injury. Guidelines for appropriate SS imaging in children are outlined by the American College of Radiology and endorsed by the American Academy of Pediatrics (23,24). The SS must be performed in a complete and technically adequate manner to optimize identification of both underlying medical conditions and skeletal injuries that are not clinically evident (e.g., rib or metaphyseal fractures). A limited view or 'babygram' is not an acceptable substitute. A bone scan may be helpful when used in conjunction with the skeletal survey. However, due to poor sensitivity for metaphyseal, epiphyseal and skull fractures, a bone scan alone should not be used for diagnosis (6). Review of skeletal imaging by a paediatric radiologist is recommended. While not all skeletal injuries discovered on radiographic imaging require medical intervention, they may be important for determining injury cause.

If the initial SS is negative or equivocal and maltreatment remains a concern, a follow-up SS should be conducted approximately 2 weeks later (6,23). In the case of a positive initial SS, follow-up images may identify additional injuries and contribute valuable information on healing and timing of injury. Consider omitting images of the skull, pelvis and lateral spine in follow-up studies, because injuries to these areas are typically identified on the initial series and eliminating them later reduces radiation exposure (25,26).

Consider neuroimaging for all infants presenting with fractures and suspected maltreatment. Additional imaging studies may be indicated when laboratory evaluation raises concern for abdominal injury.

## DATING OF SKELETAL INJURIES

Healing of musculoskeletal injuries occurs on a continuum, generally with a predictable progression of radiographic signs in young children. Findings include soft-tissue swelling, periosteal reaction, callus formation and remodelling. Estimating the age of skeletal trauma is important for identifying inconsistencies in the presenting history related to injuries found on physical examination or radiologic studies. Time frames for dating long bone fractures are broad and demonstrate significant overlap (27). The presence of fractures of different ages suggests multiple injury events at different times.

## DOCUMENTATION AND CONSULTATION

The documentation of all historical and clinical information should be detailed, using clear, objective language and

conclusions. When the clinical, radiographic or laboratory information suggests a pre-existing medical condition, a consult with genetics, metabolic diseases or endocrinology may be particularly helpful (Figure 2). An orthopedic consultation is often necessary to assist with fracture immobilization, surgical management or concerns regarding suboptimal healing or growth.

### ***Any reasonable suspicion of child maltreatment requires reporting to the appropriate child protection authorities, in all provinces and territories in Canada.***

Consultation with clinicians who have expertise in child maltreatment paediatrics can assist medical management, facilitate collaboration between health care providers and community child protection investigators, and help with medico-legal aspects of communication and documentation. The child maltreatment clinician can provide a comprehensive assessment of the historical and clinical features of the case, as well as an opinion on how well the historical events explain injury findings.

## CONCLUSION

Musculoskeletal injury is one of the most common injury complaints presenting for medical care in paediatrics. This practice point highlights the historical and clinical features of fractures that should alert the clinician to the possibility of inflicted injury and to the numerous but infrequent medical conditions that may present with skeletal abnormalities. The presence of additional injuries increases concern for child maltreatment. When suspicions for maltreatment arise, the clinician must report them to child protection authorities and clearly communicate any features of concern for inflicted injury.

## Acknowledgements

This practice point was reviewed by the Community Paediatrics, Injury Prevention and Acute Care Committees of the Canadian Paediatric Society. It was also reviewed by the CPS Paediatric Emergency Medicine and Hospital Paediatrics Section executives.

## References

1. Leventhal JM, Martin KD, Asnes AG. Incidence of fractures attributable to abuse in young hospitalized children: Results from analysis of a United States database. *Pediatrics* 2008;122(3):599–604.
2. Belfer RA, Klein BL, Orr L. Use of the skeletal survey in the evaluation of child maltreatment. *Am J Emerg Med* 2001;19(2):122–4.
3. Duffy SO, Squires J, Fromkin JB, Berger RP. Use of skeletal surveys to evaluate for physical abuse: Analysis of 703 consecutive skeletal surveys. *Pediatrics* 2011;127(1):e47–52.

4. Maguire S, Cowley L, Mann M, Kemp A. What does the recent literature add to the identification and investigation of fractures in child abuse: An overview of review updates, 2005–2013. *Evid-Based Child Health* 2013;8:2044–57.
5. Jenny C; American Academy of Pediatrics, Committee on Child Abuse and Neglect. Clinical report – evaluating infants and young children with multiple fractures. *Pediatrics* 2006;118(3):1299–303.
6. Flaherty EG, Perez-Rossello JM, Levine MA, Hennrikus WL; American Academy of Pediatrics Committee on Child Abuse and Neglect; Section on Radiology, American Academy of Pediatrics; Section on Endocrinology, American Academy of Pediatrics; Section on Orthopaedics, American Academy of Pediatrics; Society for Pediatric Radiology. Evaluating children with fractures for child physical abuse. *Pediatrics* 2014;133(2):e477–89.
7. Kemp AM, Dunstan F, Harrison S, et al. Patterns of skeletal fractures in child abuse: Systematic review. *BMJ* 2008;337:a1518.
8. Servaes S, Brown SD, Choudhary AK, et al. The etiology and significance of fractures in infants and young children: A critical multidisciplinary review. *Pediatr Radiol* 2016;46(5):591–600.
9. Pierce MC, Bertocci GE, Vogeley E, Moreland MS. Evaluating long bone fractures in children: A biomechanical approach with illustrative cases. *Child Abuse Negl* 2004;28(5):505–24.
10. Pierce MC, Bertocci GE, Janosky JE, et al. Femur fractures resulting from stair falls among children: An injury plausibility model. *Pediatrics* 2005;115(6):1712–22.
11. Worlock T, Stower M, Barbor P. Patterns of fractures in accidental and non-accidental injury in children: A comparative study. *Br Med J (Clin Res Ed)* 1986;293(6539):100–2.
12. Bulloch B, Schubert CJ, Brophy PD, Johnson N, Reed MH, Shapiro RA. Cause and clinical characteristics of rib fractures in infants. *Pediatrics* 2000;105(4):E48.
13. Barsness KA, Cha ES, Bensard DD, et al. The positive predictive value of rib fractures as an indicator of nonaccidental trauma in children. *J Trauma* 2003;54(6):1107–10.
14. Pandya NK, Baldwin K, Wolfgruber H, Christian CW, Drummond DS, Hosalkar HS. Child abuse and orthopaedic injury patterns: Analysis at a level I pediatric trauma center. *J Pediatr Orthop* 2009;29(6):618–25.
15. Pandya NK, Baldwin KD, Wolfgruber H, Drummond DS, Hosalkar HS. Humerus fractures in the pediatric population: An algorithm to identify abuse. *J Pediatr Orthop B* 2010;19(6):535–41.
16. Rewers A, Hedegaard H, Lezotte D, et al. Childhood femur fractures, associated injuries, and sociodemographic risk factors: A population-based study. *Pediatrics* 2005;115(5):e543–52.
17. Capra L, Levin AV, Howard A, Shouldice M. Characteristics of femur fractures in ambulatory young children. *Emerg Med J* 2013;30(9):749–53.
18. Kleinman PK, Perez-Rossello JM, Newton AW, Feldman HA, Kleinman PL. Prevalence of the classic metaphyseal lesion in infants at low versus high risk for abuse. *Am J Roentgenol* 2011;197(4):1005–8.
19. Sheets LK, Leach ME, Koszewski IJ, Lessmeier AM, Nugent M, Simpson P. Sentinel injuries in infants evaluated for child physical abuse. *Pediatrics* 2013;131(4):701–7.
20. Jenny C, Hymel KP, Ritzen A, Reinert SE, Hay TC. Analysis of missed cases of abusive head trauma. *JAMA* 1999;281(7):621–6.
21. Ward MG, Ornstein A, Niec A, Murray CL; Canadian Paediatric Society, Child and Youth Maltreatment Section. The medical assessment of bruising in suspected child maltreatment cases: A clinical perspective. *Paediatr Child Health* 2013;18(8):433–42.
22. Haney SB, Starling SP, Heisler KW, Okwara L. Characteristics of falls and risk of injury in children younger than 2 years. *Pediatr Emerg Care* 2010;26(12):914–8.
23. American Academy of Pediatrics, Section of Radiology. Diagnostic imaging of child abuse. *Pediatrics* 2009;123(5):1430–35.
24. American College of Radiology. ACR-SPR Practice Guideline for Skeletal Surveys in Children. 2011. [www.acr.org/~media/ACR/Documents/PGTS/guidelines/Skeletal\\_Surveys.pdf](http://www.acr.org/~media/ACR/Documents/PGTS/guidelines/Skeletal_Surveys.pdf) (Accessed August 17, 2017).
25. Harlan SR, Nixon GW, Campbell KA, Hansen K, Prince JS. Follow-up skeletal surveys for nonaccidental trauma: Can a more limited survey be performed? *Pediatr Radiol* 2009;39(9):962–8.
26. Sonik A, Stein-Wexler R, Rogers KK, Coulter KP, Wootton-Gorges SL. Follow-up skeletal surveys for suspected non-accidental trauma: Can a more limited survey be performed without compromising diagnostic information? *Child Abuse Negl* 2010;34(10):804–6.
27. Prosser I, Lawson Z, Evans A, et al. A timetable for the radiologic features of fracture healing in young children. *AJR Am J Roentgenol* 2012;198(5):1014–20.

#### CPS CHILD AND YOUTH MALTREATMENT SECTION EXECUTIVE

**Members:** *Burke Baird MD (past Member), Laurel Chauvin-Kimoff MD (Secretary-Treasurer), Catherine Murray MD (Member at Large), Amy Ornstein MD (President), Karine Pépin MD (Member at Large), Michelle Shouldice MD (past President), Juliet Soper MD (Member at Large), Michelle Ward MD (Vice President)*

**Liaisons:** *Claire Allard-Dansereau MD, Association des médecins en protection de l'enfance du Québec; Laura Stymiest MD, CPS Residents Section*

**Principal authors:** *Laurel Chauvin-Kimoff MD, Claire Allard-Dansereau MD, Margaret Colbourne MD*