A90 Differences in Fracture Healing Between Unintentional and Abuse-Related Fractures in Young Children

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Learning Overview: After attending this presentation, attendees will recognize the potential effect of physical abuse on fracture healing in young children and its impact on assessment of fracture age in cases of suspected child abuse.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by informing attendees of the results of this study that has the potential to impact the application of fracture healing timelines when assessing fracture age in cases of suspected abuse.

Young children (0–3 years) are most vulnerable to death as a result of abuse and maltreatment.[1] Children under one year of age are at the highest risk for physical abuse and have the highest number of fatalities due to maltreatment.[1] Over half of child physical abuse cases involve skeletal fractures, and the presence of multiple fractures in varying stages of healing may be highly concerning for physical abuse.[2,3] An accurate time-since-injury estimation of healing fractures may provide an opportunity for identification and characterization of physical abuse, especially in young children unable to verbalize. Timelines of fracture healing are primarily derived from unintentional (i.e., accidental) fractures in otherwise healthy children and applied to children suffering physical abuse and other forms of maltreatment. The objective of this study was to examine the potential effect of abuse on fracture healing in a sample of young children and the predictive potential of fracture healing data.

This Institutional Review Board (IRB) -approved retrospective, radiographic study examined children under two years old evaluated for a humerus fracture between 2000–2016 at a pediatric level I trauma center. Humeral fractures in immobile infants without a known mechanism of injury are considered highly concerning for abuse but are also seen as a result of birth-related trauma and unintentional injury.[4] Exclusion criteria included: (1) casted radiographic exams, if the fracture was obscured on all views; (2) unknown date of injury; (3) individuals with known comorbidities or disorders affecting bone; and/or (4) fractures requiring instrumentation. Features of fracture healing (Subperiosteal New Bone Formation [SPNBF] and callus formation) were evaluated from initial and follow-up radiographic exams. Determination of abuse was made by the hospital's child protection team; however, not all children in the sample were necessarily evaluated. Kruskal-Wallis H tests were performed to determine if there were significant differences in fracture healing time between abuse-related and unintentional fractures. Building on previous research that demonstrated a difference in fracture healing time between abuse-related and unintentional fractures, mixed effects models were developed to investigate influences of fixed and random effects and predictive potential of these data.[5]

Fifty-six humeral fractures (abuse-related: 19, unintentional: 37) were analyzed from 63 patients (males: 31, females: 32). Twenty (36%) were infants less than one year and 36 (64%) were age 1–2 years. A total of 76 abuse-related and 100 unintentional radiographic exams were analyzed, with an average of three post-injury exams per patient (abuse-related: 4, unintentional: 2.7). Exams were performed a mean of 19.95 days (Standard Deviation [SD]=23.81) post-injury for abuse-related fractures and 19.35 days (SD=19.71) post-injury for unintentional fractures. Most abuse-related fractures occurred in infants and were complete and diaphyseal. Multiple fractures were observed in over half (n=11, 58%) of children with abuse-related fractures and three children (8%) with unintentional fractures. SPNBF and all levels of callus matrix occurred earlier in abuse-related fractures, but only intermediate callus approached statistical significance ($p < 0.05$). Clinical/forensic relevance (as opposed to statistical significance) should be considered. While a difference of two days is unlikely to make a significant difference in fracture age estimation, a difference of 7–10 days may have implications for identification of abuse. Results from the mixed effects models demonstrate that abuse-related fractures heal slightly faster than unintentional fractures at a fixed rate of 3.4 days when indicators of healing are controlled. Equations generated from the final model predict time since injury and have the potential to discriminate abuse status in the middle and advanced stages of healing.

The population from which a fracture healing timeline is derived (healthy children) and to whom the method is applied (abused children) should be considered. In addition, equations to predict time since injury may assist in identification of physical abuse in children.

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