A123 Early Bone Healing Response in an Acute Occipital Skull Fracture of a 19-Month-Old After a 72- to 78-Hour Survival Interval

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Learning Overview: The goal of this presentation is to demonstrate through case example the timing of fracture repair in a pediatric occipital fracture. Subperiosteal new bone is observed macroscopically in this case in which the death occurred after an interval ranging from 72 to 78 hours following cranial fracture in a 19-month-old.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by providing a time frame for early bone response in a pediatric skull fracture using casework with a documented timeline.

This case study follows a 19-month-old female with an acute occipital fracture. The patient was medically treated for 42 hours prior to pronounced brain death and survived 30 additional hours on a ventilator awaiting organ harvesting. The perpetrator had sole custody of the child for six hours prior to the 911 call. Autopsy findings included an acute occipital skull fracture terminating in the foramen magnum, subgaleal, periosteal, subdural, and subarachnoid hemorrhages, cerebral edema with uncal and cerebellar herniation, bilateral multi-layered ocular hemorrhages, scattered contusions, and healing fractures of the right radius and ulna. An anthropology examination using a stereomicroscope revealed Subperiosteal New Bone Formation (SPNBF) in a diffuse pattern surrounding the cranial fracture site and no evidence of bony remodeling of the fracture gap. Other anthropology findings included a healing fracture of the right ulna with separated cortical walls, bridging callous and subperiosteal new bone formation surrounding the fracture, and a healing right radius fracture presenting as a swelling of the cortex with the cortical walls intact.

Fracture healing rates in human infant/child crania have few references in the literature, although it is reported that infants and children have a faster healing rate with deposition of new bone occurring within hours of injury.[1,2] The cranium undergoes intramembranous bone repair, a process that requires no cartilaginous precursor. Early events include cell proliferation and differentiation. Osteoprogenitor cells, including undifferentiated stem cells that convert to osteoblasts, are present in the cambium layer of the periosteum. New bone matrix is synthesized by osteoblasts under the periosteum and deposited onto the cortical surface adjacent to the fracture and progresses toward the fracture.[3,4] The immature dura mater has been shown to produce higher rates of osteogenic cellular activity that contributes to the rapid repair of cranial trauma.[1] It is suggested that the interaction of vascular components and the initiation of the periosteal response facilitate intramembranous bone formation.[4] Histologically, intramembranous ossification is shown to occur a few days following injury.[5] Hard callous is found to develop under the periosteum as early as two to five days in rats.[6]

The knowledge of the timing of the healing response is primarily based on published radiographic data that highlights the time of appearance of SPNBF.[7] It is hypothesized that macroscopic observation will reveal bony change earlier in the process. Anthropologists and pathologists working in the medical examiner setting have the diligence, dedication, and devotion to collect gross and histologic data from cases with known survival intervals to ascertain the timeframe for early healing response in subadult cranial fractures. When interpreting findings of fracture healing in a forensic report, practitioners can report only to the limits of the knowledge shared through publication. This limits the narrow time frame provided to investigators and the judicial system. This presentation provides a documented time frame for the formation of SPNB in a healing cranial fracture and begins a study of known forensic cases to more accurately define time-since-injury estimates.

Reference(s):

1. Love, Jennifer C., Derrick Sharon M., and Jason M. Wiersema. *Skeletal Atlas of Child Abuse*. New York: Humana Press, 2011.
2. Marks, Murray K., Marden, Kerriann, and Darinka Mileusnic-Polchan. Forensic Osteology of Child Abuse. In: *Hard Evidence: Case Studies in Forensic Anthropology, 2nd Edition,* edited by Dawnie Wolfe Steadman, 205-220. Upper Saddle River: Prentice Hall, 2009.
3. Bolander Mark E. Regulation of Fracture Repair by Growth Factors. *Pro Soc Exp Biol Med.* 200 (1992):165-170.
4. Gerstenfeld, Louis C., Cullinane, Dennis M., Barnes, George L., Graves, Dana T., and Thomas A. Einhorn. Fracture Healing as a Post-Natal Developmental Process: Molecular, Spatial, and Temporal Aspects of Its Regulation. *J Cel Biochem.* 88 (2003):873-884.
5. Einhorn, Thomas A. The Cell and Molecular Biology of Fracture Healing. *Clinical Orthopaedics and Related Research.* 355S (1998):S7-S21.
6. Phillips, A. Mark. Overview of the Fracture Healing Cascade. *Injury, Int. J. Care Injured* .36S (2005):S5-S7.
7. O'Conner John F. and Jonathan Cohen. Dating Fractures. In: *Diagnostic Imaging of Child Abuse*, edited by Paul K. Kleinman, 168-177. Baltimore: Williams and Wilkins, 1998.

Subperiosteal Bone Formation, Fracture Healing, Pediatric Skull Fracture