A45 Evaluating Bone Fracture Healing and Variability Across Forensic Samples Using an Anabolic/Catabolic Model of Bone Repair

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Learning Overview: The goal of this presentation is to evaluate bone fracture healing and the staging systems that are currently used to estimate its progression and timing in a forensic context. Microscopic and macroscopic comparisons of healing fractures across a diverse forensic sample are used to document variability in timing and character of bone healing and illustrate the inadequacies and errors associated with current models and stages of bone repair. This variability is interpreted through a newer anabolic and catabolic model of bone reparation focused on the coordinated and integrated processes of osteoblastic-driven bone deposition and osteoclastic bone resorption.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by demonstrating that research will enhance forensic scientists' recognition of variability in the bone fracture healing process and its outcomes as well as the factors that produce and influence this variability. Researchers and clinicians will recognize the importance of comorbidities for fracture repair and will be cautioned that reliance on the application of previously published fracture healing estimates across forensic samples of varying age, fracture and trauma type, and health may lead to inaccurate Time Since Injury (TSI) estimates and interpretations. Use of a more fluid and integrated anabolic/catabolic model for bone repair will aid in more accurate interpretation of bone fracture healing (including TSI).

Interpretation of non-accidental pediatric and elderly injury is often dependent upon evaluation of previous bone injury and its repair process and timing. Currently, a myriad of bone healing schemata have been published, with little understanding of their application to forensic contexts. It is hypothesized that demographic (e.g., age), biomechanical (e.g., fracture and trauma type and location), and biomedical (e.g., treatment of fracture, presence of comorbidities) factors significantly influence bone healing and complicate and, in some cases, nullify the use of these published staging systems in a forensic context.

This hypothesis will be tested by first conducting a comparative review of published bone fracture healing staging systems across major forensic and biomedical sources dating back to 1980. Bone healing schemata variables compared include stages of healing presented, terminology used to describe the healing process, timetable for repair, and modality on which the stages are based. These staging systems are then applied to the forensic fracture sample from the Radford University Forensic Science Institute's Antemortem Fracture Archive (RUFSI AFA). This forensic sample consists of more than 250 antemortem fractures of varying type and location derived from (currently) 20 individuals ranging in age from 27 days to 92 years. It contains more than 3,000 macroscopic and microscopic (5x–200x magnification, using a 3D digital light microscope) images illustrating all phases of the bone repair process.

Results of this study identify at least 13 distinct bone healing staging systems that have been applied to fracture healing interpretations in a forensic context. All, to some degree, derive from radiographic assessments of bone repair across a variety of cohort demographics, fracture and trauma types, and locations from non-forensic contexts. They employ inconsistent fracture repair terminology, rely on rigid classification systems, and consider the bone healing process a categorical progression through finite and mutually exclusive stages. Application of these published staging systems to the diverse forensic fracture sample produces widely varying and unclear characterizations of bone healing and its timing and interpretation.

Utilization of a microscopic anatomy-based anabolic/catabolic model based on a continuous, coordinated, and integrated process of bone repair involving osteoblastically driven bone deposition and osteoclastic bone resorption produces more accurate results. This model has the advantage of flexible adaptation to documented variability in demographic, biomedical, and biomechanical influences on bone fracture.[1,2]

It is concluded that both macroscopic and microscopic evaluations of bone healing are important components of fracture interpretation, as is the recognition of the significant effect of many variables upon the fracture repair process and timing. This research illustrates well the 2020 AAFS theme of *Crossing Borders*—the use of an interdisciplinary (in this case, biomedical and anthropological) approach and model produces more accurate interpretations of bone fracture healing, its outcome, and interpretation in a forensic context.

Reference(s):

1. Boyd, D.C. The Anatomical Basis for Fracture Repair: Recognition of the Healing Continuum and its Forensic Applications to Investigations of Pediatric and Elderly Abuse. In *Forensic Anthropology: Theoretical Framework and Scientific Basis*, edited by C.C. Boyd and D.C. Boyd, 151-200. Chichester, West Sussex, UK: Wiley, 2018.
2. Little, D.G., Ramachandran, M., Schindler, A. The Anabolic and Catabolic Responses in Bone Repair. *Journal of Bone and Joint Surgery* (2007):89-B(4):425-33.

Antemortem Fracture, Bone Healing, Comorbidities