



A59 Investigating the Impact of Opioid Abuse on Intracortical Porosity and Bone Cellular Density: A Synchrotron-Radiation Micro-Computed Tomography (SR μ CT) Approach

Janna M. Andronowski, PhD*, University of Akron, Department of Biology, Akron, OH 44325-3908; Reed A. Davis, MS, The University of Akron, Department of Biology, Akron, OH 44325-3908; Mary E. Cole, PhD, The University of Akron, Department of Biology, Akron, OH 44325

Learning Overview: The goals of this presentation are to: (1) describe how bone tissue pathology associated with opioid use (e.g., increased cortical pore density) is discernable in rib and femur microarchitecture; and (2) present high-resolution SR μ CT as a tool to characterize opioid-related bone microstructural pathology with a precision that exceeds traditional brightfield microscopy.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by disseminating novel research related to the effects of chronic opioid use on bone microstructural integrity. As the opioid crisis is not showing any signs of slowing nationwide, it is critical that further research efforts be undertaken to understand the impacts on bone metabolism. Forensic anthropologists are specifically challenged by the confounding effects of opioid use on age-at-death estimation and fracture assessment from bone tissue.

Prolonged opioid use has been demonstrated to induce osteoporotic-like bone loss and increase the risk of bone fracture in chronic analgesic users. The current theory is that opioids act directly on opioid receptors of bone forming cells (osteoblasts), resulting in more bone resorption than formation. Indirect effects may be caused by lower serum levels of estradiol and testosterone in response to opioids, resulting in decreased bone mineral density and increasing the risk of osteoporosis.¹⁻³ With the current trend of opioid overdoses poised to expand its impact further, it is critical that additional research related to the impact of chronic opioid use on bone remodeling be undertaken to expand the forensic toolkit. The primary goal of this preliminary study was to describe how opioid use affects microscopic structures and overall porosity of cortical bone microarchitecture at two sites commonly used in histological age-at-death estimation: the mid-shaft sixth rib and anterior femoral mid-shaft. It was hypothesized that: (1) cortical bone porosity in chronic opioid users exceeds that of healthy controls; and (2) the abundance and density of cortical bone's cellular spaces (e.g., osteocyte lacunae) varies between controls and opioid users.

Osteocyte lacunae and cortical porosity were visualized in the anterior femur via SR μ CT at the Canadian Light Source synchrotron facility in Saskatchewan, Canada. Cortical porosity was visualized in the mid-shaft sixth rib using laboratory micro-CT at The University of Akron's National Polymer Innovation Center. Anterior femoral cores included known opioid users (ages 25, 27) and non-users (ages 21, 90, 93). Mid-shaft sixth ribs were age-matched for known opioid users (ages 24, 25, 27) and non-users (ages 21, 90, 94). Cylindrical Volumes Of Interest (VOIs) were isolated from reconstructed images of cortical bone via Bruker's CT-Analyser image processing software. Osteocyte lacunar spaces were separated from the high-density bone using global thresholding and segmentation. Standard nomenclatures for lacunar indices were applied for the analysis of 3D lacunar parameters within the VOIs. The variables measured included: Total VOI Volume (TV), total Canal Volume within VOI (Ca.V), average Canal Diameter (Ca.Dm), total Number of Lacunae (N.Lc), and average Lacunar Volume (Lc.V). To determine lacunar density per mm³ (N.Lc/BV), Bone Volume (BV) was calculated as TV-Ca.V. Cortical porosity was calculated as Ca.V/TV.

In the anterior femur, pore density of young drug users (1,606–2,114 pores/mm³) considerably exceeded non-users (534–1,444 pores/mm³). In the rib, maximum pore density for young drug users (234 pores/mm³) similarly exceeded non-users (40–173 pores/mm³). Pore thickness in the rib for young drug users (91.7–115.3 μ m) resembled the young non-users (96.7 μ m) more than elderly non-users (24.1–24.5 μ m), as large pores were previously resorbed in the elderly via severe cortical thinning. In the anterior femur, osteocyte lacunar density of young drug users (range=40,213–42,262 lacunae/mm³) exceeds both a young non-user (34,834 lacunae/mm³) and elderly non-users (range=23,594–29,583 lacunae/mm³). These preliminary results suggest that opioid use may accelerate new pore accumulation. This study further detected a concurrent increase in cellular density.

This work represents the first examination of human bone tissue from known opioid users via SR μ CT. This ongoing research seeks to further characterize opioid use comorbidities such as osteopenia and osteoporosis. Results of this preliminary research have broader applications as they offer promise to identify risk factors for early-onset osteoporotic fracture that have both clinical and forensic applications for predicting and identifying skeletal trauma.

Reference(s):

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Opioid Abuse, 3D Imaging, Cortical Porosity