Objective Assessment of Bone Viability in a Fracture Model Using Quantitative Dynamic Contrast-Enhanced Fluorescence Imaging

Ida Leah Gitajn MD*; Jonathan Elliott PhD; Jason Gunn BS; Alberto Ruiz MSc; Eric R Henderson MD; Brian Pogue PhD; SHUDONG JIANG PhD*
Dartmouth Hitchcock Medical Center, Lebanon, NH, United States

Purpose: Bone requires adequate perfusion to facilitate healing and avoid infection following high-energy trauma. Standard of care does not include an objective method for bone perfusion assessment to guide surgical debridement, relying rather on subjective signs. Our goal is to translate fluorescence-guided surgery principles to an orthopaedic fracture model and evaluate dynamic contrast-enhanced fluorescence imaging (DCE-FI) as a method to objectively assess bone perfusion.

Methods: Sequential injury to 12 porcine tibias was performed during surgical anesthesia consisting of baseline, osteotomy, and sequential soft-tissue stripping designed to disrupt endosteal then periosteal blood supplies in a clinically relevant manner. Indocyanine green (ICG)-based DCE-FI was performed after each event, collecting 4 minutes of dynamic inflow/outflow kinetics. Kinetic modeling used an approach that accounted for hemodynamics attributed to endosteal and periosteal blood supplies.

Results: ICG-based DCE-FI effectively and quantitatively measured systematic sequential injury to bone blood flow. All kinetic-curve and modeling-related variables reflected the systematic changes to bone blood flow including maximum ICG intensity (Imax), total bone blood flow (TBBF), and endosteal flow fracture (EFF). The combination of TBBF and EFF was most effective at differentiating injured from healthy bone with accuracy, sensitivity, and specificity of 89%, 88%, and 90%, respectively (Fig. 1).

Conclusion: This work demonstrates that ICG-based DCE-FI can effectively provide a nuanced and detailed objective measure of bone perfusion kinetics. This suggests that ICG-based DCE-FI is an extraordinarily promising technique that may provide surgeons with an objective intraoperative measure of bone viability that can be used to improve treatment of traumatic injuries.