

## **Beyond Closure: AI-Enhanced Digital Image Speckle Correlation as a Quantitative Biomechanical Endpoint for Wound Healing**

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**BACKGROUND:** Chronic wounds affect 10.5 million Medicare beneficiaries annually at a cost exceeding \$22 billion (1). A recent NIDDK Diabetic Foot Consortium study found that 35% of ulcers meeting visual criteria for complete healing recurred within 16 weeks because surface closure did not reflect underlying tissue integrity (2). The FDA has sought validated alternatives to wound closure as a primary clinical endpoint through expert working groups and dedicated workshops, but no quantitative mechanical measure exists (3). We developed an AI-driven wound healing platform based on digital image speckle correlation (DISC) that measures mechanical force propagation through healing tissue, a property that visual inspection and perfusion-based imaging cannot capture.

**METHODS:** In DISC, a controlled point force is applied adjacent to the wound and the resulting displacement of natural skin features is tracked through video, producing a force propagation ratio (R-value) that quantifies tissue mechanical integrity (4). We automated wound boundary detection using two zero-shot AI foundation models (Grounding DINO, SAM) that segment wounds from video frames without manual annotation or wound-specific training data. Using a 28-day porcine burn model, we collected 939 measurements across six treatment groups (Bacitracin, RECELL, fibrin scaffold, and combinations) at two application timepoints (24-hour and 48-hour post-debridement) with independent histopathological validation.

**RESULTS:** DISC captured a non-monotonic biomechanical healing signature that tracked wound healing physiology. Force propagation dropped to its lowest point during inflammation (days 0 to 4), then recovered progressively through proliferation (days 7 to 17) as re-epithelialization advanced from 25% to 87% and granulation tissue restored structural continuity. A secondary dip at day 21 corresponded with type III to type I collagen remodeling. At day 21, wounds appeared 70% closed with 99% re-epithelialization, yet DISC detected ongoing mechanical remodeling beneath the surface. By day 28, force propagation exceeded pre-injury hemostasis levels, indicating formation of mechanically stronger tissue, though curves had not yet plateaued. Treatment stratification showed RECELL-treated wounds maintained consistently higher force propagation ratios throughout the study, whereas Bacitracin controls showed persistently lower mechanical recovery. Independent validation in a murine wound model confirmed the force propagation principle, where DISC detected mechanical discontinuity at the wound boundary after visual closure at day 7, with histology confirming incomplete vascular anastomosis.

**CONCLUSIONS:** AI-driven DISC provides the first quantitative, non-invasive measurement of tissue mechanical integrity during wound healing. These data position DISC as a candidate FDA endpoint for wound healing trials, with applications in burn management, treatment evaluation, and chronic wound monitoring.

**References:**

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