NEW
PRODUCT
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AREA 1435

RECREATING MORPHOGENESIS WITH SOUND: A NEW PARADIGM FOR REGENERATIVE MEDICINE

Tiziano Serra, PhD, AO Research Institute Davos, Switzerland
(tiziano.serra@aofoundation.org)

Background

Chronic wound care has traditionally focused on wound closure, yet true recovery requires functional tissue repair: the coordinated regeneration of vascular, neural, and structural networks and extra-cellular matrix. Current regenerative approaches struggle to recreate this biological complexity.

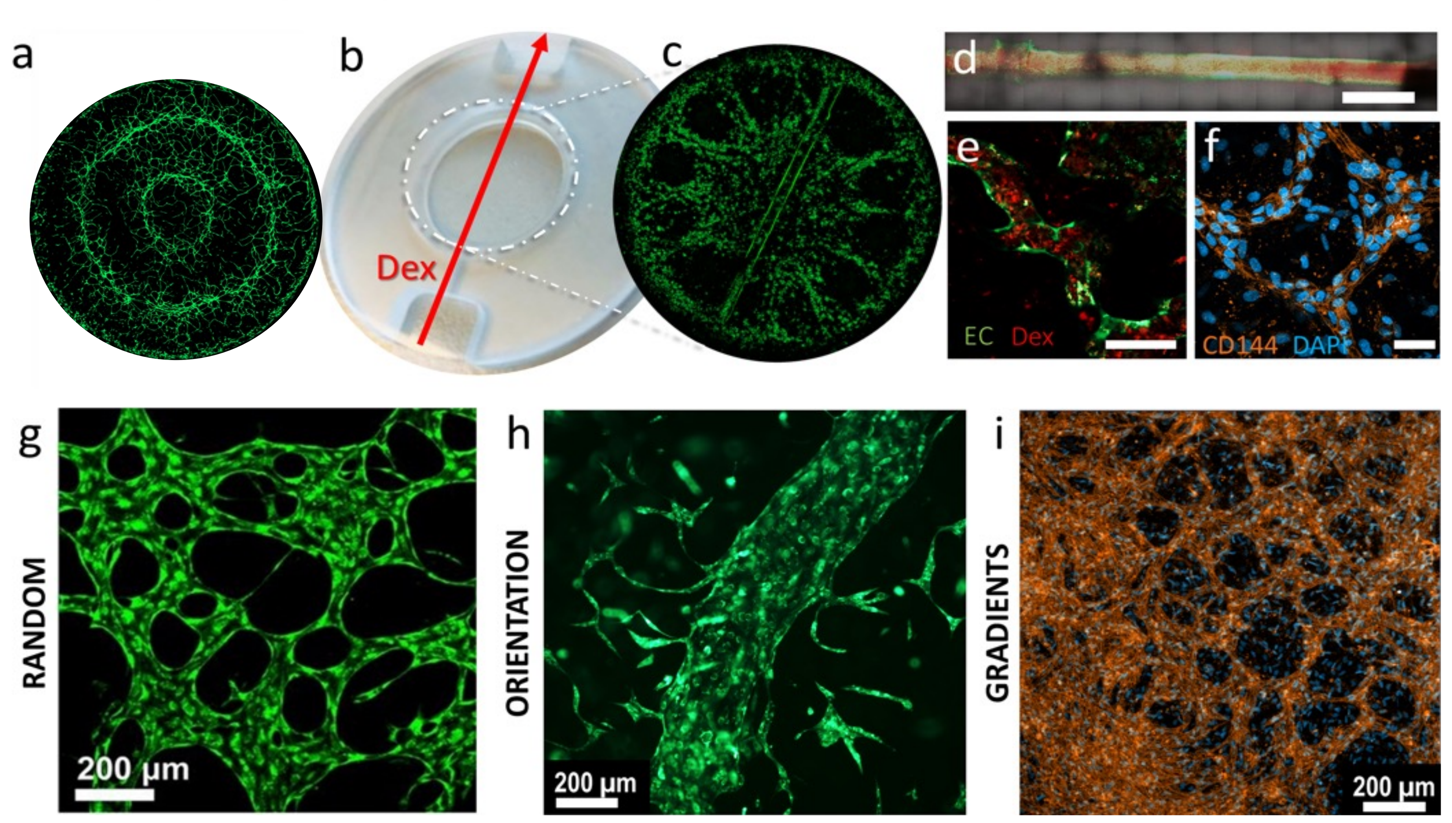
Sound Induced Morphogenesis (SIM) introduces a disruptive strategy that uses precisely tuned acoustic fields to guide cellular self-organization and extracellular matrix (ECM) formation. Inspired by natural morphogenesis, SIM enables the spatial patterning of cells, organoids, and tissue fragments into bio-functional constructs, including microvascular and neuronal networks.

By reproducing nature's design principles, bioactive condensation and controlled pattern formation, SIM may shift advanced wound care from the current variable and independent approaches to an orchestrated and aligned continuum depending on the wound needs. The potential impact of SIM on three critical areas associated with wound repair are outlined below:

Micro Vascularization Engineering

No Tissue Regeneration Without Vascularization

Vascularization is essential for tissue development, wound healing, and physiological homeostasis. Without a functional vascular network, thick engineered tissues are prone to ischemia and limited viability. Sound Induced Morphogenesis enables the formation of organized, functional vascular networks with physiologically relevant multiscale architecture. These microvascular structures can be integrated into engineered tissues to support perfusion, maturation, and long-term functionality. Potential applications not only include wound repair but also myocardial repair, and large bone constructs, where pre-formed vasculature may accelerate integration, healing, and tissue maturation.

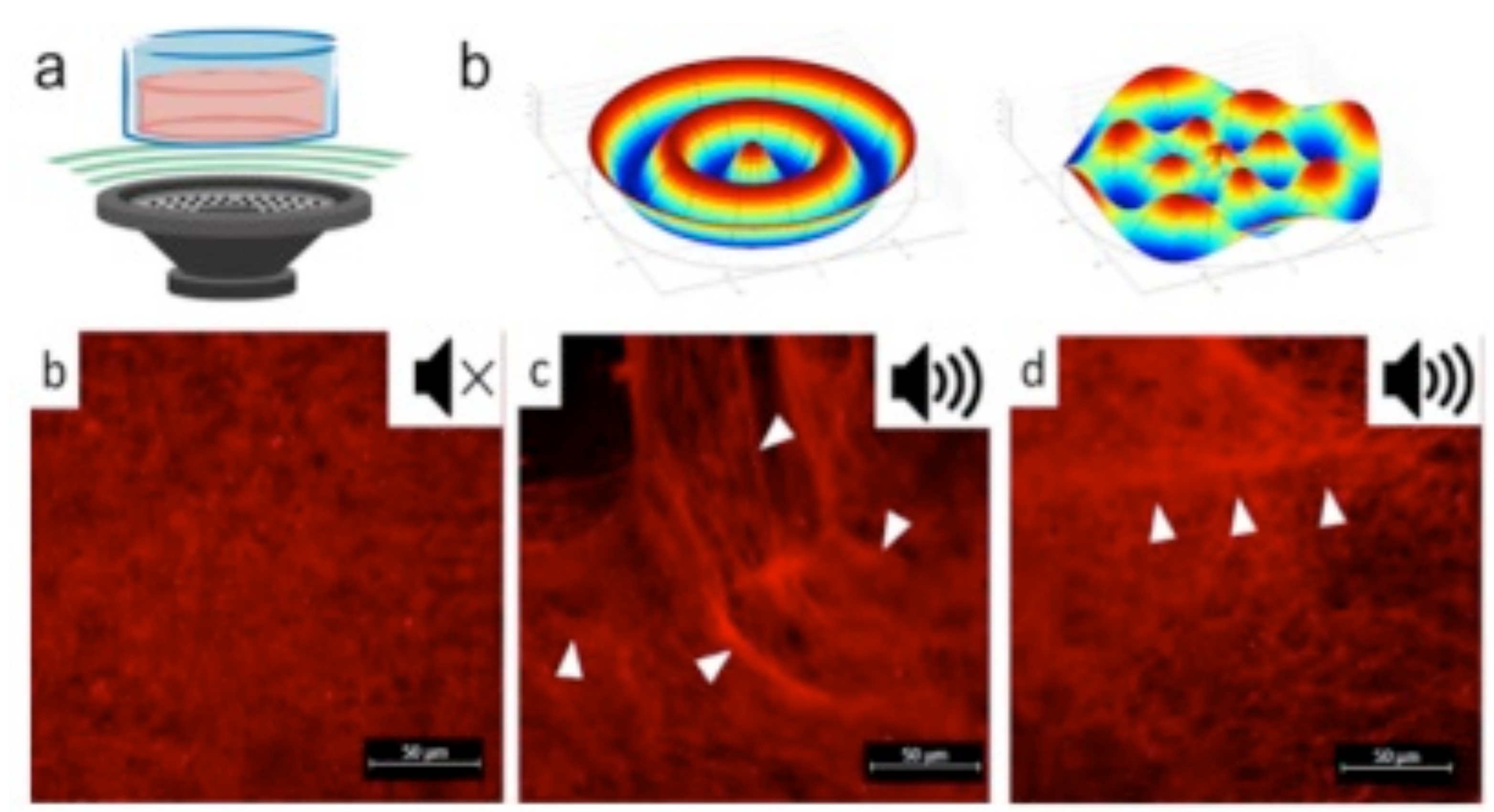


Petta et al., Biofabrication 2021 / Di Marzio et al., Materials Today Bio 2022, Biomat & Biosyst 2024

a) Spatially patterned vasculature; b) cm-scale fluidic chamber for integration of SIM patterning and dextran (Dex) perfusion; c) example of multiscale vascular network (diameter > 2 cm) with large vessel and SIM patterned hMSCs/ECs for capillary sprouting; d) large vessel perfusion, scalebar 2mm; e) microcapillaries perfusion and f) cadherin staining (CD144) for vessel maturation, scalebar 50 µm. DAPI: nuclei; g) typical randomly organized vascular network via self-assembly process87; h) spatially defined vessel orientation and i) vessels gradients via SIM patterning followed by self-assembly process.

Shaping Extracellular Matrices With Sound

ECM remodeling and spatial fibrillar densification



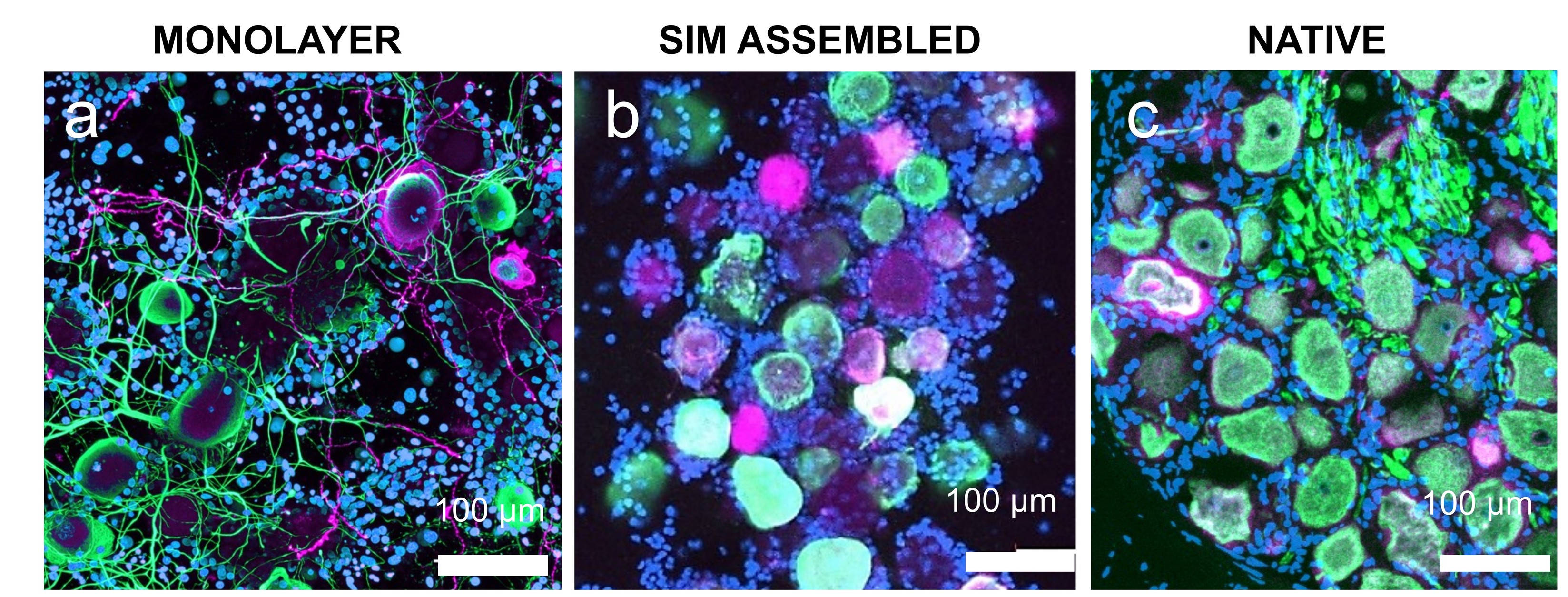
Schematic of the vibrating system for structural orchestration of fibrillar ECM. b) Two examples of MATLAB visualization of the energy drift related to a specific set of pattern parameters (frequency, Amplitude. Morphology of fluorescently labelled fibrin a) without and b,c) with the application of acoustic waves during the crosslinking process. The arrowheads show areas of fibrin densification.

The extracellular matrix (ECM) plays a central role in tissue morphogenesis, cell migration, and vascular network formation. Its mechanical properties and fibrillar architecture regulate cell behavior, differentiation, and tissue homeostasis.

Using acoustic fields, Sound Induced Morphogenesis (SIM) enables controlled spatial organization and densification of ECM fibrillar networks. This acoustic remodeling modifies ECM porosity, fiber distribution, and mechanical cues that guide multicellular organization.

In the context of advanced wound care, controlled ECM architecture may support cell migration, angiogenesis, and granulation tissue formation, helping create microenvironments that promote functional and sustainable tissue regeneration vs scar-driven repair.

Engineering Sensory Tissue Architecture with SIM to Support Chronic Wound Repair



Ma et al., Adv. Science 2023 NF CGRP Nuclei

a) Immunofluorescence comparison between traditional monolayer culture and a sound-assembled multicellular system that closely mimics the native Dorsal Root Ganglion (DRG) architecture, scale bars = 100 µm.

Sensory neurons play a key role in wound healing, tissue regeneration, and pain signaling. In chronic wounds, impaired neurovascular communication and neuropathy contribute to delayed healing and persistent pain, yet current in vitro models poorly replicate the complex architecture of sensory ganglia.

Sound Induced Morphogenesis (SIM) enables the controlled assembly of multicellular dorsal root ganglion (DRG) systems, recreating neuronal architectures that resemble native tissue organization and support cell–cell communication.

These biomimetic constructs may help advance the understanding of sensory regeneration and neurovascular signaling, supporting the development of therapies to improve healing and pain management in patients with chronic wounds.

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