Standing-Wave Induced Regeneration of Otic Neurites (SIRON)

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Degeneration of spiral ganglion neurons (SGNs) and synapses is a hallmark of sensorineural hearing loss, creating a physical separation between cochlear implant (CI) electrodes and their target neurons. Current commercial CIs are limited because they must drive electrical signals across this bone-separated electrode-neuron gap and cannot restore native tissue architecture or promote neural regeneration. Using acoustic wave technology, auditory neurites were patterned and anchored at electrode-aligned pressure nodes. Simultaneously, a sustained chemical gradient of brain-derived neurotrophic factor (BDNF) was established to promote directed neurite extension across the electrode–neuron interface. The system was designed to both physically reposition and stabilize new auditory neurons near CI electrodes and chemically provide long-term neurotrophic signaling to guide neurite growth.

The primary objectives of this study were to: (1) utilize acoustic wave technology to position and anchor auditory neurites near cochlear implant electrodes, (2) generate a long-lasting BDNF concentration gradient, (3) provide stable neurotrophic signaling, and (4) promote directed neurite extension across the electrode–neuron gap. To achieve these goals, we developed a multi-channel microfluidic module integrated along the CI array. Within this platform, acoustic patterning positioned otic neural progenitor (ONP) spheroids at electrode-aligned pressure nodes inside a hydrogel channel, while an adjacent PODS-BDNF channel maintained a sustained neurotrophin gradient that directed neurite growth toward the electrodes.