Washington University in St. Louis
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WIRELESS, DISSOLVABLE ELECTRICAL STIMULATION DEVICE FOR NERVE OR BONE REGENERATION

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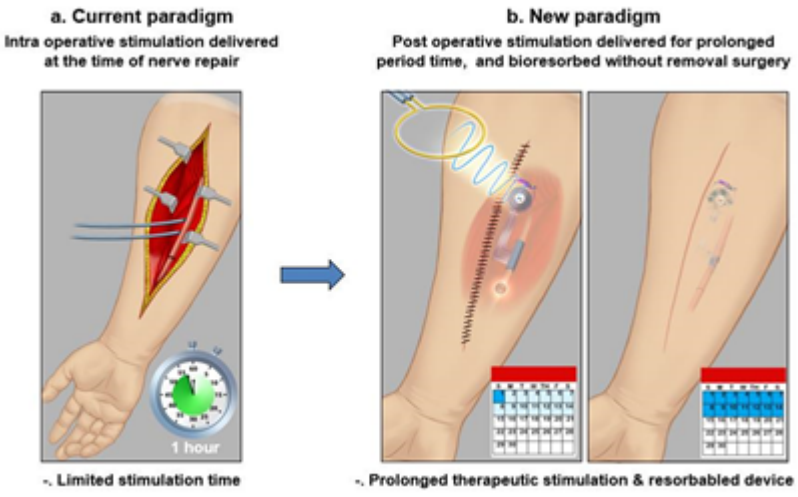
Technology Description

An interdisciplinary team of inventors has developed an implantable, bioabsorbable device to accelerate nerve or bone repair by delivering programmable electrical stimulation over the course of days or weeks following surgery. Direct electrical stimulation during surgery for peripheral nerve injury is known to trigger the release of growth-promoting proteins which the nerve cell's natural ability to repair faster. However, currently there is no way to continue the transient stimulation throughout the early weeks after surgery to speed functional recovery and reduce the total cost of care. This technology is designed to provide that longer term electrical stimulation through a device that delivers programmable electrical pulses for days before it harmlessly dissolves in the body without a trace. Because the circuit elements and substrates of the device are bioabsorbable, the risks and costs of a second surgery to remove the device are elimnated. In addition, the external wireless power supply and control module provides spatial and temporal control over the stimulation while reducing the risk of infection from an implanted power source.

Initial studies of this device in rats with peripheral nerve injury demonstrated that it helps the animals regrow nerve and recover nerve and muscle function more quickly than conventional surgical stimulation. The technology could also be adapted for use in other tissues, including central nervous tissue or bone.



Stage of Research

The inventors developed a prototype resorbable nerve stimulation device and tested it in vivo with a rat model of sciatic nerve injury. They demonstrated that post-operative electrical stimulation delivered

over 6 days improved functional recovery compared with a single stimulation during surgery. The inventors are continuing to test devices for bone growth and spinal cord. In addition, they are developing a peripheral nerve stimulator that can provide electrical pulses for weeks before degrading.

Applications

- **Nerve repair and regeneration:**
  - peripheral nerve repair and sensorimotor recovery following injury
  - conceivably implanted at any nerve repair site, including brain and spinal cord
- **Bone growth** – stimulation to accelerate bone growth for extremity fracture healing and spinal fusion
- **Pain treatment** – transient nerve stimulation for analgesia
- **Electrical stimulation in other tissues** – the basic resorbable platform could be broadly applicable to a variety of other targeted tissues and organ systems

Key Advantages

- **Faster recovery:**
  - sustained electrical stimulation throughout healing process
  - in vivo rat studies of peripheral nerve injury showed accelerated nerve regeneration and increased muscle mass and twitch force
  - decreases inflammation and scar tissue
- **Reduced time in surgery -** post-operative stimulation eliminates need for traditional 1 hour stimulation during surgery
- **Transient, biocompatible and bioabsorbable device –** promotes analgesia or healing without placement of permanent device
  - reduces overall cost of treatment
  - no need for second surgery to extract a device or to maintain a permanent implant
  - engineered to dissolve in a few weeks before being completely absorbed into the body
  - materials can be tailored to control how long the device lasts before disintegrating
- **Programmable -** can modulate frequency and intensity of electrical stimulation at select time points during the healing process
- **Wireless power -** inductive coupling power transfer acts like cell phone charging mat, reducing the risk of infection because power supply is not implanted

Publications

- Koo, J., MacEwan, M. R., Kang, S. K., Won, S. M., Stephen, M., Gamble, P., ... & Birenbaum, N. (2018). Wireless bioresorbable electronic system enables sustained nonpharmacological neuroregenerative therapy. *Nature medicine*, 24(12), 1830.
- Implantable, biodegradable devices speed nerve regeneration in rats, *theSource*, Oct. 8, 2018.

Patents

- Resorbable implant for stimulating tissue, systems including such implant, and methods of using (US Patent No. 11,179,564)

Website

- Ray/MacEwan Laboratory of Neural Engineering