### WE BUILD TRANSLATION

# Advanced Platform Technology Center

A VA Research Center



## **PROJECT OVERVIEW** Restoring Natural Sensation to Lower Limb Amputees

No lower limb prosthesis offers a permanent and reliable method to restore natural sensation of the missing foot and joints for the 2.1 million people, including 1600 military members, living with limb loss in the US today. This sensory feedback could play an important role in reducing risk for trips and falls, improving ability to negotiate uneven terrain, and helping with gait symmetry and balance.

The purpose of this study is to determine the feasibility of providing natural sensation of foot-floor contact and loading to lower limb amputees. Small electrical currents delivered to the peripheral nerves remaining in the residual limb via implanted nerve cuff electrodes are interpreted by the brain as sensations originating from the missing limb.



The impact of electrically elicited sensation on standing balance, gait symmetry and stability, fall risk, ability to negotiate changing surfaces, confidence, and cognitive attention are being determined.

Initial results indicate that sensations of various modalities (e.g., touch, pressure, movement) can be elicited at discrete location referred to the missing toes, foot, and ankle. One volunteer who lost his limb during the Vietnam War experienced sensation in his missing foot with neural stimulation 48 years after amputation. Our goal is to develop the next generation of prosthetic devices that are integrated into the nervous system to provide the natural sensations required to improve standing and walking stability, and safely participate in unstructured community environments.

#### **APT Center Contributions:**

- Thin film, high-density peripheral nerve cuff
- Sensor system hardware and software
- Design controls and documentation within a quality system to facilitate future commercialization
- Regulatory affairs expertise for interactions with US FDA



#### **Project Funding History:**

US Department of Veterans Affairs, Merit Review A1334R, April 2014 – March 2018 National Institutes of Health, R01 EB001889, April 2014 – March 2018 Defense Advanced Research Projects Agency, N66001-15-C-4038, July 2015 – December 2019 Congressionally Directed Medical Research Programs, Defense Medical Research and Development, W81XWH-18-1-0321, August 2018 – August 2022

#### **Selected Publications:**

"High density peripheral nerve cuffs restore natural sensation to individuals with lower limb amputations," H. Charkhkar, C. Shell, P. Marasco, G. Pinault, D. Tyler, R. Triolo, *J Neural Eng* 15(5), p.056002, 2018.

"Visuotactile synchrony of stimulation-induced sensation and natural somatosensation," B. Christie, E. Graczyk, H. Charkhkar, D. Tyler, R. Triolo, J Neural Eng, 16(3), p.036025, 2019. "Probing peripheral neural pathways in electrically stimulation induced sensation," K. Cheng, H. Charkhkar, J. Yu, N. Makowski, R. Triolo. 9th International IEEE/EMBS Conference on Neural Engineering (NER), pp. 453-456, 2019.

"Visual inputs and postural expectations affect the location of somatosensory percepts elicited by electrical stimulation," B. Christie, H. Charkhkar, C.E. Shell, P.D. Marasco, D. Tyler, R. Triolo, Scientific Reports, Under review.

The **APT CENTER** is a Department of Veterans Affairs Rehabilitation R&D Center that creates novel, cross-cutting technologies for the diagnosis, treatment or study of high priority clinical conditions within a structured framework that facilitates regulatory compliance, dissemination within the rehabilitation community and commercialization by outside manufacturers. Center projects focus on the following: prosthetics and orthotics, health maintenance, neural interface and enabling technologies. The Center has over 30 investigators, engineering and clinical staff, and support services including regulatory affairs, quality systems, project management and grants administration.



Louis Stokes Cleveland Veterans Affairs Medical Center Main Telephone Number: 216.707.6421





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