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# Innovative Technologies in NeuroRehabilitation

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# Conflict of Interest

- None to disclose.
- Medical Director:
  - Brooks Rehabilitation Hospital
  - Brooks Center for Innovation

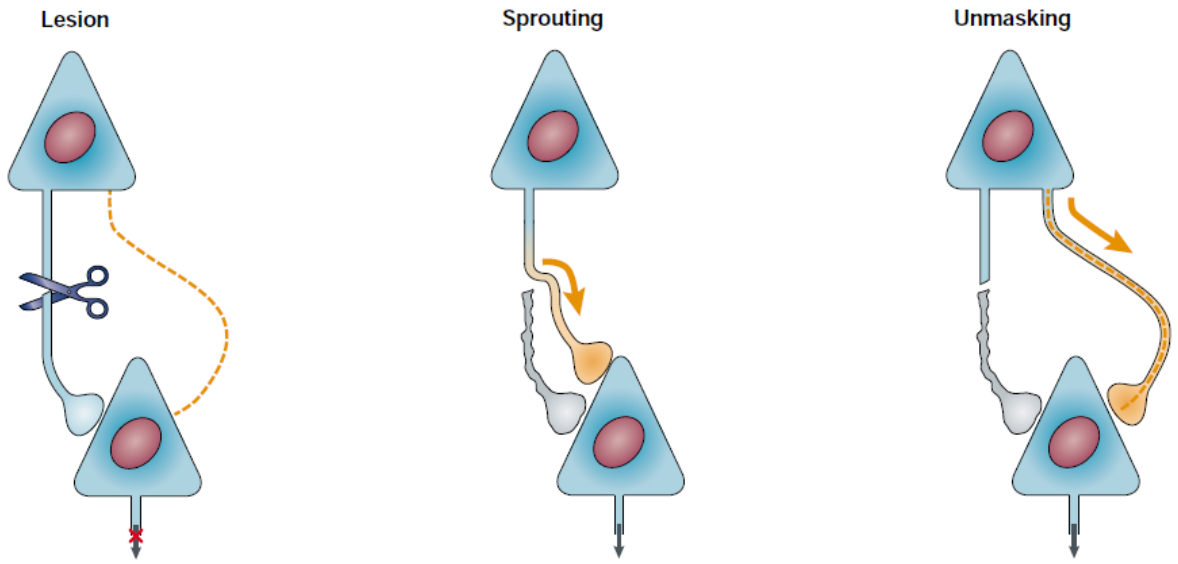
- Brief overview of current technologies in neurorehabilitation & evidence
- Touch on emerging technologies
- Potentials for telerehabilitation

# Neuroplasticity

"Neuroplasticity can be defined as the ability of the nervous system to respond to intrinsic or extrinsic stimuli by reorganizing its structure, function, and connections."

Cramer, S et al. Harnessing neuroplasticity for clinical applications. Brain 2011.

# Mechanisms of Recovery

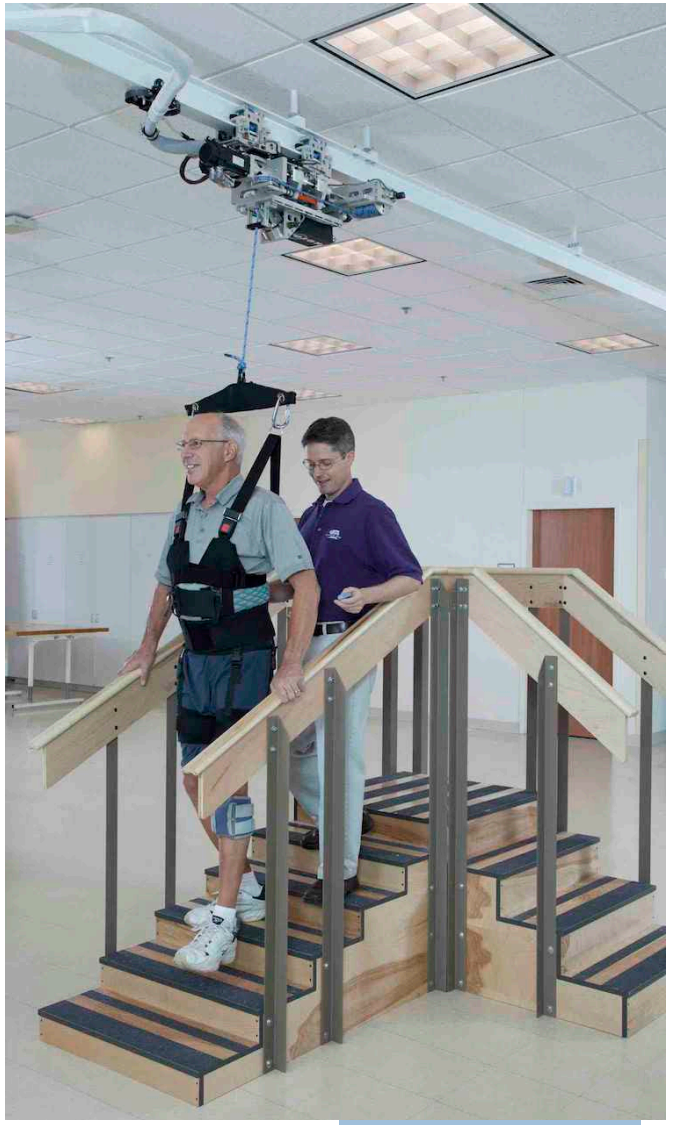


# Neuroplasticity

- Brain has ability to form and re-organize synaptic connections ***in response*** to learning & experience
- FES stimulates motor & sensory fibers → changes in cortex & motor networks, cortical reorganization
- FES induces antidromic firing of motor fibers → depolarization of anterior horn cells → pre- & post-synaptic coupling & enhanced synaptic modeling
- Visual feedback further enhance learning
- Rehabilitation leads to recovery!

# Neuroplasticity

- How do we harness this potential of neuroplasticity?
  - Manually
  - Robotics
  - Functional electrical stimulation (FES)



Rehabilitation

# Manual vs. robotics/FES

# Robotics/FES for lower extremity

- Indego exoskeleton
- Lightweight
- Modular design
- Wireless control
- Track individual progres

http://www.indego.com/indego/en/home

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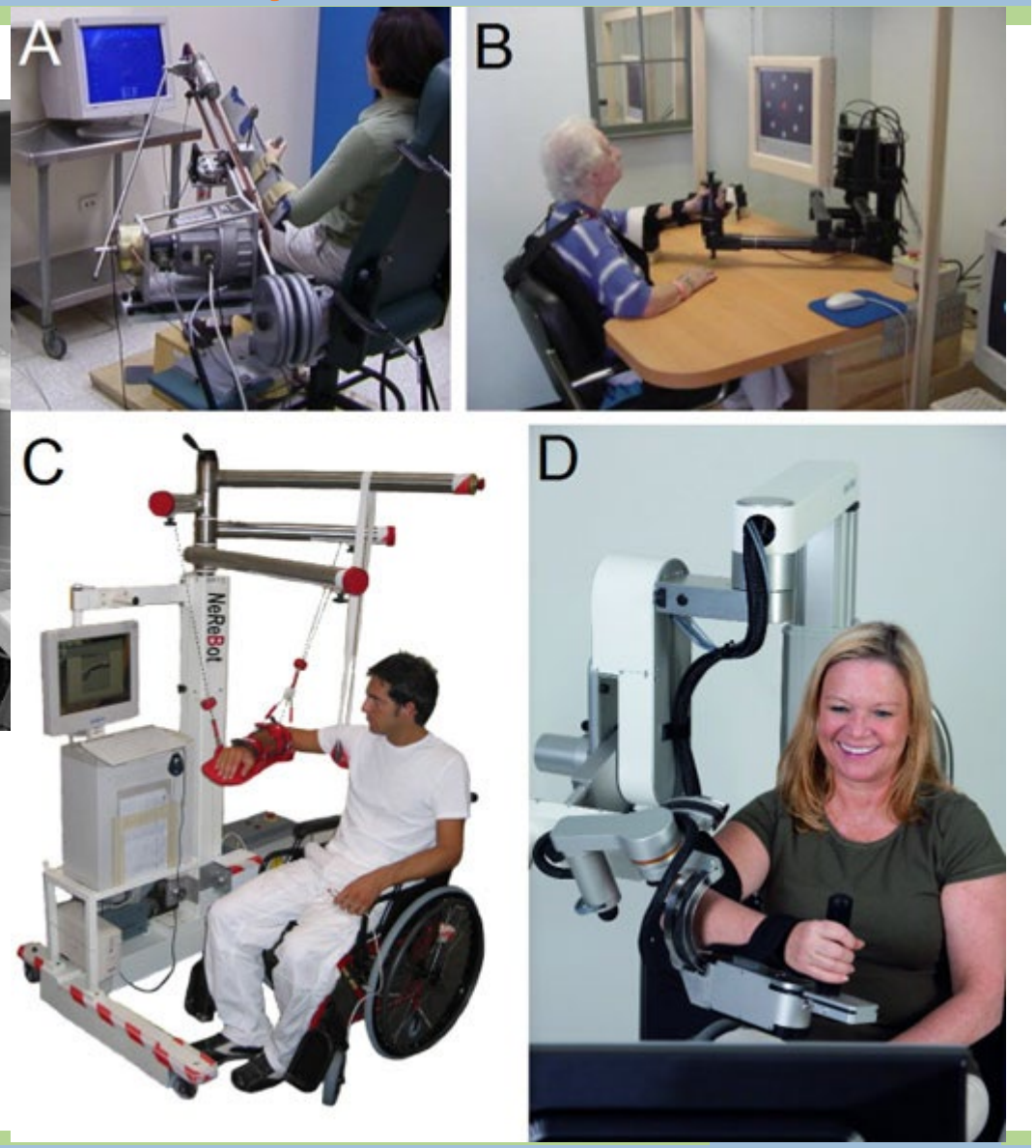
# Robotics/FES for upper extremity

Palo Alto MIME




A. ARM Guide  B. InMotion ARM
C. NeReBot  D. ArmeoPower
(Atrain Education)

# Robotics/FES for upper extremity

- ReoGo
- Fully motorized
- Easy to use
- Patient-specific exercises & progre
- Better motor & functional recover therapies

http://motorika.com/product-1/

# Robotics/FES for upper extremity

- Armeo Power
- Exoskeleton for the upper extremity
- Intensive early arm rehabilitation
- Assist movements
- Fun exercises

https://www.hocoma.com/us/solutions/armeo-power/

# Robotics/FES for upper extremity

- Diego
- Bilateral upper extremity
- Virtual reality
- Signals are amplified
- Improved participation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# Vivistim Paired VNS System

**The Implantable Pulse Generator (IPG, Model 1001) is placed underneath the chest wall.**


**The Lead electrodes are attached to the left vagus nerve in the neck and connected to the Implantable Pulse Generator (IPG)**

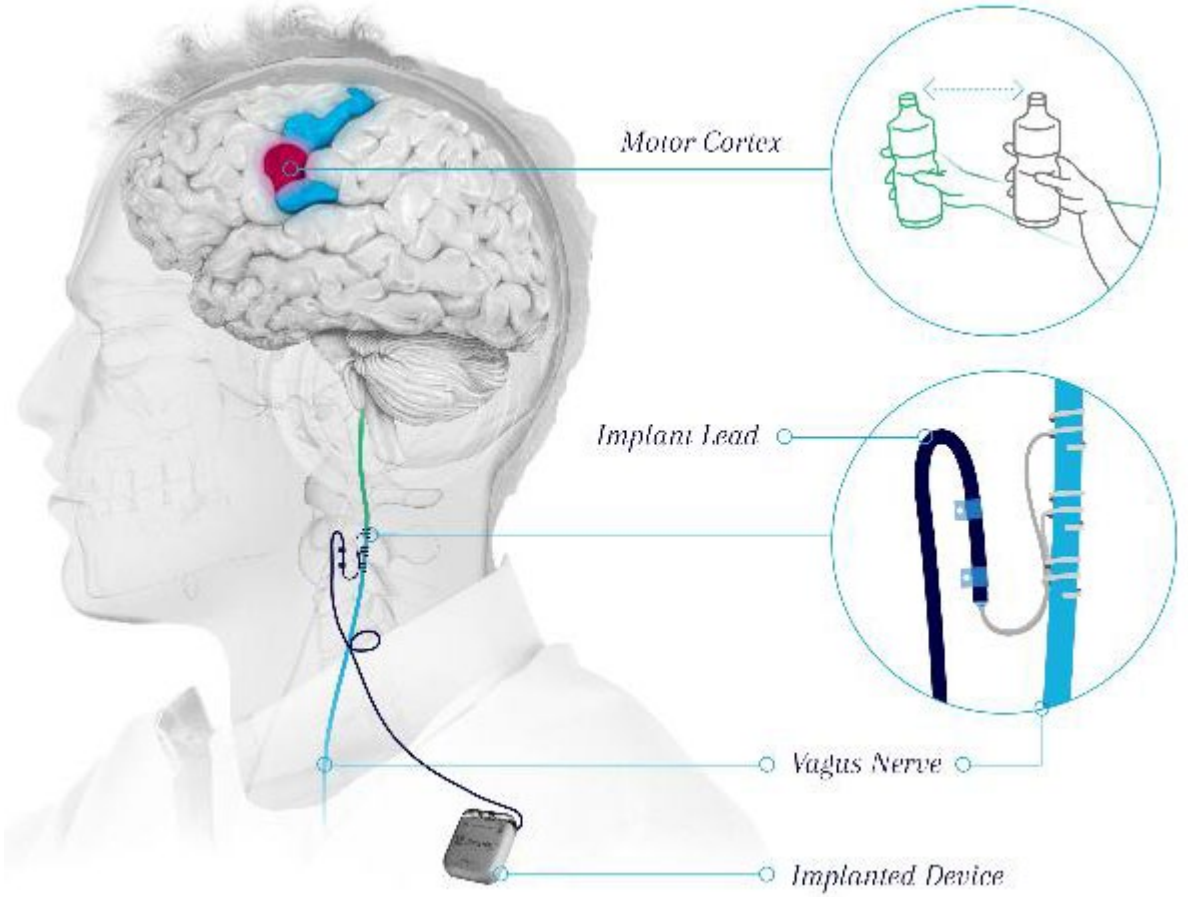


Image used with permission from MicroTransponder.

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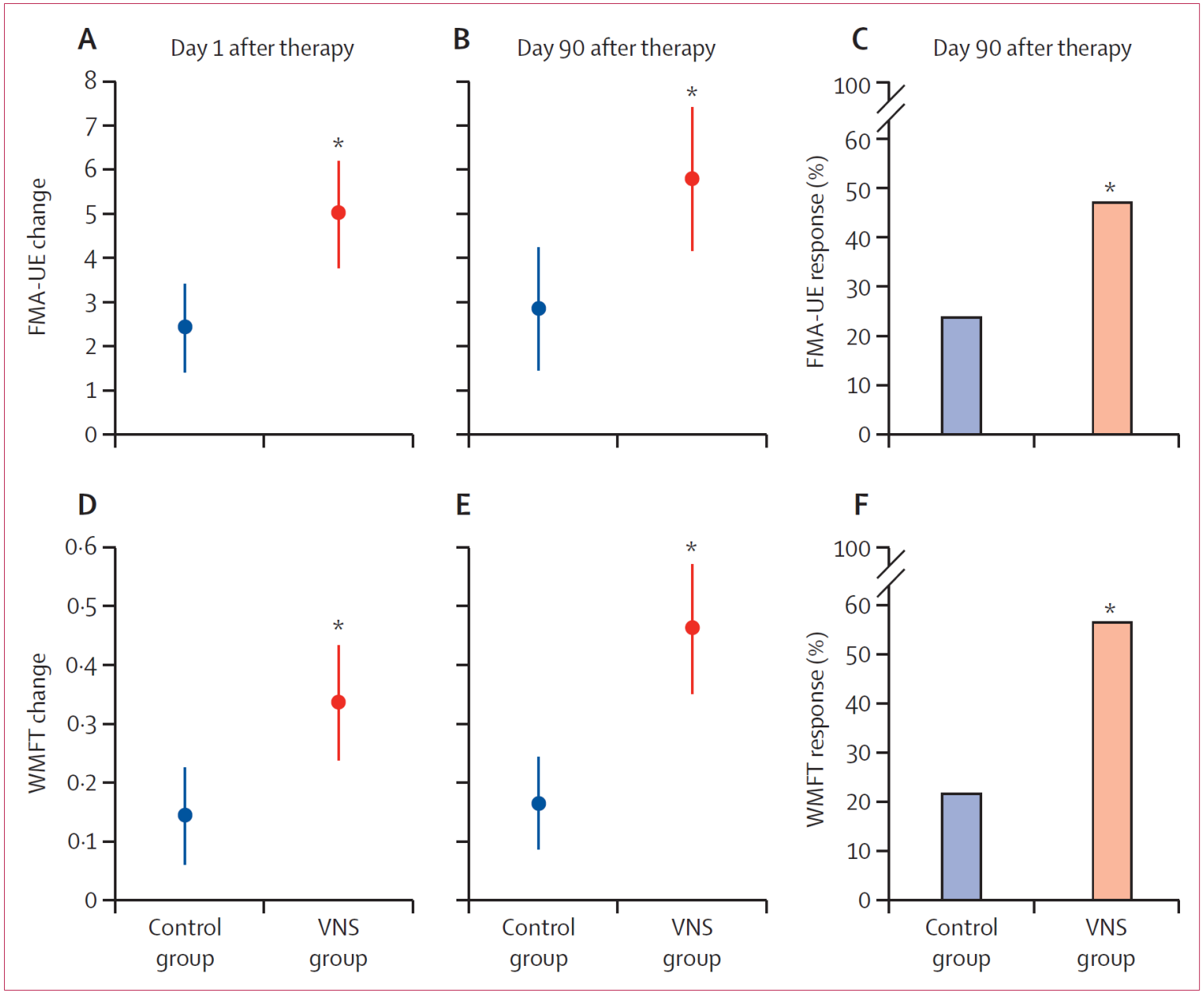
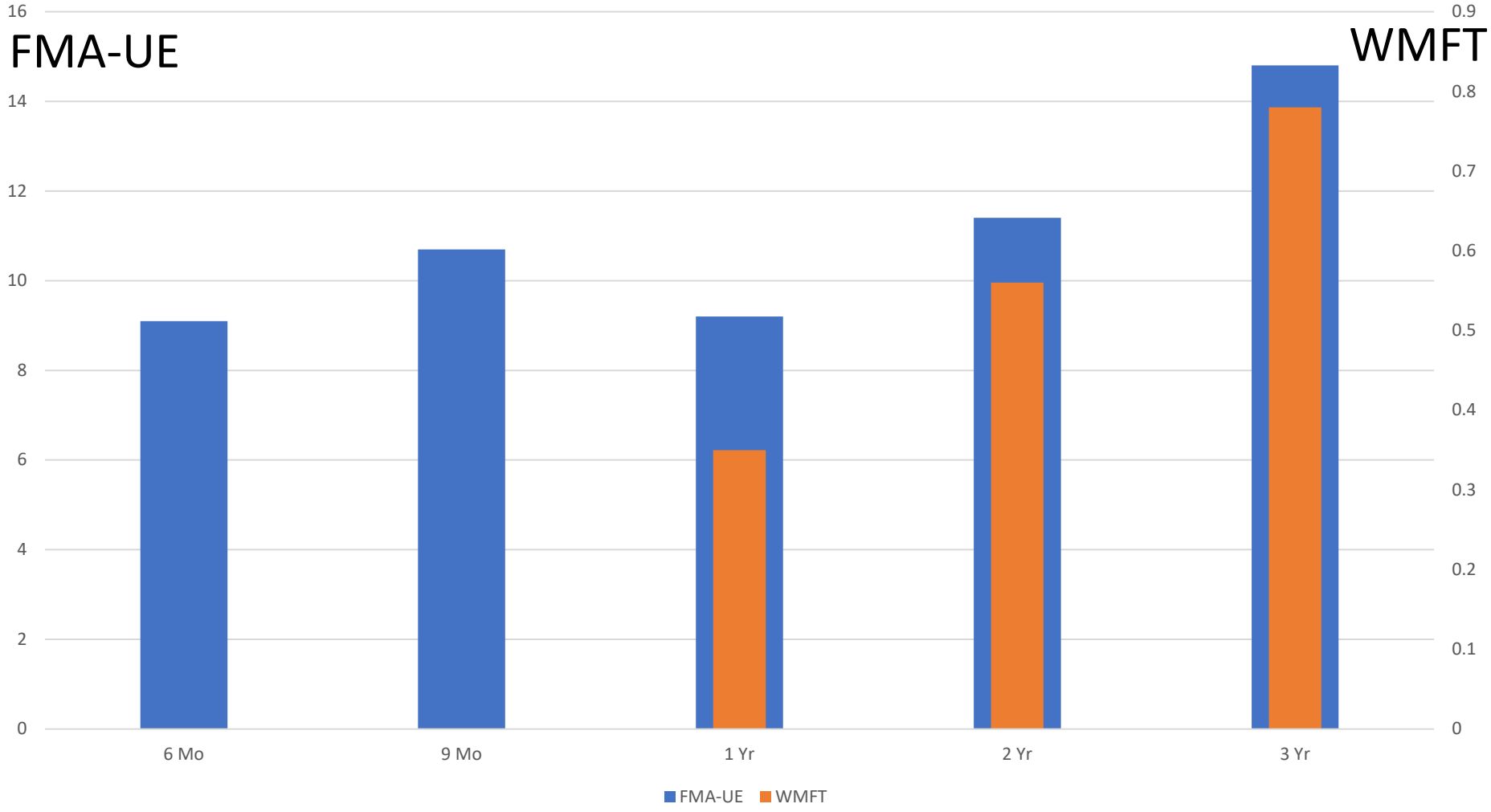
# Outcome Measures Summary




Dawson J *et al*, ***The Lancet,*** 2021

# Outcome Measures 2 – 3 Years Post

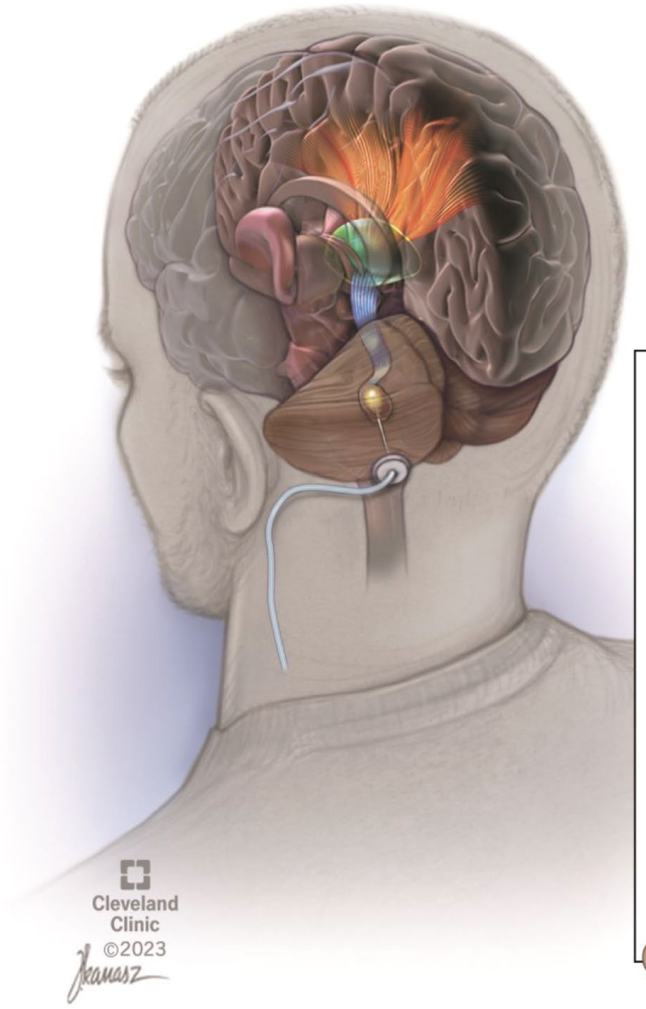


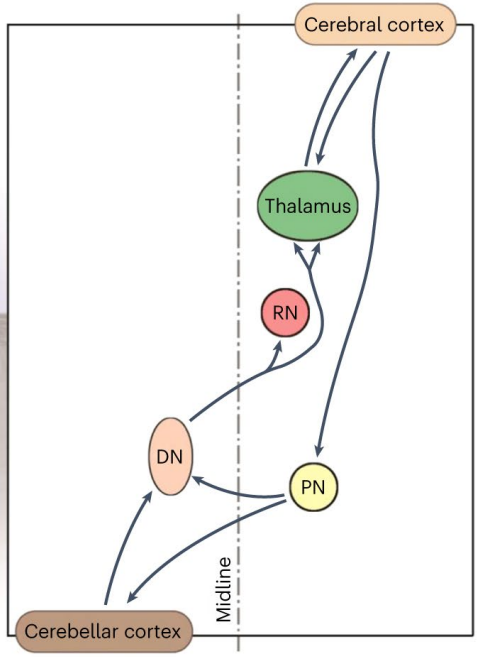
# Enspire Deep Brain Stimulation

- N = 12 pts
- Age: 57.4 ± 6.5 years
- Time after stroke: 2.2 ± 0.7 years
- FM-UE: 22.9 ± 6.2 points

- Implant, wait 1 month, 2x/week therapy x 2 months, then → DBS program continuous + 2x/week therapy + home therapy x 3 months

- Outcome: + 15 FM-UE gains!




Baker, K.B., Plow, E.B., Nagel, S. *et al.* Cerebellar deep brain stimulation for chronic post-stroke motor rehabilitation: a phase I trial. *Nat Med* **29**, 2366–2374 (2023). https://doi.org/10.1038/s41591-023-02507-0

# PoNS (Portable Neuromodulation Stimulator)

# Potentials for Telerehabilitation

- Treat patients in their own homes
- Virtual/augmented/mixed reality technologies
- Portable rehabilitation technologies that can be deployed in the home setting
- Outcome measures imbedded in these technologies
- Artificial intelligence: assess patients, prescribe therapies, learn and adapt to specific patient needs

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