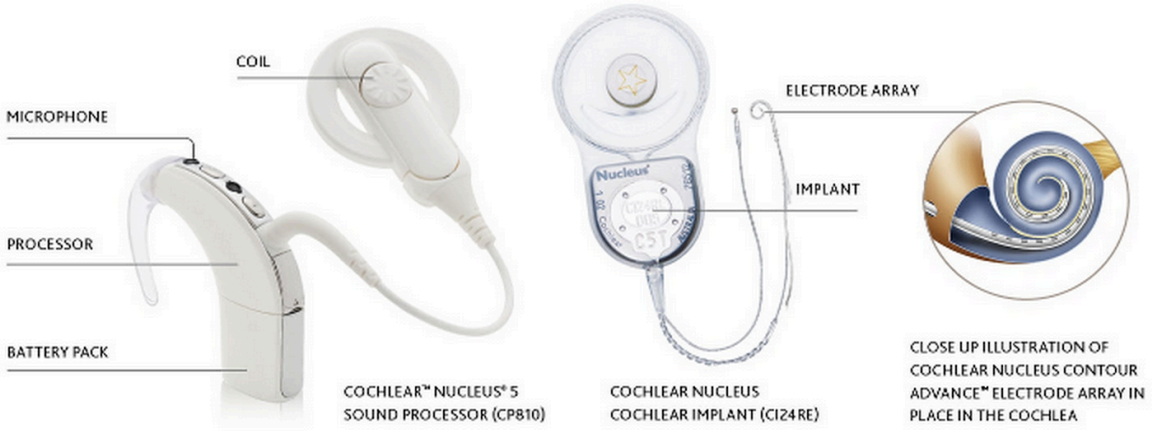
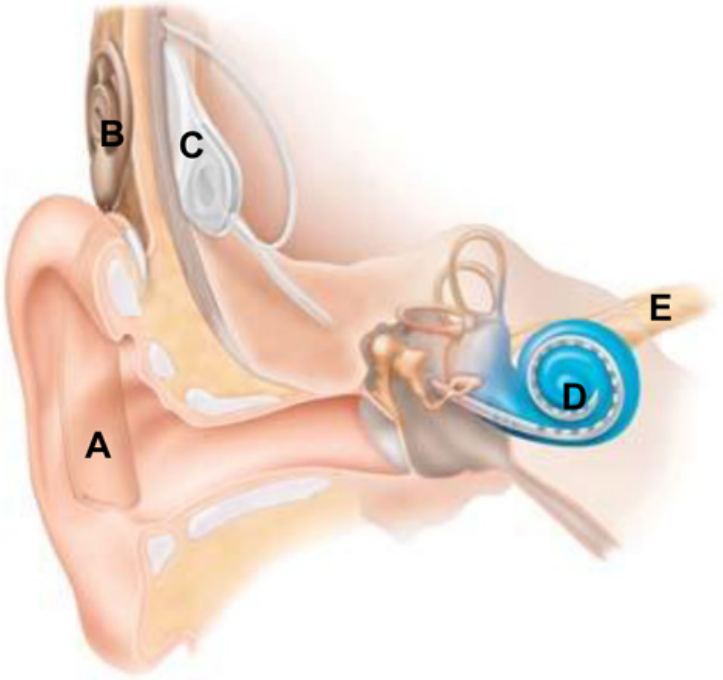
Force-Sensing Forceps for Cochlear Implant Surgery



Cochlear implants restore hearing in deaf patients.

- Cochlear implants are the earliest form of neuromodulation.
- A sound processor converts auditory signals into an electrical signal.
- An electrode directly stimulates the cochlear nerve.



Force-Sensing Forceps for Cochlear Implant Surgery

- **Background**
  - During cochlear implant surgery, surgeon inserts an electrode into the cochlea using forceps. Currently, the process is entirely dependent on surgeon dexterity and there exists no established method to monitor insertion progression or feedback to the surgeon.
  - Trauma rate (17.6%)
  - Important to preserve residual hearing to optimize audiological performance.
  - There exist multiple studies attempting to measure insertion force. Other automated insertion mechanisms have been conceived, but none of these are used in surgery or are handheld by the surgeon.

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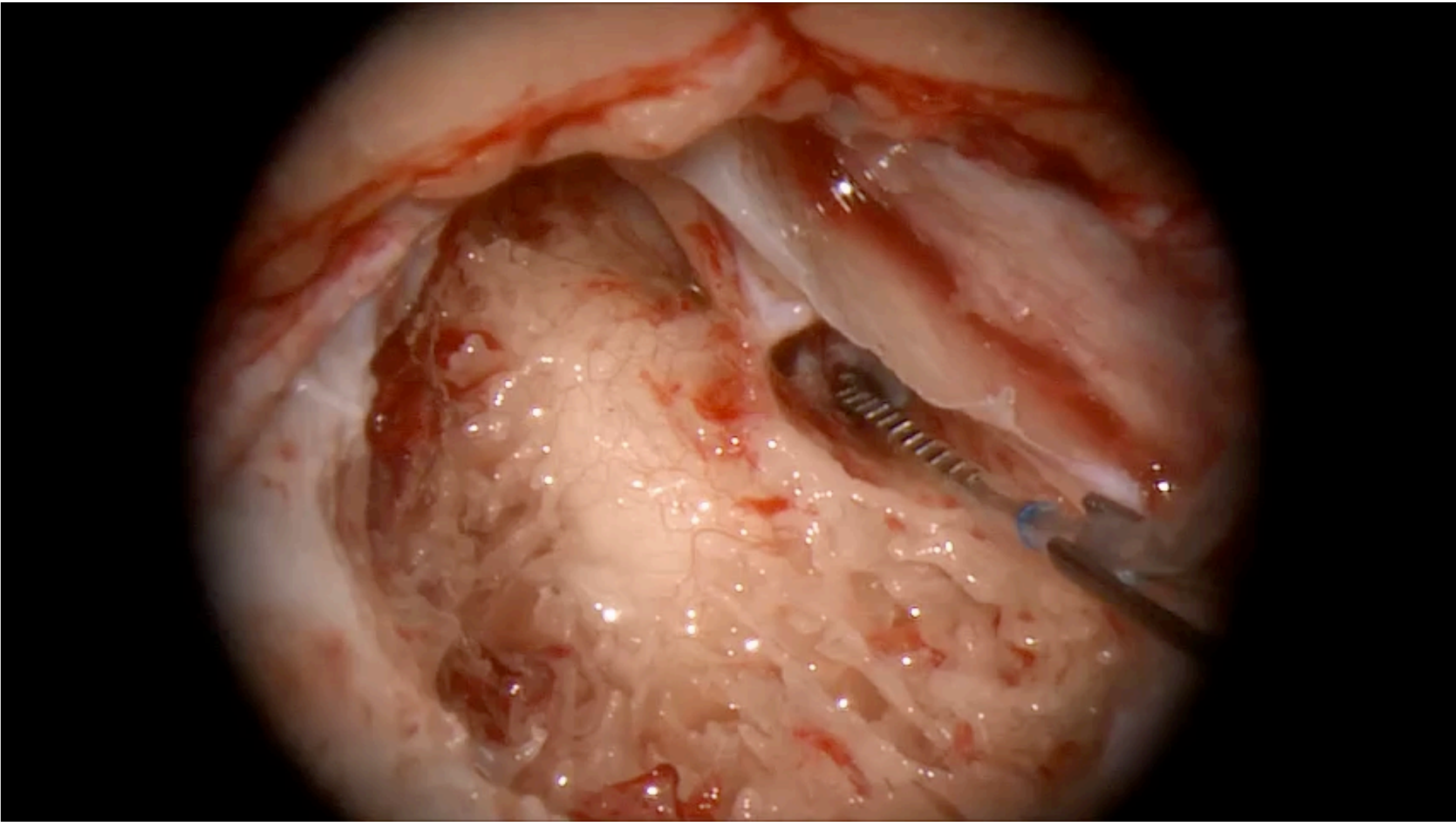

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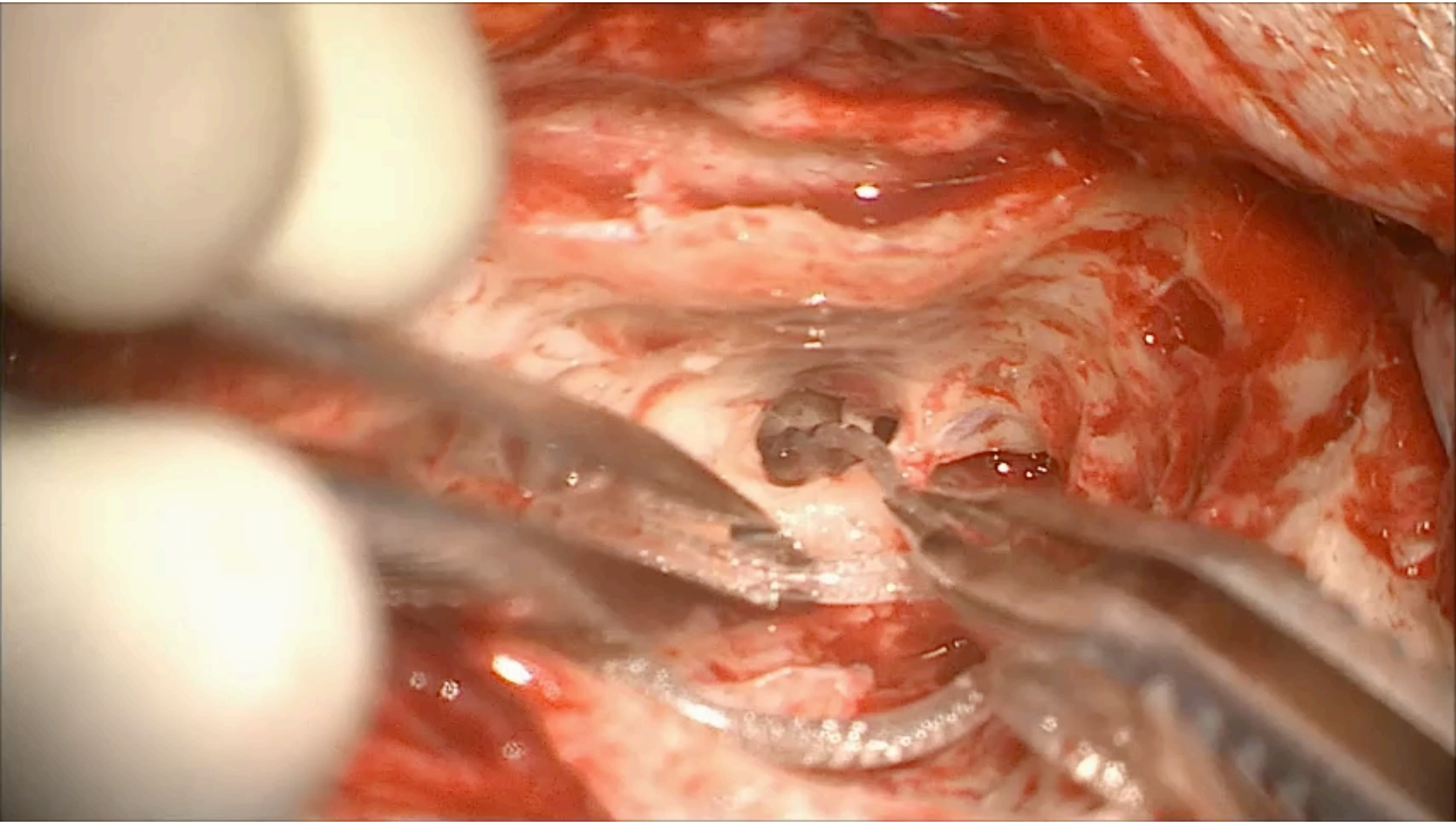

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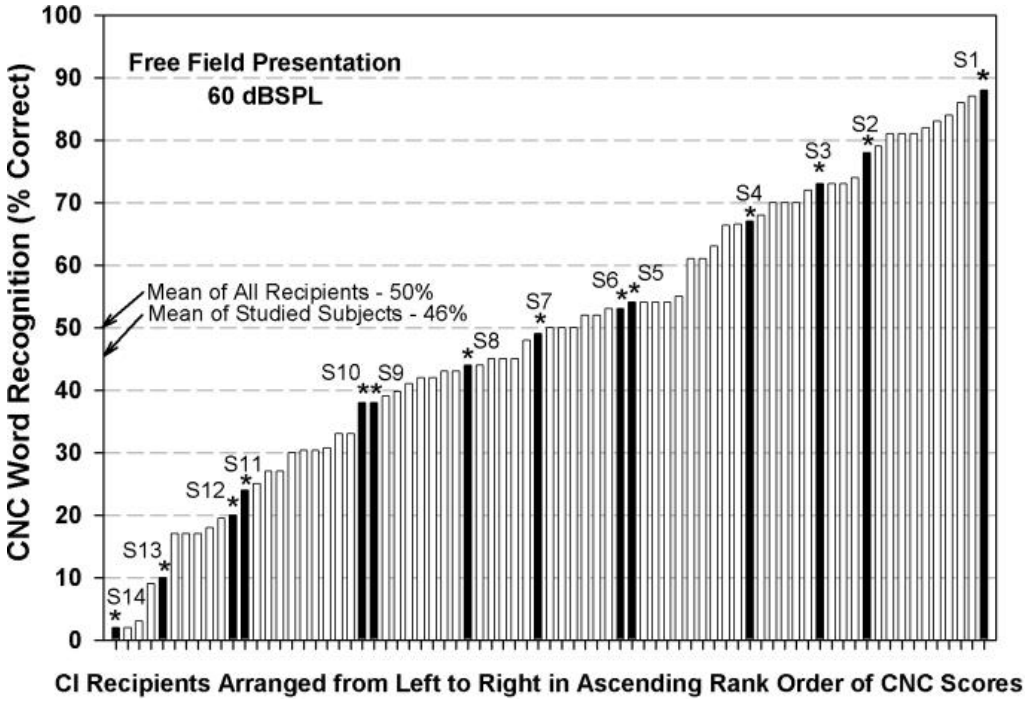
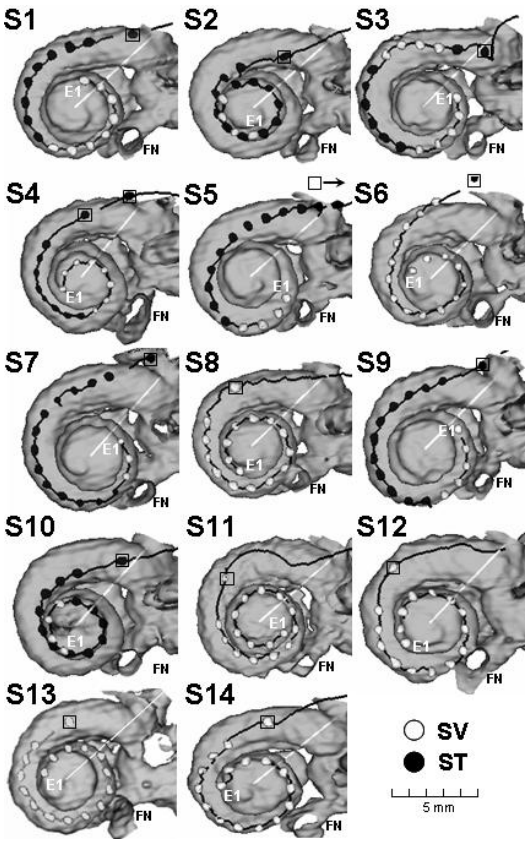
Electrode Position Matters





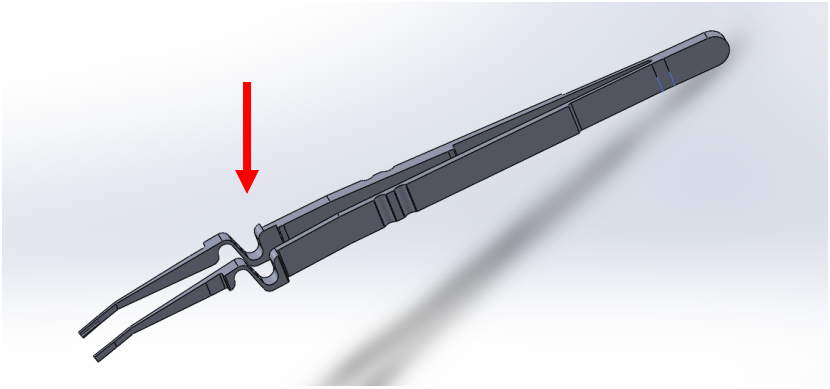
Electrode Force Matters

- Force of insertion is measured to be 20-40 mN in cadaveric models
- Force of trauma to the basilar membrane is ~120 mN
- This is beyond the resolution that a surgeon can detect

Force-Sensing Forceps for Cochlear Implant Surgery

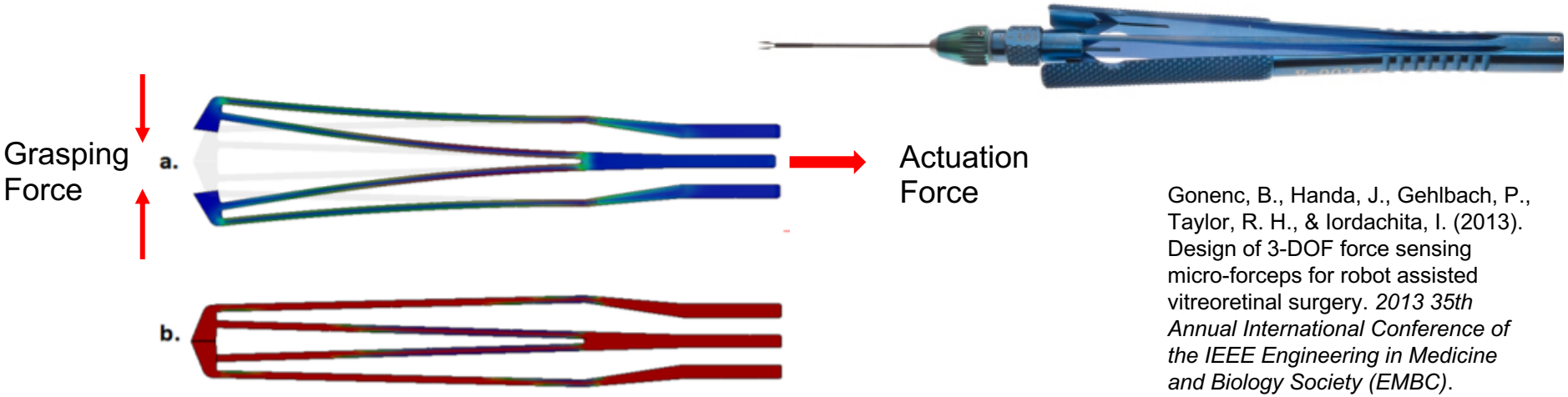
- **Goal:**
  - Design and build ergonomic forceps that can reliably measure electrode insertion force ~ 20mN
  - Minimize and isolate pinching force vs. insertion force
  - Study dependance on orientation

- **Current design: (2020)**
  - Visually very similar to commercial forceps
  - Mechanically weakened region
  - Strain gauge (1) installed



Force-Sensing Forceps for Cochlear Implant Surgery

- **New Design** based on vitreoretinal forceps



Gonenc, B., Handa, J., Gehlbach, P., Taylor, R. H., & Iordachita, I. (2013). Design of 3-DOF force sensing micro-forceps for robot assisted vitreoretinal surgery. *2013 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. doi:10.1109/embc.2013.6610841

- **What Students Will Do:**
  - Design a new force sensing forceps
    - Determine geometry
    - perform FEA
    - Identify force sensors installation location
  - Build prototype
    - Install force sensors (1~3 DOF) & accelerometer
  - Calibrate

Force-Sensing Forceps for Cochlear Implant Surgery

- **Deliverables:**
  - New design of force-sensing forceps
  - Finite Element Analysis (FEA) of the design
  - Build prototype
  - Calibration and test data
- **Size group:** 2

- **Skills:**
  - Mechanical Design (mostly deformation)
  - Solidworks CAD & FEA
  - Prototype build (Laser cut, EDM, 3D print, outsourcing)
  - Analytical skills
- **Mentors:**
  - Anna Goodridge: anna.goodridge@jhu.edu
  - Dr. Deepa Galaiya: gdeepa1@jhmi.edu
  - Prof. Iulian Iordachita: iordachita@jhu.edu