Optimizing Material Properties of Tape Spring Based Steerable Needles to Minimize Required Insertion Force

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Steerable Needles

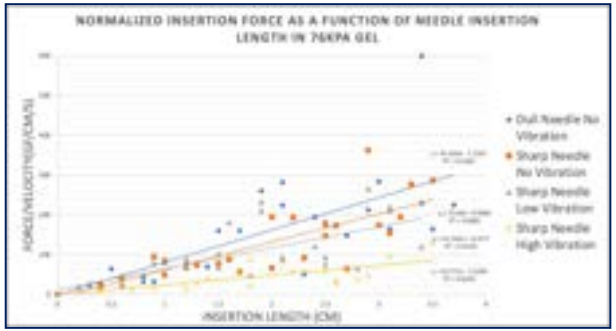
- **Conventional needles** are limited to straight trajectory
- **Steerable needles** can allow physicians to reach more inaccessible regions of the body:
  - ablations
  - targeted drug delivery
- **Tape spring** steerable needles designs:
  - smaller turn radius
  - easier, more accurate navigation within the body
- Necessary insertion force for the needle in the tissue must be minimized to prevent needle **buckling**.

Methodology

- Two tape spring needle prototypes were tested
  - 3mm wide, 8.5 cm shaft, dull tip
  - 3mm wide, 8.5 cm shaft, sharp tip
- 16000 RPM Motors were attached to the base of needles.
- 76 kPa gels were positioned vertically on top of a **force transducer** to measure insertion force with
  - no vibration
  - low vibration
  - high vibration
- Position and velocity extracted from video

Experimental Results

- **Dull needle with no vibration** had the largest required insertion force
- **Sharp needle with high vibration** had the lowest required insertion force
- **Sharp needle with no vibration** and **sharp needle with low vibration** had similar insertion forces within this range



Discussion

Buckling is the primary modality of failure of tape spring steerable needles. Thus minimizing the insertion force necessary for the needle to cut through tissue is advantageous as it will:

- reduce likelihood of **buckling**
- **minimize damage** to surrounding tissue
- allow the steerable needle to cut through more tough, **fibrous tissue**.
- Since velocity and force are correlated, this data indicates that can enable the device to be used at **higher velocities** as well.

Future Work: Characterize effect of vibration on insertion force in porcine liver and muscle tissue.

- **Fibrous regions** in tissue require large cutting forces
- Magnitude of reduced cutting force could be greater in cutting force dominated medium such as liver or muscle