Needle-Membrane Puncture Mechanics

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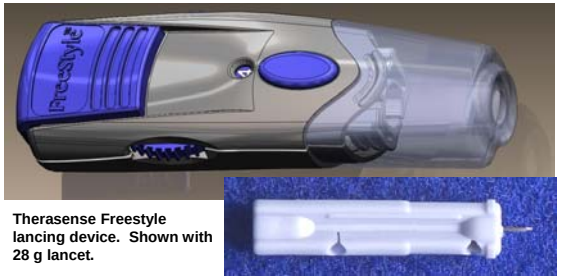
Introduction

- Needle-tissue puncture events are important in both diabetes lancing and needle steering
- Immediate objective: Measure forces and torques on the needle during puncture to inform future modeling efforts.
- Long-term goal: optimize needle tip geometry for desired result (e.g. steering or blood retrieval).

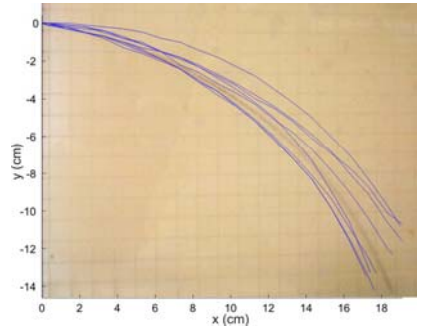
Lancet Application



Therasense Freestyle lancing device. Shown with 28 g lancet.

Goal: Minimize pain while maximizing blood volume extracted

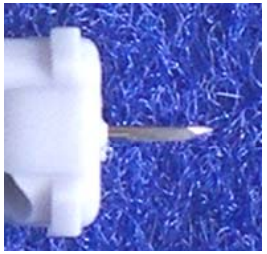
Steerable Needle Application

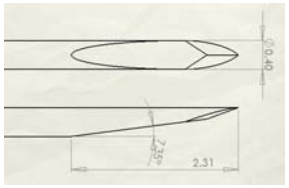


Trajectories of eight insertions overlaid on example experimental photo. Needle tip appears to deflect initially, then follow constant curvature.

Goals: Minimize deflection at membranes, increase maximum curvature

Tip Geometries

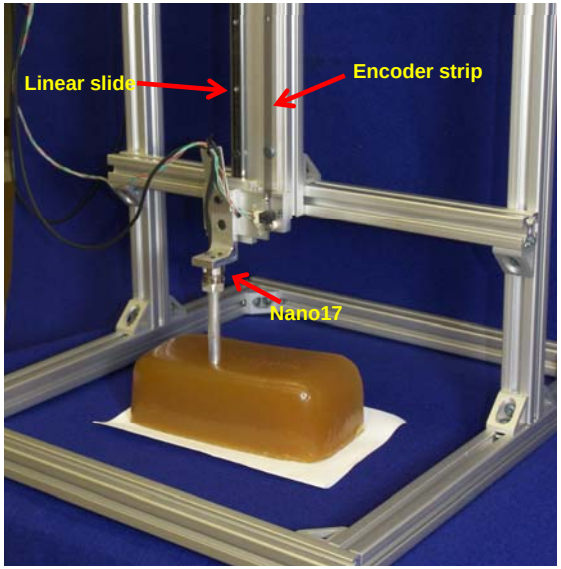




(Above, Left) Lancet tip geometry

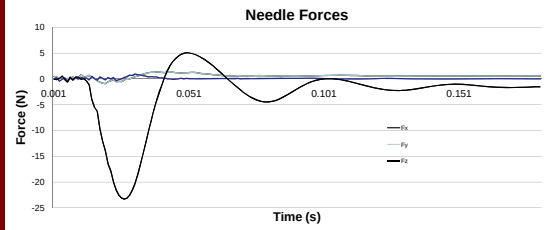
(Below) Ground ¼" solid and hollow needles used for initial experiments

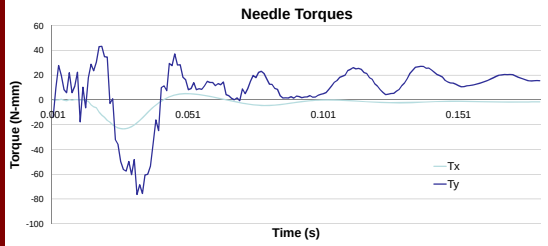
Experimental Apparatus



- Vertical, encoded linear slide, Nano17 force/torque sensor holds needle
- Needle carriage can be released from proper height to achieve desired entry velocity

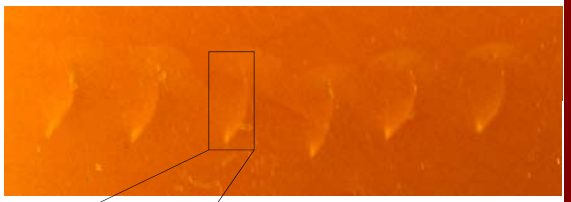
Preliminary Experimental Data

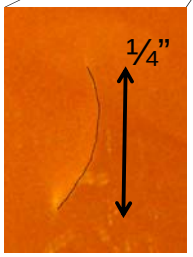




- Needle released from 200 mm to simulate lancing, wrench recorded at needle base
- Can reduce velocity for quasistatic cutting
- Damped, second order response evident for SimTest media.

Tissue Incisions





Needle punctures in SimTest phantom tissue.

(Top, Left) Incisions made by ¼" OD solid needle ground with single-faceted bevel

(Right) Incisions made by ¼" OD hollow needle ground with single-faceted bevel

Note: Cuts in all images made with needle points entering at the right

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