4. RESULTS

Water-jet technology has been used extensively for decades industrially for many applications including mining, plastic, metal, stone, wood, and produce cutting. The use of water-jet in medical applications has been developed more recently and it is used for different applications such as soft tissue resection, bone cutting, wound debridement, and surgery [1]. Decreasing the insertion force is important in medical applications since high insertion forces can complicate reaching the intended target with needle bending and tissue deflection [2]. It can also reduce the pain felt by the patient during procedure [3]. Therefore, researchers have actively researched ways to reduce the insertion forces. Methods proposed in the literature to reduce the insertion forces include changing needle insertion speeds and/or vibration. To the best of our knowledge, this is the first time that water-jet is incorporated into traditional needles and insertion forces are measured.

2. HYPOTHESES

Water-jet can reduce the insertion forces by eliminating the tip forces and only friction force will remain. The tip force in the water-jet needle is even smaller than frictional force due to lubrication provided by water. Depth of cut is a linear function of fluid velocity for different tissue stiffnesses.

3. MATERIALS AND METHODS

Custom-designed needle for needle insertions

Custom-designed suction system. It includes a 3D printed part near the base of the needle that collects the water spreaded back while running water-jet experiments. The collected water is then sucked by a suction canister attached to a vacuum pump.

The output of the developed software in Matlab to measure the depth of cut. The software first load the image and zooms in the area of interest. Then it asks to select a real-world measurement and enter the real value of it (10 mm in the example) for calibration. Then the user will select the area of interest to measure, and the software associates the pixel distance to a real-world measurement.

Depth of cut as a function of fluid velocity for 15% (blue circles and line) and 20% (red squares and line) SEBS tissues. 5 experiments are conducted for each flow rate and the average of them are reported in this figure. The bars on the graph show one standard deviation above and below the mean. Circles and squares show the experimental data, and the dotted lines show the lines fitted to experimental data.

5. CONCLUSIONS

Water-jet needles resulted in a reduction in insertion force of over 50%.

Lubrication provided by water-jet further reduced the insertion force by reducing friction.

ACKNOWLEDGEMENT

We would like to thank Sean Journot, Alex Rodrigues, and Jamie Midkiff for their help in preparing experimental setup and developing the control software.

REFERENCES


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