Tissue penetration via helical microrobots *in Vitro*

Penetration of tissues using helical robots is influenced by several parameters. Some parameters are related to the setup used to control the helical robots such as the strength of the magnetic field, magnetic field gradient, and rotation frequency of the rotating dipole fields. Another parameter that affects the penetration process is related to the type of tissue since certain tissue are harder than others. Here we will focus on penetration of several types of tissues including heart, liver and brain tissue and assessing the ability of helical microrobots to penetrate the different types of tissues.

Objective

Helical microrobots have proved their efficiency in drilling/grinding blood clots (Fig.1). Magnetic field strength, magnetic field gradient, actuation frequency, and the geometry of the helical microrobots influence the grinding time [1]. It is essential to investigate the ability to penetrate tissues since that could prove beneficial in performing simple operations.

Tasks

- Control of helical microrobot [2] and drilling of several types of tissues;
- Investigating the influence of the type of tissue on the penetration rate;
- Investigating the influence of several parameters related to the magnetic field on the penetration rate

Materials

- HeliMag is available in MNRLab;
- The tissues have to be prepared and microrobots have to be fabricated;
- Phosphate buffered saline and catheter segments [3].

PREREQUISITES

Students are expected to have a working knowledge of control theory, differential equations, linear systems, statics, kinematic and dynamics, dynamics at low Reynolds numbers. Familiarity with programming, especially with Matlab, LabVIEW, and C++.

OTHER NOTES

This project will involve a weekly meeting with the instructors and progress reports have to be prepared. All reports should be written in academic paper format.

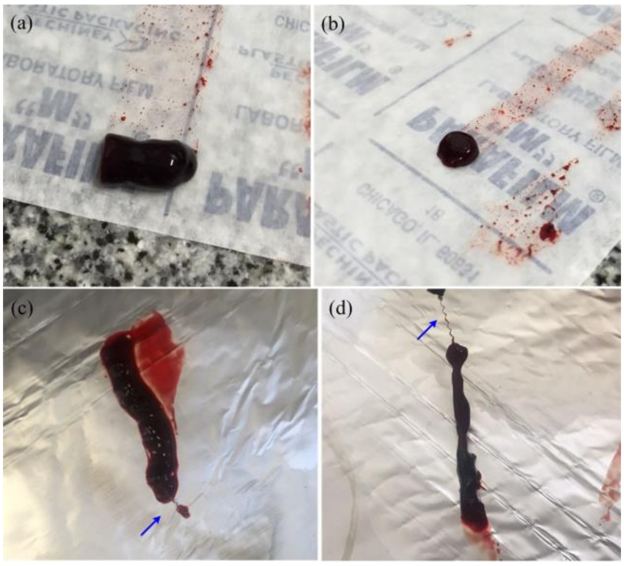

Figure 1. Pre- and Post-conditions of the blood clots following 20 minutes of drilling using a helical microrobot (blue arrow). (a) The mother clot with a long columnar shape is prepared to provide daughter clots. (b) Daughter clot is cut with length of 3 mm. (c) and (d) Dissolved blood clots after drilling using the microrobot for approximately 20 minutes.

1. References

[1] I. S. M. Khalil, A. F. Tabak, K. Sadek, D. Mahdy, N. Hamdi, and M. Sitti, "Rubbing against blood clots using helical robots: modeling and in vitro experimental validation," *IEEE Robotics & Automation Letters*, vol. 2, no. 2, pp. 927-934, April 2017.

[2] A. Hosney, A. Klingner, S. Misra, and I. S. M. Khalil, "Propulsion and steering of helical magnetic microrobots using two synchronized rotating dipole fields in three-dimensional space," in *Proceedings of the IEEE/RSJ International Conference of Robotics and Systems (IROS)*, Hamburg, Germany, pp. 1988-1993, November 2015.

[3] A. Hosney, J. Abdalla, I. S. Amin, N. Hamdi, and I. S. M. Khalil, "*In vitro* validation of clearing clogged vessels using microrobots," in *Proceedings of the IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob)*, pp. 272-277, Singapore, June 2016.