Transactions on Additive Manufacturing Meets Medicine
Trans. AMMM, 2023, Vol. 5, No 1, Suppl. 1, Article ID 836, 1 Page

Infinite Science Publishing

Abstract

3D-printed anatomical models for robotic surgery training exercises

A. C. Dell[1*], F. Malekzada[2], J. Hagenah[1], G. Männel[1], Th. Friedrich[1], M. Thomaschewski[2], T. M. Buzug[1], T. Keck[1,2]

[1] *Fraunhofer Research Institution for Individualized and Cell-Based Medical Engineering IMTE, Lübeck, Germany*
[2] *University Hospital Schleswig-Holstein (UKSH), Department of Surgery, Lübeck, Germany*
[*] *Corresponding author, email: annika.dell@imte.fraunhofer.de*

In recent years, robot-assisted surgery (RAS) has become an established method of performing surgery due to benefits including three-dimensional visualization, improved user ergonomics and heightened precision and control. However, there is a great degree of variation in training methods to educate operators. RAS operator training is most commonly done using virtual and augmented reality simulation, animal or cadaver models, or synthetic organ models [1]. Augmented and virtual reality training is a necessary part of training operators, yet it doesn't adequately simulate realistic haptics and instrument function. Animal or cadavers have commonly been used to develop user competency in RAS systems, but the acceptability of these models is limited by access, financial, and ethical issues. Thus, in recent years, synthetic organ models have been proposed to gather skills for highly specific operations on that organ [2]. However, these models aim at reproducing one organ's anatomy as closely as possible, while this might not be necessary for training general skills in RAS. In lieu of focusing on a single complex pathology, we aim to develop more general models to train users in a realistic environment, performing tasks that are common in internal medicine. Additionally, printable materials were used that behave similarly to human tissue. We have developed two types of models for training RAS operators using additive manufacturing. The first model type aims to emulate anatomy and haptics. In this model type, two segments of the small intestine have been printed on the Keyence Agilista 3200 using a soft silicone printing material, AR-G1L, which has a Shore hardness of 35A (Keyence Corporation, Osaka, Japan). This model allows for training suturing intestinal anastomoses, including end-to-end, side-to-end, and side-to-side anastomoses. Thus, a simple model can be used to practice different suturing techniques. The second model type focuses less on anatomical structures, but rather on emulating a soft, generalized tissue-like environment with different types of tissue structures and layers. This allows for practicing the tugging and pushing motions with the robotic arms that must be carefully performed during surgery, without damaging the tissue. Several layers of "tissue" must be gently removed to access lower levels of the multi-layer, cuboid model, to access spheroid "cysts", which must be resected without damage. The second model type has also been printed with the Agilista 3200, among other materials. With these two 3D-printed model types, we have developed uncomplicated yet novel tissue-like models that allow for the development of new curricula for training robot-assisted surgery operators.

Author's Statement

Conflict of interest: Authors state no conflict of interest.

Funding: This project has been partially funded by the European Union–European Regional Development Fund (ERDF), the Federal Government and Land Schleswig Holstein, Project No. 12420002 (IMTE1) and Project No. 12422005 (Lübeck Innovation Hub for Robotic Surgery (LIROS))

References

[1] D. M. Costello, I. Huntington, G. Burke, B. Farrugia, A. J. O'Connor, A. J. Costello, B. C. Thomas, P. Dundee, A. Ghazi, N. Corcoran. *A review of simulation training and new 3D computer-generated synthetic organs for robotic surgery education,* in J Robot Surg., Volume 16, Issue 4, pp. 749-763. doi: 10.1007/s11701-021-01302-8. Epub 2021 Sep 3, 2022.

[2] H. H. Bendre, A. Rajender, P.V. Barbosa. et al. *Robotic dismembered pyeloplasty surgical simulation using a 3D-printed silicone-based model: development, face validation and crowdsourced learning outcomes assessment.* In: J Robotic Surg, Issue 14, pp. 897–902, 2020. https://doi.org/10.1007/s11701-020-01072-9

DOI: 10.18416/AMMM.2023.2309836