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Abstract Title: Evaluation of Ergonomics and Learnability in a Novel Soft Robotic Tool for Endoscopic Surgery

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Background:

The EU-FP7 project STIFF-FLOP (STIFFness controllable Flexible and Learn-able manipulator for surgical OPERations) aimed at creating a new soft robotic manipulator for minimally invasive surgery. STIFF-FLOP proposes a manipulator that will help overcome the limitations arising from the current rigid surgical tools. This study aims at objectively assessing the new tool in terms of ergonomics and learnability in comparison with conventional laparoscopic tools.

Methods:

A simulated surgical environment consisting of a 2:1 scaled phantom of the pelvis and inferior abdominal cavity, with trocar ports for the laparoscopic tool and the endoscopic was prepared. The soft robotic manipulator consisted of 2 segments, controlled through 2 corresponding joysticks. Surface Electromyography (sEMG) sensors were placed on the participants' forearm for the continuous monitoring of their muscle activity while they performed targeted motion tasks inside the phantom. Each participant performed two trials for the STIFF-FLOP manipulator to assess for learnability through time measurements and ergonomics through sEMG recordings and one trial with the laparoscopic tool as control. Following these simulated tasks, the participants were also asked to fill out a questionnaire to also obtain a subjective assessment of the new tool. N=25 Participants were tested with varying expertise levels. The sEMG signals were analysed to obtain an assessment of force and fatigue involved with the tasks.

Results:

From the 1st to the 2nd STIFF-FLOP trial ('SF1' and 'SF2'), average elapsed time dropped by 32%, reaching the level of the familiar laparoscopic tool, showing a high learnability for STIFF-FLOP. Participants had in average 26% lower muscle activity when using the STIFF-FLOP compared to the laparoscopic tool, showing ergonomical improvements in using the robotic system. Questionnaire results show that more than 80% of the participants experienced no mental or physical exhaustion in using the robot.

Conclusion:

The novel soft robotic manipulator showed higher learnability and ergonomics compared to standard laparoscopic tools. One of the aims of surgical robotics is to improve the working conditions for surgeons. This will help surgeons by reducing risks of psychological and physiological stress which will reduce procedural errors and improve overall performance in the long run.

Topic: Robotics, Telesurgery and Virtual Reality

Presentation: Oral Presentation