ELIMINATING THE FULCRUM POINT WITH A TRANSFORMATIVE SINGLE-PORT ROBOTIC SURGERY PLATFORM

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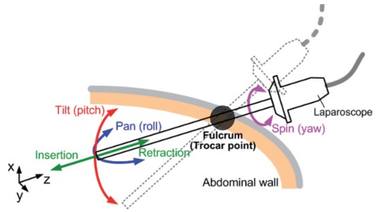
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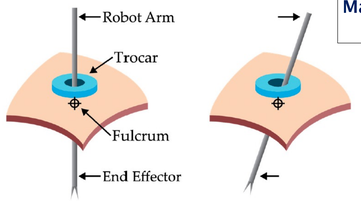
Purpose:

The fulcrum point of multi-port robotic minimally invasive surgery has been the topic of much research and debate, presenting an obstacle to overcome during training and requiring careful consideration in the design of soft tissue robots[1]. In multi-port robotics, each robotic arm pivots around a fulcrum at the entry point to the abdomen such that movements of the end effector are inverted and automatically translated by the robot to mimic the movement of the surgeon[2].

While multi-port robotics attempt to minimize trocar movement at the fulcrum, unnecessary torque may still be applied by the robotic arm to the abdominal wall tissues, **causing potential issues maintaining pneumoperitoneum, possible increased post-operative pain at the entry site, as well as raising concern for higher herniation rates during abdominal surgery.**







Fulcrum Effect in Multi-Port Robotics Today

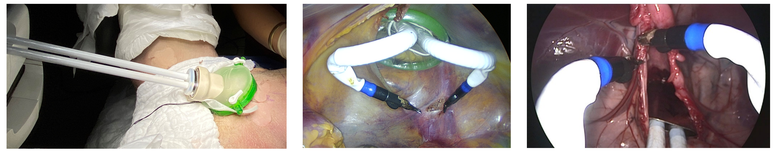
Materials and Methods:

A novel single port, transformative robotics platform eliminates the fulcrum effect as the **2 articulating instrument arms and end effectors encompass joints that move entirely within the abdominal cavity limiting the potential of unnecessary forces** at the access port.

- System features miniature humanoid-shaped robotic arms that provide human level dexterity, multi-planar flexibility and 360 degrees of articulation for various access configurations.
- The biomimetic instruments are designed to replicate the motions and capabilities of a surgeon's arms, with shoulder and elbow joints, in addition to an unlimited 360-degree wrist joint rotation.
- After introduction into the workspace while extended, the two robotic arms then retroflex or anteflex towards the anatomy of interest.
- This study simulated the entry of this two-arm robotic system at 3 different access points: **transvaginal, umbilical and Pfannenstiel.**

The simulation then kept the angle of entry of the arms relative to the abdominal access point constant while measuring the reach throughout its entire workspace in the abdomen by generating a set of 200,000 different configurations of the robotic arms. **Maintaining a constant angle of entry simulates the elimination of the fulcrum effect.**





Eliminating the Fulcrum Effect with Anovo Surgical System

Results:

The results show that, due to the shoulder, elbow and wrist joints of the arms that perform all their articulation after entry, the reachable workspace encompasses the entirety of the average male and female abdomen from the para-aortic nodes to the pelvic floor, across from abdominal sidewall to sidewall and from the abdominal wall to vertebrae, thus allowing multi-quadrant surgery, **enabling a feasible and effective surgical approach without any fulcrum effect on the abdominal wall access ports.** Because the wrist joints have unlimited rotation and the shoulder and elbow joints allow the arms to function as they cross over each either, the manipulability index also remains high (high usability) within the abdominal cavity and particularly around anatomy of interest.

Conclusion:

The design of this new robotic technology has the **potential to provide a broad applicability to surgical treatment by expanding single port surgery or natural orifice translumenal endoscopic surgery approaches thus reducing collateral tissue damage, scarring and the effect a mechanical fulcrum at each point of entry has on abdominal tissue[3].**



Currently FDA authorized for benign hysterectomy, with salpingo-oophorectomy, with salpingectomy, salpingectomy, oophorectomy, adnexectomy, ovarian cyst removal.

EPD is a consultant of Momentis
CL and HY are consultants of Momentis
MC and MM are employees and shareholders of Momentis

[1] Gruijthuijsen C., Vander Poorten E. Leveraging the Fulcrum Point in Robotic Minimally Invasive Surgery. IEEE Robotics and Automation Letters, Vol. 3, No. 3, July 2018.
[2] Longmore SK., Naik G., Gargiulo GD. Laparoscopic Robotic Surgery: Current and Perspective Future Directions. Robotics 2020. *9, 42; doi:10.3390/robotics9020042*
[3] Khandalavala, K., Shimon, T., Flores, L., Armijo, P., & Oleynikov, D. (2019). Emerging surgical robotic technology: a progression toward microbots. *Annals Of Laparoscopic And Endoscopic Surgery, 5.* doi:10.21037/ales.2019.10.02