Safety and Feasibility of a Dexterity-Enhancing Handheld Robot for Endoscopic Neurosurgery: An In-Vivo Animal Study (IDEAL Stage 0)

*J.G. Hanrahan[1,2], *J. Starup-Hansen[1,2], E. Dimitrakakis[3], H.J. Marcus[1,2,3]

[1] *Victor Horsley Department of Neurosurgery, National Hospital for Neurology and Neurosurgery, UK*

2 UCL Hawkes Institute, University College London, UK

[3] *Panda Surgical Ltd, London, UK*

j.starup-hansen@ucl.ac.uk

Aims

Minimally invasive neurosurgery offers access to deep intracranial lesions while reducing collateral tissue damage, but is limited by straight, rigid instruments with restricted dexterity. To address this, we developed a handheld robotic system with multi-degree-of-freedom (DoF) end-effectors to enhance surgical dexterity in narrow corridors. This study evaluates the safety and feasibility of the system in a live ovine model across three neurosurgical approaches.

Materials and Methods

The Panda Surgical Dexterity-Enhancing Handheld Robot consists of a lightweight ergonomic handheld controller, interchangeable articulated end-effectors, and a tethered external console. Each end-effector, including forceps, dissector, and curette, features 2-3 DoF articulation, providing both pitch and yaw motion, with select instruments incorporating a third DoF for opening and closing. The end-effectors fit through standard endoscopic ports and are actuated by integrated micro-motors. The controller incorporates a joystick interface, allowing intuitive control over articulation and grasping functions. The system is designed for seamless integration into existing neurosurgical workflows, requiring no additional footprint in the operating room. Power is transmitted from the console to the handheld unit via a slim, flexible tether, ensuring low-weight, ergonomic handling suitable for prolonged procedures.

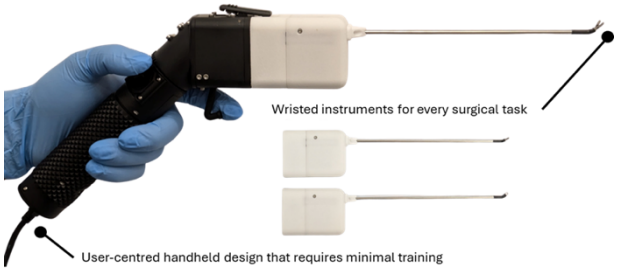

Fig. 1 Panda Surgical Handheld Robot

This preclinical in-vivo study (IDEAL Stage 0) was conducted using two adult female sheep. Each animal underwent three neurosurgical approaches (subfrontal, transparietal, supracerebellar), with predefined tasks performed using robotic dissector, forceps, and curette instruments. Safety was assessed through intraoperative adverse event monitoring, post-procedure necropsy, and blood toxicity testing. Feasibility was scored by surgeons (very easy to impossible) and usability feedback was collected. Outcomes were independently reviewed by veterinary staff.

Results

No device-related adverse events occurred. Mild to moderate haemorrhage was observed at surgical sites but was attributed to the surgical approach rather than device malfunction. All predefined tasks were feasible, with no task rated "impossible." Across approaches, the curette was rated the easiest to use, with 100% of tasks deemed as either "very easy" or "easy." The forceps were rated "very easy" or "easy" in 96% of tasks, while the dissector received these ratings in 81% of tasks. Surgeons reported high usability, with feedback guiding minor design refinements, particularly around instrument sharpness and retraction force.

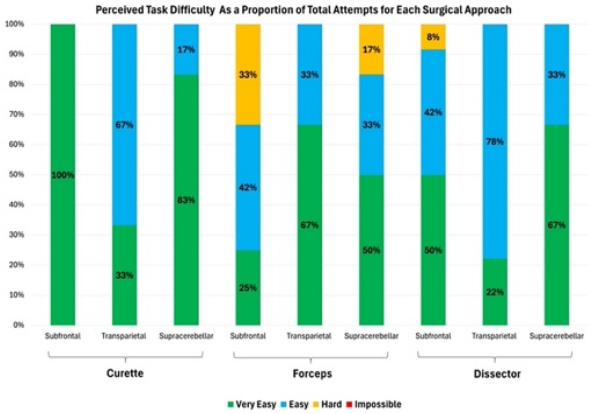

Fig. 2 Stacked bar graph demonstrating perceived easy of use across surgical tasks.

Conclusions

This is the first in-vivo evaluation of a dexterity-enhancing handheld robotic system for minimally invasive neurosurgery. The system demonstrated initial safety and feasibility across multiple approaches, supporting further engineering refinement and progression to first-in-human studies.

Acknowledgements: This project is funded by the NIHR i4i Programme (NIHR206456) and supported by the animal testing facility Veranex (Paris, France).