Handheld Robotic System for Endoscopic Neurosurgery

Emmanouil Dimitrakakis[1,2], George Dwyer[1,2], Hani J. Marcus[1,2,3], and Danail Stoyanov[1,2]

1: University College London, London UK
2: Panda Surgical Limited, London, UK
3: The National Hospital for Neurology and Neurosurgery, London, UK

UCL

BACKGROUND AND PURPOSE

The endonasal approach, a prime example of endoscopic neurosurgery, facilitates access to the skull base through the nostril as shown in Figure 1. Current standard instruments, lacking articulation, restrict surgeon dexterity [1]. Our study introduces a novel handheld robotic system, designed with detachable end-effectors to enhance these approaches.

Figure 1. The current technique during the endonasal approach.

METHODS

The robotic system features articulated 3mm instruments paired with an ergonomic handheld controller. The end-effector located at the distal end of the instrument, shown in Figure 2(a), deploys a tendon-driven spherical-joint, for increased distal articulation and force application when compared to continuum manipulators [2]. The handheld controller is designed to enhance user-comfort and efficiency by deploying a rotating joystick-body that allows for different hand-sizes and handedness [3]. The main features of the handheld controller can be seen in Figure 2(b), with the series of articulated instruments in 2(c). We evaluated the system depicted in Figure 2(d) during bench-tests investigating its workspace and force-delivery capabilities. We also conducted an exploratory cadaveric pilot study involving 6 surgeons of various expertise investigating the system's clinical relevance, feasibility, robustness, and durability [4].

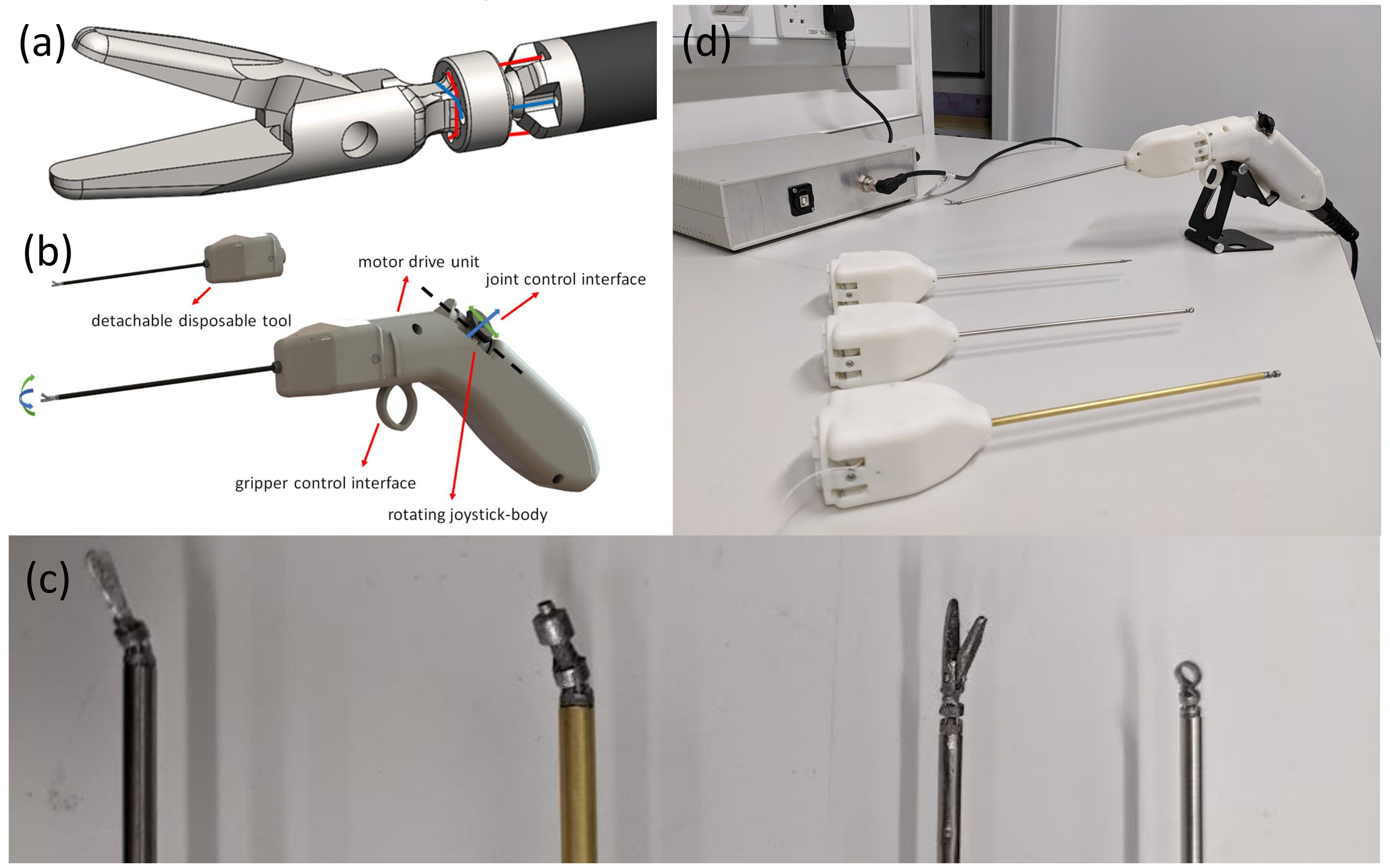

Figure 2. (a) The tendon-driven spherical-joint end-effector, (b) The main features of the handheld system, (c) (left to right) The articulated end-effectors, namely the spatula dissector, the endoscope, the grasper, and the ring-curette, and (d) The handheld robotic instrument with different instruments.

RESULTS

The instruments demonstrated a maximum workspace of ±40 degrees and highest force delivery of 1.34N maintaining their structural integrity up to 5N. In the cadaveric trials, shown in Figure 3, participants reported superior dexterity compared to traditional tools, sufficient force-delivery when the instrument was stable, and satisfactory structural integrity. However, they also identified areas for improvement, particularly in force-delivery when the instrument was moving, and its precision.

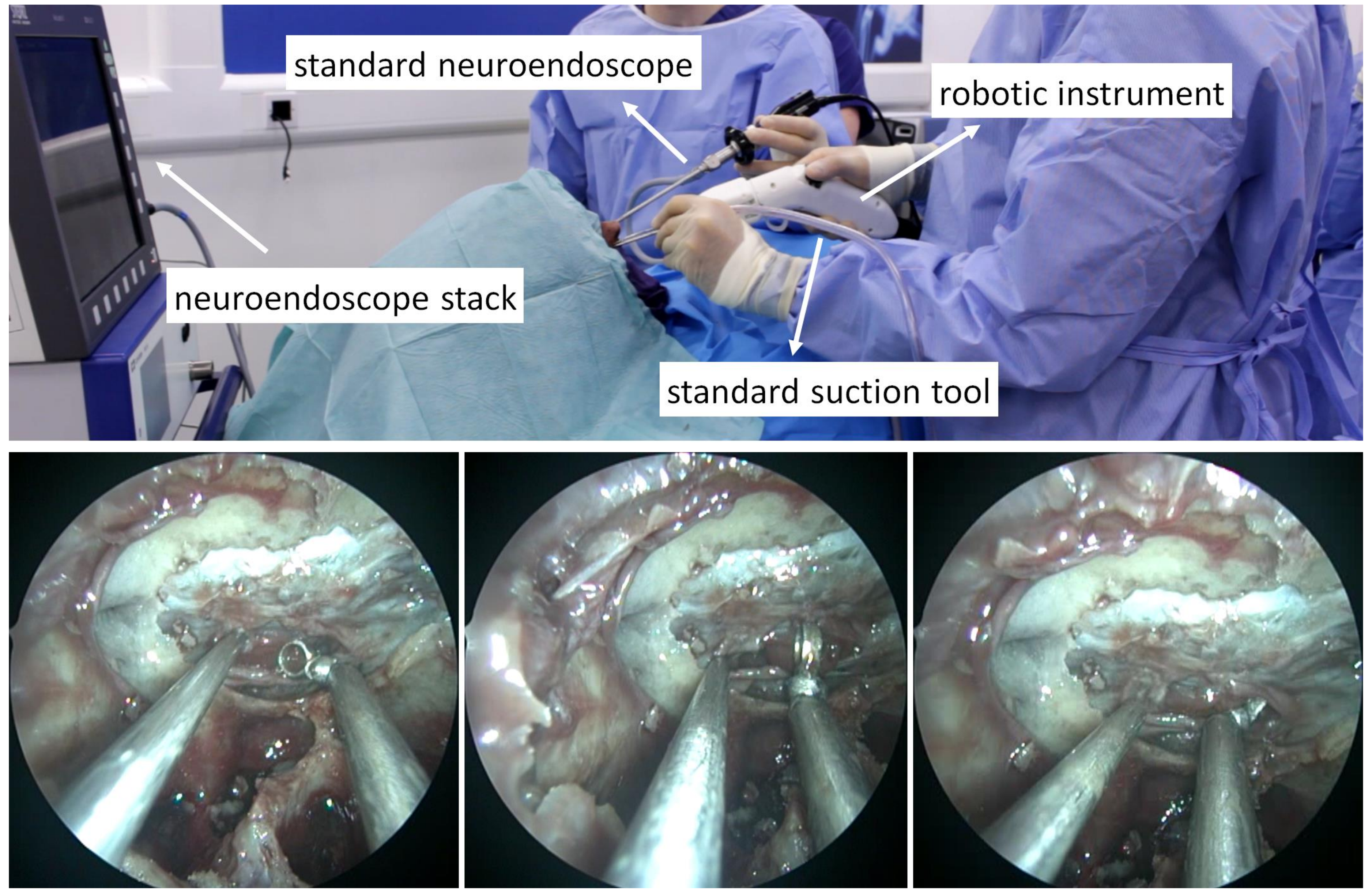

Figure 3. (a) The cadaveric test setup, and (b) The endoscopic feed.

CONCLUSIONS

We present a novel handheld robot for endoscopic neurosurgery with an ergonomically designed controller and a series of 3mm articulated end-effectors. The robotic system was tested in the lab and during a cadaver pilot study. Encouraging study results suggested clinical relevance with the current focus being on human-trials and surgical adoption

REFERENCES

[1] H. J. Marcus, et al., "Endoscopic and keyhole endoscope-assisted neurosurgical approaches: a qualitative survey on technical challenges and technological solutions", British journal of neurosurgery, 2014
[2] E. Dimitrakakis, et al., "A spherical joint robotic end-effector for the expanded endoscopic endonasal approach", Journal of Medical Robotics Research, 2020.
[3] E. Dimitrakakis , et al., "Robotic handle prototypes for endoscopic endonasal skull base surgery: Preclinical randomised controlled trial of performance and ergonomics", Annals of biomedical engineering, 2022.
[4] E. Dimitrakakis, et al., "A Novel Handheld Robotic System for Endoscopic Neurosurgery: A Cadaver Pilot Study", Hamlyn Symposium on Medical Robotics, 2023