PROPOSAL OF WIRE-DRIVEN SPHERICAL FORCEPS
FOR SUTURE IN DEEP BRAIN

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ABSTRACT

Neuroendoscopic surgery is a minimally invasive procedure to the deep brain. In neuroendoscopic surgery, a 40[mm] incision is made in the parietal region and a soft endoscope is inserted to remove the tumor in the deep brain. However, suture manipulation is not possible. Therefore, we considered it necessary to propose a neurosurgical robot that enables suturing of the deep brain. The purpose of this study is to develop forceps that can perform operations of tumor resection and suture ligation of blood vessels in the deep brain surgery. We propose robotic forceps for neurosurgery that can insert two forceps and one endoscope into the surgical field of minimally invasive deep brain surgery, and has the range of motion and workability to perform suture ligation with one forceps and ligation with two forceps. Since the motion and range of motion required for suture ligation is unknown, we conducted an experiment to confirm the forceps' motion in the surgical field.

In the experimental method, two laparoscopic forceps and an endoscope were inserted into a simulated neurosurgical site, and the range of motion and field of view for forceps manipulation were confirmed. As a result, suture ligation was impossible. Therefore, we reexamined the degree of freedom and operability required for suture ligation. We performed two operations, suture and ligation, on the artificial skin, and reexamined whether the forceps tip had the degree of freedom necessary for suture ligation. As a result, since suture can be performed only by rotation of the forceps tip, we consider that suture can be performed with a single robotic forceps by rotational manipulation in a bent position in the deep brain surgical area.

Based on the above, we propose a wire-driven spherical forceps that can operate independently of the pitch and yaw axes in order to enable delicate manipulation and an enlarged field of view. A simplified magnification model was created, and whether the forceps has a sutureable range of motion was evaluated from drive simulations. Ten bending movements were performed on the pitch and yaw axes, and quantitative evaluation was made from the angle from the reference point, and qualitative evaluation was made by stabbing with a single forceps.

The results showed that the wire-driven spherical forceps proposed in this study had a sutureable degree of freedom. The pitch axis cleared the target value, but the yaw axis did not. However, we believe that the target values can be met by modifying the grasping part and the method of wire placement. As a future prospect, we believe that modifying the shape of the forceps and the driving method will lead to the development of robotic forceps that can suture deep brain regions as used in clinical practice.