New Surgical Robotics for Clinical Use in Neurosurgery

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Minimally invasive surgery (MIS) has become so explosively popularized throughout the world because there is a significant difference in the postoperative quality of life of the patients with MIS from that with open surgery. The patients can enjoy earlier recovery to normal life or normal activity after MIS than after conventional open surgery. Although there are clear benefits, MIS has also some disadvantages for the surgeons. Long instruments placed through fixed entry points creating a fulcrum effect, with the surgical field viewed on a 2-D screen and with the camera under an assistant’s control, create an unnatural environment where the surgeon loses orientation, the eye-hand-target axis, and visual depth perception. All these obstacles reduce the surgeon’s normal dexterity and limit his ability to deal with difficult situations.

Computer-aided surgery, known as Robotic surgery, is proposed to overcome some of the drawbacks of traditional MIS.*1 This technology includes master-slave telemanipulator systems. The goals of these surgical systems are to enhance manipulation capabilities and to increase the performance precision. It provides secure precise procedures without any limitation in whichever direction the operator desires. The da Vinci is the most popular surgical robotic system among the commercially available types. More than 430 sets of the da Vinci are already installed all over the world at present. More than 300 sets are installed in the United States and more than 50 sets are in Europe. Robotic surgery provides you with a 3 dimensional view as well as 7 degrees of freedom of the instruments with an articulate at the tip. It is easier for you to perform complicated procedures such as ligature or suturing with a needle in a confined space. That is the reason why more than 40 percent of all prostatectomies have been performed with the surgical robotic system in the United States.

However, the size of the robotics is so large at this moment that it has been impossible to apply the system to microsurgery such as neurosurgery where there are so many critical conditions to be resolved. The target area is surrounded by the so important normal tissue that the access to the deeper targeting area is limited. The paper by Nishizawa et al. in this issue of the journal is considered significant, as they have developed new surgical robotics with the concept of MIS via a single insertion part and the prior-confirmation based safety control. It required several technical developments to enable the performance of MIS via a single hole. They made neurosurgery in one-opening craniotomy under fine and accurate control to avoid damage to the surrounding important normal tissues.

The issue of interference between mechanical elements was solved by developing a hollow flexible torque tube with one end segment of the hollow pipe. This mechanism allows the torque and thrust for rotation and translation movements successfully transmitted to the joint at the tip of the manipulator, resulting in the production of fine and high performance with an accuracy of less than 10μm. There is no need for concern over collision among the arms holding the manipulators and medical staff. There is a serious problem in Japan that some parties have discontinued the development of therapeutic tools. This paper is thus highly evaluated as the authors have confirmed the basic function of the new robotics in clinical settings.

The authors evaluated the feasibility of robotics for clinical use, especially focused on safety control. Actual movement of the manipulator takes places only after prior calculation of the position that would result from the input manipulate. They

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call the safety control system “prior-confirmation based safety control.” It prevents any movement of the manipulator beyond the predetermined range in the field of neurosurgery. These fine and accurate control systems as well as safety control make it possible to perform MIS via one-opening craniotomy in neurosurgery, which was impossible in conventional methods. This provides the possibility of expanding MIS to other fields of microsurgery. Although the working area is limited to that within 1 cm³ in the present robotic system, the utility and possibility would be further expanded with the development of technology on molecular image or genetic information.

The goal of future surgery will be to change the function rather than the structure of the organ or disease.² In this concept, termed biosurgery by Randall Wolf, MD, the purpose will be to change the biological processes of the body though direct modification of cellular, molecular, metabolic, and perhaps even genetic processes. The new robotic system developed by Nishizawa et al. will lead us to the second step towards attaining the goal.

References