DEVELOPMENT OF FORCE PRESENTATION MECHANISM USING PNEUMATIC FORCEPS SHAFT FOR SURGICAL ROBOT FORCEPS

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ABSTRACT

Laparoscopic abdominal surgery has been attracting attention from the viewpoint of quality of life, such as early return of patients to society, and is rapidly becoming popular in current abdominal surgery. Therefore, surgical robots have been developed to reduce the burden on both the patient and the surgeon.

Most surgical robots are divided into a leader part that is operated by the surgeon and a follower part that works inside the patient's abdominal cavity, and can be operated remotely. With the introduction of robotic technology, the degree of freedom of the forceps joints has been improved and the surgeon's burden has been reduced by allowing flexible manipulation of the field of view. However, the burden on the surgeon is still great, and the lack of a sense of force can be cited as a factor.

The inability to transmit a sense of force to the surgeon leads to problems such as organ damage due to compression of organs with forceps, inability to grasp the lesion with certainty, and time required to learn the technique. In particular, the risk of organ damage increases when contact with the organ is made at the shaft. Therefore, the purpose of this study is to improve safety by preventing organ damage, and to present force perception at the shaft. The final goal is to develop a device that enables the surgeon to identify the reaction force, contact direction, and contact range at the time of contact.

We proposed a pneumatic presentation mechanism that is attached to the forearm so as not to impair the operability of the surgeon. In addition, we investigated the sensation in the forearm for the detailed design of the mechanism. The forearm sensation was investigated based on the measurement of the two-point discrimination thresholds for different measurement positions and different shapes of the simulated cell to be contacted. The results showed that the surface area of the presentation cell should be as small as possible, the circumference should be long, and the edges should be distinct. The placement of the presentation cell and air block was determined based on the possible thresholds for two-point discrimination and the impossible thresholds for two-point discrimination. Based on the experimental results, a functional tester was created and evaluated to see if it could be presented in 12 blocks.

When implemented, the pneumatic control mechanism was installed in the actuator, and the presentation was based on the information detected from the forceps.