Bringing surgical insight to medical robot design

Robot-assisted surgery is becoming increasingly common for its greater stability, precision, and flexibility for complex procedures. From minimally invasive endoscopic surgery, to complicated heart or brain surgeries, robotic systems are widely used, with the growing demand for minimally invasive procedures that are less painful and safer for patients.

In China, the surgical robot industry is still in its infancy. In the 'Medium-to-Long-Term Plan for the Development of Science and Technology' issued by the government in 2006, the development of intelligent robots was, for the first time, earmarked as being of national strategic importance, and listed as a cutting-edge technology for boosting advanced manufacturing.

In line with this, in 2008, when the da Vinci Surgical System was introduced to China, a collaborative project was initiated with government funding support to develop China's own robotic system for minimally invasive laparoscopic surgery. This has led to the invention of Micro Hand S.

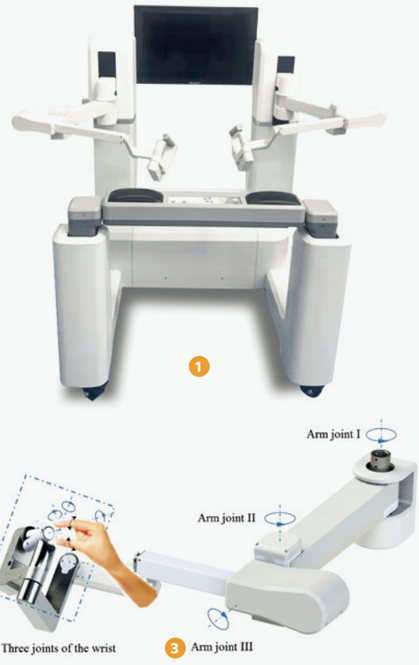
The development of Micro Hand S has involved clinicians from its beginning. This insight helps robotic researchers better understand the issues faced by surgeons, so that they can adjust designs to address clinical needs, such as greater dexterity for complicated procedures, improved force control to ensure safety, a clearer view through the endoscope to allow for precise operation, increased user comfort to reduce fatigue, and shorter time under anaesthesia.

Clinical researchers from the Third Xiangya Hospital of Central South University have advised on the initial design with their clinical experience. Their rich data helped inform the establishment of evaluation criteria for product safety and effectiveness. In the development of the prototype machine, researchers from the hospital also performed *in vitro* and animal experiments, as well as clinical trials to guarantee evidence-based design.

After more than 10 years of research, design, evaluation tests, and retrospective and prospective clinical studies, the prototype was updated and improved. A phase III clinical trial is planned to ensure the robotic system meets all the clinical requirements.

"Robot-assisted surgery is an inevitable trend given all the benefits it affords," said Shaihong Zhu, a lead researcher of the Micro Hand S collaborative project from the Third Xiangya Hospital. "It's not taking away surgeons' jobs, but making our work easier."

The development of Micro Hand S heralds the rise of the medical robotics industry in China, and it enhances collaboration to achieve clinical and engineering innovation. ■



INNOVATIVE DESIGN

1. With a foldable design, Micro Hand S is compact, while allowing for a wide range of movement space of the manipulator.
2. With a single docking on the patient cart of the robotic system, the slave manipulator can operate across multiple quadrants. The range of rotation angles for its two joints are (-120°, 120°) and (-30°, 140°) respectively.
3. The master manipulator of the surgical robot adopts three rotary joint structures to assist the surgeon with location. As the axes of the first two joints are upright, the motion is less affected by gravity, allowing for easier and more flexible operation.

A research team at the Third Xiangya Hospital of Central South University advised on the medical robot design.

DEVELOPMENT OF MICRO HAND S

2013
This version features: a rotational manipulator with three axes intersecting at the tip of the robotic arm, allowing for a large degree of freedom; a design for the operating arm to automatically adjust based on the incision procedure; and a strategy for mapping the slave and master device movement.

2016
An interface was developed to allow for intelligent, rapid shifting of surgical instruments during an emergency; the modular arrangement for a three-finger robotic hand was proposed to solve complex issues like pre-procedure positioning and operation adjustment; a handle design based on ergonomic factors improves control at the master end, while solving the problem of operator hand fatigue.

2017
The single-arm modular arrangement was proposed for the multi-incision laparoscopic surgery robot; an open design for the structure of the master console was introduced to enable easy observation; a stacked design of the slave arm was proposed to make the robotic system more compact.

2019
A control strategy of multi-function intervention was introduced; instrument designs were implemented to allow for ultrasonic or electro-cutting, electrocautery and other functions; updates were made to improve safety control for the surgical instruments.