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IDEAS AND INNOVATIONS

Breast

Using a Microsurgical Robotic Platform for In-flap Anastomosis in Autologous Bipedicular Breast Reconstruction

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Summary: Autologous microsurgical breast reconstruction has become a standard of care. As techniques become more individualized and aim for less-invasive approaches, vessels ever smaller in diameter are considered for flap anastomosis. Robot-assisted surgery has great potential to reduce tremor and enhance precise motion. The Symani Surgical System (Medical Microinstruments, Inc., Wilmington, Del.) is a robotic platform designed for microsurgery. It was used for a microsurgical in-flap anastomosis of a bipedicular deep inferior epigastric artery flap for unilateral breast reconstruction. The procedure included fully robot-assisted anastomoses with significant size mismatches using a 3D-exoscope for magnification. Arterial and venous anastomoses were entirely robot-assisted completed in 23 minutes (seven stitches) and 28 minutes (eight stitches) using 9/0 nylon sutures. The intra- and postoperative course was uneventful. This robotic platform facilitates in-flap anastomoses of small vessels by increasing the precision of instrument handling and eliminating tremor. The combination of robotic platforms and exoscopes provides superior ergonomics in comparison with conventional (super) microsurgery. We expect robotic platforms to play a significant role in modern microsurgical breast reconstruction. *(Plast Reconstr Surg Glob Open 2024; 11:e5511; doi: 10.1097/GOX.0000000000005511; Published online 10 January 2024.)*

INTRODUCTION

The evolution of microsurgery through improvements in operating microscopes, instruments, and surgical techniques has led to less-invasive procedures, reduced morbidity, and better outcome and, thereby, has improved patients' quality of life.[1,2] In-flap anastomoses in bipedicular deep inferior epigastric artery (DIEP) flaps allow for bilateral flap harvest with minimal trauma to the rectus abdominis muscle and improved flap perfusion.[3] Small caliber vessel anastomoses are considered to limit vessel dissection and, thus, reduce morbidity,[4] even though posing a challenge to the human abilities through manual boundaries and physiologic tremor.[5–8] Implementation of robotic-assisted microsurgery can help compensate for these limitations. Here, we report on our experience with a robotic platform in its first application for an in-flap anastomosis in bipedicular DIEP flap breast reconstruction.

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PATIENTS AND METHODS

Robotic System

The Symani surgical system is a two-armed robotic platform, with exchangeable surgical instruments (Fig. 1A, B), that is tele-controlled by the surgeon. (**See Video [online],** which shows the artrial and venous anastomosis as the surgeons see the operation site on the video screen.) Physiologic tremor is eliminated, and precise motion can be improved by scaling down the surgeon's hand movements between seven- and 20-fold. The microsurgical instruments are available in two sizes, designed for microsurgery and super-microsurgery. They provide 7 degrees of freedom and allow for motion within the range of tens of microns. The surgeon tele-controls the robotic

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system by using cable connected only "free-air" masters, which resemble manual instruments in haptics and shape. To avoid ergonomic compromise, we use a 3D video microscope (ORBEYE 4K-3D-Digital-Video-Microscope, Olympus Europe SE & Co. KG, Hamburg, Germany) with 3D-screens. Preparation of the system occurred during the operation (10–20 minutes) and did not prolong surgery.

Presurgical Training

Every surgeon underwent an intensive, standardized 15 hour training program, monitored by a Symani specialist before human application, including multiple end-to-end anastomoses on artificial vessels with diameters between 2 mm and 0.5 mm, as well as end-to-side and mismatch anastomoses.

Clinical Case

A 48-year-old female patient presented with a history of total right-sided mastectomy for multicentric invasive breast cancer. We opted for a bipedicular DIEP flap due to limited abdominal tissue (body mass index 26.5 kg/m^2) and a significant demand for additional skin (Fig. 2). to ensure perfusion of the whole flap, we performed an in-flap-anastomosis using the Symani robotic system (Fig. 1 A, B). The artery and vein of the right pedicle (artery diameter: 1.2 mm, vein diameter: 1.4 mm) were anastomosed to the lateral branch of the left pedicle (artery diamter: 0.8 mm, vein diameter: 0.7 mm; Fig. 3). The robotic-assisted arterial anastomosis took 23 minutes (seven stitches), and the venous anastomosis, 27 minutes (eight stitches). (**See Video [online]**.) After establishing flap perfusion via hand-sewn and coupler anastomoses of the left pedicle to the right internal mammary vessels, all anastomoses were patent and no corrective additional stitches were needed. Robotic-assisted anastomosis to the internal mammary vessels are challenging because the robotic arms stay static above the respiratory excursions of the thoracic wall. Total ischemia and operation times were 83 and 458 minutes, and the patient was discharged, after an uneventful course, 6 days after surgery. (**See Video [online]**.)

Takeaways

Question: In-flap anastomoses in bipedicular deep inferior epigastric artery (DIEP) flaps with significant mismatches and small diameters pose a challenge to human abilities due to physiologic limitations and tremor. How can robotic technology help in this context?

Findings: We report on our experience of how robotic-assisted microsurgery can help compensate for these limitations. Arterial and venous in-flap anastomoses of vessels with diameters below 0.8 mm were performed successfully, followed by an uneventful postoperative course.

Meaning: Robotic technology in the field of microsurgery has the potential to improve manual abilities through enhanced precision, ergonomics, and outcome.

DISCUSSION

We present the first-in-human fully robotic-assisted in-flap anastomosis in autologous breast reconstruction. The uneventful intra- and postoperative course demonstrates the capability and safety of robotic-assisted microsurgery in delicate microsurgical procedures, even in cases of small vessels and significant size mismatch. The implementation of the da Vinci robotic system in urogynecology and general surgery had a profound impact on surgical practice in the last three decades.[9] However, the da Vinci system is not adaptable to the requirements of micro- and super-microsurgery.[10] The Symani robotic system has been solely developed for applications in microsurgery. It enables (super) microsurgery with enhanced control and precision, beyond the physiologic capabilities of a human hand, and providing its own surgical tools adaptable for micro- and super-microsurgery.[10] It enables fine-tuned motion due to scaling down of movements, provides a high degree of freedom, and allows for great

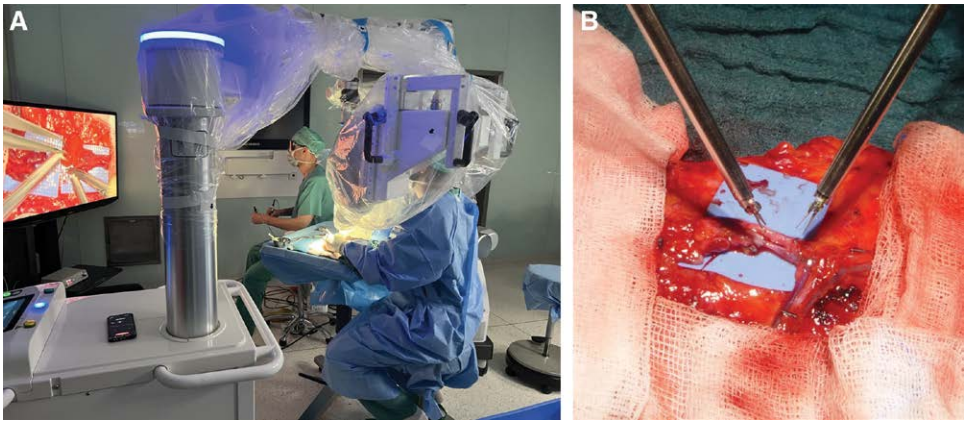

Fig. 1. Robotic system setup for the back-table in-flap-anastomosis in combination with an exoscope. A, The main surgeon controls the robotic arms with "free-air" masters. Both surgeons watch the surgical site on a 3D screen. B, In-flap anastomosis with a significant mismatch of the right pedicle to the lateral branch of the left hemi-DIEP.

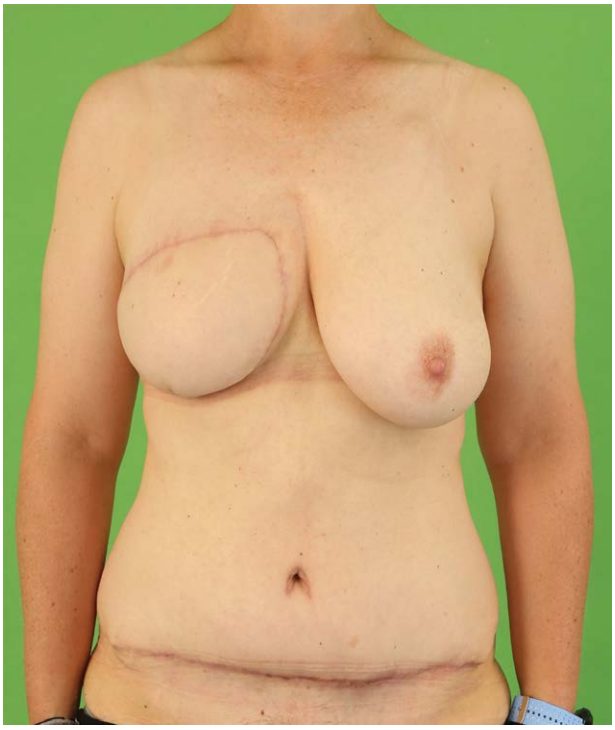

Fig. 2. Frontal view 2 months postoperatively after reconstruction of the right breast with a bipedicular DIEP flap and significant skin replacement in a patient with slender abdominal excess tissue and grade 3 ptosis of the left breast.

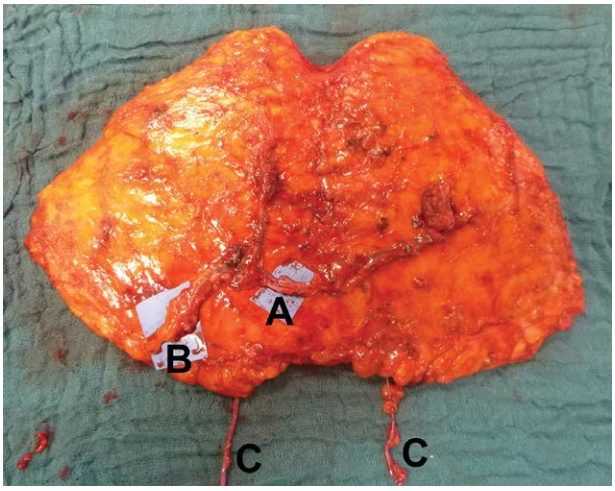

Fig. 3. "A" indicates in-flap anastomosis of the right pedicle to the lateral branch of the left hemi-DIEP. "B" denotes left pedicle. "C" indicates SIEV (superficial inferior epigastric vein), and backup options for additional venous outflow.

control in challenging situations, like anastomoses with a severe mismatch. It supports microsurgeons by eliminating physiologic tremor and the combination of "free air" masters, and exoscopes allow for advanced ergonomic performance, independently of the patient's or the operating table's position.[11] In general, the advantages of robotic technology, with regard to improved precision, ergonomics, and fatigue have already been recognized.[12] Future studies will have to determine if these advantages have a positive effect on complications, performance, outcome, and surgeons' work strain.

CONCLUSIONS

The Symani robotic system is suitable for carrying out in-flap anastomoses with a significant size mismatch and diameters below 0.8 mm in autologous breast reconstruction. This opens new frontiers in the field of supermicrosurgery, allowing for less-invasive techniques and improved outcomes.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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