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Breast

Minimally Invasive Robotic-assisted Perforator-to-Perforator DIEP Flap Breast Reconstruction

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Summary: Reducing morbidity has been the goal of many reconstructive microsurgery efforts. Several techniques have been described for deep inferior epigastric perforator flap breast reconstruction to minimize abdominal donor-site morbidity. Although these techniques have certain tradeoffs, we designed a minimally invasive robot-assisted perforator-to-perforator approach to achieve minimal donor- and recipient-site morbidity. Simultaneous identification of the deep inferior epigastric artery (DIEA) and internal mammary artery (IMA) perforator was performed, followed by a small fascial incision around the dominant DIEA perforator. The IMA perforator was prepared for a prepectoral anastomosis. The short DIEA pedicle was dissected without further longitudinal fascial incision until an adequate diameter compared with the IMA perforator was reached, and a robot-assisted perforator-to-perforator anastomosis was performed prepectorally. All patients underwent reconstruction performed by a single surgeon. The smallest abdominal incision was 2.5 cm with a DIEP pedicle length of 6 cm. The average IMA perforator diameter was 1.14 mm (1.0 mm–1.2 mm). The average vein diameter was 2.0 mm (1.5–3.0 mm). The incision to closure lasted 330 minutes (313–348 minutes). Flap ischemia was 105 minutes (82–118 minutes), whereas the time for robot-assisted anastomosis was 25 minutes (22–30 minutes). All anastomoses were performed successfully. Our initial experience with robot-assisted perforator-to-perforator anastomosis for DIEP flap breast reconstruction demonstrates promise in achieving minimal patient morbidity. Raising only a very short pedicle can be compensated by adding the prepectoral IMA perforator length and enabling a good size match for small-caliber anastomosis. This technique combines important aspects of most minimally invasive DIEP flap harvests and insets. *(Plast Reconstr Surg Glob Open 2024; 12:e5800; doi: 10.1097/GOX.0000000000005800; Published online 13 May 2024.)*

INNOVATION

Reducing morbidity has been the goal of many recent efforts in reconstructive microsurgery. Laparoscopic and robot-assisted techniques have been described to minimize abdominal donor-site morbidity in autologous breast reconstruction.[1,2] These techniques have certain tradeoffs, such as additional incisions in the abdominal wall and intraabdominal preparation. Raising the flap pedicle through a microfascial incision has been described previously.[3] Although rib-sparing techniques for internal mammary artery (IMA) exposure decrease recipient-site morbidity,[4] even less-invasive anastomoses to the prepectoral IMA perforators (IMAPs) create a significant mismatch between deep inferior epigastric artery (DIEA) and IMAPs if the deep inferior epigastric perforator (DIEP) flap is raised in a conventional fashion.[5] Using a surgical robot specifically designed for open microsurgery[6] in combination with a robotic microscope[7] in a fully telemetric setup, we designed a minimally invasive robot-assisted perforator-to-perforator approach for DIEP flap breast reconstruction (miraDIEP) to achieve minimal invasiveness.

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Preoperative planning included abdominal computed tomography angiography for main perforator identification and determination of intramuscular course followed by duplex ultrasound for flow and size determination of the medial or lateral row up. IMAPs with a flow rate of more than 15 cm per second were identified as potential recipient vessels (**See figure, Supplemental Digital Content 1,** which shows a duplex ultrasound performed preoperatively for perforator characterization. **http://links.lww.com/PRSGO/D192**). Intraoperatively, simultaneous perforator identification was performed on the hemiabdomen and breast. A small fascial incision was made around the dominant DIEA perforator with no further longitudinal incision of the rectus abdominis muscle. The pedicle was dissected until an adequate diameter for the DIEA, compared with the IMAP, was reached. Robotic-assisted anastomosis (Fig. 1) was performed prepectorally using the Symani (MMI, Wilmington, Del.) and RoboticScope (BHS, Innsbruck, Austria). The surgeon performs the anastomosis being decoupled from the operating site using controllers in an electromagnetic field and wearing head-mounted displays. The assistant has the same head-mounted display gear but with a mirrored image. The assistant hands the needle from the scrub nurse to the robotic instruments and can pull the thread following the stitch, if needed. The thread is cut by the surgeon.

Two patients underwent unilateral ablation, one had a nipple-sparing mastectomy and implant reconstruction, and the fourth underwent nipple-sparing mastectomy with immediate autologous reconstruction. All patients received miraDIEP flap reconstruction performed by a single surgeon. The smallest abdominal incision was 2.5 cm with a DIEP pedicle length of 6 cm (Fig. 2). Average abdominal incision was 2.88 cm (2.5–3.4 cm). The average IMAP diameter was 1.14 mm (1.0 mm–1.2 mm). Two veins were used in two cases. The average vein diameter was 2.0 mm (1.5–3.0 mm). Incision to closure was 330 minutes (313–348 minutes). The time from incision to flap ischemia continuously decreased from 164 to 118 minutes (average, 135 minutes). Flap ischemia was 105 minutes (82–118 minutes). The time for robot-assisted anastomosis was 25 minutes (22–30 minutes). The average flap weight was 613 g (246 g–1198 g). In one patient, there was no flow on the IMAP before anastomosis, but regular flow thereafter. In another patient, the pedicle was repositioned intraoperatively due to kinking. No arterial or venous thrombosis, hematoma, flap loss, or partial fat necrosis occurred, and no revisions were performed. The mean follow-up period was 143 days.

Takeaways

Question: Reducing morbidity has been the goal of many efforts in DIEP flap breast reconstruction. A novel robotic-assisted approach may hold potential to further reduce morbidity through less-invasive donor- and recipient-site preparation and smaller vessel anastomoses.

Findings: Initial operations demonstrated feasibility and safety of the minimally invasive robotic-assisted DIEP (miraDIEP) approach.

Meaning: The initial findings indicate potential for less patient morbidity in DIEP flap breast reconstruction and encourage further exploration of such robotic-assisted minimally invasive microsurgical procedures.

DISCUSSION

The initial experience with the miraDIEP concept demonstrates promise in achieving minimal patient morbidity at the donor as well as recipient sites. Using enhanced precision in microsurgery by robotic assistance may enable more reliable small diameter anastomosis as needed for this concept for a wider audience of surgeons. Raising only a very short pedicle can be compensated by adding the prepectoral IMAP length and more superficial anastomosis. A shorter pedicle also enables a better size match for the anastomosis.

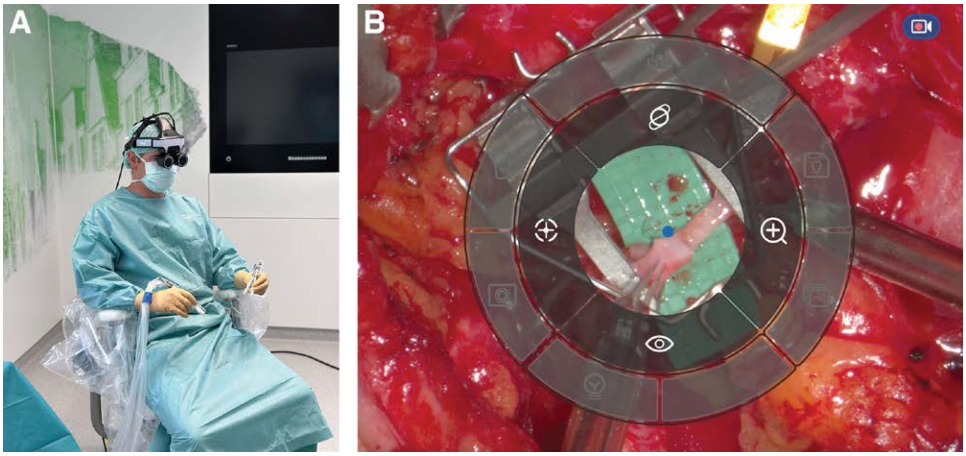

Fig. 1. The surgeon's position and perspective. A, The surgeon performs the arterial anastomosis in a comfortable position while being disconnected from the operating site. B, During robotic-assisted anastomosis, the robotic microscope is operated through a menu overlay via head movements, which enables setting changes without anastomosis interruption.

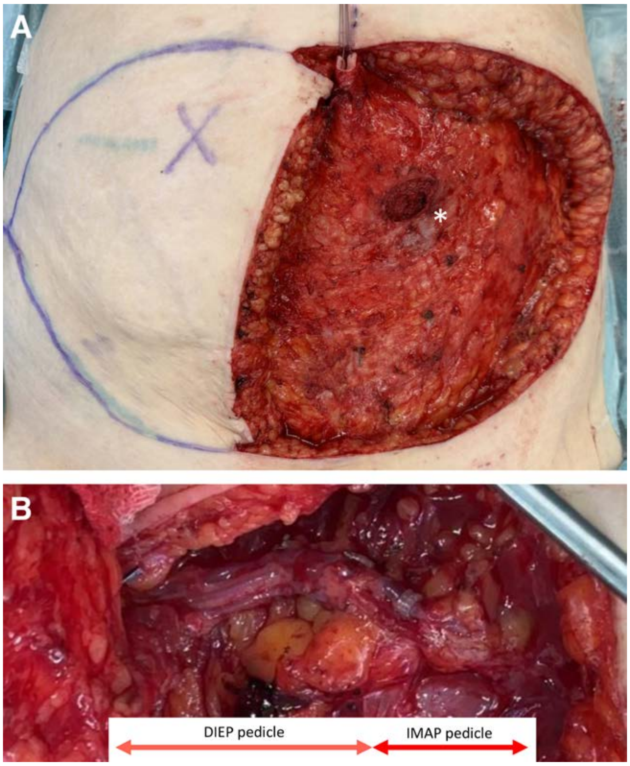

Fig. 2. Donor and recipient site. A fascial incision (<2.5 cm) was needed for a 6-cm pedicle preparation. No further longitudinal incision was performed (A). The short pedicle enabled an acceptable arterial and venous size match for end-to-end anastomosis to the prepectoral IMAP. Using the perforator adds additional length to the overall pedicle, enabling a flexible flap inset (B); orange arrow: DIEP pedicle; red arrow: IMAP).

Robotic assistance with downscaling, tremor elimination, and comfortable ergonomics enables precise small-caliber arterial anastomoses as needed for this concept. (**See figure, Supplemental Digital Content 2,** which shows the setup with telemetrically controlled visualization and robotic assistance enabling a comfortable environment with complete disconnection from the operating site. **http://links.lww.com/PRSGO/D193**.) Becoming proficient in the miraDIEP approach entails several steps: (a) preclinical training of robot handling; (b) initial clinical learning curve in robot-assisted standard microsurgical procedures, which takes around 10 cases; (c) learning curve with prepectoral perforator preparation and short DIEP pedicle preparation through minimal fascial incision; and (d) performing perforator level anastomosis with robotic assistance.

Possible limitations preventing the application of this method may include the lack of adequately sized IMAPs or injury during mastectomy, dominant caudal DIEA perforator in the lateral row, and long intramuscular DIEP pedicle course. However, several anatomical studies have demonstrated a relatively reliable IMAP anatomy.[8,9] The patient's suitability for miraDIEP reconstruction was determined preoperatively using duplex ultrasound. The incision to closure time was longer compared with robot-assisted DIEPs with anastomoses directly to the IMA, although the time for anastomosis was not longer. This was likely attributed to the new pedicle and recipient vessel preparation techniques, certainly with room for improvement. Furthermore, the contralateral DIEP flap was preserved until successful completion of anastomosis as a safety measure. Another potential fall back in case of postoperative thrombosis would be a conversion to the IMA with a rib-resecting approach, gaining several centimeters of IMA length to add to the short pedicle. We have not yet performed the miraDIEP in bilateral reconstruction as we want to go through the learning curve first in unilateral cases.

Whether the suggested outcomes justify the added costs of robotic assistance remains to be demonstrated. The additional costs are comprised of system acquisition costs[10] and the single-use instruments for the Symani (currently $2400 per procedure). An additional 10–15 minutes during preoperative marking needs to be calculated for thoracic and abdominal Duplex ultrasound. Once the learning curve is complete, it should be demonstrated if operation times are longer or shorter than with conventional techniques. It also needs to be demonstrated if imposing a smaller diameter anastomosis with less invasiveness will actually lead to lower morbidity at equal safety levels compared with conventional techniques. Therefore, we initiated a prospective clinical trial centered around patient-reported outcome measures comparing the miraDIEP approach with conventional DIEP reconstruction.

The miraDIEP technique combines important aspects of most minimally invasive DIEP flap harvest and inset. Future research should focus on the potential benefits of this concept for patient-reported outcomes.

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DISCLOSURES

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