Article published online: 2023-08-03

Robotics in Implant-Based and Autologous Breast Reconstruction

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Semin Plast Surg 2023;37:168–175.

Abstract

Autologous and implant-based breast reconstruction continues to evolve as new technology and mastectomy techniques become available. Robotic-assisted breast reconstruction represents a growing field within plastic surgery, with the potential to improve aesthetic and functional outcomes, as well as patient satisfaction. This article provides a review of indications, techniques, and outcome data supporting the use of robotic assistance in both implant-based and autologous breast reconstruction from surgeons around the world.

Keywords
- robotic surgery
- robotic breast reconstruction
- robotic latissimus dorsi flap
- robotic DIEP

Mastectomy techniques have undergone considerable changes since the radical mastectomy was first introduced in 1894.[1] As oncologically sound surgical options for mastectomy have increased, reconstructive options have evolved with them.[1,2] Boyd et al were the first to demonstrate the utility of robots in breast reconstruction by successfully harvesting the internal mammary vessels in 2006.[3] Toesca et al pioneered robotic assistance for both mastectomy and direct to implant (DTI) reconstruction.[4] Other surgeons describe the use of the new or existing nipple sparing mastectomy (NSM) incisions to perform robotic-assisted latissimus dorsi harvest (RALDH), and secure acellular dermal matrix (ADM) to improve coverage of tissue expanders (TEs).[5–8] Applications of robotic assistance have also extended into microsurgery where harvest and inset of a deep inferior epigastric perforator (DIEP) flap and lymphovenous bypass for postoperative lymphedema have been described.[9,10]

Robotic-Assisted Implant-Based Reconstruction

There are many factors to consider for implant-based reconstruction in breast cancer patients including implant size, type, reconstruction timing, tissue plane for implant insertion, need for adjuvant radiation, and additional coverage requirements. The increased use of robotic-assisted nipple sparing mastectomy (R-NSM) procedures has led to the creation of novel techniques for robot-assisted implant-based reconstructions.[2,11] Robotic assistance has been used to elevate the pectoralis major for dissection of a submuscular pocket, raise pedicled latissimus dorsi (LD) muscle flaps for coverage of implants, and secure ADM to the chest wall for both delayed reconstruction with TEs and DTI reconstruction.[12–15] Notably, placement of the implant itself is exclusively done manually, sometimes employing no-touch methods including the use of the Keller Funnel (Keller Medical, Stuart, FL).[16]

R-NSM has been shown in limited studies to produce improved patient satisfaction with similar complication profiles and oncologic efficacy for select patients.[17,18] In these patients, DTI reconstruction using robotic assistance for submuscular pocket dissection was performed in the majority of cases,[4,7,14,17,19,20] including the use of ADM for coverage of the implant,[7] while other authors placed the implant directly into the subglandular pocket.[15,18] A minority of patients underwent delayed reconstruction using

article published online
August 3, 2023

Issue Theme New and Updated Applications for Robotic Surgery in Plastic Surgery; Guest Editors: Jessie Z. Yu, MD, and Jesse C. Selber, MD

Thieme Medical Publishers, Inc., 333 Seventh Avenue, 18th Floor, New York, NY 10001, USA

DOI https://doi.org/10.1055/s-0043-1771235.
ISSN 1535-2188.

robotic assistance to place ADM with TEs, followed by staged reconstruction with TE to implant exchange.[7,17,21] Additionally, Houvenaeghel et al reported on the use of RALDH to provide additional soft-tissue coverage of an implant with a pedicled LD flap.[8]

Technique

For DTI reconstruction following R-NSM, several authors report the use of a single port technique utilizing the same incision for R-NSM; however, the device used has not been approved for use in the United States by the Food and Drug Administration (FDA).[22] Other minimally invasive techniques including the insertion of multiple ports can also be used. Under direct vision, 6-mm bipolar forceps and a monopolar cautery spatula are used to elevate the pectoralis major muscle from its lateral to the level of the nipple, proceeding inferomedially until an adequate submuscular pocket is created.[23] If desired, ADM can then be sutured to the inferior border of the pectoralis major superiorly and the inframammary fold (IMF) inferiorly with interrupted sutures, leaving space for lateral insertion of an implant. After irrigation with antibiotic saline, the implant is typically placed using a no-touch method, followed by manual closure of the ADM pocket and skin.[19,23]

Jeon et al used robotic assistance to reduce the palpable implant edge and upper pole rippling seen in subglandular reconstruction.[7] This modified submuscular technique, the anterior tenting method, involves dividing the pectoralis major muscle near the planned upper border of the implant, elevating the superior portion of the pectoralis major, suturing ADM to the superior muscle flap proceeding medially, then suturing the ADM sling to the superficial surface of the pectoralis major toward the IMF, leaving a space for manual insertion of the implant laterally. After undocking the robot, the implant is inserted, and the ADM pocket and skin are closed.[7,19,23] In a cadaveric study, robotic assistance was used to both perform NSM and place a prefabricated ADM construct, followed by manual insertion of an implant using a no-touch method.[16]

Ahn et al described a technique that used a modified external retractor with the robotic system to secure the working space as opposed to gas insufflation. After partial elevation of the pectoralis muscle manually, the robot was used to complete the dissection and place an ADM sling. All procedures were successful with no major complications; one patient experienced mastectomy flap congestion that spontaneously resolved; however, the authors reported interference between the manual retractors and robotic arms.[19]

Robotic-Assisted Latissimus Dorsi Flap

The pedicled LD muscle flap is a workhorse flap frequently used for autologous breast reconstruction.[24] It can be used for immediate breast reconstruction alone, in conjunction with an implant, or used in a delayed fashion, particularly if a patient needs adjuvant radiotherapy.[6,12,24,25] LD flap reconstruction is particularly useful for patients undergoing immediate implant-based reconstruction with thin mastectomy flaps in whom tissue viability is a concern.[13] It is also employed in patients undergoing delayed reconstruction with thick capsules or scarring secondary to radiation therapy, which require capsulectomy and threaten soft-tissue coverage of the construct.[12,13]

Although endoscopic methods for LD harvest have been described, they have fallen out of favor due to technical challenges; however, they are still employed by providers who lack sufficient training or do not have access to robotic systems.[10] Selber was the first to describe the RALDH in 2011 as a minimally invasive reconstructive option with less donor site morbidity compared to open techniques.[26] Subsequently, Selber et al reported on a case series in which seven patients underwent RALDH, two raised as free flaps for scalp reconstruction, and five raised as pedicled flaps for breast reconstruction. Three patients underwent immediate implant-based reconstruction following NSM, and two underwent delayed postradiation reconstruction at the time of TE to implant exchange.[27]

Technique

After mastectomy, patients are placed in a lateral decubitus position with the ipsilateral arm free.[27] A 4- to 5-cm axillary incision is used to isolate the thoracodorsal pedicle and release the anterior border of the muscle. The incision from axillary lymph node dissection is often used in either immediate or delayed cases if available. After isolating the pedicle, the incision is temporarily closed over a 12-mm port to allow insufflation and port placement. Insufflation pressure is typically maintained at 7 to 10 mm Hg.[4,27] Two to three additional ports are placed inferior to the axillary port, typically 8 cm apart, located 5 to 8 cm anterior to the border of the muscle to facilitate robotic instrumentation (►**Fig. 1**).

The robot is docked into position and the dissection starts along the undersurface of the muscle to preserve the optical window, as dissection of the superficial surface first would allow the pressure to compress the submuscular space during subsequent dissection (►**Fig. 2**). After the muscle is released on both deep and superficial surfaces, it is divided along the inferoposterior, posterior midline, and thoracolumbar fascia. Once hemostasis is achieved and the flap is fully elevated on its pedicle to the tip of the scapula, the robot is detached from the axillary port, and the LD flap is tunneled and inset into the postmastectomy space and incisions are closed. Port sites are also commonly used for drain placement to minimize additional incisions. A position change from decubitus to supine is typically required to facilitate inset and additional procedures including implant placement, implant exchange, and contralateral mastectomy or mammaplasty.[27]

Several modifications to this technique have been proposed. Some surgeons have developed retractors as a gasless alternative citing concerns with the potential risks of CO_2 insufflation, including hypercarbia, hypercapnia, respiratory acidosis, subcutaneous emphysema, and hypothermia.[1,28–31] However, these risks were reported in the general surgery literature involving insufflation of the peritoneum, which is a larger space, and more prone to hemodynamic changes through effects on

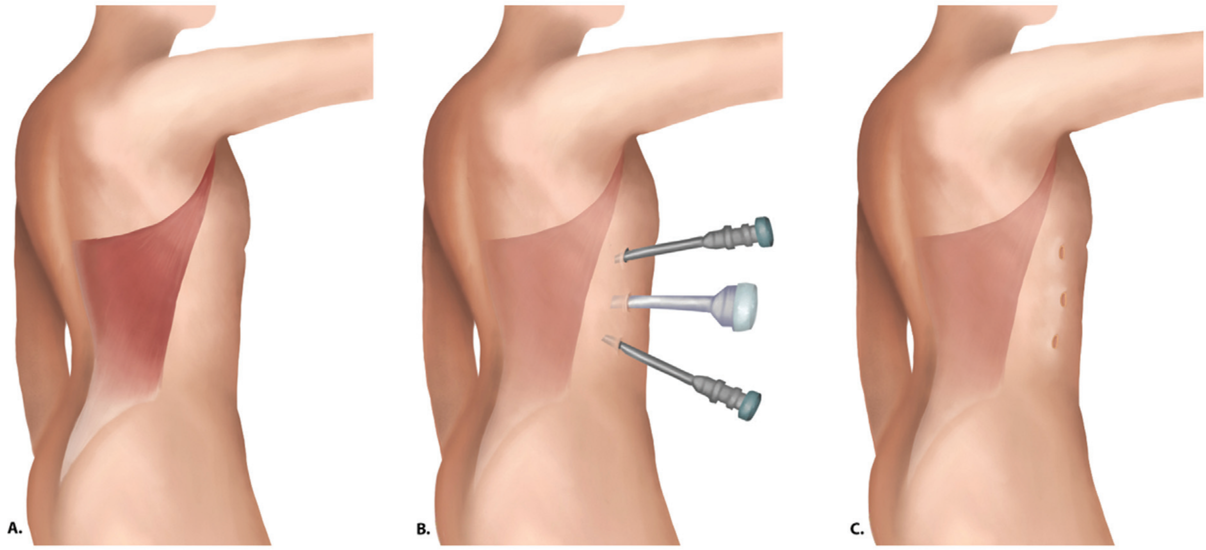

Fig. 1 (**A**) Anatomical location of the latissimus dorsi muscle. (**B**) Robotic latissimus dorsi harvest port placement. Robotic ports are located along the posterior axillary line. The most superior port is located along the posterior axillary line and within the inferior axilla, 5 cm anterior to the latissimus dorsi border. The second port is 8 to 10 cm caudal to the first port and 5 cm anterior to the lateral border of the latissimus dorsi. The inferior port is 8 to 10 cm caudal to the second port and 5 cm anterior to the latissimus dorsi border. (**C**) Port incision placement along the posterior axillary line.

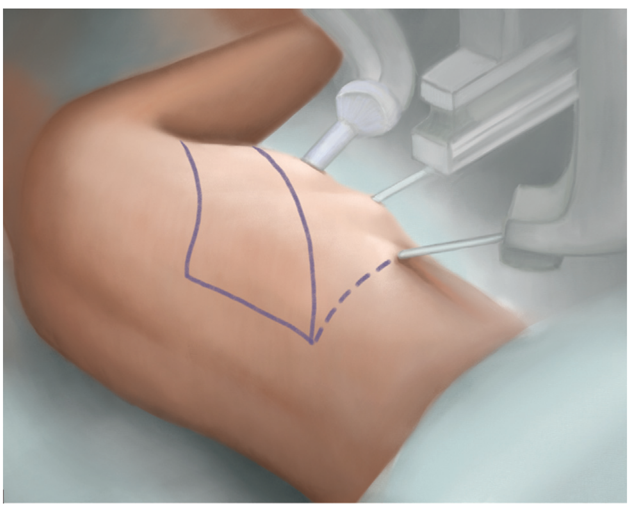

Fig. 2 The robotic side cart is positioned posterior to the patient with the robotic arms extending over the patient to the ventral side. The robotic arms are oriented in such a way that the robotic instruments align with the surgical plane of the latissimus dorsi muscle.

major vessels and solid organs.[30] Additionally, these retractors can interfere with placement of robotic instrumentation, and excessive traction may result in skin flap ischemia and necrosis.[19]

Lai et al described a robot-assisted quadrantectomy via a monoport with RALDH for oncoplastic volumetric filling.[32] Houvenaeghel et al reported concomitant placement of an implant with LD flap, and myocutaneous LD flap with an oblique skin paddle.[33] Robotic harvest of LD flaps has been reported for other types of reconstruction, including turndown flaps for sacral defects, chest wall reconstruction for Poland's syndrome, and free tissue transfer to the scalp and lower extremity.[27,34]

Outcomes

Like other robotic studies, a learning curve in terms of operative time was observed (►**Table 1**). Selber's initial cadaveric feasibility study found an average robot docking time of 23 minutes and LD muscle harvest time of 68 minutes.[26] In Selber's subsequent case series, LD flap harvest time was from 2 hours and 35 minutes for the first patient and 1 hour and 5 minutes for the final patient.[27] Lai et al published a small study in which RALDH was performed on two patients with LD harvest taking 267 minutes in the first case and 90 minutes in the second; the only complication was seroma formation on the back.[25] Chung et al performed RALDH on 12 patients with a mean robot utilization time of 85.8 minutes and docking time of 54.6 minutes; however, both times declined with repeated attempts.[29] Fouarge and Cuylits successfully performed RALDH in five patients with an average LD harvest time of 110 minutes with later procedures taking less time.[34]

Total complication rates for robotic mastectomy followed by RALDF harvest reconstruction differed greatly from study to study, ranging from 0% in two case series to 51.4% in a 35-patient case series (►**Table 2**).[29,34,35] Additional studies found complication rates of 20 and 16.7%.[12,35] For RALDF breast reconstructions, the most common complication was donor site seroma formation. For studies with greater than five patients, seroma formation rates ranged from 0 to 35%; all cases of seroma resolved spontaneously or with repeated needle aspiration.[6,12,13,35] Grade 2 and 3 complications were reported as well including infection with or without implant removal, revisional surgery, implant failure, and capsular contracture.[6,12,13,34,35] No cases of nipple areolar complex or mastectomy flap necrosis were reported. Thermal injuries and partial thickness burns due to fiberoptic lighting and internal electrocautery have been

Table 1 Comparison of surgical time required for robotic-assisted latissimus dorsi harvest (RALDH) harvest alone and with immediate breast reconstruction

Study	Study type			RALDH harvest time			Total reconstruction time	
		Year	*n*	First	Last	Average	RALDH	Open
Selber[26]	Cadaver	2011	10			1:08		
Selber et al[27]	Case series	2012	5	2:35	1:05			
Clemens et al[12]	Retrospective	2014	12	2:35	1:05	1:32		0:58
Chung et al[29]	Case series	2015	12	2:00	0:50	1:26	6:40	
Lai et al[25]	Case series	2018	2	4:27	1:30	2:58		
Lai et al[32]	Case report	2018	1			1:37		
Winocour et al[13]	Retrospective	2020	25				6:28	5:11
Fouarge and Cuylits[34]	Case series	2020	6			1:50		
Houvenaeghel et al[33]	Retrospective	2020	46				5:50	5:20

Note: Total reconstruction includes implant placement, fat grafting, symmetrizing procedures, etc. Time in hours:minutes.

reported[14,36] and may be mitigated by evacuation of hot smoke and placement of cold moist gauze over the skin superficial to the dissection.[31,37]

When comparing RALDH to open LD harvest, one retrospective review found no statistically significant differences in complication rates or hospital length of stay, with longer operative times.[13] More recently, Winocour et al found that RALDH resulted in significantly higher seroma rates and surgical times, although no differences in rates of revision procedures, hematoma, or pain requirements were observed.[13] Houvenaeghel et al found RALDH resulted in lower rates of seroma, bleeding, and infection than open techniques.[33] A longitudinal study assessing complications in RALDH found higher complication rates to be associated with the older Da Vinci Si system as well as inexperience with the robotic system.[6]

Overall, RALDH represents an appropriate alternative technique for pedicled LD flap harvest, providing the benefit of improved aesthetic outcomes with minimal scarring, reduced analgesic requirements, and shorter hospitalizations, with similar or reduced complications compared with the traditional open technique.[12,13,29,34] RALDH may also provide an alternative option for volume replacement in patients undergoing lumpectomy, who would like to avoid oncoplastic reduction or contralateral symmetrizing breast reduction.[32] As a relatively simple procedure with minimal donor site morbidity, studies have shown high levels of patient satisfaction with pedicled LD reconstruction both overall and when compared with other types of autologous reconstruction.[24]

Robotic-Assisted Deep Inferior Epigastric Perforator Flap

The popularity of the DIEP flap for autologous breast reconstruction emerged over the past 20 years, surpassing the previous gold standard transverse rectus abdominal muscle (TRAM) flap for autologous reconstruction.[38] Due to its reliability, bulky nature, and preservation of the abdominal wall, the DIEP flap has largely replaced the TRAM flap for breast reconstruction.[39] While donor site morbidity has been greatly reduced by utilizing the DIEP flap, it still remains to a certain degree. As the DIEP pedicle runs along the undersurface of the rectus muscle, the muscle is split in order to achieve pedicle access, which can damage both the rectus muscle and neurovascular bundles encountered during dissection.[10] Pedicle harvest proceeds with abdominal incisions up to 15 cm in length in order to trace the pedicle to its origin, creating the potential for nerve damage, abdominal wall weakness and/or spasticity, bulging, and herniation.[39]

Numerous studies have shown the benefit of reducing abdominal donor site morbidity by preserving as much muscle and fascia during abdominally based breast reconstruction as possible.[40,41] When investigating factors that contribute to postoperative herniation and abdominal bulging, the degree of fascial sparing has been presumed to be the most important.[42] Hilven et al found a 26% reduction in postoperative neurogenic changes on electromyogram (EMG) for DIEP patients who underwent a limited fascial incision technique of 3 to 4 cm when compared to conventional DIEP patients whose facial incisions measured between 12 and 15 cm on average, suggesting small fascial incisions mitigate the risk of neurogenic rectus injury.[39] The desire to decrease abdominal morbidity in autologous breast reconstruction in addition to the movement toward minimally invasive surgery has inspired alternative techniques for DIEP flap harvest.

Gundlapalli et al was the first to report use of the da Vinci robotic system for submuscular pedicle dissection during DIEP flap harvest in 2018.[9] Further studies reinforced the feasibility and success of robotic submuscular DIEP pedicle dissection and to date include two cadaver studies, four case reports, and four retrospective cohorts.[10,43–50] Robot-assisted DIEP harvest allows pedicle dissection from a novel posterior, intra-abdominal approach. As the pedicle is dissected deep to the rectus muscle surface, the fascial incisions need only be 3 to 4 cm in order to allow delivery of the clipped pedicle once free.[51] In the

Table 2 Comparison of RALDH and open latissimus dorsi harvest complications

Study	Type of study			RALDH complications		Open LD complications	
		Year	*n*	Total		Total	
Selber[26]	Cadaver	2011	10	–		–	
Selber et al[27]	Case series	2012	5	20%	Contralateral radial nerve palsy	–	
Clemens et al[12]	Retrospective	2014	12	16.7%	Seroma (8.3%) Infection (14.1%) Reoperation (8.3%)	37.5%	Seroma (8.9%) Delayed wound healing (7.8%) Reoperation (12.5%) Capsular contracture (4.7%)
Chung et al[29]	Case series	2015	12	0%		–	
Lai et al[25]	Case series	2018	2	0%		–	
Lai et al[32]	Case report	2018	1	100%	Seroma	–	
Winocour et al[13]	Retrospective	2020	25	35%	Seroma (16%)[a] Reoperation (19%)	27%	Reoperation (24%) Hematoma (3%)
Fouarge and Cuylits[34]	Case series	2020	6	17%	Conversion to open Poor port placement	–	
Houvenaeghel et al[33]	Retrospective	2020	46	45%	Clavien–Dindo grade I (30%) Clavien–Dindo grade II (4%) Clavien–Dindo grade III (11%)	62%	Clavien–Dindo grade I (57%) Clavien–Dindo grade II (0%) Clavien–Dindo grade III (3%)

[a]Statistically significant.

traditional approach, the rectus muscle is retracted, and the fascia is incised up to 15 cm to allow for optimal visualization as the pedicle is chased to its origin in a superficial to deep approach. Utilizing a posterior dissection approach, the robot provides optimal visualization to both the pedicle and its origin through three 8-mm ports. Optimal candidates for robotic DIEP harvest are patients with single-dominant or two closely grouped perforators shown on angiography studies preoperatively.[47,52] Robotic DIEP candidates must also have pedicles with short intramuscular courses, with studies reporting anywhere from 2.5 to 5 cm as ideal.[47,52]

Proponents of the laparoscopic approach for minimally invasive DIEP harvest cite cost savings and availability of laparoscopic equipment as the main advantages over robot-assisted DIEP harvest.[41] However, comparative studies on robotic versus laparoscopic DIEP harvest suggest robot employment permits tremor elimination while enhancing operative dexterity, maneuverability, pedicle visualization, and instrument positioning, and angulation.[2,44,53]

Technique

The technique for robot-assisted DIEP pedicle harvest described below reflects that which has been outlined by Egan and Selber,[2] Selber,[51] and Daar et al.[53]

The patient is positioned identical to open DIEP harvest, with placement in a supine position and arms abducted to 90 degrees using arm boards attached to the operating table. DIEP flap elevation then occurs in the standard open fashion. Target perforators are isolated, and perfusion is confirmed via Doppler ultrasound. The fascia is minimally incised (2–4 cm), and intramuscular perforator dissection is completed until the submuscular portion of the pedicle is encountered. The robot is brought into the field and positioned on the ipsilateral side of flap harvest with arms docked across to the contralateral abdomen for unilateral harvest and docked centrally above the umbilicus for bilateral harvest.

The peritoneal cavity is then insufflated to 10 to 15 mm Hg using a Veress needle technique. The camera scope is placed through the insufflation port for direct visualization during subsequent port placement. Three ports are placed directly through the fascia into the contralateral abdomen from the flap site. The most cranial port is placed inferior to the costal margin, in line with the anterior axillary line. The most caudal port is placed superior to the anterosuperior iliac spine, also in line with the anterior axillary line. The middle port is placed directly between the two ports. The camera is then moved to the middle port.

Console visualization of the interior epigastric pedicle on the underside of the rectus muscle is obtained. Monopolar scissors and bipolar graspers are placed into the lateral ports and used to sharply incise the peritoneum. After peritoneal entry, the origin of the pedicle at the external iliac vessels is identified and pedicle dissection ensues, releasing the pedicle from the undersurface of the rectus and continuing until the fascial opening is reached. The pedicle is freed, divided, and removed through the small fascial opening. A clip is used to ligate the origin vessels. Pneumoperitoneum is reduced to 8 to 10 mm Hg for posterior rectus sheath closure. Dissection instruments of the lateral ports are replaced with two needle drivers, which are used to close the posterior rectus sheath with a running barbed suture. The robot is undocked, ports are removed, and port sites are closed. The rest of the case resumes in the standard DIEP reconstruction fashion.[2,51,53]

Alternative Techniques

While cadaveric studies have emphasized supraumbilical port placement, lateral port placement, as is utilized for robotic rectus harvest, was adapted by Selber for robotic DIEP harvest.[43,48,51,53,54] Lateral port placement allows for improved visualization and operative access during pedicle dissection and is gaining favor as the preferred method for robot-assisted DIEP pedicle.[51,53]

Tsai et al have proposed a novel technique for port placement specifically for patients undergoing bilateral robotic DIEP reconstruction.[49] Bilateral ports are placed at the superior edges of the raised DIEP flap, which allows the surgeon to carry out robotic dissections of the bilateral flap pedicles through the same port locations, negating the need for additional incisions. The camera port is placed within the linea alba, 5 cm above the umbilicus, with bilateral working ports placed 10 cm laterally from the camera port. As the port incisions are located within the flap margins, additional scarring is minimized.[49]

Outcomes

Numerous studies have shown the reduced morbidity conferred by minimal fascial incisions (3–4 cm) during abdominally based breast reconstruction.[40,41,55] Utilizing the robot for DIEP pedicle dissection makes a fascial incision length of 3 to 4 cm possible while still maintaining optimal visualization during pedicle dissection. Less traction trauma is sustained by the rectus muscle, and the risk of neurovascular injury during dissection is minimized as the pedicle is dissected in a deep to superficial manner relative to the rectus muscle. By reducing the fascial incision and surgical manipulation of the rectus muscle, abdominal wall morbidity is minimized during DIEP flap reconstruction.

Bishop et al published a case series of 21 patients who successfully underwent robotic DIEP.[10] At the 5-month follow-up, zero patients had developed an abdominal wall hernia or bulge, with one patient reporting minor wound healing delay at the donor site. Five patients underwent bilateral procedures in which one side was performed robotically and one side conventionally. Four of the five bilateral patients reported less postoperative pain on the robotic side.[56]

In a retrospective matched study of 254 patients comparing robotic to conventional DIEP patients, Lee at al found that those undergoing robotic DIEP surgery had significantly decreased postoperative pain, reduced hospital length of stay, and overall higher abdominal physical well-being as indicated by the BREAST-Q.[46] The type of postoperative complications reported, as well as complication rates, were similar between the two groups and included flap loss (1 robotic and 4 conventional), fat necrosis, hematoma, seroma, wound healing issues, and abdominal hernia. Robotic employment in DIEP pedicle dissection increased the operative times by around 69 minutes on average, including the additional time required for robot setup and docking.[46]

Reports of timing for robotic DIEP pedicle harvest range from an average of 35.8 to 86 minutes.[9,43,45,49] Of those currently reported, average dissected pedicle length ranges from 10 to 13 cm.[9,10,53] Tsai et al found a significantly reduced incision length (2.67 ± 1.13 cm) of the anterior rectus sheath in patients undergoing robotic DIEP reconstruction when compared to conventional DIEP patients (8.14 ± 1.69).[49] Additional studies describe similar findings, reporting fascial incisions measuring 1.5 to 4.3 cm.[9,10,46,49]

As more patients undergo robotic DIEP flap harvest, high-powered, long-term follow-up studies are needed to ascertain if robotic DIEP harvest results in reduced rates of postoperative abdominal hernias and bulging when compared to conventional techniques.

Challenges for Robotic-Assisted Breast Reconstruction

One of the most cited drawbacks to robotic-assisted surgery is the amount of time and training required to become proficient at using the platform.[5,14,17,18,25,32] Nearly all authors showed significant reductions in operative time as surgeon familiarity with the robotic operating system grew.[15,26,27,29,36] Fouarge and Cuylits[34] and Houvenaeghel et al[6] found the newer model Da Vinci Xi to curb operative times relative to the older Si model. It is possible that further optimization of the Da Vinci robotic system will continue to close this time gap. Although surgeons have shown that they can get faster with robotic-assisted breast reconstruction with experience and newer robotic platforms, retrospective reviews of studies performed by experienced surgeons have shown that robot utilization results in longer operative times versus open techniques.[12,13] Interestingly, Lai et al found that after 10 to 12 RANSMs, the operation time was equivalent to that of an open NSM.[14]

Cost

Numerous studies remark on the significant cost related to the purchase of a robot, the skills training to use it, and its yearly maintenance fees.[5,14,18,36,57] However, hospitals routinely purchase other forms of durable equipment and the robot should not be viewed any differently from this.[36] Others have observed that increased research is needed to fully understand the price discrepancy incurred by robotic surgery.[14,36] Several authors have suggested that large hospital systems with established robotic surgery programs may incur minimal additional cost by expanding the number of specialties using the system.[18] Increased robotic utilization within these systems may allow for cost sharing for maintenance and bulk pricing, overall improving the return on investment for hospital systems.

Conclusion

Robotic assistance has shown promising results in performing both implant-based and autologous breast reconstructions, including LD muscle flaps and deep inferior epigastric free flaps. These techniques have been shown to be safe and technically feasible methods to minimize scarring and improve aesthetic outcomes in appropriately selected patients. Through improved visualization and surgical maneuverability within the mastectomy pocket, robotic assistance may allow greater precision and improved aesthetic outcomes; however, it comes at the expense of increased cost and operative time compared to open or endoscopic techniques.[4,15,36] Further studies and long-term follow-up are needed to further delineate how the learning curve, long-term costs (including need for revisional procedures), complications, and oncologic safety of robotic surgeries compare to that of open or endoscopic techniques.

Funding
None.

Conflict of Interest
None declared.

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