1000 Consecutive Venous Anastomoses Using the Microvascular Anastomotic Coupler in Breast Reconstruction

Shareef Jandali, M.D.
Liza C. Wu, M.D.
Stephen J. Vega, M.D.
Stephen J. Kovach, M.D.
Joseph M. Serletti, M.D.

Philadelphia, Pa.; and Rochester, N.Y.

Background: Microvascular anastomosis is one of the more critical aspects of free flap surgery. A safe, effective, and expedient method for venous anastomosis minimizes flap ischemia time, is easier on the surgical team, and saves costly operating room time. The authors report on their experience using the Synovis microvascular anastomotic coupling device in 1000 consecutive venous anastomoses in free flap breast reconstruction.

Methods: The authors retrospectively reviewed 1000 consecutive venous anastomoses that were performed using the microvascular anastomotic coupler between July of 2002 and July of 2008. Data were obtained on flap type, recipient vessel, coupler size, incidence of venous thrombosis, timing of venous thrombosis, and morbidity as a result of venous thrombosis.

Results: All anastomoses were performed in an end-to-end fashion. There were 460 unilateral cases and 270 bilateral cases of breast reconstruction. Flap types included muscle-sparing free transverse rectus abdominis myocutaneous, deep inferior epigastric perforator, superficial inferior epigastric artery, superior gluteal artery perforator, and inferior gluteal artery perforator. The vast majority of the recipient vessels were the internal mammary or thoracodorsal vessels. Most of the couplers that were used were either 3 or 2.5 mm in diameter. Overall, there were six instances of venous thrombosis (rate of 0.6 percent). There were no total flap losses due to venous thrombosis in this series, although two patients had partial flap necrosis.

Conclusions: The patency rate for venous anastomoses performed with the microvascular coupler is excellent when compared with standard suture techniques and has the advantage of overall easier application. (*Plast. Reconstr. Surg.* 125: 792, 2010.)

Microvascular anastomosis is one of the more critical aspects of free flap surgery. Most incidences of free flap failure are due to technical problems with the anastomosis and resultant thrombosis of the vessel. Anastomoses, both arterial and venous, have traditionally been hand-sewn using 8-0 or 9-0 permanent suture. In addition, the venous anastomosis has been recognized as being more technically demanding than the arterial anastomosis. Several years ago, a more rapid mechanical connecting device, referred to as the coupler, was introduced as an alternative to the hand-sewn process for venous anastomosis.

The current coupling device was initially manufactured by 3M Healthcare (St. Paul, Minn.) and is currently manufactured by Synovis Micro Companies Alliance, Inc., a subsidiary of Synovis Life Technologies, Inc. (St. Paul, Minn.). The device consists of two disposable rings made of high-density polyethylene, with a series of six to eight (depending on the size of the coupler) stainless steel pins evenly spaced around each ring. The rings are

From the Division of Plastic Surgery, University of Pennsylvania Health System, and the Division of Plastic Surgery, University of Rochester Medical Center.
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manufactured with inner diameters that range in size from 1.0 to 4.0 mm, allowing anastomoses of vessels that are 1.0 to 4.5 mm in diameter.

The device has been used in microvascular breast, head and neck, and extremity surgery, with patency rates apparently comparable to those with conventional hand-sewn suture techniques.[1–10] This device, however, is not universally used by reconstructive microsurgeons. We reviewed our large two-center experience of autologous microvascular breast reconstruction with use of the coupler for venous anastomosis so as to provide additional data on the effectiveness of this technique.

PATIENTS AND METHODS

Hospital records, operative reports, coupler records, and office charts were retrospectively reviewed in 1000 consecutive venous anastomoses that were performed using the microvascular anastomotic coupler between July of 2002 and July of 2008. Beginning in July of 2002, the coupler completely replaced the hand-sewn technique for venous anastomosis. Hand-sewn anastomoses were rarely performed during the study period; almost all of these were veins that had been subjected to previous irradiation and lacked the distensability for coupler application. For this reason, a history of irradiation to the chest was not recorded because this would have caused a selection bias.

The clinical setting was two major teaching medical centers. The procedures were all performed by one of the four senior authors, all experienced microsurgeons. Indications included immediate or delayed breast reconstruction after mastectomy for breast cancer or breast cancer prophylaxis. Data were obtained on flap type, recipient vessel, coupler size, incidence of venous thrombosis, timing of venous thrombosis, and morbidity as a result of venous thrombosis. Statistical analysis was performed using Fisher's exact test, and comparisons were made between the type of flap used and the rate of venous thrombosis.

Coupler Application Process

The recipient and donor vein are occluded with separate vascular clamps and placed in a position close to one another. A vessel-measuring gauge is used to determine the correct coupler size (Fig. 1). The true vessel diameter should be slightly larger than the marked diameter on the measuring device. In other words, if the diameter of the vein is exactly equal to the 3-mm-diameter mark on the measuring device, then the 2.5-mm-diameter coupler should be selected. After the appropriate-sized coupler is selected, first the donor vein, followed by the recipient vein, is attached to its individual coupling component. The ends of the vessels to be anastomosed are pulled through the opposing rings and everted onto the pins. The vessel edge is first everted onto three pins, creating a triangle and evenly anchoring the vessel onto the ring. The vessel is then hooked on the remaining three pins, ensuring that the vessel wall is completely everted and splayed onto the ring (Fig. 2). The vessels are irrigated with heparinized saline, and then the instrument knob is rotated to mate the vessel ends (Fig. 3). Forceps are used to compress the two rings together as they are pushed out of the end of the instrument (Fig. 4). The force of the coupler device may sometimes not be adequate to fully pierce the opposing vessel wall with the pins and ensure a tight apposition of the interlocking pins and rings.

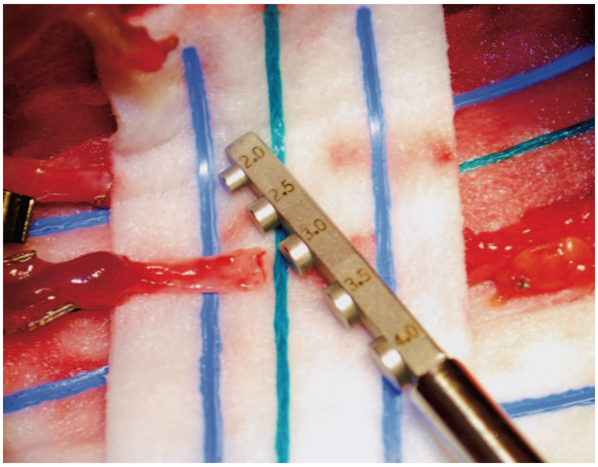

Fig. 1. Vessel measuring gauge.

RESULTS

All patients were women, and follow-up ranged from 1 month to 6 years. There were a total of 460 cases of unilateral breast reconstruction and 270 cases of bilateral breast reconstruction.

Flap types included muscle-sparing free transverse rectus abdominis myocutaneous (TRAM; n = 572, 57.2 percent), deep inferior epigastric perforator (DIEP; n = 305, 30.5 percent), superficial inferior epigastric artery (SIEA; n = 108, 10.8 percent), superior gluteal artery perforator (SGAP; n = 10, 1 percent), and inferior gluteal artery perforator (IGAP; n = 5, 0.5 percent) (Table 1).

Recipient vessels included internal mammary (n = 685, 68.5 percent), thoracodorsal (n = 311,

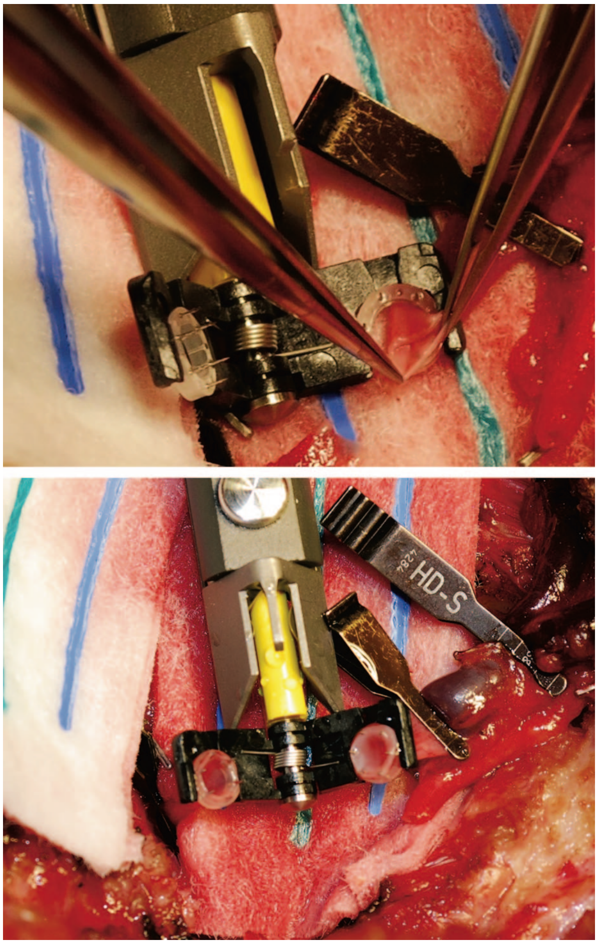

Fig. 2. (*Above* and *below*) Ends of the vessels are pulled through the opposing rings and everted onto the pins.

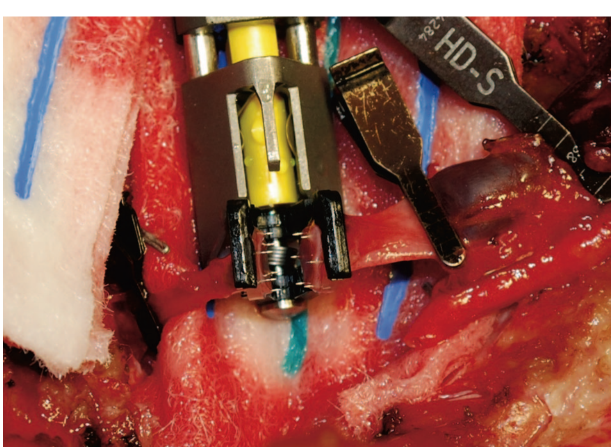

Fig. 3. Coupler knob is rotated to mate vessel ends.

31.1 percent), and lateral thoracic vessels (*n* = 4, 0.4 percent; Table 2). All anastomoses performed with the coupler were end-to-end anastomoses. In cases in which two internal mammary veins were present, the larger of the two veins was always chosen for the anastomosis. In 15 of the free TRAM and DIEP cases, a second vein, usually the superficial inferior epigastric vein, was coupled in addition to the primary venous anastomosis. This was usually done because of intraoperative venous congestion in the flap that was not due to thrombosis of the primary coupled anastomosis but rather a poor inherent venous drainage pattern of the flap. These extra venous anastomoses were not counted in the final numbers shown here, and it should be noted that none of these cases had any instances of venous thrombosis.

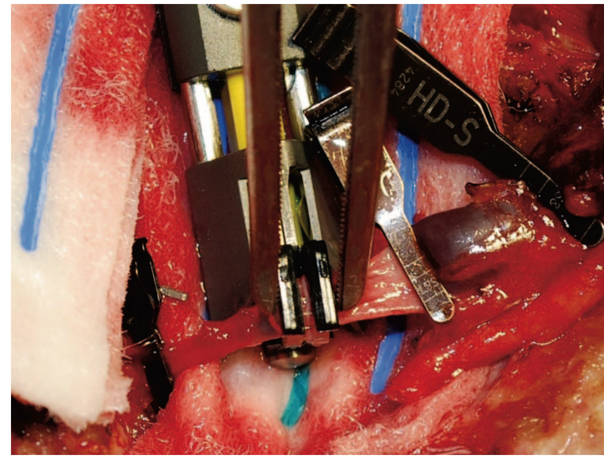

Fig. 4. Forceps are used to ensure a tight apposition of the rings as they are pushed out of the end of the instrument.

Table 1. Flap Type

Flap Type	*n* (%)	Percent Thrombosis
Muscle-sparing free TRAM	572 (57.2)	0.7 (4/572)
DIEP	305 (30.5)	0.3 (1/305)
SIEA	108 (10.8)	0 (0/108)
SGAP	10 (1.0)	0 (0/10)
IGAP	5 (0.5)	20 (1/5)

TRAM, transverse rectus abdominis myocutaneous; DIEP, deep inferior epigastric perforator; SIEA, superficial inferior epigastric artery; SGAP, superior gluteal artery perforator; IGAP, inferior gluteal artery perforator.

Table 2. Recipient Vessel Used

Recipient Vessel	*n* (%)	Percent Thrombosis
Internal mammary	685 (68.5)	0.6 (4/685)
Thoracodorsal	311 (31.1)	0.6 (2/311)
Lateral thoracic	4 (0.4)	0 (0/4)

Coupler sizes that were used included 3.0 mm (*n* = 852, 85.2 percent), 2.5 mm (*n* = 130, 13 percent), 2.0 mm (*n* = 14, 1.4 percent), 3.5 mm (*n* = 2, 0.2 percent), 1.5 mm (*n* = 1, 0.1 percent), and 4.0 mm (*n* = 1, 0.1 percent; Table 3). The

Table 3. Coupler Size Used

Coupler Size	*n* (%)	Percent Thrombosis
3.0 mm	852 (85.2)	0.9 (5/852)
2.5 mm	130 (13.0)	0.8 (1/130)
2.0 mm	14 (1.4)	0 (0/14)
3.5 mm	2 (0.2)	0 (0/2)
1.5 mm	1 (0.1)	0 (0/1)
4.0 mm	1 (0.1)	0 (0/1)

time to perform a coupled anastomosis was measured in 20 consecutive cases near the end of the retrospective review to account for any learning curve in use. The average time to couple the vein was 3 minutes, with a range of 2 to 6 minutes.

There were a total of six instances of venous thrombosis ($n = 6$), which give a rate of thrombosis for coupled venous anastomoses of 0.6 percent. One thrombosis occurred in each year of the retrospective collection period, showing that there was no learning curve to the coupler application process that could have predisposed the anastomosis to thrombosis. Of these six venous thromboses, four were muscle-sparing free TRAM flaps, one was a DIEP flap, and one was an IGAP flap. The first venous thrombosis was intraoperative and the anastomosis was taken down, the thrombus in the vessel was flushed out with heparinized saline, and the anastomosis was redone with a smaller coupler. There were no other thrombotic complications in this patient, and the flap survived completely. The second thrombosis occurred on postoperative day 1, was redone with the same size coupler, and then urokinase was infused through the flap with total flap survival. The third thrombosis occurred on postoperative day 6, was not taken back to the operating room, and resulted in partial flap necrosis. The fourth thrombosis occurred on postoperative day 4, a segment of vein was resected in the operating room, a vein graft was used to bridge the gap (coupled on both ends), and urokinase was infused through the flap. There was complete survival of this flap. The fifth thrombosis occurred late on postoperative day 10, was not taken back to the operating room, and resulted in partial flap necrosis. The sixth thrombosis occurred on postoperative day 1, the revised anastomosis was handsewn, and urokinase was infused, with complete flap survival. The details of the six venous thromboses are listed in Table 4. There were no total flap losses in this series due to venous thrombosis, although two patients did have partial flap loss as described above.

Statistical analysis showed that the comparison between the proportion of TRAM patients with thrombosis and the proportion of non-TRAM patients with thrombosis was not significant ($p = 0.71$). If one compares the TRAM flap with the DIEP flap, there is no significant difference ($p = 0.66$; the proportion of TRAM patients with thrombosis is not significantly different from the proportion of DIEP patients with thrombosis). If one compares the TRAM flap with IGAP flap, there is a significant difference ($p = 0.04$). If one compares the DIEP flap with the IGAP flap, there is also a significant difference ($p = 0.03$). It is important to keep in mind, however, that the significant results may be due to random sampling error. With such small numbers for the IGAP flaps, it is possible that the one case of IGAP with thrombosis of the five inferior gluteal cases was random and that one could sample a large number of patients and not see another inferior gluteal case with thrombosis.

DISCUSSION

The incidence of intraoperative and postoperative thrombosis with traditional sutured microvascular anastomoses has been quoted as high as 10 percent.[1–4] The rate of thrombosis in breast reconstruction is usually on the lower end of this spectrum, with a mean in the 3 percent range and most being venous thromboses.[1,2] The coupler has been routinely and successfully used by a number of surgeons for venous anastomosis in breast, head and neck, and extremity reconstruction, with venous thrombosis ranging from 0 to 3 percent.[5–15,19] The largest previous clinical experience with the

Table 4. List of Coupled Venous Thromboses

Thrombosis No.	Postoperative Day	Flap Type	Comment
1	0	Muscle-sparing free TRAM	Intraoperative thrombosis, redone with smaller coupler, complete flap survival
2	1	Muscle-sparing free TRAM	Redone with same size coupler, complete flap survival
3	6	DIEP	Not redone—partial flap necrosis
4	4	IGAP	Vein graft used and coupled, complete flap survival
5	10	Muscle-sparing free TRAM	Not redone—partial flap necrosis
6	1	Muscle-sparing free TRAM	Revised anastomosis hand-sewn, complete flap survival

TRAM, transverse rectus abdominis myocutaneous; DIEP, deep inferior epigastric perforator; IGAP, inferior gluteal artery perforator.

coupler showed a venous thrombosis rate of 1.4 percent in 139 anastomoses in 139 free flaps.[19] Our study in 1000 consecutive anastomoses now represents the largest clinical series, yielding a low thrombosis rate of 0.6 percent. This compares favorably with the best results reported for hand-sewn venous anastomoses, which was published as 2.8 percent (1.4 percent intraoperative and 1.4 percent postoperative) in a previous study from our group on 500 free TRAM operations.[15]

Many of the potential or theoretical etiologies for thrombosis are minimized with use of the coupler: foreign body suture contacting blood flow, subendothelial collagen exposure from imperfect intima-to-intima contact, and luminal narrowing (the coupler stents the vessel open at the anastomotic site). Basic microsurgical principles still apply in using the coupler: use heparin flush, minimize handling of the vessel wall that could cause intimal damage, evenly distribute the vessel wall on the coupler pins, minimize tension, and avoid twisting or kinking of the pedicle. The venous anastomosis is usually coupled in 3 minutes, compared with the arterial anastomosis, which usually is hand-sewn in about 12 to 20 minutes. Although this may appear as a minimal time savings, the coupler is far easier to perform and is certainly less taxing on the surgeon as compared with performing a hand-sewn venous anastomosis. At present, approximately half of our free flap breast reconstruction patients undergo bilateral immediate reconstruction. This is where the time savings and limited fatigue factor make the coupler the technique of choice. A formal cost analysis was not performed comparing coupled with sutured venous anastomoses, so it is unknown whether there are overall savings when using the coupler.

The two academic centers that contributed to this clinical series have well-established training programs for both plastic surgery residents and reconstructive microsurgery fellows. We have been criticized by some that by using this faster, more effective technique, we are somehow taking away from resident and fellow education with respect to hand-sewn anastomoses. This same argument has been made many times in the past with the introduction of new surgical technologies. Laparoscopic versus open cholescystectomy, the introduction of minimally invasive techniques, and robotic surgery have all been similarly criticized. The coupler technique will likely continue to grow in terms of acceptance and usage, and hence, all surgical educators in this field will have a responsibility to teach this technique to their residents and fellows.

It should be noted that arterial anastomoses are not routinely performed with the anastomotic coupler at our institution. Like others, we have only used the coupler for the arterial anastomosis when the thoracodorsal vessels have been used as the recipient vessels to the flap. The native structure to the artery makes using the coupler device more challenging. The thicker and less distensible arterial walls do not allow for easy placement of the arterial wall onto the coupler pins. A coupler size smaller than the diameter of the artery must be used to overcome these inherent difficulties. Even when using a smaller coupler, intimal tearing and fragmentation have been common. Using a smaller coupler for arterial anastomoses would potentially reduce functional blood flow and could lead to thrombosis. We have used the coupler for the arterial anastomosis on five flaps, with a postoperative thrombosis occurring several hours after surgery in the fifth flap. This was successfully salvaged with repeated hand-sewn anastomosis. In a series by Ahn et al.,[14] there were five intraoperative thromboses of 29 total arterial thromboses early in their series. This was attributed to the same technical difficulties we have mentioned above.[14] Other studies have reported on its successful use for arterial anastomoses in breast and head and neck reconstruction, both with good patency rates.[16,17] Because of the variable patency rates observed by us and others, we have discontinued our use of the coupler for the arterial anastomosis.

We believe this study is an accurate reflection of what other microsurgeons should expect with the use of the coupler for the venous anastomosis in free flap surgery. All four of the participating surgeons are experienced microsurgeons, and this contributed to no observed learning curve with the introduction of this technique. We, almost always, secure the donor vein first as compared with the recipient vein. The length of the donor vein and the ability to position the flap allow for a greater degree in freedom with positioning the donor vein. The recipient vein is usually less mobile. The donor vein is secured first and then the device is moved to the more restricted recipient vein. Because of the greater freedom of the donor vein, there are no issues of tension on the donor vein or flap during this process. If this process was done in reverse, there is the potential for unrecognized tension on the more limited recipient vein while trying to secure the donor vein. The compact size of the coupler makes it useful for anastomoses performed in tight or deep surgical spaces (e.g., the axilla when anastomosing to the thoracodorsal vessels). Immediately after completion of the coupling process, forceps are used to reinforce the engagement of the two rings. This is an important step, as there have been sporadic anecdotal reports of coupler separation in the postoperative period, whereby the pins disengage and the anastomosed vessel ends separate. Although there are a range of coupler sizes available, we have routinely used the 3-mm- and 2.5-mm-diameter devices for the great majority of our free flap breast reconstructions.

Although all of the anastomoses in our series of breast reconstructions were performed in an end-to-end manner, there have been reports of successful use of the coupler in end-to-side venous anastomoses in head and neck reconstruction.[18] We have successfully used the coupler in end-to-side fashion for both head and neck and lower extremity reconstruction. Our experience is too limited to add to this particular patient population, but we have had the same excellent results in these other groups of patients. We would expect end-to-side use, as well as the general use of this device in all forms of free flap surgery, to mimic the results achieved in this study. In addition, although significant venous size discrepancies are rare in autologous breast reconstruction, they occasionally occur, particularly with the SGAP and IGAP flaps. Hand-sewn anastomoses between vessels with significant size mismatch can result in pleating of the larger vessel wall around the perimeter of the smaller vessel with incomplete intimal contact. These significant size mismatches have been considered to have a greater risk of postoperative thrombosis. Because of the secure intima-to-intima contact with the coupler technique, the technical problem of significant caliber mismatch is generally overcome. An example of this can be seen in Figure 5, in which an inferior gluteal vein has been coupled to the internal mammary vein with obvious significant vessel size discrepancy.

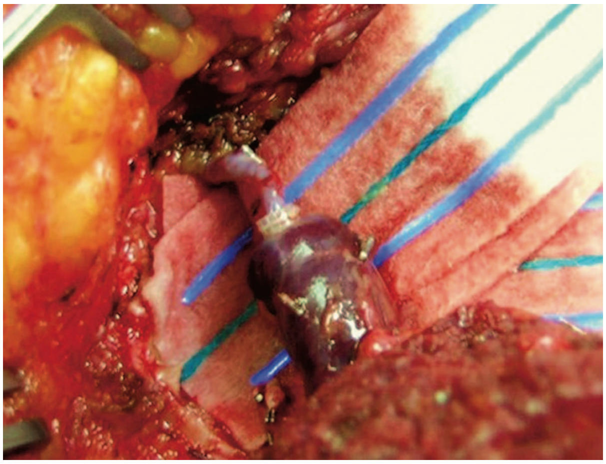

Fig. 5. Inferior gluteal vein coupled to the internal mammary vein with obvious significant vessel size discrepancy.

CONCLUSIONS

When performed carefully by a trained microvascular surgeon, the microvascular anastomotic coupler is an effective, reliable, and fast method for microvascular venous anastomoses. The compact size of the coupler facilitates its use in tight or deep surgical spaces. The availability of multiple coupler sizes allows its use for almost all venous microanastomoses, even when there is significant size discrepancy. Most venous anastomoses can be performed in 3 minutes, which minimizes overall surgical time. Finally, the patency rates for venous anastomoses performed with the microvascular coupler are excellent when compared with standard suture techniques.

Shareef Jandali, M.D.
Division of Plastic Surgery
University of Pennsylvania Health System
3400 Spruce Street
10 Penn Tower
Philadelphia, Pa. 19104
shareef.jandali@uphs.upenn.edu

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