

Applying the Microvascular Anastomotic Coupler Device to End-to-side Venous Anastomosis in Reconstructive Surgery

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Background: Microsurgical vascular anastomosis plays an important role in successful free-tissue transfer. The Microvascular Anastomotic Coupler Device (MACD) aims to simplify anastomosis and decrease the time spent on this step, thereby reducing surgeon stress and improving the overall quality of the surgery, especially when venous end-to-side anastomosis is required. Our comparative retrospective cohort study aimed to determine the effect of this widely used device on anastomosis times and complications in head and neck/esophageal reconstruction cases involving venous end-to-side anastomosis using the internal jugular vein as the recipient vessel.

Methods: All consecutive patients who underwent head and neck/esophageal reconstruction with hand-sewn or MACD-mediated venous end-to-side anastomosis using the internal jugular vein by three experienced microsurgeons in our tertiary-care hospital in 2012–2020 were identified. Venous anastomosis times and venous trouble cases were recorded.

Results: Of the 191 cases, 44 and 147 underwent hand-sewn and MACD-mediated anastomosis respectively. The average venous anastomosis times of these groups were 31 and 11 minutes, respectively. Venous trouble was observed in two hand-sewn (4.5%) and four MACD (2.7%) cases, respectively. Vein twisting and improper coupler placement were the causes in the latter four cases.

Conclusions: This study confirmed that MACD simplifies end-to-side venous anastomosis and reduces the time spent on this procedure. Also, for safer anastomosis, it is necessary to pay attention to preventing twisting and improper coupler placement when using MACD. We believe the MACD can improve the quality of reconstructive surgery. (*Plast Reconstr Surg Glob Open* 2022;10:e4018; doi: 10.1097/GOX.0000000000004018; Published online 14 January 2022.)

INTRODUCTION

To improve patient prognosis and activities of daily living after trauma or malignant tumor resection in the head and neck, breast, trunk, and limb regions, it is necessary to conduct reconstruction surgery via tissue transfer. This surgery involves a number of important steps, namely flap design and elevation, vascular management, microsurgical vascular anastomosis, flap suture, and donor-site closure. Although all of these steps play vital roles in surgical

outcomes, meticulous microsurgical vascular anastomosis is particularly important for the survival of the transferred tissue.¹⁻³

Vascular anastomosis can be very time-consuming and thus can result in operator fatigue, which in turn can lead to inaccurate flap sewing and failure to detect thrombus formation after anastomosis.⁴ A method that shortens the vascular anastomosis procedure would thus help improve outcomes.

The Microvascular Anastomotic Coupler Device (MACD) is produced by GEM Synovis. It was designed to quickly anastomose veins and arteries in the peripheral vascular system that are commonly encountered in microsurgery, specifically those that have an outside diameter

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between 0.8 and 4.3 mm and a wall thickness of 0.5 mm or less. This simple device is suggested to promote intima-to-intima contact without employing sutures, which may decrease the thrombosis rate. It also manages vessel size mismatches. Several studies show that it is safe, convenient and associates with a good postoperative patency rate.⁵⁻⁸

In the present study, we investigated the venous anastomosis times and complications of patients who underwent head and neck or esophageal reconstruction with hand-sewn or MACD-mediated end-to-side anastomosis using the internal jugular vein. A video of one case of anastomosis with MACD is provided.

METHODS

Study Design and Ethics

This retrospective single-center cohort study was conducted in a tertiary referral hospital (Nippon Medical School Hospital, Tokyo, Japan). It adhered to the principles of the Declaration of Helsinki and was approved by the institutional review board of Nippon Medical School Hospital (Approval No. B-2021-403). All patients consented in writing to the possibility that their surgery-related data would be used for research purposes.

Patients, Surgery, and Study Variables

The cohort consisted of all consecutive patients who underwent head and neck or esophageal reconstruction with venous end-to-side anastomosis using the internal jugular vein between 2012 and 2020. Venous anastomosis was conducted either by hand or by using the MACD. Arterial anastomosis was conducted by hand. MACD was introduced in our hospital in October 2013. Thus, the hand-sewn cases in the study cohort consisted of (1) pre-October 2013 cases, (2) cases where the MACD had not been sterilized in time for surgery, and (3) cases where the MACD was being repaired. All surgeries were performed by three experienced microsurgeons. These surgeons used MACD at similar rates during the study period.

The following data were collected from the medical records: patient age and gender; the disease that led to defects requiring reconstruction; venous anastomosis time; and postoperative complications. Postoperative complications were defined with the Clavien-Dindo classification. This classification is graded I (deviations from the normal postoperative course that does not require intervention), II (deviations requiring pharmacological interventions), III (deviations requiring surgical or invasive treatment), IV (life-threatening deviations), and V (death).⁹ In our study, the CD classification was expressed as CDI or CDII and CDIII or higher. The frequency of CDIII or higher cases whose complication was venous trouble that led to flap congestion and salvage surgery was also recorded.

Statistics

In this largely descriptive study, the data were expressed as mean ± SD or n (%). The two groups were compared in terms of venous anastomosis time by Student's *t* test and in

Takeaways

Question: Is there a way to use the Microvascular Anastomotic Coupler Device (MACD) to increase safety and convenience in microsurgical end-to-side venous anastomosis?

Findings: This article describes how to use MACD to anastomosis the flap vein to the internal jugular vein end-to-side. In our method, we made a cross-incision in the recipient vein and carefully placed the coupler so that the anastomosis could be completed safely and easily.

Meaning: When applying MACD to end-to-side anastomosis to large veins such as the internal jugular vein, it is important to use the vein wall on the recipient side without excision, and to pay attention to the placement and twisting of the coupler.

terms of venous trouble rates by chi-squared test. *P* values less than 0.05 were considered to indicate statistical significance. All statistical analyses were conducted with Excel software (Microsoft Corp., Redmond, Wash.).

RESULTS

In total, 191 cases underwent hand-sewn or MACD venous end-to-side anastomosis. Of these, 44 (23%) and 147 (77%) were hand-sewn or involved MACD. The hand-sewn and MACD groups were similar in age and sex distribution. The diseases were similar except the hand-sewn group had fewer hypopharyngeal cancer cases (16% versus 37%) (Table 1).

The hand-sewn cases tended to involve longer venous anastomosis times than the MACD cases (31.5 versus 11.0 min, *P* = 0.011 (Table 1). In this study, hand-sewn was interrupted suture, and all the couplers used in MACD were 3.0 mm in size.

In total, there were 35 complications, namely 10 (23%) in the hand-sewn group and 25 (17%) in the MACD group. There were 11 CDIII or higher complications, namely four (9%) in the hand-sewn group and

Table 1. Demographic and Surgical Characteristics of the 191 Patients

Variable	Hand-sewn	MACD
No. patients	44	147
Age, y	66.1 ± 11.4	66.2 ± 11.1
Male gender	35 (80)	118 (80)
Disease		
Hypopharyngeal cancer	7 (16)	54 (37)
Esophageal cancer	9 (20)	20 (14)
Oral cancer	13 (30)	48 (33)
Laryngeal cancer	4 (9)	9 (6)
Parotid gland cancer	5 (11)	8 (5)
Other	6 (14)	8 (5)
Venous anastomosis time, min	31.5 ± 6.7	11.0 ± 5.0
Postoperative complications		
Total	10 (23)	25 (17)
CDI or II	6 (14)	18 (12)
≥CDIII	4 (9)	7 (5)
Venous trouble	2/4 (4.5)	4/7 (2.7)

The data are expressed as mean ± SD or n (%). CD, Clavien-Dindo classification.

seven (5%) in the MACD group. Of the CDIII or higher complications, six involved venous trouble that led to flap congestion: two and four were in the hand-sewn and MACD groups (4.7% versus 2.5%). Thus, MACD tended to associate with a lower rate of venous trouble ($P=0.027$) (Table 1).

All cases of flap congestion due to venous trouble were reoperated on the same day; the congestion was relieved in all cases. There were two cases of flap necrosis due to arterial trouble in the hand-sewn group. In both cases, flap retransplantation was performed at a later date.

Video Case

A head and neck surgeon conducted pharyngolaryngectomy on a 75-year-old man to treat hypopharyngeal cancer. Because the patient had a history of generalized peritonitis after gastric cancer surgery, it was judged that harvesting the jejunum after opening the abdomen would risk peritonitis. Therefore, a 17×10-cm anterolateral thigh flap was harvested from the thigh and processed into a roll to reconstruct the pharynx. The descending branch of the lateral circumflex femoral artery and vein was secured as the main blood vessel of the flap. The internal jugular vein and superior thyroid artery were selected as the recipient vessels. Vascular anastomosis was performed after pharyngeal and flap anastomosis. Arterial anastomosis was performed by hand sewing using 9-0 nylon. Venous anastomosis was performed by using the MACD (3.0 mm) as shown in Figures 1–5 and Supplemental Video. (See Video [online], which demonstrates how to actually use the MACD (GEM Synovis) to perform the end-to-side anastomosis technique.)

After the vascular anastomosis, a tracheal foramen was created and the surgical wound was closed. The postoperative course was uneventful. Food intake started 10 days after the operation. The patient was discharged 3 weeks after surgery with no complications. The postoperative activities of daily living of the patient were similar to those of other pharyngolaryngectomy patients: Although there was aphonia and caution when taking a bath, the patient did not have any problems with food intake.



Fig. 1. A vessel-measuring gauge was used to determine the correct incision size. A small but crucial incision was then made in the internal jugular vein.

DISCUSSION

Free flap transfer is an important procedure in head and neck reconstruction. Many factors dictate the success of this procedure, including flap selection, vascular anastomosis, the flap-suturing method, various considerations made to ensure tracheal and swallowing functions, and postoperative management^{10–13} Of these factors, microsurgical vascular anastomosis is particularly crucial. However, it should be emphasized here that successful vascular anastomosis does not mean successful surgery: the surgery is successful only if the flap fully restores the lost functions and roles. Because achieving this objective means that the surgeon must consider many variables, the less time spent on vascular anastomosis during surgery, the better.

When transferring free flaps in head and neck reconstruction, the internal jugular vein, the common facial vein, and the external jugular vein are often selected as the recipient vein. The internal jugular vein is particularly favored because of its thickness, which means that there are few limitations in terms of the position of the end-to-side anastomosis. Moreover, the negative respiratory pressure affects the blood flow of the internal jugular vein, which promotes the venous drainage of the flap.^{14–16}

In the method introduced by DeLacure et al.,⁵ “a transverse venotomy without the removal of any vessel wall is performed on the recipient vessel with an 11-blade scalpel or adventitia scissors, to the internal diameter of the implant ring selected.” Moreover, Chernichenko et al⁶ used a method of making a small hole by excising the vein wall and dilating it. On the other hand, the three surgeons involved in this study all treated the veins with the same procedure, and in the case of hand-sewing, a hole was made to match the diameter of the flap vein, the vein wall was partially excised, and the interrupted suture was performed. In the case of MACD use, a cross incision was performed without excising the venous wall so as not to make the venous wall more tense. It was thought that the tension of the vein wall hooked on the pin was reduced in the case of the cross-shaped incision, even when compared with the transverse incision such as the method which was introduced by DeLacure et al. It should be noted that when we use the internal jugular vein as the recipient vein, we incise it three times to create four venous wall flaps. In our experience, four venous wall flaps are sufficient because greater numbers of venous wall flaps require more incisions: for example, six venous wall flaps require five incisions and eight venous wall flaps require six incisions. Because the venous wall contracts every time an incision is made, high numbers of incisions can significantly complicate surgery. Therefore, we routinely create four venous wall flaps.

MACD is used in various reconstructive surgeries and has been confirmed to be safe, convenient and have a good postoperative patency rate.^{5–8,17} Such automatic suturing devices offer a number of advantages, namely, shortened operation time and simplification of the procedure. Indeed, in the present study, which examined surgeries conducted by experienced surgeons, MACD reduced the time required for venous anastomosis by two thirds compared

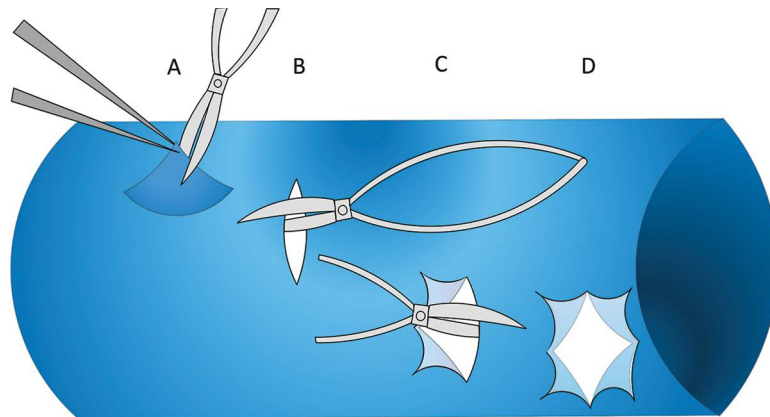


Fig. 2. The schema of preparation of IJV for anastomosis using MACD. Transverse incision in IJV (A). Second incision (B). Third incision (C). The preparation was completed (D).

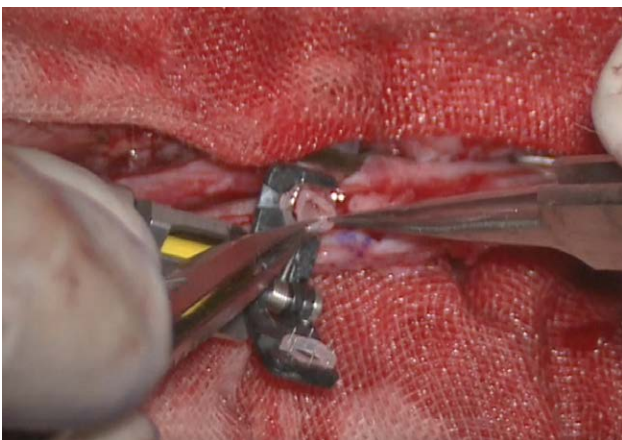


Fig. 3. The flap vein end was mounted on the coupler rings. Care must be taken not to twist the veins.



Fig. 5. After the anastomosis, the vascular clip was released and blood flow was resumed.



Fig. 4. The vein wall on the side of the internal jugular vein was pulled out slowly and carefully so as not to tear the vein. It was then covered with a coupler and the venous lumen was filled with heparin saline.

with hand sewing. In hand sewing, the result is considered to be longer than expected because it includes the time to re-thread and re-sew after removing the suture. Even

in the MACD group, depending on the case, it is considered that the time is slightly extended because it includes the time to discover the twist and reapply after starting to apply the pin. Moreover, we found that it tended to reduce the risk of anastomosed vein complications (4.5% versus 2.7%). These advantages were associated with less stress on the surgeon, as recorded subjectively, which explains why MACD was used for the vast majority of the cases after it was introduced in our hospital in October 2013.

When using MACD, it is important to check for venous twist, proper placement, and caliber differences (Fig. 6). Because the coupler is hard and thick, it cannot alleviate the twist of the vein in the whole vein, which causes the vein to tighten at one point (Fig. 5B). In addition, improper placement of the coupler can block venous blood flow in the flap due to the thickness and hardness of the coupler itself (Fig. 5C).⁴ In fact, the four venous trouble cases in the MACD group in the present study were due to twisting of the vein ($n = 2$) and improper placement of the coupler ($n = 2$). Re-operation of these cases on the same day confirmed that venous blood flow was interrupted. The salvage surgery on the same day resolved these issues. In two twisting cases, the vein on the flap side was ligated and cut, leaving the coupler, and anastomosed to another site.

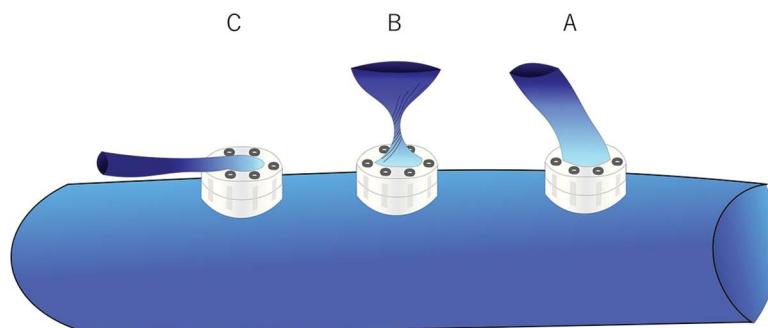


Fig. 6. Successful and unsuccessful cases after anastomosis with the MACD. (A) Successful anastomosis. Problems with blood flow are not observed. (B) A twist case. The blood flow is interrupted and thrombus formation begins. (C) Improper placement of the coupler. The vein of the flap has become crushed by the coupler, thereby interrupting the blood flow.

In the remaining two cases, there was a problem with the placement of the flap, and the veins were crushed; so it was easily resolved by devising the placement of the flap (fixing with a suture). It seemed necessary to consider the anastomosis in consideration of the postoperative position.

The third point that surgeons should watch out for is caliber differences. If this difference is large, wrinkles will form on the wall of the larger caliber vein, which causes turbulence. Both the wrinkles and turbulence of the blood flow can increase the risk of venous thrombosis. This problem is readily solved when end-to-side anastomosis is conducted with the internal jugular vein because the diameter can be adjusted on the internal jugular vein side. In this study, all the couplers used in MACD were 3.0 mm in size. This is because the maximum size of the coupler used in our hospital is 3.0 mm, the flap vein can be used in a sufficiently thick part, and the coupler can be selected independently of the recipient vein. It should be noted that because veins have poor craniocaudal extension, the vascular clip should be sufficiently separated from the anastomotic site.

Thus, once the surgeon has become accustomed to using the MACD, it greatly accelerates and simplifies end-to-side anastomosis, thereby reducing the burden on the operator during head and neck reconstruction. Understanding the pitfalls and understanding the benefits of this method may improve the quality of surgery.

Although we focused on head and neck/esophageal reconstruction using the internal jugular vein in the current study, we believe that the MACD can also be safely used for other procedures if there is a vein that is sufficiently thick compared with the coupler size. The need for a sufficiently thick vein reflects the fact that the vein wall on the recipient side must be pulled so that it can be placed into the coupler with enough of a margin that the operation does not interrupt the blood flow in the vein. Thus, along with being useful in head and neck reconstruction, the MACD may also be suitable for reconstructive surgery using major veins such as the brachial vein, subclavian vein, and femoral vein.

CONCLUSIONS

MACD reduced the anastomosis time in head and neck/esophageal reconstruction by two thirds and tended to associate with fewer venous troubles. If MACD is used carefully, with particular attention to preventing twisting and improper coupler placement, it can greatly shorten the operation time and improve the quality of surgery.

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