Horizontal mattress technique for anastomosis of size-mismatched vessels

Andrei Odobescu MD[1], Sami P Moubayed MD[2], Eugene Daniels PhD[3], Michel Alain Danino MD PhD[1]

A Odobescu, SP Moubayed, E Daniels, MA Danino. Horizontal mattress technique for anastomosis of size-mismatched vessels. Plast Surg 2015;23(2):100-102.

OBJECTIVE: To evaluate the horizontal mattress technique in microvascular anastomosis for size-mismatched vessels.
METHODS: The present study involved cadaveric simulation using size-mismatched (1.5:1) Thiel-embalmed cadaveric arteries. The authors performed horizontal mattress anastomoses using 9-0 nylon suture and recorded the procedure. Vessel patency was evaluated by saline infusion. Vessels were cut open and photographed; histological slides were prepared and stained with hematoxylin and eosin.
RESULTS: Four anastomoses were performed. Vessels were found to be patent in all cases, with grade 0 leaks. Intima-on-intima apposition with no intraluminal exposure of muscularis nor adventitia were observed.
CONCLUSION: The present cadaveric study supports the technical feasibility of using horizontal mattress sutures in size-mismatched end-to-end anastomoses.

Key Words: *Horizontal mattress; Microvascular; Mismatch; Thiel*

La technique de suture matelassée horizontale pour l'anastomose d'artères de différentes dimensions

OBJECTIF : Évaluer la technique de suture matelassée horizontale pour l'anastomose microvasculaire de vaisseaux de différentes dimensions.
MÉTHODOLOGIE : La présente étude par simulation cadavérique portait sur des artères cadavériques de différentes dimensions (1,5:1), embaumées selon la méthode de Thiel. Les auteurs ont effectué des anastomoses par suture matelassée horizontale au moyen d'un fil de nylon 9-0 et ont vidéo-enregistré l'intervention. Ils ont évalué la perméabilité des vaisseaux au moyen d'une infusion de solution saline. Ils ont ouvert et photographié les vaisseaux et préparé des lames histologiques qu'ils ont colorées à l'hématoxyline et à l'éosine.
RÉSULTATS : Quatre anastomoses ont été effectuées. Dans tous les cas, les vaisseaux étaient perméables et les fuites, de grade 0. Les chercheurs ont observé une apposition intima-sur-intima sans exposition intraluminale de la musculeuse ou de la séreuse.
CONCLUSION : La présente étude cadavérique corrobore la faisabilité technique des sutures matelassées horizontales pour les anastomoses termino-terminales d'artères de dimensions différentes.

The patency of the microvascular anastomosis is paramount for flap survival in microsurgery (1). In addition to endothelial dysfunction and hypercoagulability, flow turbulence is an essential part of Virchow's triad and must be minimized to prevent anastomotic thrombosis (2). Unfortunately, microsurgeons occasionally encounter cases in which mismatched vessels must be anastomosed, which is a situation at high risk for flow turbulence and thrombosis (1).

Mismatch, defined as a vessel diameter ratio of ≥1.5:1, is typically encountered in 33% of arterial and 50% of venous anastomoses (3). Multiple, technically demanding techniques to overcome this problem have been described including coupling devices, forced dilation of the smaller vessel, oblique cuts, fish-mouth incisions, end-to-side anastomoses and interpositional grafts (1).

We describe a simple technique using horizontal mattress (HM) sutures based on our previously published work in size-appropriate arteries (4). We believe this can overcome the problem of size mismatched arteries without excessive manipulation of the vessels in an end-to-end fashion.

METHODS

An experimental study using size-mismatched (1.5:1) Thiel-embalmed cadaveric arteries (5) was conducted. The operating model has been described in previously (4).

Specimen preparation

Eight arterial sections measuring 3 cm each were prepared using radial and ulnar arteries to achieve a total of four microvascular anastomoses. The radial arteries had a diameter of 3 mm and the ulnar arteries had a diameter of 2 mm. The vessels were irrigated with physiological saline solution. The operating microscope used for all anastomoses was at 10× magnification. To perform the anastomoses, the operator initially dissected the surrounding connective tissue from the vessel.

Surgical technique

The HM technique for end-to-end anastomosis has been previously described by the authors (4). In the case of size-mismatched anastomoses, the technique is similar, with the exception of the variable pitch from one side of the vessel to the other. Any overhanging adventitia was carefully cleaned; however, a complete adventicectomy was not performed. Approximator clamps were not necessary. Using a 9-0 nylon suture, the authors started with a backhand pass of the HM suture on the larger vessel and returned with the forehand pass. The difference from the technique used on similar size vessels is the calculation of pitch, which must be proportional to the size of the vessel. Care was taken to always visualize the intraluminal side of the vessel, ensuring that full-thickness bites were taken. The tension of the knot was adjusted to provide the optimal amount of eversion at the anastomosis site. The vessel was then flipped and a corresponding suture was placed diametrically opposed. On either side of these orientation sutures, the interval was filled with another mattress suture, resulting in sutures oriented at 90° from one another. The technique is schematically represented in Figure 1 and can be viewed in Video 1. In the smaller calibre vessel, the bite on the smaller side was proportionally narrower than on the larger side. The appearance of the anastomosis can be observed in Figure 2.

Measurement of outcomes

The anastomosis procedures were video recorded. Leakage was assessed using direct microscopic evaluation by injecting physiological saline into the anastomosis set-up. The leaks were graded as 0 in the case of no leak, 1 for minor leak/oozing and 2 representing severe leaks.

Finally, the specimens were examined for eversion at the anastomosis site using light and scanning electron microscopy. The specimens were opened in between two sutures and unrolled to expose the intraluminal side. Two specimens were prepared for scanning electron microscopy and two were prepared for light microscopy.

[1]*Plastic and Reconstructive Surgery Service;* [2]*Otolaryngology-Head and Neck Surgery Service, Notre-Dame Hospital, University of Montréal Hospital Center (CHUM);* [3]*Department of Anatomy, McGill University, Montreal, Quebec*
Correspondence: Dr Michel Alain Danino, Plastic Surgery Department, Centre Hospitalier Universite de Montreal, 1560 rue de sherbrooke est, Montreal, Quebec H2L 4M1. Telephone 514-890-8000 ext 26808, e-mail daninoalain@gmail.com

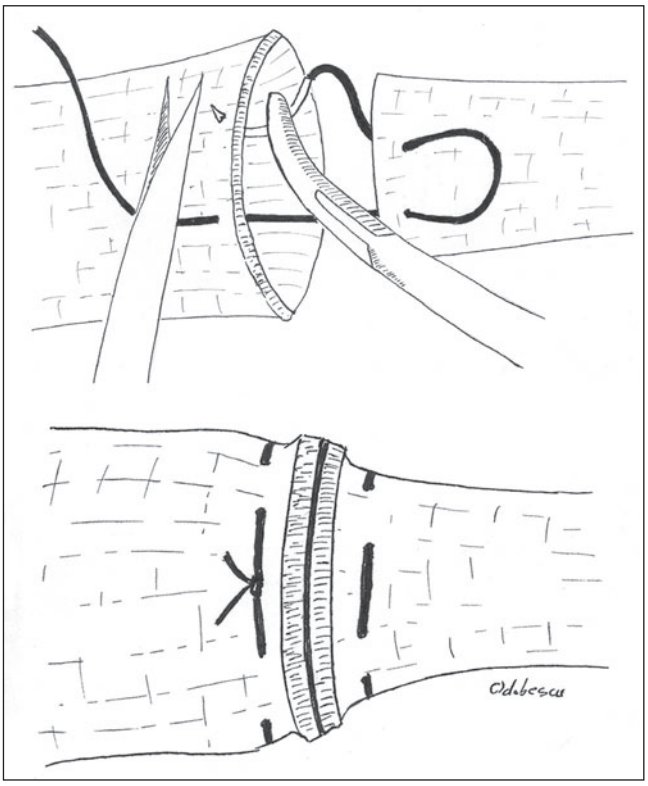

Figure 1) *Illustration of the technique used for size-mismatched vessel anastomosis*

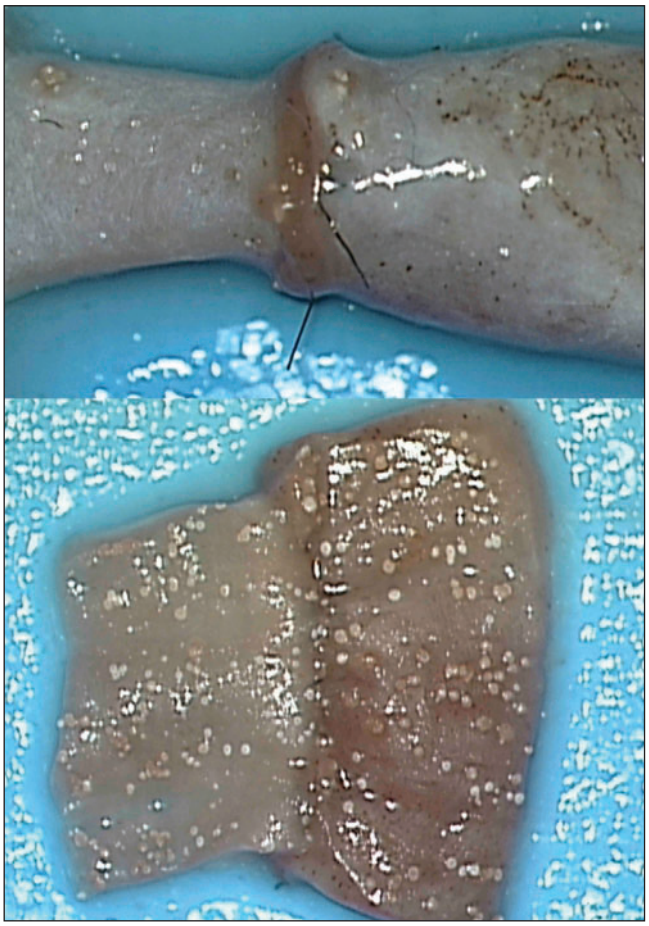

Figure 2) *Appearance of anastomosis showing a funnelled out smaller vessel that meets a cinched-down larger vessel* (**top panel**). *Intraluminal appearance after opening of the vessel showing good intimal apposition and no foreign material in the lumen* (**bottom panel**)

The specimens were fixed in 2% gluteraldehyde in a 0.1 M sodium cacodylate solution at pH 7.3. These specimens were then kept at 4°C. Subsequently, a 20 min dehydration period at room temperature was allowed before gold coating using a pulveriser (Manual Sputter Coater, Agar Scientific, United Kingdom). A scanning electron microscope (ESEM Quanta 200 FEG, FEI Company, USA) equipped with an EDAX detector (EDX, USA) for microanalysis was used. The observations were performed at 20 kV and a working distance of approximately 5 mm. XT Docu imaging software (Soft Imaging System GmbH, Germany) was used to analyze the images.

For light microscopy, the specimens were fixed in formaldehyde solution, embedded in paraffin and stained for microscopy with hematoxylin and eosin in a clinical pathology laboratory following a standard protocol.

RESULTS

Following the completion of the anastomosis, the vessels were tested by infusion of saline and were found to be patent in all cases, with grade 0 leaks.

External and intraluminal appearance of the anastomoses were evaluated (Figure 2). Intima-on-intima apposition with no intraluminal exposure of muscularis nor adventitia were observed. Microscopic evaluation was performed using light and electron microscopy, as shown in Figure 3, which revealed perfect eversion and intimal apposition.

DISCUSSION

We have demonstrated the technical feasibility of anastomosing size-mismatched arteries in an end-to-end fashion using our simple HM technique, with an absence of leaks, and perfect eversion and intimal apposition.

Microvascular anastomoses of size-mismatched vessels poses a challenge in itself. While most microsurgeons try to avoid working with size-mismatched vessels, by their choice of recipient vessel and the vascular flap pedicle that corresponds in size, this luxury is not always possible. In these instances, one needs to adapt and make use of the vessels available. Various techniques have been described to address mismatch. However, forced dilation of a vessel to >1.5 times its size can cause endothelial damage, with an associated failure rate as high as 80% reported for vessels with a size discrepancy of 1:2 (6). End-to-side anastomosis can overcome this problem, although it creates turbulence and increases flap failure rates (3,7). Interpositional vein grafting is another option, although it involves two anastomoses, which increases the risk for thrombosis (8). Other techniques have been described (9) including fish-mouth incision, oblique section, differential suture bites, wedge excision of the larger vessel and vessel invagination; however, these are more technically demanding and none have emerged as the gold standard.

The HM suture for microanastomosis has been previously described in two in vivo studies (10,11). For size-mismatched vessels, it was previously described by De Lorenzi et al (12) in a series of 190 microvascular reconstructions using HM stitches, with a 5% failure rate; however, hematoxylin and eosin images were not presented. The authors suggest that an alternative technique be used for size discrepancies >3:1 such as end-to-side or Y-shaped anastomoses. Despite this large series with a low failure rate, this technique has not been further investigated in other studies. Our results confirm the technical feasibility of this anastomosis technique.

The disadvantages of not being able to evaluate thrombosis rates and flap survival are inherent in cadaveric models. However, we believe that the specific advantages of this particular ex vivo model can be used in a variety of settings such as the evaluation of the effect of a new suture (the HM suture in our case) on the vessel wall. A possible

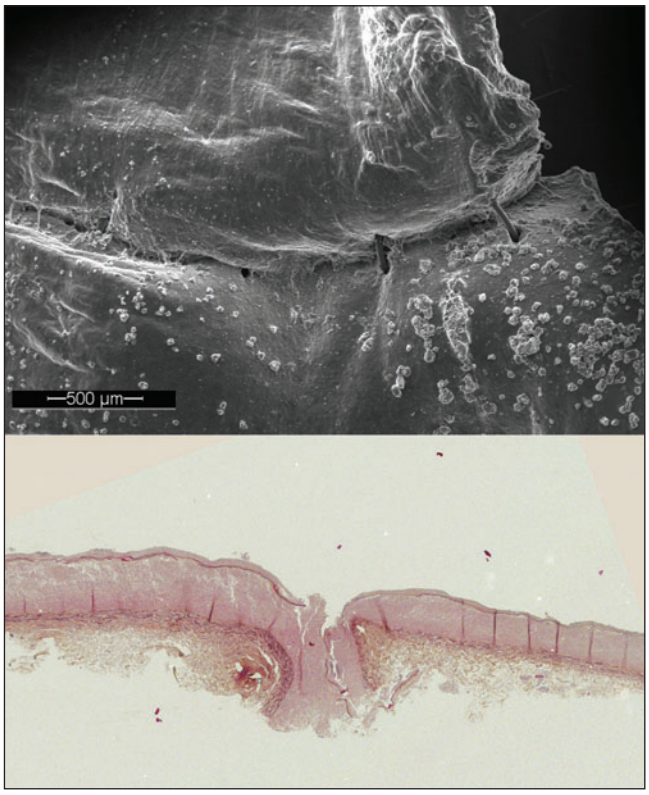

Figure 3) *Scanning electron micrograph* (**top panel**) *and hematoxylin and eosin staining* (**bottom panel**) *of two size-mismatched vessels. Note the tight intimal apposition, good eversion and distribution of excess tissue on the larger vessel*

clinical limitation of the HM technique is related to the reduced lumen at the anastomosis site. We have previously reported this finding in anastomoses of vessels of equal size (4). While a reduction in lumen size may appear to be problematic, the HM technique provides superior architecture at the anastomosis site, with circumferential eversion of the vessel wall and intima-on-intima apposition.

The present study provides an alternative method to addressing size mismatch between donor and recipient vessels by means of the HM technique in a cadaveric model. This technique results in an even distribution of the excess tissue around the entire circumference of the anastomosis, funnelling out the smaller vessel and cinching down the larger vessel to create a smooth transition (Figure 2). The challenge in performing a size-mismatch anastomosis is the even distribution of the excess around the entire circumference. Taking the example of anastomosis of a 3 mm vessel with a 2 mm vessel, and considering that eight simple interrupted sutures will be used, even distribution of the sutures around both vessels would imply a pitch of 1.2 mm in between sutures on the 3 mm vessel and 0.8 mm on the 2 mm vessel. If the proportions are not perfectly respected, the anastomosis will not be even.

While the initial description of this technique involved three HM sutures distributed at 12° from one another along the circumference of the vessel (4), vessels can be sutured with four such sutures oriented at 90° from one another as shown in Video 1. Additionally, single HM sutures can be used in conventional anastomoses to manage excess tissue that occasionally collects on the larger vessel. The use of such individual sutures has been used by the senior author with success for many years.

ACKNOWLEDGMENTS: The authors thank Dr Olga Gologan for help with histological specimen preparation. Dr Odobescu receives funding from the Quebec Health Research Fund (FRSQ) in the form of a PhD scholarship (ref # 25926).

DISCLOSURES: The authors have no financial disclosures or conflicts of intetrest to declare.

REFERENCES

1. Turker T, Tsai TM, Thirkannad S. Size discrepancy in vessels during microvascular anastomosis: Two techniques to overcome this problem. Hand Surg 2012;17:413-7.
2. Harris JR, Seikaly H, Calhoun K, Daugherty E. Effect of diameter of microvascular interposition vein grafts on vessel patency and free flap survival in the rat model. J Otolaryngolo 1999;28:152-7.
3. Cakir B, Akan M, Akoz T. [The management of size discrepancies in microvascular anastomoses]. Acta Orthopaed Traumatol Turcica 2003;37:379-85.
4. Odobescu A, Moubayed SP, Harris PG, Bou-Merhi J, Daniels E, Danino MA. A new microsurgical research model using Thiel-embalmed arteries and comparison of two suture techniques. J Plast Reconstr Aesthet Surg 2014;67:389-95.
5. Thiel W. [The preservation of the whole corpse with natural color]. Ann Anatomy 1992;174:185-95.
6. Monsivais JJ. Microvascular grafts: Effect of diameter discrepancy on patency rates. Microsurgery 1990;11:285-7.
7. Lopez-Monjardin H, de la Pena-Salcedo JA. Techniques for management of size discrepancies in microvascular anastomosis. Microsurgery 2000;20:162-6.
8. Jones NF, Johnson JT, Shestak KC, Myers EN, Swartz WM. Microsurgical reconstruction of the head and neck: Interdisciplinary collaboration between head and neck surgeons and plastic surgeons in 305 cases. Ann Plast Surg 1996;36:37-43.
9. Rickard RF, McPhaden AR, Hudson DA. Healing of two microarterial anastomoses with diameter mismatch. J Surgical Res 2014;191:239-49 e3.
10. Orak I, Guneren E, Yildiz L. A new technique for microvascular anastomosis: Eversion with 3 horizontal mattress sutures. Ann Plast Surg 2006;57:80-3.
11. Turan T, Ozcelik D, Kuran I, et al. Eversion with four sutures: An easy, fast, and reliable technique for microvascular anastomosis. Plast Reconstruct Surg 2001;107:463-70.
12. De Lorenzi F, van der Hulst R, Boeckx W. Interrupted micro-mattress sutures solve vessel-size discrepancy. J Reconstr Microsurg 2005;25:125-30.