Surgical Neurology International

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Original Article

Microvascular anastomosis at 30–50× magnifications (super-microvascular anastomosis) in neurosurgery

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Received: 12 November 10 Accepted: 16 November 10 Published: 24 January 11

Surg Neurol Int 2011, 2:6

This article is available from: http://www.surgicalneurologyint.com/content/1/2/6

This article may be cited as:
Matsumura N, Hayashi N, Kamiyama H, Kubo M, Shibata T, Okamoto S, *et al.* Microvascular anastomosis at 30–50× magnifications (super-microvascular anastomosis) in neurosurgery Surg Neurol Int 2011;2:6

Available FREE in open access from: http://www.surgicalneurologyint.com/text.asp? 2011/1/2/76143

Abstract

Background: We report a safe and precise technique of microvascular anastomosis at higher magnifications (30 – 50 ×) in neurosurgery and evaluate our experiences to examine the utility of this method for cerebral revascularization in various situations.

Methods: A retrospective review was carried out of patients who underwent microvascular anastomosis using a high-magnified operating microscope. This method was performed in 30 patients with 35 microvascular anastomoses in various situations. This microscope has two optical systems, a standard zooming system and a newly developed high magnification system. High resolution and good depth of focus are achieved by a new lens design in the optical system, which makes the image of the object very clear at higher magnifications. In this operating microscope, the combination of a 10 × eyepiece and the 200, 250, and 300-mm objective lens enables a range of final magnifications from 2.9 × to 50.4 ×.

Results: This method enabled one to pay attention to performing atraumatic manipulations of small vessels and correct suturing, intima-to-intima, of vessel walls. Microvascular anastomoses were performed safely and precisely at higher magnifications. All anastomoses were patent.

Conclusion: It is obvious that practical final magnifications of more than 30 × in neurosurgery would be super-magnified operative views. Microvascular anastomosis at 30 – 50 × magnifications (super-microvascular anastomosis) can help neurosurgeons to improve their skills, with good visualization, and to be safe and accurate when conducting cerebral revascularization in various situations.

Key words: Cerebral aneurysm, Cerebral revascularization, Microvascular anastomosis, Moyamoya disese, Operating microscope

Access this article online

Website: www.surgicalneurologyint.com

DOI: 10.4103/2152-7806.76143

Quick Response Code:

INTRODUCTION

Microvascular surgery has required techniques for suturing or anastomosing small vessels with diameters of less than 2.0 mm using an operating microscope. Microvascular anastomosis in neurosurgery has been an effective and essential technique in the treatment of symptomatic, hemodynamic, cerebrovascular occlusive diseases, moyamoya diseases, and complex cerebral aneurysms.[1,2,5,14,16] Yaşargil performed the first successful superficial temporal artery (STA)–middle cerebral artery (MCA) anastomosis in 1967.[17] STA-MCA anastomosis is usually performed as an arterial anastomosis about 1.0 – 2.0 mm in diameter at 10 - 16 ×. A standard operating microscope in neurosurgery now utilizes a 10 × eyepiece, objective lenses of focal lengths 200 to 500 mm, and a range of final magnification from 1.5 × to 17.0 ×. The highest combination of a 12.5 × eyepiece and a 200-mm objective has enabled the final magnification of 21 × (from a catalog of manufacturers). Appropriate observation and manipulation at high magnifications are of paramount importance, and optimal organization of the operative field is required.[15,17] It is obvious that practical final magnifications of more than 30 × will be super-magnified operative views.

Here, we report a safe and precise technique of microvascular anastomosis at higher magnifications (30 – 50 ×) (super-microvascular anastomosis) in neurosurgery, and evaluate our experiences to examine the utility of this method for cerebral revascularization in various situations.

MATERIALS AND METHODS

Thirty patients, 21 males and 9 females aged 16 to 77 years (mean 61.1 years), were treated for symptomatic

Table 1: A summary of the clinical characteristics of cases

Case No.	Age (yrs) / Sex	Diagnosis		Surgery (anastomosis)	Patency	Complication
1	62 / F	CI	rt MCA occlusion	STA-MCA	Good	None
2	50 / M	CI	lt MCA occlusion	STA-MCA	Good	None
3	57 / M	CI	lt MCA stenosis	STA-MCA	Good	None
4	16 / M	CI	Moyamoya disease	STA-MCA double + EMS	Good	None
5	69 / M	CI	rt MCA occlusion	STA-MCA	Good	None
6	75 / M	CI	lt MCA occlusion	STA-MCA	Good	None
7	73 / M	CI	rt neck IC occlusion	STA-MCA	Good	None
8	74 / M	CI	lt neck IC occlusion	STA-MCA	Good	None
9	77 / M	CI	rt MCA stenosis	STA-MCA	Good	None
10	57 / M	CI	lt MCA occlusion	STA-MCA + OA-MCA	Good	None
11	74 / M	CI	lt IC (C4) stenosis	STA-MCA	Good	None
12	61 / M	CI	lt MCA occlusion	STA-MCA	Good	None
13	46 / F	AN	lt IC large AN	STA-MCA double + IC ligation	Good	None
14	76 / M	TIA	lt neck IC occlusion	STA-MCA	Good	Hyperperfusion synd.
15	68 / F	ICH	Moyamoya disease	STA-MCA double	Good	None
16	77 / F	CI	rt neck IC occlusion	STA-MCA	Good	None
17	64 / M	CI	lt neck IC occlusion	STA-MCA	Good	None
18	62 / F	AN	lt IC large AN	STA-MCA + trapping	Good	None
19	50 / M	CI	lt neck IC occlusion	STA-MCA	Good	None
20	77 / M	TIA	lt neck IC occlusion	STA-MCA	Good	None
21	69 / F	CI	lt MCA occlusion	STA-MCA	Good	None
22	60 / F	TIA	rt MCA stenosis	STA-MCA	Good	None
23	72 / M	CI	rt MCA stenosis	STA-MCA	Good	None
24	62 / F	CI	lt MCA occlusion	STA-MCA	Good	None
25	47 / M	CI	rt neck IC occlusion	STA-MCA	Good	None
26	36 / M	TIA	Moyamoya disease	STA-MCA	Good	None
27	57 / M	AN	rt IC large AN	STA-MCA double + trapping	Good	None
28	60 / M	CI	lt neck IC occlusion	STA-MCA	Good	None
29	53 / M	CI	lt MCA stenosis	STA-MCA	Good	None
30	53 / F	SAH	rt PICA fusiform AN	OA-PICA + trapping	Good	None

CI: cerebral infarction, TIA: transient ischemic attack, AN: cerebral aneurysm, ICH: intracerebral hemorrhage, SAH: subarachnoid hemorrhage, MCA: middle cerebral artery, IC: internal carotid artery, STA: superficial temporal artery, OA: occipital artery, PICA: posterior inferior cerebellar artery, EMS: encephalomyosynagiosis

hemodynamic cerebrovascular occlusive diseases (23 cases), moyamoya diseases (three cases), and complex cerebral aneurysms (four cases), with 35 microvascular anastomoses at higher magnifications between November 2007 and August 2010. A retrospective review of these patients who underwent microvascular anastomosis was performed. The clinical characteristics of these patients are summarized in Table 1.

A novel high-magnified stereoscopic operating microscope with 50 × as the maximum magnifying power [Figure 1], Mitaka MM50 Surgical Microscope (Mitaka Kohoki Co., Ltd., Mitaka-shi, Tokyo, Japan), was used in this study. This microscope had two optical systems, a standard zooming system and a newly developed high magnification system, with a magnification changer in a binocular monoscope. Two object lens systems of fixed working distance were 200 and 250 mm. A novel working distance of 300 mm for neurosurgery was produced in this study. The eyepiece was 10 ×. The zoom ratio of the microscope was 1 : 8. The microscope had a 300-xenon light source and a foot pedal for hands-free operation. The microscope stand had the ability to stop until three cycles against an external impact. The combination of a 10 × eyepiece and the 200 mm objective lens enabled a range of final magnification from 4.4 × to 35.2 × and 50.2 × by changing the high magnification system. The 250 mm objective lens enabled a range of final magnification from 3.5 × to 28.2 × and 40.3 ×. Subsequently, the 300 mm objective lens enabled a range of final magnification from 2.9 × to 23.5 × and 33.6 ×. The objective lens had to be exchanged before an operation. The resolution and depth of focus for this new lens design was very high and good (distinctiveness of 7 - 8 μm and depth of 1.0 mm at 50 ×).

The usual surgical procedures and instruments in microvascular anastomosis were employed. The magnification could be altered to match the requirements as necessary. Microvascular suturing and anastomosing were performed at higher magnifications in point for a particular situation. After microvascular anastomosis was completed, the patency of the anastomosis was evaluated by intraoperative direct observation at higher magnifications and with a postoperative cerebral angiogram.

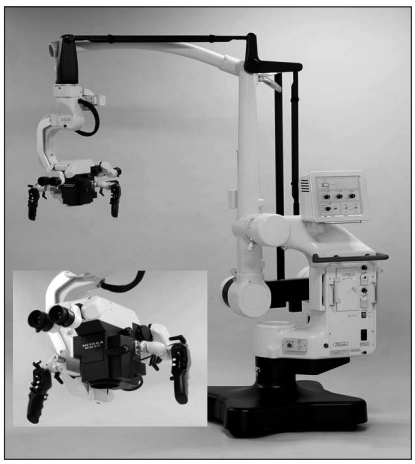

Figure 1: A photograh of a novel high-magnified operating microscope (Mitaka MM50 Surgical Microscope) and the head of this microscope

RESULTS

In our case series, 33 STA-MCA anastomoses, one occipital artery (OA)-MCA anastomosis and one OA-posterior inferior cerebellar artery anastomosis were performed. Microvascular anastomoses, in which the recipient cortical arteries were 0.5 to 1.8 mm in diameter, were performed using 10-0 or 11-0 monofilament nylon at higher magnifications. This enabled one to pay attention to performing atraumatic manipulations of small vessels and correct suturing, intima-to-intima, of vessel walls. In microvascular anastomosis, a high magnification system was used for observing the wall of the donor artery after cutting, incising of the recipient artery with microscissors after clamping, passing of a micro-needle through the vessel wall, checking the knot and cutting the suture after knotting, and observing the patency of the anastomosis in the surface and deep surgical fields. High resolution and good depth of focus were achieved by a new lens design in the optical system, which made the image of the object very clear at higher magnifications. The working space, the size of the field of vision, and the illumination of the operative fields were also suitable for small objects at higher magnifications.

The recipient cortical artery (less than 1.0 mm in diameter), such as a larger vessel of STA-MCA anastomosis, was visualized and manipulated precisely (Case 13) [Figure 2a-c]. In Case 10, cerebral angiography demonstrated that STA as the donor artery was of inadequate diameter in the cerebral angiogram. Next, OA-MCA anastomosis was performed. The distal cortical artery of the angular artery, as the recipient artery, was 0.5 mm in diameter. This microvascular anastomosis was also effective, and could be performed at higher magnifications [Figure 3a-d].

Postoperative angiograms revealed good patency of all anastomoses and patients had no complications in this procedure (but there was one hyperperfusion syndrome).

DISCUSSION

The cortical artery (M4 segment) of the middle cerebral artery was often selected as the recipient cortical artery for less invasive approaches.[3,6,12] In an anatomical study, nearly two-thirds of the recipient cortical arteries of the M4 segment of the middle cerebral artery were 1.5 mm

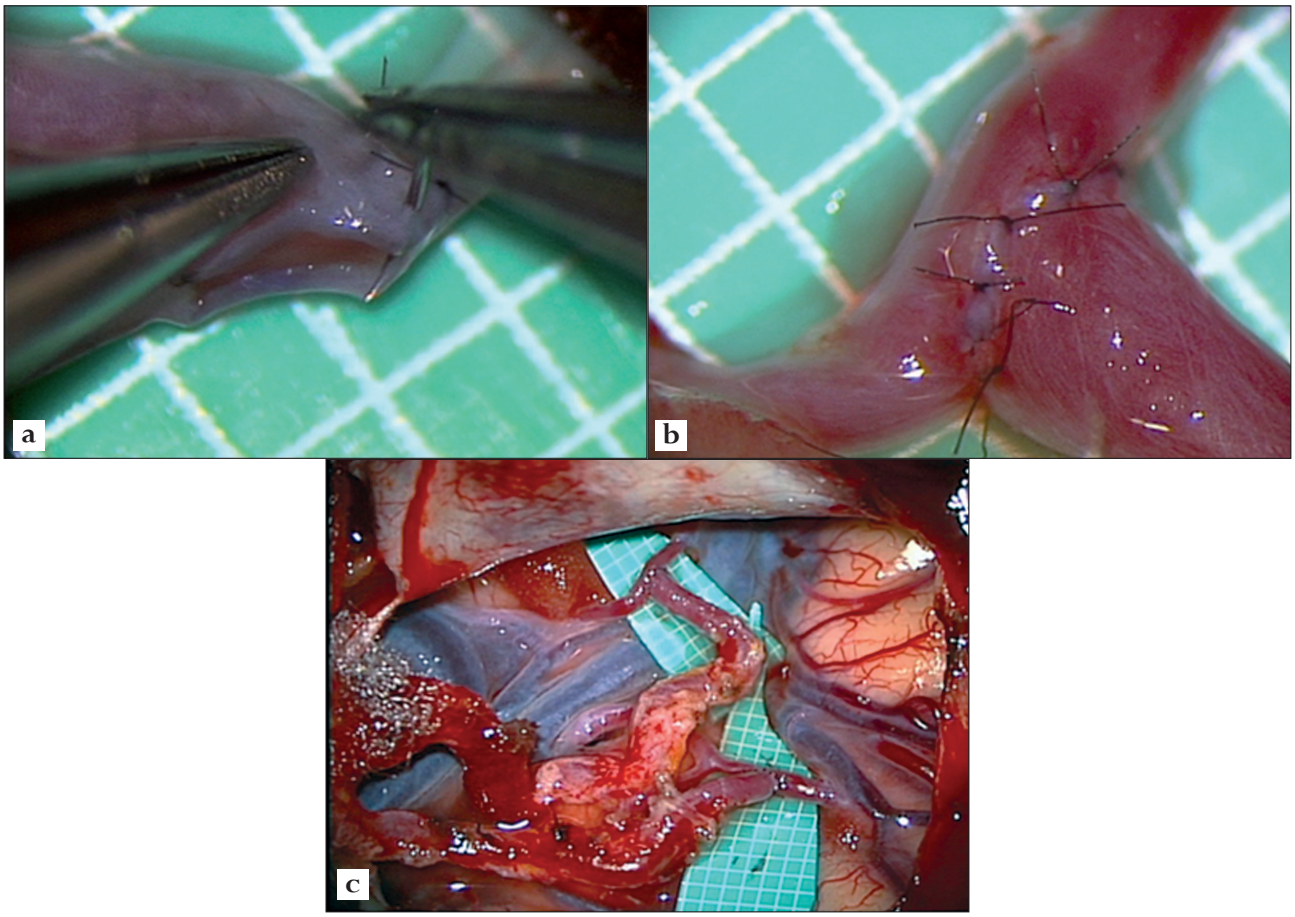

Figure 2: (a) Microvascular suturing at 50 × was performed using an 11-0 nylon suture with a needle (80-μm in diameter). Micro-forceps and micro-needle holder was used, No.3 jeweler's forceps. One scale on the sheet is 1.0 mm (b) Microvascular anastomosis of a very small vessel and a fragile vessel wall could be performed safely and precisely at 50 ×. The end-to-side anastomosis was completed and patent (c) Finally, STA-MCA double anastomosis was completed

or larger in diameter and 90% were 1.0 mm or wider. However, 10% of the vessels were less than 1.0 mm in diameter.[13] Microvascular anastomosis of small vessels was necessary in patients with moyamoya disease.[10,18] These microvascular anastomoses were difficult in patients with very small, thin, fragile, and transparent recipient arteries. Moreover, the donor scalp arteries in atherosclerotic cerebrovascular occlusive diseases could also cause problems due to intimal dissection associated with atherosclerotic changes. These cortical arteries sometimes collapsed and had less than 1.0 mm diameter.

The ostium of the recipient artery and the orifice of the donor artery must be clearly visualized for the establishment of microvascular anastomosis in various situations. The visualization methods in microvascular anastomosis have also been reported.[4,11] However, it is still necessary to be careful during observation and manipulation of the small arteries, when using the standard operating microscope. It is important that higher magnification produces a very clear image of the small object by an excellent operating microscope.

In hand surgery, a novel stereoscopic operating microscope with 40 × and 50 × magnifying power was developed and used in 2003, and reported in 2006.[7] This operating microscope acquired high final magnifications and was a practical operating microscope due to the new design of the objective lens system, and not the eyepiece. If a 20 × eyepiece was selected, the image would be magnified, but it would be poor and impracticable.[8,17] This new lens design enabled the resolution to be very high (a distinctiveness of 7 – 8 μm at 50 ×) and the depth of focus was good (1.0 mm at 50 ×). It produced a very clear image of the object and was practical in operative procedures. This operating microscope had a 10 × eyepiece, that was optically adjustable, and two objective lenses for fixed working distances of 200 and 250 mm.

The 300-mm objective lens has been developed for neurosurgery in this study. This operating microscope has a weak point, in that, the objective lens has to be exchanged and fixed before an operation in neurosurgery; 200, 250, and 300 mm objective lens were used in the surface and deep surgical fields. However, microvascular

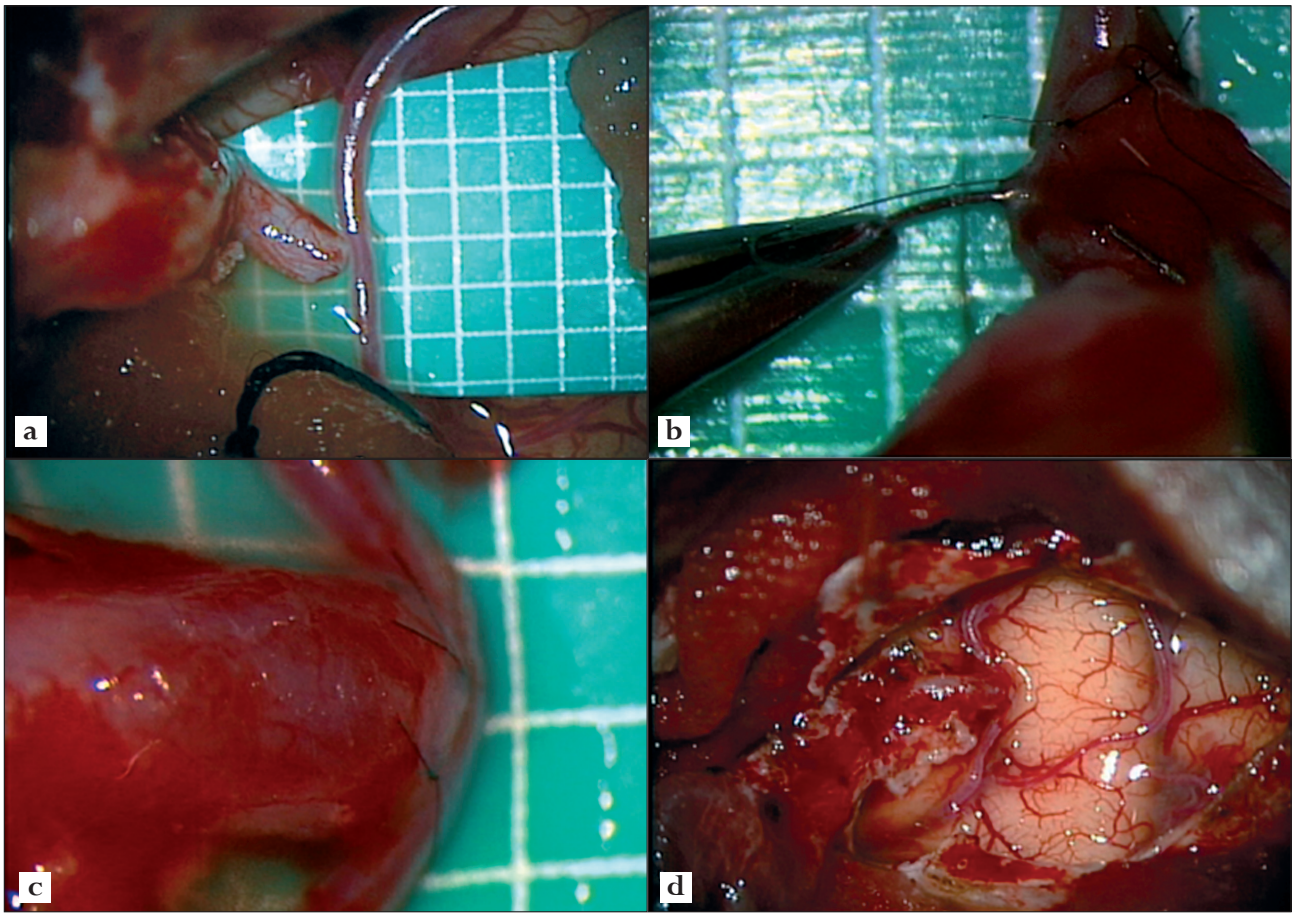

Figure 3: (a) Intraoperative view of a donor artery (subgaleal segment of OA) and a recipient artery (distal cortical artery of the angular artery). The recipient cortical artery was 0.5 mm in diameter. One scale on the sheet is 1.0 mm (b) Microvascular suturing at 50 × could be performed using an 11-0 nylon suture with a needle (80-μm in diameter and 3-mm in length) (c) Microvascular anastomosis was completed and patent (d) Finally, OA-MCA anastomosis was completed on the parieto-occipital lobe

anastomosis itself is usually performed on a plane field and does not need a change in various working distances intraoperatively. We have reported on this operating microscope from preliminary personal experiences.[9] This study indicates that 30 case series using this method have revealed good patency of all anastomoses in various situations and in the treatment of symptomatic hemodynamic cerebrovascular occlusive diseases, moyamoya diseases, and complex cerebral aneurysms. The patients have had no complications with this procedure. We think that it is the most effective technique for high patency of anastomosis, as it pays attention to performing atraumatic manipulations of small vessels and the correct suturing, intima-to-intima, of vessel walls at high and suitable magnifications.

CONCLUSION

It is obvious that the practical final magnifications of more than 30 × in neurosurgery, would be super-magnified operative views. We think that this microvascular anastomosis at higher magnifications (super-microvascular anastomosis) can help neurosurgeons improve their skills, with good visualization, and conduct safe and accurate cerebral revascularization in various situations.

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