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TECHNIQUE EVALUATION

The clinical utility of the Kopitnik arteriovenous malformation microclip during STA-MCA bypass surgery

Sung Pil Joo · Tae Sun Kim · Bo Ra Seo · Jung Kil Lee · Jae Hyoo Kim · Soo Han Kim · Joon Tae Kim · Man Seok Park · Ki Hyun Cho

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Abstract
Purpose Yasagil temporary clips have been widely used in extracranial-intracranial (EC-IC) arterial bypass surgery. However, the extremely delicate vessels involved often require the application of finer clips. We report on the use of the Kopitnik arteriovenous malformation (AVM) microclip system for superficial temporal artery-middle cerebral artery (STA-MCA) bypass.
Methods Kopitnik AVM microclips are new mechanical devices that are used during AVM surgery. They exert a predefined closing force of 50–70 g, and also feature a special, pyramid-shaped structure stamped on inner surfaces of the blades. These characteristics avoid vascular intimal injury and provide a secure grip. We prospectively studied their use in 15 patients requiring STA-MCA anastomosis.
Results Clinical results were excellent and there were no new ischemic events during 6-months' follow-up.
Conclusions Kopitnik AVM microclips have several advantages; they have small and variously sized clip blades (2, 3, 4 and 5 mm), and the small clip head allows the operator an excellent view of the pathology and clip status. The Kopitnik AVM microclip appears to be clinically effective and safe for EC-IC bypass surgery, especially when smaller vessels are involved.

Keywords Microvascular anastomosis · Microclip · STA-MCA bypass

Introduction

A large variety of extracranial-intracranial (EC-IC) bypasses are available, such as the standard superficial temporal artery-middle cerebral artery (STA-MCA) bypass, radial artery intermediate-flow bypass, and saphenous vein high flow bypass. The choice depends on the pathological condition and the haemodynamic demands of flow through the bypass. Of these techniques, STA-MCA bypass is effective at improving cerebral perfusion in selected patients with refractory cerebral ischaemia or ischaemic moyamoya disease [3]. The Kopitnik arteriovenous malformation (AVM) microclip (Aesculap, Tuttlingen, Germany) is a newly developed self-closing clip device that has been used in AVM surgery (Fig. 1). The present study was designed to evaluate the clinical usefulness and safety of the Kopitnik AVM microclip for STA-MCA anastomosis and to examine the qualities of the anastomoses created.

Patients and methods

Patient population

Between March and September 2006, 15 patients (12 male and three female patients) were enrolled in this study at Chonnam National University Hospital and Medical School. They had a mean age of 45.2 years, range 13–67 years. The characteristics of patients and surgical techniques that were used are summarized in Table 1. The

S. P. Joo · T. S. Kim (✉) · B. R. Seo · J. K. Lee · J. H. Kim · S. H. Kim
Department of Neurosurgery,
Chonnam National University Hospital and Medical School,
8 HakDong, Dong-Gu,
Gwangju 501-757, Republic of Korea
e-mail: taesun1963@yahoo.co.kr

J. T. Kim · M. S. Park · K. H. Cho
Department of Neurology,
Chonnam National University Hospital and Medical School,
Gwangju, Korea

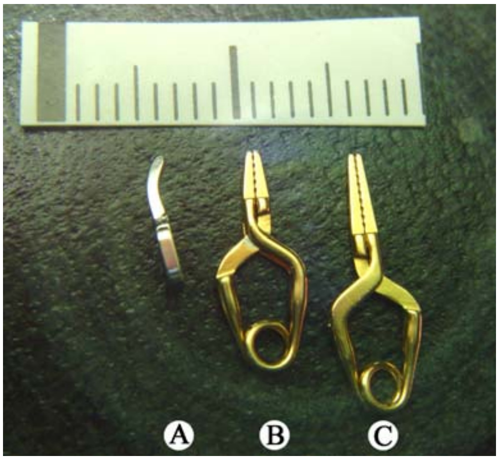

Fig. 1 Photograph of the types of clip usually used during extracranial intracranial arterial bypass. **a** Kopitnik AVM microclip, **b** Yasargil temporary miniclip, **c** Yasargil temporary clip. Kopitnik AVM microclips have a small head and are available in several clip-blade sizes

indications for STA-MCA bypass surgery were haemodynamic compromise due to atherosclerotic stenoocclusive cerebrovascular disease in 11 patients, and moyamoya disease in four patients. Bilateral operations were performed in one patient with moyamoya disease. Direct revascularization through a standard STA-MCA bypass (11 operations) was performed in atherosclerotic stenoocclusive cerebrovascular disease patients. In addition, in patients with moyamoya disease, standard STA-MCA bypass (five operations) was supplemented by indirect revascularization via encephalomyosynangiosis (EMS).

Surgical technique

All patients were operated upon by the same surgeon. In general, when the diameter of the MCA is less than 0.5 mm, direct anastomosis is not recommended. After the donor artery has been approximated to the MCA cortical branch, this branch is occluded proximally using a microclip and an additional microclip distally. An arteriotomy appropriate for the donor vessel diameter is made in the recipient vessel using a microscissors (Fig. 4a), and the

Table 1 Summary of patient characteristics (*Rt* right, *Lt* left, *ICA* internal carotid artery, *CTA* computed tomographic angiography)

No	Age	Sex	Symptom	Diagnosis	Operation name	Occlusion time (min)	Intraop. sonographic patency	Postop. CTA patency(7days)	Peioperative complication
1	31	F	Rt. Arm monoparesis	Lt ICA stenosis	EIAB	40	Good	Good	
2	52	M	Lt. hemiparesis	Rt MCA total occlusion	EIAB	32	Good	Good	Subdural hygroma
3	46	M	Rt. hemiparesis	Lt ICA total occlusion	EIAB	31	Good	Good	
4	38	M	Lt. hemiparesis	Rt ICA total occlusion	EIAB	40	Good	Good	
5	46	M	Lt. hemiparesis	Rt ICA total occlusion	EIAB	38	Good	Good	Chornic subdural hemorrahge
6	31	F	Rt. hemiparesis	Moyamoya disease	EIAB + EMS	36	Good	Good	
7	47	M	Dizziness	Rt MCA total occlusion	EIAB	32	Good	Good	
8	51	M	Rt. hemiparesis	Lt MCA stenosis	EIAB	36	Good	Good	
9	67	M	Rt. hemiparesis	Moyamoya disease	EIAB + EMS	38	Good	Good	
10	13	F	Rt. hemiparesis	Moyamoya disease	EIAB + EMS (bilateral)	40	Good	Good	
11	56	M	Rt. hemiparesis	Lt ICA occlusion	EIAB	32	Good	Good	
12	61	M	Lt. hemiparesis	Rt. ICA occlusion	EIAB	38	Good	Good	
13	63	M	Rt. hemiparesis	Both ICA stenosis	EIAB	36	Good	Good	
14	45	M	Seizure	Moyamoya disease	EIAB + EMS	30	Good	Good	
15	63	M	Rt. hemiparesis	Both ICA stenosis	EIAB	37	Good	Good	

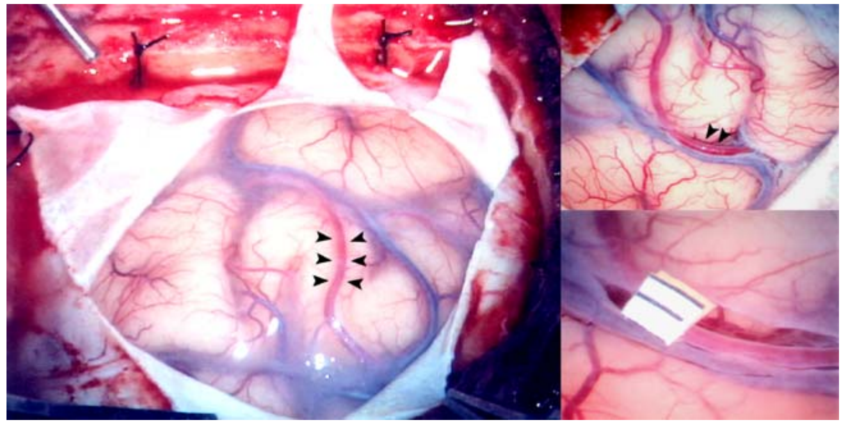

Fig. 2 Intraoperative findings showing a small (approximately 5 mm), thin, friable recipient artery. In this circumstance, finer clips are needed, so as to avoid recipient vessel injury

anastomosis completed using interrupted sutures. The recipient vessel clip was removed initially, followed by the donor vessel clip. The duration of cross-clamping of the MCA branch was approximately 30–40 min, and the anastomoses were assessed by microscopic observation and sonographic micro-Doppler.

Water-tight closure of the dura is originally impossible because the STA must run through the dural defect, which is covered by temporal muscle. To reduce frequency of subdural hygroma and subcutaneous cerebrospinal fluid (CSF) collection, we made only a minimal opening of the arachnoid membrane, and this was followed by suturing the arachnoid membrane after STA-MCA bypass using a 10-0 nylon suture (Ethicon, Somerville, N.J.) to prevent CSF leakage (Fig. 4b) in last four patients.

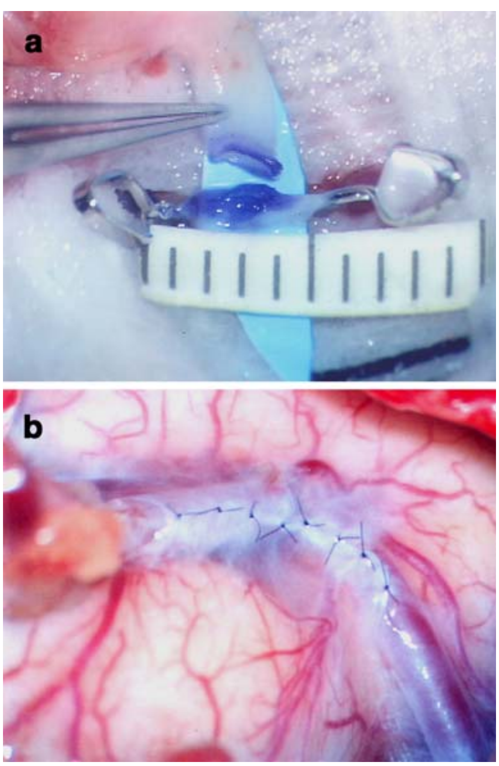

Fig. 3 Intraoperative photographs. **a** Arteriotomy appropriate for donor vessel diameter being performed, with a short cross-clamp distance so as not to injure the small perforating branch of the cortical artery. **b** Arachnoid suturing preventing delayed leakage of CSF

Follow–up

Oral aspirin (100 mg daily) was started for all patients on the second postoperatively day. Postoperative computed tomographic angiography (CTA) was performed at 7 days postoperatively to assess the STA-MCA anastomosis in each case. An experienced neuroradiologist and neurosurgeon independently assessed the patencies of the bypass.

Results

Sixteen conventional STA-MCA anastomoses, including five indirect revascularizations were performed in the 15 patients. A summary of patient profiles is provided in Table 1. One patient with moyamoya disease underwent a bilateral operation. A standard interrupted technique using 10-0 nylon sutures was used and 12 stitches were used for the bypass. The average time required for anastomosis was 30 min when 12 sutures were required (two stay sutures and ten interrupted sutures). Satisfactory anastomosis was achieved, even in patients with small or friable recipient vessels, recipient artery flow appeared to be increased in each patient after anastomosis. Transient ischaemic attacks (TIAs) ceased after operation and showed excellent bypass patency in each patient. A complication occurred in two patients; a subdural hygroma without mass effect and a chronic subdural hematoma which were appropriately treated using burr hole and drainage therapy. The Kopitnik microclip system had shortcomings: (1) closure force was reduced suddenly when clips were opened wide or applied several times; thus, they are not reusable; (2) the clips are expensive; (3) they can not be used in high-flow bypass surgery.

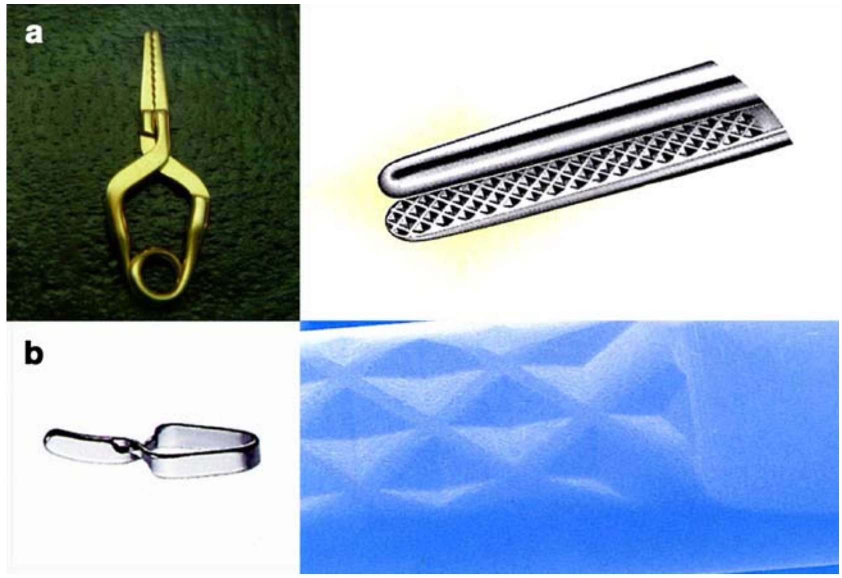

Fig. 4 Photograph of the Kopitnik clip and the inner surface of its blade. **a** Yasargil temporary clip, **b** Kopitnik AVM microclip. The Kopitnik AVM microclip features a smoother groove on its inner blade surface than the Yasargil temporary clip

Discussion

The development of microsuture materials and surgical optical magnification has introduced new surgical possibilities [2] to treat ischaemic brain diseases [9, 15]. Although a range of surgical techniques can be used for STA-MCA bypass, e.g. microsuture-tying forceps with attached scissors [4], double insurance bypass [6], partial lateral clipping [1], minimally occlusive microvascular anastomosis [5], excimer laser-assisted non-occlusive anastomosis(ELANA) [11, 12], and the microanastomotic system [7], each has unique advantages and shortcomings.

Krishnan et al. [5] described a new technique for performing microvascular anastomoses with persistent perfusion using a temporary intraluminal microshunt. The anastomosis can be performed via a minimally occlusive technique that guarantees continuous blood flow and prevents cerebral ischemia even if the suturing of the anastomosis itself takes some time. Insertion of the microcatheter into the artery lumen may cause endothelial injury and thromboembolism. The ELANA technique—developed, clinically applied, and refined by Streefkerk et al. [10–13]—may find wide application because of its uncomplicated approach to solving the problem of brain ischemia induced by temporary clipping during vascular anastomosis. However, this technique is only suitable for large calibre vessels (>3 mm) and carries doubt about the precise patten of intima-to-intima alignment of vessels.

Yasagil temporary clips have been widely used in EC-IC bypass surgery. Their closing force lies in the range 70–90 g. In animal experiments, at least 80 g was found to be required to close an artery, and more than 120 g damaged the arterial wall [14]. Ooka et al. [8] reported that both the Sugita and Yasargil temporary clips show a marked increase in closing force toward their bases (144 and 162 g, respectively), strong enough to damage an arterial wall.

In our experience, direct anastomosis is difficult in children with moyamoya diseases because the STA and MCA are very small and thin, and their walls are extremely fragile and vulnerable. Such extremely delicate vessels, so as not to injure recipient vessels, often require the application of finer clips than conventional Yasargil temporary clips. We used a special AVM microclip system for STA-MCA bypass (Fig. 2). The clips exert a pre-defined closing force of 50–70 g and feature a special, pyramid-shaped structure stamped on the inner surface of the blades (Fig. 3). This allows tissue to sink between these pyramid shapes, doubling the tissue contact surface, and ensuring a secure grip of the vessel. These characteristics avoid injury of vascular intima and reduce the possibility of delayed thromboembolism. AVM microclips have a small clip blade and head, and their characteristics allow minimization of arachnoid dissection to about a 5-mm cross-clamp distance and thus reduce injury of minute arterial branches from the MCA (Fig. 4). In addition, the small clip head allows the operator an excellent view of the pathology and clip status. In the present study, all clips worked as intended in all patients, and no failure to release or inadequate closure was encountered.

Conclusion

It was feasible to use Kopitnik self-closing microclips for STA-MCA anastomosis, especially with small-vessel disease; they did not adversely affect graft patency or quality and after 6 months of follow-up appeared effective and safe. Further study of a larger number of patients with longer follow-up is warranted.

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