

Technical Note

A simple bracing technique to correct kinking of arterial branches to avoid ischemic sequelae during neurovascular surgery

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Abstract

Background: During microscopic procedures for neurovascular disease, we sometimes encounter kinking of arterial branches resulting in ischemic sequelae. A simple and useful technique that involves inserting a small, ball-like prosthesis made of oxidized cellulose or shredded Teflon with fibrin glue that corrects the arterial branch kinking and avoids subsequent compromise is reported.

Methods: Between January and December 2014, three patients developed arterial kinking during microscopic procedures, including two in the caudal loop of the posterior inferior cerebellar artery during microvascular decompression for glossopharyngeal neuralgia and one in a branch of the middle cerebral artery (MCA) during clipping for an unruptured MCA aneurysm. Blood flow insufficiency was confirmed by microvascular Doppler ultrasonography (MDU) and indocyanine green (ICG) videoangiography. The prosthesis, which was made of shredded Teflon in two cases and oxidized cellulose in one case, was inserted into the crotch of the kinked arteries to correct the kinking of the arteries and restore the proper vascular shape and normal blood flow.

Results: The small, ball-shaped prosthesis corrected the kinked arteries and maintained the proper shape, which was confirmed by ICG videoangiography and MDU during the operation and three-dimensional computerized tomography angiography postoperatively. Postoperatively, the patients did not manifest any ischemic sequelae related to the kinked arteries.

Conclusion: The insertion of prostheses with fibrin glue into the crotch of a kinked artery for repair is considered a simple and useful method for correcting a kinked artery that avoids ischemic sequelae.

Key Words: Cerebral aneurysm, clipping, glossopharyngeal neuralgia, kinking, microvascular decompression, simple bracing technique

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INTRODUCTION

During clip application to middle cerebral artery (MCA) aneurysms, we occasionally encounter stenosis of a peripheral arterial branch resulting in ischemic sequelae caused by torsion or twisting of the branches of the MCA due to inappropriate clip application. To avoid such situations, some approaches, such as combination clip technique^[3] and vascular reconstructive clipping,^[11] are

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used to maintain intact blood flow. Arachnoid dissection is also effective to increase mobility and maneuverability of the vasculature to avoid stenosis or occlusion of the parent artery and peripheral branches of aneurysms. However, excessive arachnoid dissection sometimes leads to loss of plasticity and support of surrounding tissue. As a result, kinking of the vasculature to be dissected is occasionally observed. The intraoperative kinking is considered caused by forced transfer from the original anatomical position of the normal arterial branches and redundancy of the arterial vasculature caused by thorough dissection of the arachnoid membrane and trabeculae. In this technical report, a simple and useful method to correct kinked arteries by insertion of a small, ball-like prosthesis made of shredded Teflon or oxidized cellulose with fibrin glue during the operation, including three patients undergoing direct clipping of an MCA aneurysm, as well as two cases of microvascular decompression (MVD) for glossopharyngeal neuralgia (GPN), is reported.

MATERIALS AND METHODS

Operative technique

Before surgery, the surgeon prepared various sizes of oxidized cellulose or shredded Teflon to use as the prosthesis for MVD or as material for hemostasis during the microscopic procedure in cases with neurovascular disease. Fibrin glue was also provided for such operations not only to seal the defect of the dura mater after microvascular surgery but also to use as an agent to enhance the effect on hemostasis with matrix such as oxidized cellulose or polyglycolic acid and holding the prosthesis in place to keep the offending vessel away from the root exit zone (REZ). When kinking of the arterial branch was observed during a microsurgical procedure, the small, ball-like prosthesis, made of shredded Teflon or oxidized cellulose soaked with thrombin solution, was applied to the crotch of the kinking site to correct the deformation of the artery and normalize the flow of the artery. Then, the fibrinogen solution of the fibrin glue was added to the ball to fix it to the kinked site to maintain the corrected shape and the normal flow of the artery. By placing the ball just near the crotch, it acted as a bolster held in place by the fibrin glue. During the microscopic procedure, microvascular Doppler ultrasonography (MDU) and indocyanine green (ICG) videoangiography were useful not only for identification of the kinked arterial branches, but also for verification of the correction of the kinked arteries and the patency of the arterial branches. The use of neurophysiological monitoring, such as motor-evoked potentials and sensory-evoked potentials, might also be able to help verify patency of the parent artery if the kinked artery contributed to the functional region. When three-dimensional computerized tomography angiography (3DCTA) was undertaken, the kinked artery could be confirmed to be corrected after

surgery.

RESULTS

During the microscopic procedure, there was arterial branch kinking in three patients, including two with GPN and in one with an MCA aneurysm that was thought to be caused by thorough dissection of the arachnoid membrane and trabeculae. Correction of the kinked vessels was accomplished by insertion of a small, ball-like prosthesis into the crotch of the kinked artery. The balls were made of shredded Teflon fixed to the affected arteries by fibrin glue in two cases of MVD for GPN, and oxidized cellulose in the one case of MCA aneurysm surgery. Intraoperative ICG videoangiography and MDU were useful for detecting kinked arteries and confirming normalized flow of the corrected arteries. The patients' postoperative courses were uneventful, and no other sequelae were observed in all patients. Even though the follow-up periods were only 2 years, no other complications, including infarction and recurrence, as well as granuloma formation, were observed.

CASE DESCRIPTION

Case 1

A 74-year-old man, presenting with a 4-year history of severe left throat pain while swallowing, was diagnosed with GPN, which was refractory to medical treatment. Because magnetic resonance imaging demonstrated the offending vessel compressing the REZ of the affected glossopharyngeal nerve, the patient underwent MVD for the GPN. During operation via a transcondylar fossa approach, the posterior inferior cerebellar artery (PICA) was confirmed to compress the origin of the glossopharyngeal nerve [Figure 1a]. The PICA was twisted and twined through a bundle of lower cranial nerves. Thus, the PICA needed to be dissected over a long length to transpose the offending part away from the site of compression. The loose offending artery after dissection was transposed easily by the microdissector and held in place with the dura mater on the jugular tubercle using fibrin glue.

After the procedure had been accomplished, the peripheral part of the PICA that was dissected for transposition to the REZ was observed to be kinked in the caudal side of the lower cranial nerves [Figure 1b]. MDU demonstrated insufficient flow of the PICA in the distal part of the PICA. Redundancy and loss of supporting tissue were thought to have led to PICA kinking. Correction of the kinked vessel was not achieved by transposition of this vessel in some other direction. Therefore, an attempt was made to restore the lost supportive function of the arachnoid tissue by placement of the prosthesis. The shredded Teflon was crumpled into

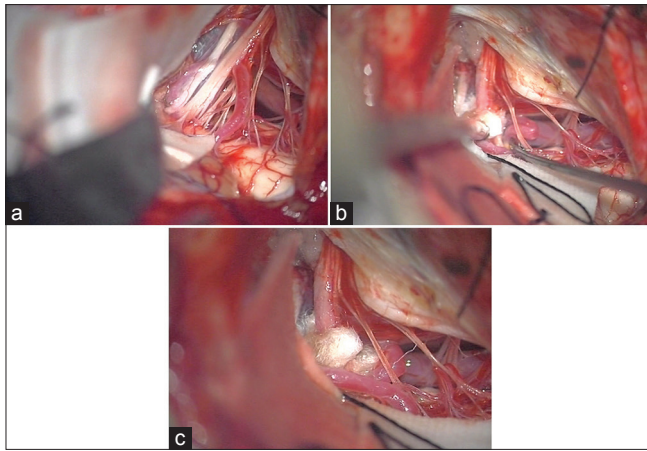


Figure 1: (a) Intraoperative microscopic view demonstrates that the posterior inferior cerebellar artery (white arrow) is compressing the glossopharyngeal nerve (black arrow), (red arrow: Vagal nerve). (b) After decompression, the caudal loop of the posterior inferior cerebellar artery is kinked (white arrow). (c) The inserted ball of shredded-Teflon soaked with the thrombin solution of the fibrin glue kit is held in place by the fibrinogen solution spray to correct the kinked branch of the posterior inferior cerebellar artery

a small ball with a diameter of approximately 5 mm. It was soaked with thrombin solution that was one part of a fibrin glue kit and inserted into the crotch of the kinked artery to recover its tubular shape [Figure 1c]. It was then held in place by fibrinogen solution spray, another part of the fibrin glue kit, to maintain the proper unkinked shape. After confirmation of normalized flow of the PICA by MDU, the microscopic procedure was finished. The neuralgia completely disappeared immediately without any postoperative sequelae.

Case 2

A 65-year-old man having an incidental aneurysm of more than 7 mm in his left MCA underwent surgical intervention. The aneurysm was approached through dissection of the sylvian fissure via a standard pterional craniotomy. The entire circumference of the dome of the aneurysm was dissected thoroughly [Figure 2a]. The dome of the aneurysm was obliterated completely by clip application to the neck, as confirmed by ICG videoangiography. However, ICG videoangiography demonstrated that the flow of the inferior trunk of M2 branches was later than that of the other arteries, and there was a flow defect near the dome of the aneurysm on that branch, which represented the kinking [Figure 2b]. MDU also showed insufficient blood flow of that artery. A redundant artery caused by wide dissection of the arachnoid trabeculae bent strongly by the clip applied to the neck of the aneurysm was found to be the cause of the kinking. Two pieces of oxidized cellulose crumpled into a ball were inserted into the crotch of the bent branch of the superior trunk of M2. The prosthesis was soaked with the thrombin solution from the fibrin glue kit and held in place by the fibrinogen solution spray after the kinking

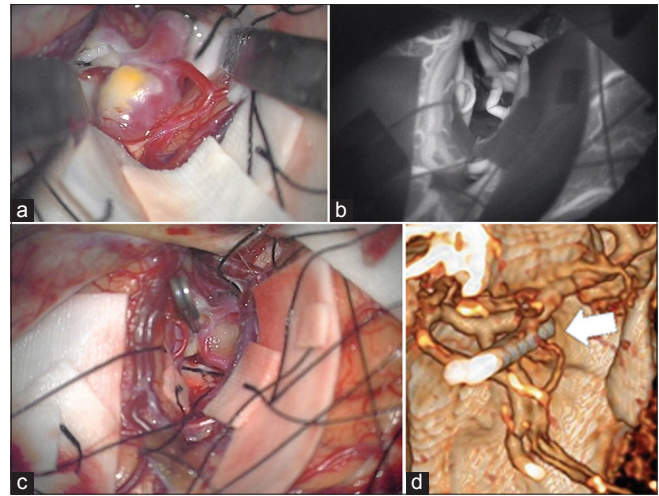


Figure 2: (a) Intraoperative photograph shows the aneurysm originating from the bifurcation of the middle cerebral artery. (b) Indocyanine green videoangiography after application of the clip to the neck of the aneurysm shows the kinking of the superior trunk of the middle cerebral artery. (c) Insertion of the prosthesis made of crumpled oxidized cellulose with fibrin glue corrects the kinked frontal branch of the middle cerebral artery. (d) Postoperative three-dimensional computerized tomography angiography shows complete clipping of the aneurysm and no evidence of stenosis or kinking of the superior trunk of the middle cerebral artery (white arrow)

was corrected [Figure 2c]. MDU also demonstrated a normalized flow sound of that artery. The microscopic procedure was finished after hemostasis was confirmed. The patient's postoperative course was uneventful, and 3DCTA 1 week after the operation showed complete obliteration of the aneurysm and intact flow of the superior trunk of the M2 branches [Figure 2d].

DISCUSSION

In neurosurgery to create a sufficient corridor to the lesion or obtain mobility of the vasculature for maneuverability, a variety of methods are used, including removal of the bony structure and dissection of supporting tissues, such as rongueing the sphenoid wing or anterior clinoid process, and dissection of the carotid dural ring.^[1,2] Thorough dissection of the arachnoid membrane has also been reported as an important procedure in neurovascular surgery providing much more mobility and maneuverability.^[7] However, the arachnoid membrane acts as supporting tissue and regulates the cerebrospinal fluid. Therefore, extensive dissection of the arachnoid membrane could lead to adverse effects or some complications, such as cerebrospinal fluid leakage into the subdural space or subcutaneous layer.^[6] Kinking of arterial branches is also due to extensive arachnoid dissection, which is sometimes encountered during microscopic.

Kinking means that the vessel is extremely bent and the vessel loses the ability to maintain its lumen, so that the shape of the cross-section of the vessel changes from

round to flat and collapses, at which point the vessel would be wound sharply. As a result, the lumen of the vessel narrows severely. In the vasculature, kinking of the vessel leads to insufficiency of blood flow and ischemic sequelae in cases of arterial branches and congestion in veins.

We sometimes observe kinking in extracranial carotid and vertebral arteries as one of the findings of atherosclerotic changes, as well as coiling or tortuosity.^[10] Those atherosclerotic changes have developed for many years, and symptoms caused by them that need to be treated surgically are extremely rare.^[8] There are fewer opportunities to observe kinking of vessels in the intracranial vasculature than in the extracranial vasculature. During microscopic procedures, however, neurosurgeons sometimes encounter iatrogenic kinking of the vessels. Intracranial vasculature with a large caliber is mainly located in the subarachnoid space, which is connected and supported by the leptomeninges to surrounding brain parenchyma, cranial nerves, and other vasculature. Therefore, extensive dissection would lead to redundancy and loss of support provided by the arachnoid membrane. During microscopic procedures for neurovascular disease, the surgeon often dissects these arachnoid membranes and trabeculae to create enough space to observe and approach the lesion and to obtain mobilization and maneuverability of the vasculature to inspect and handle the target. At the same time, however, redundant vessels without any of the supportive tissue that initially maintained their own original shape and position would easily be bent sharply and then kinked. One case of clipping of an MCA aneurysm and two of MVD for GPN were included in this study. This issue of kinking is not limited to MCA aneurysmal surgery since any kind of aneurysmal surgery that requires wide opening of the sylvian fissure may result in kinking of arterial branches. For example, the anterior temporal approach for aneurysms of the ICA and basilar artery requires wide opening of the sylvian fissure, in which the anterior temporal artery needs to be dissected from the medial surface of the temporal lobe to mobilize the temporal lobe.^[2,4] As well as aneurysmal surgery, kinking of the PICA, AICA, or superior cerebellar artery branches may occur with MVD for not only GPN, but also for hemifacial spasm, as well as trigeminal neuralgia. To achieve appropriate transposition, it is not enough to insert the prosthesis at only the REZ. The offending vessel should be transferred as an entire segment of the artery. To do so, wide dissection of the offending vessels, including the PICA or AICA, affecting the REZ is necessary to obtain mobilization.^[7]

Kinking of the vessel may cause ischemia in arterial branches and congestion in veins. This insufficiency of blood flow could lead to infarction or swelling of the brain parenchyma and then a large variety of

symptoms, depending on the areas affected. The details of the ischemic complications associated with kinking of vessels during microsurgery have not been previously reported. However, empirically, surgeons realize the danger of sequelae associated with kinking. Practically, the kinking of only one arterial branch would rarely cause severe complications. However, if other adverse factors, such as sacrifice of a large vein, long duration of the microscopic procedure, or excessive compression of the brain parenchyma with a spatula, would be combined with ischemia due to kinking of an arterial branch, the likelihood of brain damage would increase. In such situations, intermittent release of the spatula, a retractorless procedure,^[9] and preservation of large veins such as the petrosal vein or the sylvian vein are thought to be important to avoid ischemic complications during microscopic procedures.^[5]

Troubleshooting for kinking of a vessel has never been described in detail before, even though its importance has been reported. If a step of the procedure was an immediate cause of the kinking, retracing of that step would be primary. When clip application to the neck causes the branch to twist, leading to kinking, release of the clip would resolve the kinking. Basically, a method of clip application that would not cause kinking is important. However, there may be many situations, in which reapplication of the clip is difficult, including an aneurysm with premature rupture. Another explanation is that the additional dissection to untether the branch more distally may also lead to resolution of kinking, by allowing the vessel to assume a gentler curve.

The bracing technique presented here is so simple and less invasive that it is very useful and feasible for prevention of postoperative complications. The immediate feedback provided by the intraoperative flow measurement by MDU and the confirmation of restoration of the proper shape on ICG videoangiography after resolution of kinking are important adjuncts to the success of this strategy.

In these patients, Teflon and oxidized cellulose were used. For a small, ball-shaped prosthesis inserted in the crotch of the kinked site, an appropriately sized material that can be easily shaped is needed. The prosthesis should also stay in position, and for this, an adherent agent as fibrin glue is necessary. Furthermore, the material should be able to maintain its size and shape for a period. When selecting the material, a sponge or other artificial material could be considered. However, side effects, such as a foreign body reaction, must be taken into account, so that alternatives such as an autograft of fascia, fat, and muscle have been used. Recently, granulation associated with Teflon implanted during surgery has been reported.

Even though it is a rare complication, we must take such disadvantages into consideration and ensure long-term follow-up when selecting the materials for prostheses.

CONCLUSION

Thorough dissection of the arachnoid membrane and trabeculae can lead to kinking of arteries during microscopic procedures for neurovascular disease. Correction of kinked arteries using insertion of prosthesis is considered a simple and useful method for avoiding ischemic sequelae in neurovascular surgery. We should pay attention to the occurrence of kinked arteries that can cause ischemic sequelae during aneurysmal surgery and MVD that requires wide dissection of arachnoid membranes. ICG videoangiography and MDU are useful for the detection of kinking and confirmation of repair.

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Conflicts of interest

There are no conflicts of interest.

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