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Clinical Article

Treatment of spontaneous arterial dissections with stent placement for preservation of the parent artery

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Summary

Background. A wide variety of treatment regimens have been advocated for dissections involving the intracranial arteries. Recently, the stent can be used to exclude the aneurysm from the circulation and preserve the parent artery. We evaluated the safety and efficacy of stent angioplasty for intracranial arterial dissections.

Methods. Ten patients with spontaneous dissections, nine vertebral artery and one internal carotid artery lesions underwent endovascular treatment using stent placement as primary treatment modality. One stent placement was attempted in five patients initially. Three patients were intentionally treated with two overlapping stents which completely covered the aneurysm orifice. Two tandem stents were used in one patient to allow spanning the entire length of the dissection. Stent-assisted coil embolization was performed in one patient.

Results. Of the 10 patients in whom stenting was tried, the overall success in reaching the target lesion with stents was 90%. Of the 9 patients treated with stents, stent release and positioning were considered optimal in 7 patients (77.8%) and suboptimal in two. Lesions of 8 patients were improved or stable in angiographic follow-up. However, one pseudo-aneurysm was enlarged, and subsequently, was treated by proximal occlusion using coils. There were no instances of postprocedural ischaemic attacks, new neurological deficits, and no new minor or major strokes prior to patient discharge. All parent arteries of the patient who underwent the successful procedure were preserved. On the modified Rankin scale used for the follow up, all patients were assessed as functionally improved or of stable clinical status.

Conclusions. The success in reducing dissection-induced stenosis or pseudo-aneurysm, the patency rate obtained at follow-up, and the lack of strokes (ischaemic or haemorrhagic) suggest that stent placement offers a viable alternative to complex surgical procedures or deconstructive procedures. The long-term efficacy and durability of stent placement for arterial dissection remains to be determined in a large series.

Keywords: Angioplasty; dissections; dissecting aneurysm; endovascular treatment; stents.

Introduction

Arterial dissection has recently drawn attention as a relatively common cause of stroke. Intracranial arterial dissection may lead to significant arterial stenosis, occlusion, pseudo-aneurysm formation with subsequent haemodynamic and embolic infarcts, or subarachnoid haemorrhage (SAH). It has been proposed that patients initially suffering from SAH should undergo early repair of the aneurysm by open surgery or obliteration of the aneurysm by endovascular procedures [17, 25, 32, 40]. On the other hand, unruptured arterial dissection has recently been recognized to follow a relatively benign clinical course and outcome, and, consequently, conservative treatment has been advocated [8, 18, 26, 42]. However, the natural history of this lesion remains poorly understood and the optimal treatment has not been established.

A wide variety of treatment regimen have been advocated for dissections involving the intracranial artery, including conservative management [18], anti-platelet medications, anti-coagulant therapy, and surgical resection of the involved artery [14, 28, 36]. Over the last two decades, endovascular interventions have had a significant impact on the treatment options for a variety of diseases affecting the intracranial vasculature. These minimally invasive techniques are now considered to be the preferred treatment modality in a number of conditions. Parent vessel occlusion with coils or balloons, or occlusion at the dissection site achieved using coils provides effective protection against rebleeding of the dissecting aneurysms [1, 16, 20, 27, 33]. However, proximal occlusion can sometimes be associated with growth and rebleeding of the aneurysm secondary to reflux across the vertebral confluences [41].

Endovascular stents have been shown to be of benefit for the treatment of intimal dissection of extracranial arteries resulting from balloon angioplasty and trauma [4, 6, 10, 11, 24]. By virtue of their design, stents provide the necessary centrifugal force to permit apposition of the dissected segment to the vessel wall to obliterate the false lumen and resolve the stenosis [9, 11]. With the advent of navigable intracranial stents, intracranial arterial dissections, especially dissecting aneurysms, are now amenable to endovascular stent placement [19, 22, 39]. The stent can be used to exclude the aneurysm from the circulation and preserve the parent artery [37]. In order to determine the clinical and radiographic outcome of this form of treatment, we present our endovascular management of intracranial arterial dissections, achieved using stent angioplasty in a retrospective series of 10 patients.

Methods

Patients

We obtained approval from our institutional review board to study the use of stent placement to treat intracranial arterial dissections. Only arterial dissections involving the vertebral artery above C2 or the intracranial internal carotid artery were included in this study. Saccular berry aneurysms or atherosclerotic or fusiform aneurysms or intimal dissections during endovascular procedures were not included. Aneurysms were considered dissecting if one or both of the following conditions were met: 1) The aneurysm was associated with an intimal flap, or irregular or beaded parent arterial narrowing. 2) MR study confirmed a false lumen involving the parent artery.

Between 1997 and 2004, 26 patients with spontaneous intracranial arterial dissections were treated at our institution. Of these, 16 patients underwent surgery or endovascular proximal occlusion with coils or balloons as initial treatment option. The remaining 10 patients underwent endovascular treatment of spontaneous dissections using intraluminal stent placement as first treatment method. There were six men and four women in this group, with ages ranging from 33 to 60 years (mean age 49 years). Demographic and clinical presentation data of the patient population are shown in Table 1. Three patients initially presented with SAH. Seven patients who presented with ischaemic symptoms were studied. MR studies of five patients revealed infarction in the territories supplied by the dissecting artery.

Angiographic findings and indications for stenting

Angiograms were assessed for size, shape, and location of the dissections with respect to the major branches and collaterals (i.e., the presence or absence of the contralateral vertebral artery (VA) or posterior communicating artery). Each lesion was examined for evidence of extension of the dissection into adjacent arterial segments, including the posterior inferior cerebellar artery (PICA) and basilar artery. The angiographic features in this study were divided into the following four groups: "pearl and string sign" (corresponding to a fusiform dilation associated with proximal or distal narrowing; 5 dissections), "string sign" (corresponding to an isolated irregular narrowing; 2 dissections), "double lumen" (corresponding to the visualization of two channels; 1 dissection), and fusiform dilation (3 dissections). Nine patients had dissections involving the VA and one patient harbored a dissection involving the supraclinoid internal carotid artery (ICA). Each VA dissection was classified as follows: 4 lesions proximal to the origin of the PICA, 2 lesions across the PICA, and 4 lesions distal to the origin of the PICA.

Patients were considered eligible for stent insertion with or without adjunctive GDC placement only if their dissecting aneurysm presented with SAH, were unable to undergo anticoagulation, or if they had no other therapeutic option of acceptably low risk. The indications focused on arterial dissecting stenosis included the presence of transient ischaemic deficits (TIAs) or vertebrobasilar insufficiency (VBI) despite anticoagulant or antiplatelet therapy, contraindication to anticoagulant, contralateral vertebral or carotid occlusion or stenosis in a patient who was neurologically unstable or had clinical evidence of haemodynamic insufficiency, and documented poor collateral circulation.

Table 1. *Summary of the clinical characteristics in 10 patients with arterial dissection treated using stent placement*

Patient no.	Age (yrs)/sex	Clinical presentations	Clinical diagnosis	MRS on admission	Dissection type	Location
1	37/M	sudden mental change	SAH	2	pearl and string sign	left VA distal to PICA
2	50/F	headache, dizziness	infarction, pontine	1	pearl and string sign	right VA distal to PICA
3	41/M	right-sided weakness	infarction, thalamic	3	string sign	right VA proximal to PICA
4	54/M	left-sided paresthesia, dizziness	infarction, PICA	1	string sign	left VA across PICA
5	55/F	left-sided weakness	infarction, pontine	2	fusiform dilation	right VA distal to PICA
6	52/F	dizziness	VBI	1	fusiform dilation	left VA proximal to PICA
7	60/M	left-sided weakness	infarction, MCA	2	double lumen	right ICA, supraclinoid
8	53/M	sudden mental change	SAH	1	pearl and string sign	left VA distal PICA
9	33/M	headache, dizziness	VBI	0	pearl and string sign	left VA across PICA
10	55/F	sudden mental change	SAH	2	pearl and string sing	right VA proximal to PICA

MRS Modified Rankin scale, *SAH* subarachnoid haemorrhage, *VA* vertebral artery, *PICA* posterior inferior cerebellar artery, *VBI* vertebrobasilar insufficiency, *MCA* middle cerebral artery, *ICA* internal carotid artery.

Stenting procedures

Informed consent was obtained from patients or medical guardians. Patients scheduled for elective procedures received oral acetylsalicylic acid (100 mg) and oral clopidogrel (75 mg) for 3 days before the stent procedure, and patients undergoing emergency procedures for acute SAH underwent combined antiplatelet therapy on the day of surgery. All patients were kept on a regimen of both medications for 3 months, after which clopidogrel was no longer given.

The patient was given local anaesthesia with light neuroleptic analgesia to allow continuous neurological monitoring, and received systemic heparinization. A unilateral or bilateral intra-arterial approach was initiated following standard Seldinger puncture. Catheterization was used and a No. 8-F introducer sheath was placed in the right femoral artery. Full systemic heparinization was achieved by administrating a 5,000-IU bolus followed by hourly boluses of 2,500 IU and monitoring of the activated clotting time. We also performed a balloon occlusion test in selective cases immediately before treatment to determine options for endovascular salvage if the stenting failed. A guiding catheter system consisting of a No. 6-F Envoy guiding catheter (Cordis, Miami Lakes, FL) coaxial to a No. 8-F catheter was advanced into the diseased artery by using a standard 0.035-in guidewire. A microcatheter was introduced into the dissecting lumen through the 6-F guiding catheter. Then a stent was navigated over the wire coronary stent, with balloon inflation delivery system. The stent was positioned across the diseased segment with enough overlap on each side of the dissection orifice. The stent was then deployed by inflation of the balloon delivery system at a pressure of 6–9 atmospheres. After stent deployment, the aneurysm lumen continued to fill through the stent; hence, it was decided to pack the aneurysm lumen with GDCs through the microcatheter (patient 5). Alternatively, a second stent was next deployed within the first stent to minimize the size of perforations leading to the aneurysm (patients 1, 8, and 10). We used devices currently applied in interventional cardiology such as the self expandable Wallstent (Boston Scientific, one case), the balloon expandable S670 [Arterial Vascular Engineering (AVE), five cases], Flexmaster (JoMED, 1 case), and Microdrive (AVE, 3 cases). Check angiography confirmed complete angiographic occlusion of the aneurysm or complete resolution of the stenosis with preservation of parent artery or perforators. The catheters were removed, and the sheath was left in the groin. The patient was moved to the neurosurgery intensive care unit for monitoring and received heparin 1,000 IU/hour for the next 24 hours. Heparinization was discontinued after 24 hours post-treatment but not reversed.

Follow-up

Follow-up was determined by phone interview or from the most recent office note, and a modified Rankin score was assigned. Overall outcomes were defined as excellent, Rankin score 0–1; good, Rankin score 2; poor, Rankin score 3–4; or death, Rankin score 5. Follow-up angiography, gadolinium-enhanced MR angiography, or CT angiography was performed at 6–12 months to determine whether the affected segment was smaller or healed. Further examinations were obtained yearly if needed.

Results

Endovascular treatments are summarized in Table 2. In the 10 patients in whom stenting was tried, the overall success in reaching the target lesion with stents was 90%. One procedure (patient 2) was abandoned because the tortuosity of the blood vessel made it impossible to manipulate the device, and subsequently proximal occlusion was performed using coils. Of the 9 patients treated with stents, stent release and positioning were considered optimal in 7 patients (77.8%) and suboptimal

Table 2. *Summary of treatment options, complication related to treatment, and angiographic and clinical outcomes*

Patient no.	Endovascular treatment	Stent type and size (mm)	Angiographic results	Parent artery preservation	Complications	Follow-up MRS
1	two stent insertion	AVE S670 3 × 12, S670 3 × 9	Aneurysm disappeared	preserved	none	0
2	PO with GDCs	ND	completely occluded Aneurysm	sacrificed	failed stenting	1
3	stent insertion	Easy wallstent 4 × 20	resolved stenosis	preserved	none	2
4	two stents insertion	AVE S670 3 × 9, S670 3 × 12	resolved stenosis	preserved	none	1
5	stent insertion with coiling	AVE S670 3.5 × 24	occluded Aneurysm	preserved	none	1
6	stent insertion	AVE S670 4 × 24	Aneurysm disappeared	preserved	none	0
7	stent insertion	AVE S670 3 × 18	healed dissection	preserved	none	1
8	two stents insertion	JOSTENT Flexmaster 2.75 × 19 AVE Microdrive 2.75 × 24	decreased Aneurysm in size	preserved	temporary vasospasm	0
9	stent insertion, finally PO with GDCs	AVE Microdrive 2.5 × 24	enlarged Aneurysm in size		folded stent	
			decreased Aneurysm in size	sacrificed	none	0
10	two stents insertion	AVE Microdrive 3.5 × 18 AVE Microdrive 3 × 12	Aneurysm disappeared	preserved	none	1

MRS Modified Rankin scale, *AVE* arterial vascular engineering, *PO* proximal occlusion, *ND* not done.

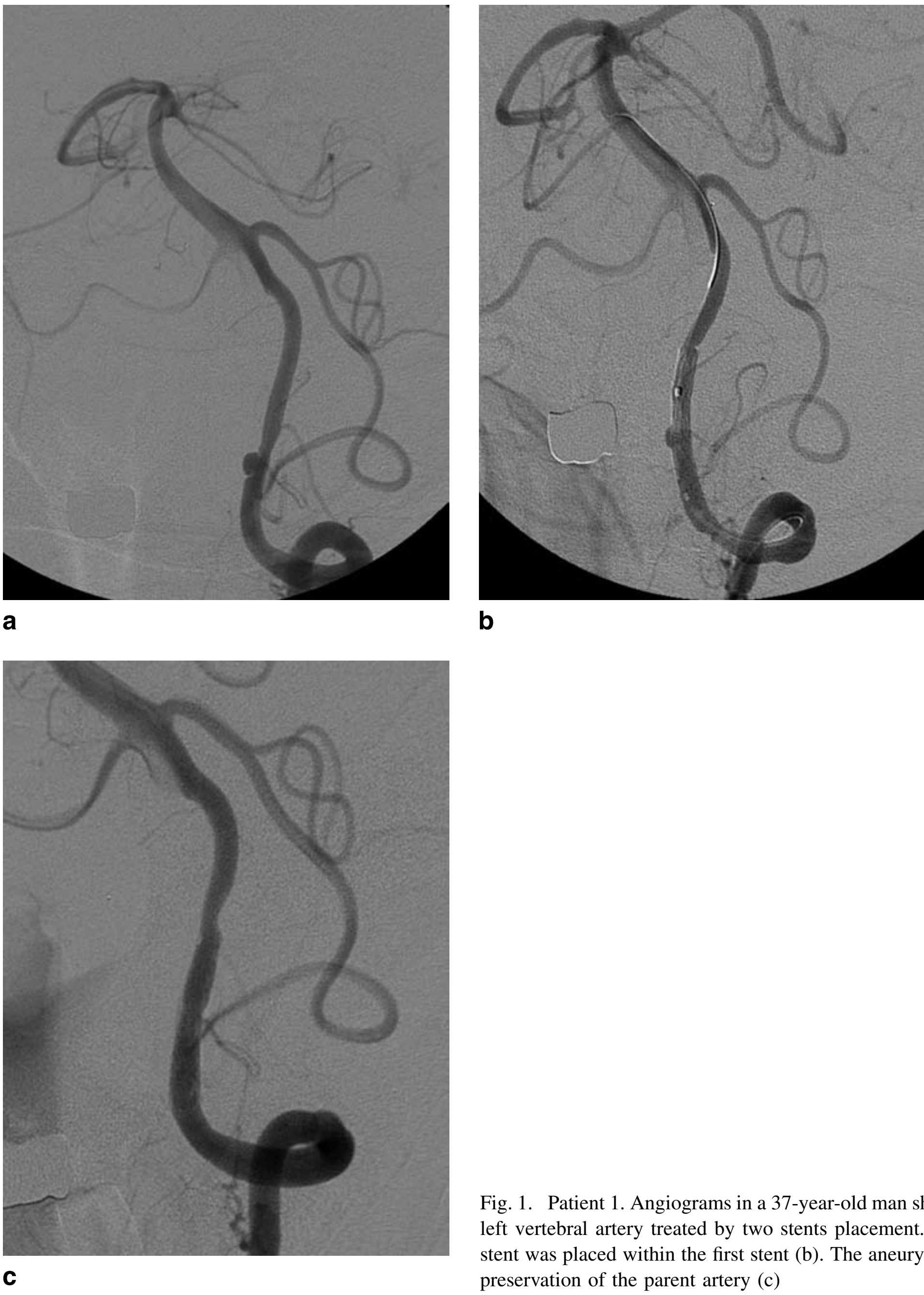
in two. In the one patient (patient 8) in whom placement was suboptimal due to underestimation of the dissection resulting from temporary vasospasm, a longer second stent had to be positioned within the first stent lumen. In the other patient (patient 9) in whom first stent placement was successful, the distal end of the inserted first stent was folded during the advancement of the second stent. Therefore, the second stent was retrieved. Three patients (patients 1, 8, and 10) were intentionally treated with overlapping stents which completely covered the aneurysm orifice. Two tandem stents were used in one patient (patient 4) to allow spanning the entire length of the dissection.

There were no instances of postprocedural ischaemic attacks, new neurological deficits, and no new minor or major strokes (0%) prior to patient discharge (Table 2). No patients with VA dissections experienced mild ischaemic complications caused by occlusion of the perforating arteries supplying the brainstem and spinal cord. One patient (patient 8) had intraprocedural vasospasm of the intracranial vertebral artery; this vasospasm was severe enough to necessitate intra-arterial papaverine injection and balloon angioplasty. All parent arteries of the patient who underwent the successful procedure were preserved. In two of four patients with "pearl and string sign" treated by stenting without coiling (patients 1 and 10), follow-up angiography showed near-complete elimination of the false lumen and restoration of the original vessel diameter. One lesion (patient 8) was improving on angiographic follow up, with a slight residual regular fusiform dilation. The aneurysm of remaining one patient (patient 9) was enlarged, and therefore, the patient underwent proximal occlusion with coils after balloon occlusion test. In two patients (patients 3 and 4) with "string sign" treated using stenting, follow-up angiography demonstrated complete resolution of the stenosis. Two lesions with fusiform dilation (patients 4 and 5) completely disappeared. One lesion with double lumen (patient 7) was completely cured. No recurrent haemorrhage occurred during the mean follow-up period of 2.1 years. On the modified Rankin Scale used in follow up, all patients were assessed as functionally improved or of stable clinical status.

Discussion

The natural history of arterial dissections is not well known. Some dissections may heal spontaneously with reconstitution of the vascular lumen; others can cause ischaemic symptoms or stroke attacks due to thrombotic occlusion of the stenotic lesion or distal emboli, or by further occlusion of the perforating arteries resulting from progression of the dissection. Still others may develop pseudo-aneurysms. Once ruptured to cause SAH, dissecting pseudo-aneurysms carry a significant risk of rebleeding with high morbidity and mortality rates [2, 25]. Therefore, acute treatment aimed at reducing the rate of rebleeding or recurrent thromboembolism in arterial dissection is clearly indicated. Conceptually, approaches to treatment of arterial dissections can be divided into deconstructive (involving occlusion or sacrifice of the parent vessel) and reconstructive (preserving blood flow through the parent vessel). Deconstructive surgical or endovascular techniques include proximal occlusion of the parent artery and trapping of the involved segment. Deconstructive procedures alone can be sufficient if branch vessels are not involved in the segment of the vessel to be occluded and collateral blood flow to the remainder of the circulation is adequate. However, for some patients it is not possible to perform proximal artery occlusion, because the contralateral artery is hypoplastic or affected by atherosclerotic degenerative changes. Also, proximal occlusion of the parent vessel in the vertebral dissecting aneurysm, either with a clip or by endovascular techniques, is associated with the risk of retrograde flow into the pseudo-aneurysm from the contralateral vertebral or basilar artery, with persistence of flow into the aneurysmal sac [35].

On the contrary, recontructive techniques preserve the parent vessel, which can be acceptable when angiography reveals inadequate collateral flow or when the dissected segment involves major branch vessels. The ability to preserve the parent vessel in such cases seems to increase safety when it is unclear from vascular anatomical factors whether parent vessel occlusion would be tolerated or when balloon occlusion is precluded by the patient's poor clinical condition. Surgical repair is reserved for the management of symptomatic patients with lesions in an accessible location, but the technique for the preservation of the artery is technically demanding and time consuming. For many years, endovascular revascularization of the affected artery has involved the use of stent and/or coils as an alternative to surgery [13]. The techniques are much easier and safer than surgical repair, and published case reports have described their successful application in the extracranial circulations [4, 6, 7, 12]. Recently, the main experience of stenting has been gained from endovascular treatment of intracranial atherosclerotic disease and intracranial arterial dissections have been now amenable to endovascular stent placement. The stent maintains the patency of the arterial lumen while allowing strategic coil placement in the aneurysmal sac, providing an artificial aneurysm neck [19, 23, 37]. Several articles have been reported the endovascular reconstructive treatment of stent-assisted coil embolization for an intracranial dissecting pseudo-aneurysm [15, 19, 21, 22, 31]. The advantage of stent-assisted coil embolization is that the tight aneurysm packing with coils is attainable with less risk of coil migration or coil bulging into the parent artery. Theoretically, reconstructive procedures are more reasonable than deconstructive ones because we cannot predict a destiny of collateral vessels such as atherosclerotic stenosis or repeated vessel injury in the rest of one's life. We thought that the more the parent artery is preserved if possible the better prognosis. And then, we preferentially performed endovascular reconstructive procedures, and if we failed, considered surgery or proximal occlusion of the parent artery after balloon occlusion test. Based on this favorable result



a b c

Fig. 1. Patient 1. Angiograms in a 37-year-old man show a dissecting aneurysm (a) of the left vertebral artery treated by two stents placement. After one stent placement, second stent was placed within the first stent (b). The aneurysm was completely obliterated with preservation of the parent artery (c)

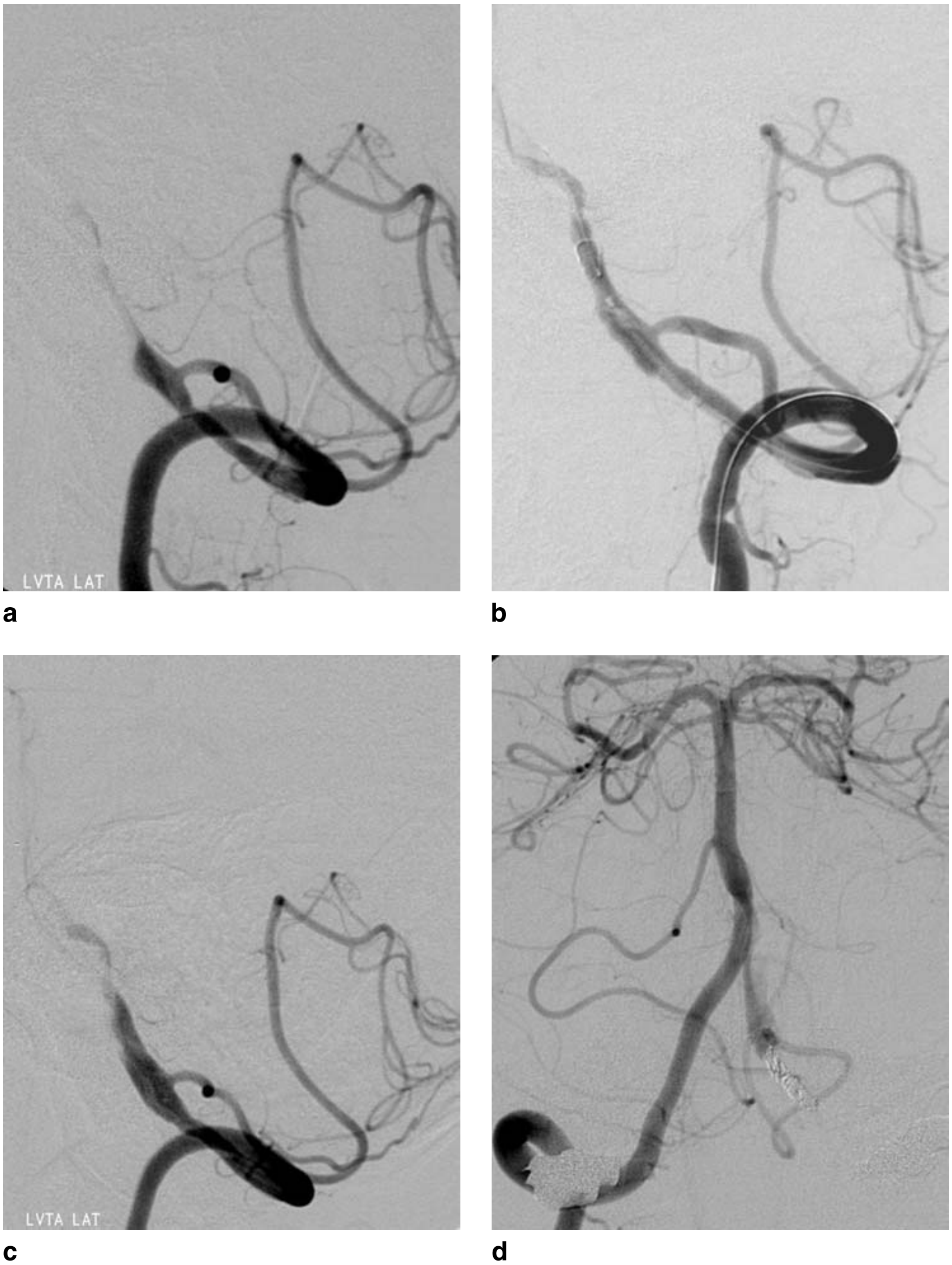


Fig. 2. Patient 9. Lateral angiogram of the left vertebral artery in a 33-year-old man with a dissecting aneurysm (a). After the first stent insertion, the distal end of the inserted first stent was advanced. However, the distal end of the first stent was folded during the advancement of the second stent (b). Therefore, the second stent was retrieved. Follow-up lateral angiogram of the left vertebral artery showed the enlarged aneurysmal sac in size (c). After proximal occlusion of the left vertebral artery, anteroposterior view of the right vertebral artery angiogram revealed slow retrograde flow to the aneurysm with preservation of the left posterior inferior cerebellar artery (d)

in the current series, we propose endovascular management strategy for arterial dissections or dissecting aneurysms (Fig. 3).

Most of stenting procedures have been performed under general anaesthesia [21, 22, 33, 39]. Balloon expansion of intracranial arteries can be problematic under local anaesthesia. In this study, however, all procedures could be done under local anaesthesia with light neuroleptic analgesia. Propofol was administered intravenously at the time of stent placement. We thought it was important to one-stage balloon occlusion test in the awake state for endovascular salvage if stenting failed.

We experienced two cases of proximal occlusion after stenting trial. Two causes were: the technical problems

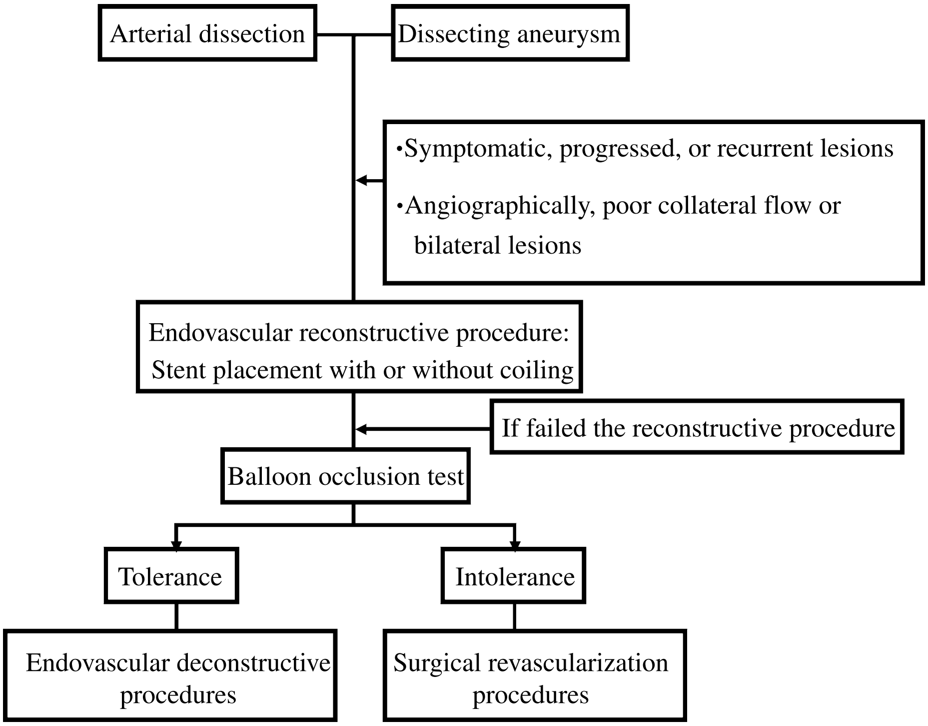


Fig. 3. Proposed endovascular management strategy for arterial dissections or dissecting aneurysms

during access to the lesion and incomplete coverage of pseudoaneurysmal orifice. The latter resulted in aneurysmal growth as shown in the follow-up angiographic study, and subsequently, proximal occlusion was indicated. Suboptimal stent placement was observed in this study. Selection of inadequate stent size, underexpansion of the stent, and the inability to deflate the balloon fully after stent release have contributed to suboptimal placement.

The balloon-expandable stent we used was flexible, a feature which allowed us to place it in an angled portion of the vessel. The regional effect on the arterial wall with stent placement leads to neo-intimal formation through transient and regional proliferation and migration of smooth muscle cells mixed with various degrees of connective tissue matrix [3]. However, immediate obliteration is often not accomplished in the dissecting pseudo-aneurysm [19]. By deploying a telescoping stent or a stent within a stent across the ostium of an aneurysm, the operator can decrease the porosity of the stent construct. This method can further alter the inflow within the aneurysm, promoting stasis and immediate thrombosis and safely allowing subsequent neo-intimal endothelial formation. Alternatively, by deploying graft stents in the intracranial vasculature, the pseudo-aneurysm can be sealed successfully in selective cases [5]. Concern also exists regarding occlusion of the ostia of small side branches and perforating arteries with stent placement, which may result in ischaemia or infarction [34]. However, experimental evidence obtained in dogs suggests that small lateral vessels tend to remain patent if less than 50% of the ostial diameter is covered by the stent [29, 30, 38].

In this article we reported on the safety of stent placement for arterial dissections and the long-term efficacy of prevention of recurrent bleeding or ischaemic attack. The guiding principle of repairing vital arteries is elimination of the arterial pathology without compromising arterial flow.

Although the current series is the largest reported to date, the number of patients treated remains small. Nonetheless, the procedure has proved to be safe, because it was not associated with any periprocedural complications. The success in reducing dissection-induced stenosis or pseudo-aneurysm, the high patency rate obtained at follow-up, and the lack of strokes (ischaemic or haemorrhagic) suggest that stent placement offers a viable alternative to complex surgical bypass procedures or deconstructive procedures. The long-term efficacy and durability of stent placement for arterial dissection remains to be determined in a large series.

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Comments

The authors present a well-written description of their experience with endovascular stent and/or stent coil treatment of both extracranial and intracranial arterial dissections. Although there is no novel information presented in this paper, it is a relatively large series with good clinical and angiographic outcomes and a clear description of the authors' techniques and indications.

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This is an interesting report on quite an impressive series of intra- and extracranial dissecting aneurysms treated with endovascularly deployed stents. To my knowledge no larger series has been published. Despite the relative large number of patients treated for this rare entity a conclusive assessment of the merits and risks of the endovascular approach appears premature. A particular aspect of intracranial stents is the question of intimal hyperplasia as known from coronary stenting and the possibilities of prevention with drug eluting or radioactive stents.

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