Endovascular Treatment for Very Small Supraclinoid Aneurysms with Stent-Assisted Coiling

Long-Term Follow-up in Six Cases

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Key words: supraclinoid aneurysm, very small, stent assisted coiling, follow-up

Summary

The endovascular treatment of very small aneurysms (lesions less than 3 mm in maximum diameter) with wide necks remains a challenge for saccular embolization. We retrospectively analyzed our data using Neuroform stent-assisted coiling for very small supraclinoid aneurysms with wide neck to evaluate the feasibility and efficacy of endovascular treatment of these lesions.

We conducted a review of our experience and results of endovascular treatments in six patients with seven very small aneurysms. All aneurysms were located at the side wall of the supraclinoid segment of the ICA. They were ruptured in two patients and unruptured in four. The technique of stent-assisted coiling was used in all cases with coiling before stenting and additional coils after deployment of the stent in the same session.

All patients were successfully embolized with stent-assisted coiling. The coils were introduced into the lumen for subtotal occlusion in five aneurysms and for partial occlusion in two. During one to two years follow-up angiography, all aneurysms were completely occluded and no recurrence occurred. No complications were observed.

Endovascular stent-assisted coil embolization of supraclinoid very small aneurysms with wide necks is effective and feasible. Subtotal aneurysm occlusion might progress to total occlusion.

Introduction

Although it has been widely used for intracranial aneurysms¹⁻³, endovascular coil embolization is a controversial technique for very small aneurysms (lesions less than 3 mm in maximum diameter) with wide necks⁴⁻⁷. Endovascular strategies for managing wide-necked aneurysms have frequently used a stent as a support to keep the coils inside wide-necked aneurysms and allow dense packing of the aneurysm lumen. However, for very small aneurysms with wide necks, dense packing would be more difficult. There are different strategies of combined stent deployment with coiling.

We report the result of our experience using Neuroform stent-assisted coiling for very small supraclinoid aneurysms with wide necks. Technical success, efficacy and complications related to the method will also be discussed.

Materials and Methods

Patients

We performed a retrospective review of the databases at our institutions to identify cases in which the stent-assisted coiling technique had been used to treat very small supraclinoid aneurysms with wide necks. From 2005 to 2007, six patients (four women, and two men; ranging in age from 43 to 60 years) with very small

supraclinoid aneurysms were treated with the Neuroform 3 microdelivery stent system (Neuroform 3, Boston Scientific, USA) and detachable platinum coils (GDC, Boston Scientific, USA and Microplex coil, Microvention, USA).

Among these patients, six had seven supraclinoid aneurysms located at the side wall of the supraclinoid segment of the ICA (one patient presented with bilateral very small supraclinoid aneurysms). All patients presented with SAH caused by ruptured aneurysm. All aneurysms were initially detected by MRA, subsequently confirmed by DSA.

The WFNS classification before treatment was Grade I in five patients and Grade II in one patient. All patients underwent endovascular procedures within one to three days after SAH onset. Detailed information is provided in Table 1. Surgical and endovascular treatment options, as well as the option of observation, were discussed with the patient in detail. After evaluating risks, benefits and potential complications, the patients chose endovascular treatment.

Therapeutic Strategy and Endovascular Procedure

Although there are different opinions of combined stent deployment with coiling, we selected the strategy of coiling before stenting and additional coils after deployment of the stent in the same session.

Endovascular treatment was performed under general anesthesia and systemic heparinization. Double 6 French guiding catheters were placed in the ipsilateral ICA via the bilateral femoral artery respectively. After a Neuroform stent was advanced over the neck of the

aneurysm through the guiding catheter, a microcatheter was navigated in another guiding catheter and inserted into the aneurysm along the microwire. The position of the tip of microcatheter was near the aneurysm neck (Figure 1). Before deploying the Neuroform stent, part of a detachable microcoil was placed into the lumen of the aneurysm (Figure 1). The Neuroform stent was deployed to cover the neck of the aneurysm, the microcatheter with coil was jailed between wall of parent artery and stent. Then additional coils were introduced into the lumen via microcatheter for loose coiling (Figures 2 and 3). After stent-assisted saccular coil embolization, immediate angiography was obtained to evaluate and Brain CT scanning was performed to exclude the hemorrhage.

Anticoagulation

After MRA, all patients were premedicated with antiplatelet therapy consisting of 100mg aspirin and clopidogrel 75 mg six to 12h before the procedure. Clopidogrel (75mg daily) was continued for an additional six months. During the procedure, all patients received heparin to raise the activated clotting time (ACT) two to three times compared to baseline. If there was no evidence of intracranial hemorrhage, low molecular heparin 4100U was subcutaneously injected for 12 hours which may last three days.

Evaluation

Evaluation of efficacy determining the extent of aneurysm occlusion was done immediately after treatment and at follow-up angiography which was performed at three or six months thereafter at six month intervals.

Table 1 Clinical and angiographic characteristics of six patients with supraclinoid very small aneurysms.

case /age /sex	size of AN (mm)	size of neck (mm)	Grade	initial occlusion	occlusion at 6 mths	GOS at 6 mths	follow-up
1/43/F	2.5x3	2.5	I	subtotal	total	good recovery	18 mths
2/45/M	3x2.5	3	II	subtotal	total	good recovery	14 mths
3/57/F	2x2.5	2.5	I	partial	total	good recovery	16 mths
4/60/F	2x3	3	I	subtotal	total	good recovery	24 mths
	3x2.5	3	I	partial	total	good recovery	21 mths
5/52/M	2x2	2	II	subtotal	total	good recovery	18 mths
6/48/F	3x2	3	I	partial	total	good recovery	20 mths

Figure 1 A 52-year-old man with SAH. A) The brain CT film showed the subarachnoid hemorrhage. B) Control angiography in the oblique view showed a very small supraclinoid aneurysm with wide-neck of the left ICA, the size was 2x2 mm. C,D) Before the Neuroform stent was deployed, the tip of the microcatheter was placed in the lumen near the neck, a partial coil was introduced into sac via the microcatheter (C). After the Neuroform stent was deployed, the microcatheter was jailed between wall of parent artery and stent, the tip of microcatheter with partial coil was pushed into mid position in the lumen and the loop of coil contacted with the wall of dome. E,F) After stent-assisted coiling, immediate control angiography in the oblique view showed subtotal occlusion of aneurysm (arrow). G,H) Six-month follow-up angiography in oblique view confirmed the total occlusion of aneurysm and no recurrence occurred.

Figure 2 A 57-year-old woman with SAH. A) Control angiography in the lateral view showed a very small aneurysm with wide-neck of left supraclinoid ICA, the size was 2 x 2.5 mm. B) Plain film showed the deployed Neuroform stent covered the neck of aneurysm, the microcatheter with coil was jailed between wall of parent artery and stent, the tip of microcatheter with partial coil was pushed into dome. C,D) After stent-assisted coiling, immediate control angiography showed partial occlusion of the aneurysm. Partial coil was caged by stent at the ostium of the aneurysm (arrow). E,F) Left ICA control angiography confirmed the aneurysm had progressed to total occlusion at 3 month follow-up (E) and the aneurysm demonstrated no recurrence occurred at 21-month follow-up (F).

The occlusion rate was divided into:

1) Total/near total, occlusion rate from 95% to 100%; 2) Subtotal, occlusion rate from 80% to 95%; 3) Partial, occlusion rate less than 80%. Clinical outcome for patients with ruptured aneurysms was ascertained according the Glasgow Outcome Scale (GOS).

Results

Immediate Angiographic Results

All patients were successfully embolized with stent-assisted coiling. Neuroform stents completely covered the neck of the aneurysm, the

parent artery was preserved in all patients. The coils were introduced into the lumen for subtotal occlusion in four aneurysms (Figures 1,3), partial occlusion in three aneurysms (Figure 2).

We found the final coil could not be completely introduced into lumen of aneurysm in three cases. The remaining part of the coil was jailed between the vessel wall and the stent (Figure 2). No coil migration occurred, the remaining coil was still stable during follow-up.

Follow-up Angiographic and Clinical Results

All aneurysms were confirmed as completely occluded by control angiography at three or six

Figure 3 A 43-year-old woman with SAH. A) Control angiography in the lateral view showed a very small aneurysm with wide-neck of left supraclinoid ICA, the size was 2.5x3 mm (arrow). B) Road-map film showed a microcatheter and a Neuroform microdelivery stent system placed in the ipsilateral parent artery, the tip of microcatheter was placed in the sac near the neck and a partial coil was introduced into the lumen via the microcatheter before Neuroform stent deployment. At the same time, the Neuroform stent system was placed over the neck of the aneurysm along the microwire. C) After stent-assisted coiling, immediate angiography confirmed subtotal occlusion of the aneurysm. D,E) Left ICA control angiography confirmed the aneurysm had progressed to total occlusion at 3 month follow-up (D) and the aneurysm demonstrated no recurrence occurred at 18-month follow-up (E).

months follow-up (Figure 1). There was no recurrence during one to two year follow-up angiography (Figures 2 and 3). No coil compaction or migration into thrombus occurred in any patient.

No rehemorrhage or neurologic symptom of ischemic stroke occurred in any patient. The GOS scores for patients with SAH were good recovery during follow-up. No progressive clinical problem occurred after treatment.

Complications

No other complications were observed during the endovascular procedure and follow-up

including dome perforation, embolic infarction and stenosis in stent.

Discussion

An effective treatment is necessary for ruptured very small aneurysms, since ruptured small aneurysms may cause even more extensive SAH than larger aneurysms⁸. Embolization with stent-assisted coiling is an advanced technique for cerebral aneurysms with wide necks. It has become a widely accepted method and compares favorably with surgical clipping⁹. On the basis of the long-term follow-up of

aneurysms treated with detachable coils, the size of the aneurysmal neck is considered an important determinant of success, especially for very small aneurysms with a dome-to-neck ratio less than 1.5. In the case of the very small aneurysms, it is difficult to retain detached coils inside an aneurysmal sac with a wide neck and small lumen with a high risk of coil protrusion and migration into the parent artery. The neuroform stent technique can be effectively used to reconstruct the parent artery and avoid coil protrusion, and further increase the stability of the sacular coil in a very small aneurysm.

The strategy of neuroform stent-assisted coiling is a different option¹⁰. Biondi et Al. detailed the different strategies of combination stent deployment and coiling, including

- 1) Stenting before coiling;
- 2) Coiling before stent deployment at the end of the session;

- 3) Coiling before stenting and additional coils after deployment of the stent in the same session. Different strategies regarding the timing of stent deployment in relation to coiling are practised. Coiling was usually performed with the microcatheter placed in the aneurysm through the mesh of the stent or less frequently using the “jailed technique” in which the microcatheter is caged between the vessel wall and the stent. For very small aneurysms, failure to catheterize the stent interstices has been reported because of very small size and the high probability of microcatheter dislodgment intraprocedure^{6,10}. Using the technique of coiling before stenting and additional coils after deployment of the stent in the same session, the “jailed technique” could permit stabilization of the microcatheter during coil delivery and prevent dislodgment. Moreover, if the final microcoil could not be completely introduced inside the sac, the remaining part of the coil could be jailed between the vessel wall and the stent. In our series, the remaining coil was jailed in three patients and was still stable during follow-up.

Procedure-related rupture, one of the most feared complications of endovascular therapy for ruptured aneurysms, is associated with high rates of neurological disability and mortality^{4,6,11-13,15}, especially for very small aneurysms. Small lesion size is associated with high bleeding rates intraprocedure^{4,6}. Nguyen et Al, describing 682 aneurysms selectively treated with coils in 668 patients, reported procedure-relat-

ed rupture occurred in seven (11.7%) out of 60 aneurysms ≤ 3 mm, compared with 14 (2.3%) out of 622 aneurysms ≥ 3 mm, procedure-related ruptures were five times as frequent during coil embolization of very small (≤ 3 mm) cerebral aneurysms compared with larger ones⁶. Because smaller aneurysms tend to have a thin fragile wall, and there is limited space in small lesions to allow coiling and movement of the tip of the microcatheter during coil delivery, devices may be easy to position inadvertently in the vicinity of the initial rupture site and random displacement of a device by a few millimeters could lead to rupture. In our series, the microcatheter was jailed between the vessel wall and stent, enhancing the stabilization of the microcatheter during coil delivery and combined with the looser coiling, no procedure-related rupture occurred. Another hypothesis is an increased risk of dome perforation: when stents are deployed after microcatheter placement, the stent might cause force the tip of microcatheter to move to the dome or initial rupture site.

In our series, before stent deployment, one or two loops of the first coil would be introduced into the sac with low tensility of the microcatheter, and the tip of the microcatheter was kept near the neck (Figure 1). When the stent was deployed, the soft loop was in contact with the dome of the aneurysm with enough space for movement of the microcatheter to decrease the force on the aneurysm wall. No procedure-related perforation occurred in any cases.

Recurrence is a known disadvantage of endovascular coiling for aneurysms due to coil compaction and migration of the coil mesh into the thrombus. Dense packing with coils could prevent aneurysm recurrence. However, for very small aneurysms less than 3 mm in maximum diameter, the risk of aneurysm perforation during the procedure is greater. This seems to be due to the fact that very small aneurysms do not have enough room for insertion of the microcatheter and coils, and therefore direct transmission of the force either via the microcatheter or coil may cause aneurysm wall perforation as described by Sluzewski et Al. who proved that small aneurysm size is a risk factor for procedure-related rupture⁴. The low packing ratio of the aneurysms was not predictive of future recurrence- Some have reported the satisfactory stability and low recurrence for these

unstable-looking embolized aneurysms with low packing ratio^{14,16-18}. In our series, an unfavorable dome-to-neck ratio increased the difficulties for dense packing. To avoid the high risk of wall perforation, we selected partial occlusion for aneurysms with loose coiling. In addition, endovascular stent reconstruction for very small aneurysms may induce spontaneous aneurysmal thrombosis with the hemodynamic change. We found no clinical rebleeding and no recurrence in any patients with follow-up angiography, and all aneurysms with incomplete occlusion became obliterated from circulation with the passage of time.

Although all aneurysms with unfavorable dome-to-neck ratios were treated with stent-assisted coiling and the results of initial treatment were subtotal or partial occlusion, the efficacy and durability were satisfactory. According to our long-term follow-up angiography, the aneurysms might progress to total occlusion in relation to the size and location of the aneur-

ysm. Partially thrombosed aneurysms treated with endosaccluar coil embolization may easily reopen because of the common phenomenon of coil migration into the thrombus with the passage of time, but this was not observed in our series. It may be easier for very small aneurysms to be occluded than other aneurysms by stent-assisted coiling. Due to the lack of a large series, this conclusion awaits confirmation in the future.

Conclusions

Endovascular stent-assisted coil embolization of very small supraclinoid aneurysms with wide necks is effective and feasible. The initial subtotal or partial aneurysm occlusion might progress to total occlusion and the results were stable during follow-up. Long-term follow-up angiography has confirmed the overall role of subtotal occlusion of stent-assisted coiling for very small aneurysms in our series.

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