Periprocedural complications associated with endovascular embolisation of intracranial ruptured aneurysms with matrix coils

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ABSTRACT

Introduction: Matrix is a type of bioactive coil expected to produce healing of cerebral aneurysms. We reviewed periprocedural complications associated with endovascular embolisation of ruptured intracranial aneurysms with matrix coils and evaluated the effects of matrix coils.

Methods: From October 2003 to September 2005, a total of 102 patients with 102 ruptured aneurysms and ten unruptured aneurysms underwent embolisations with matrix coils. We reviewed the medical records, radiographical studies and endovascular procedures to evaluate the morbidity and mortality related to ruptured aneurysm coiling.

Results: 16 complications (15.7 percent) occurred, of which 14 were in the anterior circulation and two in the posterior circulation. Complications included nine intraprocedural ruptures (8.8 percent), three thromboembolism (2.9 percent), one coil migration (1.0 percent) and three parent vessel occlusions (2.9 percent). Six complications had no neurological consequences, three were with transient deficits, six resulted in persistent neurological deficits, and one caused the patient to die. No complication was associated with balloon remodelling technique, and coil migration occurred during one of the neuroform-assisted embolisations. Procedural-related neurological morbidity and mortality for all 102 embolisations of ruptured aneurysms were 5.9 percent and 1.0 percent, respectively.

Conclusion: Endovascular treatment of ruptured intracranial aneurysms with matrix coils is as safe as with bare platinum coils. Matrix coil does not increase the risk of thromboembolism. However, we must be cautious when we embolise small aneurysms with matrix coils, especially when the aneurysms are less than 5 mm in diameter.

Keywords: cerebral aneurysm, endovascular embolisation, intracranial aneurysm, matrix coil, ruptured aneurysm

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INTRODUCTION

Aneurysm recanalisation is an unavoidable problem for the neurointerventionalist.[1-3] Matrix is a new kind of coil which consists of a thin platinum coil covered with a bioabsorbable polymeric material. Compared with bare metal coils, some of its traits, such as flexibility and smoothness, are different. Hence, its performance related to technique may be different. Animal experiments have shown that matrix coils can accelerate intra-aneurysmal fibrosis and neointima formation without parent artery stenosis.[4] Clinical findings showed predominantly stable angiographical results on follow-up after aneurysm embolisation.[5-7] The purposes of this study are to review our experience with periprocedural complications associated with endovascular embolisation of ruptured intracranial aneurysms using matrix coils, and to evaluate the effects of matrix coils by analysing detailed data on the types and frequency of complications.

METHODS

From October 2003 to September 2005, 118 embolisations using detachable matrix coils were performed by two neurosurgeons to treat 118 aneurysms (102 ruptured) in 108 consecutive patients in our hospital. We reviewed the medical records, radiographical studies and endovascular procedure reports of 102 patients with 102 ruptured aneurysms and ten unruptured aneurysms. Of all the 102 patients who presented with subarachnoid haemorrhage (SAH) attributable to aneurysmal rupture, 62 were female (60.8%) and 40 male (39.2%), aged 12–79 (mean 47.6) years.

Table I. Locations of the 102 ruptured aneurysms and nine intraprocedural ruptured aneurysms.

Location	Ruptured aneurysms	Intraprocedural ruptured aneurysms
Anterior circulation	93	8
Posterior communicating artery	39	2
Anterior communicating artery	35	5
Middle cerebral artery bifurcation	12	1
Paraclinoid internal carotid artery	2	0
Internal carotid bifurcation	2	0
Distal anterior communicating artery	2	0
Anterior choroidal artery	1	0
Posterior circulation	9	1
Basal artery tip	1	0
Disal posterior communicating artery	3	0
Superior cerebellar artery	1	0
Basal artery	1	0
Vertebrobasilar junction	1	0
Posterior inferior cerebellar artery	1	0
Anterior inferior cerebellar artery	1	1

The clinical status of patients was assessed by the Hunt-Hess scale:[8] 17 were grade I; 53 grade II; 25 grade III; five grade IV; and two grade V. Ten of the 102 patients had a second aneurysm and SAH. The ruptured aneurysms could be identified on the basis of clinical, computed tomography (CT) and angiographical findings. The unruptured aneurysms, as well as the ruptured aneurysms, were endovascularly treated. Among the 102 procedures for ruptured aneurysms, five (4.9%) were assisted by balloon remodelling technique with hyperglide (eV3) and 12 (11.8%) by stenting with neuroform (Boston Scientific, Fremont, CA, USA). No technical failure occurred. The locations of ruptured aneurysms are summarised in Table I. 93 (91.2%) aneurysms were in the anterior circulation and only nine (8.8%) were in the posterior circulation. The most common location was the posterior communicating artery, followed by the anterior communicating artery. Aneurysms were measured according to their greatest diameter. 79 (77.5%) were small (< 10 mm), 19 (18.6%) were large (10–24 mm), and four (3.9%) were giant (> 25 mm).

All the procedures were performed under general anaesthesia from the femoral artery with envoy guiding catheter (Johnson & Johnson, Miami Lakes, FL, USA). The microcatheters were Prowler serials (Johnson & Johnson, Miami Lakes, FL, USA) or Excelsior SL-10 (Boston Scientific, Fremont, CA, USA). 90 cases were treated with matrix coils (Boston Scientific, Fremont, CA, USA) only and the others combined with one or two Guglielmi detachable coils of 2 mm by 1 cm (Boston Scientific, Fremont, CA, USA). All coil introductions were under monitoring by a monoplane X-ray machine (Angiostar, Siemens, Munich, Germany) with or without a roadmap. At the beginning, heparin was routinely infused before catheterisation according to the equation: 2/3*body weight (kg)*100 (U) and every one hour, half of the initial amount was infused to keep the activating time at about 300 seconds. Coil placement proceeded, until no additional coil could be placed or until no opacification was seen in the aneurysms. After embolisation, heparin was not reversed except for obvious contraindications such as intraprocedural rupture. When a stent-assisted technique was used, all patients were infused with heparin for more than 24 hours and at the same time, 75 mg plavix (Sanofi-Synthelabo, Paris, France) with 300 mg aspirin (AstraZeneca, Wedel, Germany) was orally taken every day.

The degree of aneurysmal occlusion was classified into three categories, namely: complete occlusion, neck remnant and body filling. Of the 102 ruptured aneurysms, immediate angiography showed complete occlusion in 63 (61.8%), neck remnant in 31 (30.4%) and body filling in eight (7.9%) cases. Cases with procedural-related complications were selected, and we analysed their radiological findings, clinical presentations, treatment and clinical sequelae. The neurological deficits were classified

Table II. Procedure-related complications.

Complication	Neurological sequelae				Incidence (%)
	None	Transient	Persistent	Fatal	
Intraprocedural rupture	5	2	1	1	8.8
Thromboembolism	0	1	2	0	2.9
Coil migration	0	0	1	0	1.0
Parent-vessel occlusion	1	0	2	0	2.9
Total	6	3	6	1	15.7
Incidence (%)	5.9	2.9	5.9	1.0	

as: transient deficits, which resolved within two weeks after embolisation, or persistent deficits, which persisted longer than two weeks. We defined the procedural-related morbidity as persistent deficits.

RESULTS

16 (15.7%) complications occurred, of which 14 were in the anterior circulation and two in the posterior circulation. Complications included nine intraprocedural ruptures (8.8%), three thromboembolism (2.9%), one coil migration (1.0%) and three parent vessel occlusions (2.9%) (Table II). Among them, six complications had no neurological consequence, three had transient deficits, six resulted in persistent neurological deficits, and one caused the patient to die. No complication was associated with the balloon remodelling technique, and coil migration occurred during one of the neuroform-assisted embolisations. Procedure-related neurological morbidity and mortality for all 102 ruptured aneurysm embolisations were 5.9% and 1.0%, respectively.

Nine aneurysms ruptured during procedures due to microcatheter penetration (n = 2) or protrusion of coil (n = 7) outside the aneurysms. Microcatheter-induced rupture occurred in two aneurysms during the initial placement of microcatheter and replacement of microcatheter to deploy the second coil, respectively. Coil-induced ruptures were caused by the first coil in one aneurysm and by the second coils in six aneurysms. All intraprocedural ruptured aneurysms were small and occurred in acutely-ruptured aneurysms of which five were less than 5 mm in diameter. Their locations were: anterior communicating artery in five patients, posterior communicating artery in two patients, bifurcation of the middle cerebral artery in one patient, and anterior inferior cerebellar artery in one patient (Table I). Preoperative clinical grades of the nine patients were: two grade I, six grade II and one grade III.

All intraprocedural ruptures were managed by reversing the heparin with protamine immediately. Eight of the nine aneurysm ruptures had visible extravasation of contrast media and further coil deployment continued. CT after embolisation showed haematoma in three patients, all of which were managed with craniotomy and of whom one died. CT showed SAH in six patients, of which only one patient suffered from monolimb paresis and the others had no persistent neurological deficit. One of the nine intraprocedural ruptures was accompanied with no opacification of the cerebral artery with normal perfusive pressure for about four minutes and then embolisation was stopped. CT showed SAH and a catheter was inserted into the ventricle. Three days later, the patient recovered without any neurological deficits and he underwent another angiography and aneurysmal clipping. Overall, the morbidity and mortality at two weeks from intraprocedural aneurysmal rupture were both 1.0%.

Thromboembolic complications occurred in three of the 102 procedures, of which one resulted in transient neurological deficit (expressive aphasia) and two in persistent neurological abnormality. The locations of aneurysms were the anterior communicating artery in one patient, and bifurcations of the middle cerebral artery in the other two patients. The Hunt-Hess grades of the patients just before embolisation were grade I, grade II and grade III, respectively. One complication was obvious during the procedure and was managed with local and systemic administration of urokinase 300,000 units. The other two complications were found post-embolisation and managed with systemic administration of urokinase and heparin after which both patients were heavily disabled. No thromboembolic complications were associated with device-assisted technique. The morbidity and mortality from thromboembolism were 2.0% and 0%, respectively.

Parent artery occlusion occurred in three of the 102 procedures due to coil prolapse into the parent vessel. Angiography of all the three patients showed obvious vasospasm. Two aneurysms were located at the anterior communicating artery, in one of which the compensation of perfusion from the contralateral anterior cerebral artery was very good and there was no any clinical consequence, while in the other, compensation was poor and monolimb paresis occurred. One aneurysm was at the bifurcation of the middle cerebral artery, with limb paresis and aphasia. Coil migration occurred in one of the 102 aneurysms during embolisation of a small posterior communicating artery aneurysm with stent-assistance. The ratio of the neck to body was 1:1 and the diameter of neck was 3 mm. The last matrix coil came out of the neuroform to the bifurcation of the internal carotid artery and could not be retrieved successfully. Hemispherical infarction occurred, and craniotomy was performed with resultant hemiparalysis.

DISCUSSION

Very limited reports can be retrieved from a PubMed search about the periprocedural complications related to endovascular treatment of ruptured intracranial aneurysms with matrix coils. Linfante et al reported two strokes related to embolisation procedure with matrix coils.[5] But only 13 aneurysms were treated only with matrix. However, several groups have reported procedure-related complications of ruptured aneurysm embolisation with bare platinum coil. Park et al observed a 22.9% procedural complication rate in 118 ruptured aneurysms, with procedure-related morbidity and mortality of 5.9% and 7.6%, respectively.[9] Ng et al reported procedure-related morbidity of 8.6% and mortality of 2.5% in their group with ruptured aneurysms.[10] In the series by Byrne, of 317 consecutive patients with ruptured aneurysms, 31 (9.8%) procedural complications occurred.[11]

Our overall complication rate for 102 ruptured aneurysms was 15.7%, and the procedural morbidity and mortality were 5.9% and 1.0%, respectively. The prominent complications in this group were intraprocedural aneurysm ruptures, which accounted for more than half of the complications (9/16, 56.3%). The morbidity mostly resulted from ischaemic events (5/6, 83.3%). Persistent neurological deficits in two patients were related to thromboemblism (2/6, 33.3%), which is quite different from most of the other reports, where the morbidity was mainly caused by thromboembolism.[9-13,15,16]

Rates of aneurysmal rupture during embolisation with bare platinum coils were 1.4%–16.0% for ruptured aneurysms.[9,10,12-24] Most iatrogenic ruptures were found in previously-ruptured aneurysms, especially the acutely-ruptured aneurysms.[9,10,12,16,21-24] Rates of aneurysmal rupture reported for ruptured aneurysm were much higher than for unruptured aneurysm. Ng et al noted that intraprocedural rupture was more common with the ruptured than with the unruptured aneurysms (16% versus 1.3%) and more than 90% of ruptures that occurred during embolisations were associated with the acutely-ruptured type.[10] Several groups reported complications related to endovascular treatment of both ruptured and unruptured aneurysms, and found that all the aneurysmal ruptures were associated with small aneurysms. Yu et al observed that all the seven intraprocedural ruptured aneurysms were less than 5 mm.[20]

In our series, nine aneurysmal ruptures (8.8%) were observed during endovascular treatment of 102 ruptured aneurysms with matrix coils. Bioabsorbable polymeric material on the platinum coil may cause the surface of matrix coil to be less smooth and a little stiffer than bare metal coils. The strength of friction between matrix coils is higher than that between metal coils which may cause big problems within a very limited space. Sometimes, higher friction and less flexibility may lead to sudden release of strength of matrix, which results in the protrusion outside of the aneurysm sac. In our group, seven aneurysm penetrations were associated with coils and six of them occurred during deployment of the second coil, suggesting that the strength between matrix coils may play an important role. All intraprocedural ruptured aneurysms were small (less than 5 mm in diameter) and acutely-ruptured aneurysms. The most commonly-involved location was the anterior communicating artery (55.6%), which was consistent with other publications.[23-26] Most (77.8%) of the nine ruptures had good consequence after effective management, and only one resulted in death. The morbidity and mortality rates attributed to intraprocedural aneurysmal rupture were both 1.0% in the 102 procedures.

Animal experiments have shown that matrix coil can accelerate clot formation.[4] There has been concern that matrix coil would increase the risk of thromboembolism. In our group, only three thromboembolic events occurred, which was acceptable compared with most publications. Usually, thromboembolism is the main cause of procedure-related complications.[9-12,15,17,18] Qureshi et al reported that nearly half of complications (6/16) were thromboembolism.[17] Park et al observed nine thromboemblic events among 27 complications during embolisations of 118 ruptured aneurysms.[9] Our findings suggest that the matrix coil does not increase the risk of thromboemblism and it is as safe as the bare platinum coils. According to our experience, the most important measures to prevent thromboemblic events are enough heparinisation, shortened duration of endovascular manipulation, and sufficient prevention from injection of embolus into circulation.

In our series, 17 procedures were assisted by device (16.7%). It seemed that balloon and neuroform did not increase the risk of thromboembolism. Our findings are similar to those of some reports.[12,25,26] Cottier et al observed two thromboembolic complications among 49 balloon-assisted treatments of cerebral aneurysms.[25] Findings of Albayram et al did not suggest a strong correlation between the occurrence of ischaemic lesions associated with balloon-assisted coil placement and embolisation.[26] With regard to experience with neuroform, the reported cases are limited.[27-30] Lee et al observed stent thrombosis in one of 22 patients with wide-necked aneurysms.[27] Jabbour et al reported that two patients experienced thromboembolic events, one of which was directly related to the stent.[28] We need more experience to check the safety of neuroform with regard to thromboembolism.

Our findings indicate that endovascular treatment of ruptured intracranial aneurysms using matrix coils is as safe as with bare platinum coils. The procedure-related morbidity and mortality (5.9% and 1.0%) are acceptable. Matrix coil does not increase the risk of thromboembolism. However, we must be cautious when managing small aneurysms with matrix coils, especially when the aneurysms are less than 5 mm in diameter. We have not found thromboembolism to be correlated with balloon- or neuroform-assisted coiling.

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