ORIGINAL RESEARCH

Follow-Up of Intracranial Aneurysms Treated with Matrix Detachable Coils: A Single-Center Experience

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BACKGROUND AND PURPOSE: Matrix coils are polymer-coated bioactive coils used in treatment of intracranial aneurysms. The current study is aimed at evaluating the efficacy and safety of these coils in treatment of ruptured and unruptured aneurysms.

METHODS: Seventy-seven consecutive patients with 84 aneurysms were included in the study. Forty-six aneurysms were treated with Matrix coils alone, and 38 were treated with Matrix coils in combination with other coils/devices. Angiographic follow-up was available in 64 patients with 70 aneurysms. Length of follow-up ranged from 6 to 28 months with mean of 10 months. Both postembolization and follow-up angiograms were graded on a 3-point Raymond scale. Aneurysms were classified as stable, improved, or recanalized based on the follow-up angiograms. Recanalization was considered major if it was saccular and its size would theoretically permit retreatment with coils.

RESULTS: At the end of the initial procedure, 47 (56.0%) aneurysms showed complete occlusion (Raymond 1), 20 (23.8%) showed contrast filling the neck of the aneurysm (Raymond 2), and 16 (19.0%) showed contrast filling the sac of the aneurysm (Raymond 3). Of the 70 aneurysms in which follow-up angiograms were available, 55.7% remained stable in appearance, 20.0% showed improved occlusion, and 24.3% demonstrated recanalization; 8.6% demonstrated major recanalization. There were 2 aneurysm rebleeds (both incompletely packed); one resulted in death.

CONCLUSION: Matrix coils are safe to use and the recanalization rate of aneurysms treated with these coils appears to be at least comparable with historical studies with Guglielmi detachable coils.

Since the publication of the results of International Subarachnoid Aneurysm Trial (ISAT)[1] trial in 2002, endovascular coil embolization has become the primary technique of treatment of intracranial aneurysms in many centers around the world. ISAT studied 2143 patients with ruptured intracranial aneurysms. Updated results of the ISAT trial[2] demonstrate that the relative and absolute risk reductions in dependency or death at the end of 1 year with endovascular treatment were 23.9% and 7.4%, respectively, compared with surgical treatment. This is equivalent to 74 patients avoiding death or dependency at 1 year for every 1000 patients treated.[2] The long-term durability of endovascular coil embolization, however, has remained an important and highly debated issue, despite the obvious short-term advantages of this method of treatment. It is well known that the coil mass in a significant number of embolized aneurysms undergoes compaction resulting in aneurysm recurrence.[3,4] Most centers practicing endovascular coil embolization, therefore, have a follow-up regimen to detect aneurysm recurrence and offer patients further treatment if there is significant recurrence. This reduces, but does not eliminate, the risk of aneurysm recurrence and rebleeding. Several strategies are being currently looked at to reduce the rate of coil compaction. Most of these involve improvement in coil technology aimed at achieving better packing of aneurysms (eg, HydroCoil; Microvention, Aliso Viejo, Calif) and promoting a healing response in the embolized aneurysm (eg, Matrix coils; Boston Scientific, Fremont, Calif).

Matrix coils are copolymer-coated detachable coils that have been reported[5] in animal experiments to elicit accelerated aneurysm fibrosis and neointima formation. Angiographic evidence of a healing response at the aneurysm neck in human subjects has also been reported.[6] This study presents a single-center experience of treating 84 aneurysms in 77 patients with Matrix coils.

Materials and Methods

Eighty-seven consecutive patients (22 male and 65 female) with 94 aneurysms were treated with Matrix detachable coils with or without other coils/devices between July 2002 and November 2004. Aneurysms were treated with Matrix coils alone as well as with Matrix in combination with other coils and devices. Ten aneurysms in 10 patients were treated with Matrix in combination with Hydrocoil and/or Neuroform (Boston Scientific) stent. These were excluded, leaving 77 patients (19 male and 58 female), with 84 aneurysms in the study.

All aneurysms were assessed before endovascular treatment with conventional angiography. Angiography was performed with Phillips Integris V3000 (Phillips Medical Systems, Best, The Netherlands) equipment. Aneurysms were measured with standard software by using the 6F guide catheter as reference. Maximum length and width of the aneurysms were measured. Aneurysms were grouped into wide- and small-necked aneurysms. A wide neck was defined as an absolute neck diameter of $\geq$4 mm and/or neck:dome ratio of greater than 1:2. Aneurysm embolizations were performed under direct supervision of 2 consultant interventional neuroradiologists (A.G. and C.S.) who were present in the operating room throughout the procedure. A postembolization angiogram including at least 2 projections demon-

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strating the treated aneurysm was performed before completion of each procedure.

Forty-six aneurysms were treated with Matrix coils alone. For irregular and wide-necked aneurysms, 3D Matrix coils were used as the initial/framing coil. Packing of aneurysms was done mostly with 2D standard and soft Matrix coils. Three aneurysms treated only with Matrix coils also required balloon remodelling. Thirty-eight aneurysms were treated with a combination of Matrix and other coils/devices. Coils and devices used in combination with Matrix were UltiPaq coils (Micrus Endovascular, Sunnyvale, Calif) in 22 aneurysms, Guglielmi detachable coils (GDC) (Boston Scientific) in 16 aneurysms, MicroPlex coils (Microvention) in 3 aneurysms, Trufill Detachable Coils System (Cordis, Miami Lakes, Fla) in 2 aneurysms, and detachable single spiral coils (William Cook Europe, Bjæverskov, Denmark) in 1. In all the mixed-coil cases, Matrix constituted most of the coils used.

Follow-up angiogram results were available on 70 aneurysms (in 64 patients). Length of angiographic follow-up ranged from 6 to 28 months with a mean interval of 10 months; 48 aneurysms had 6-month follow-up, 1 aneurysm had 9-month follow-up, 10 patients had 12–18-month follow-up, and 11 patients had ≥24-month follow- up. Only the latest follow-up angiogram was compared with the postembolization angiogram for assessment of recanalization.

Follow-up angiogram was not available in 13 patients (14 aneurysms). The causes include death (7) severe disability (1), surgical clipping soon after coiling (1), and patients lost to follow-up (4).

Follow-up in all but 1 patient was performed with conventional angiography. One patient had follow up MR angiography at 12 months because she was unsuitable for conventional angiography. Follow-up angiography included a repeat of the projections obtained during postembolization check for comparative analysis. The operator obtained additional projections if it was believed to be appropriate (especially if aneurysm recurrence was noted).

The immediate postembolization angiogram and the follow-up angiogram for each aneurysm were assessed in conjunction by 2 observers (A.G. and D.M.). Angiograms were graded on the basis of a modified 3-point Raymond scale (Raymond 1 = complete obliteration of aneurysm including the neck; Raymond 2 = contrast filling the neck of the aneurysm without opacification of aneurysm sac; and Raymond 3 = contrast filling the sac of the aneurysm).[3] The postembolization and follow-up angiograms were assessed individually on the modified Raymond scale. Aneurysms were then classified as stable (no change on the Raymond scale), improved (aneurysm moving from a higher to a lower point on the Raymond scale, suggesting improved occlusion), and recanalized (aneurysm moving from a lower to a higher point on the Raymond scale suggesting worsening occlusion). Recanalization was considered major if it was saccular and its size would theoretically permit retreatment with coils.[3]

Data were transferred to an Excel (Microsoft, Redmond, Wash) worksheet for analysis. Analysis was done separately for all aneurysms and for those aneurysms treated with Matrix coils only.

Results

Out of 84 aneurysms in the study, 71 (84.5%) aneurysms were ruptured, 12 (14.3%) aneurysms were unruptured/recurrent/coincidental, and 1 (1.2%) aneurysm manifested as third nerve palsy. Most (50) of the ruptured aneurysms were in patients presenting with World Federation of Neurosurgical Societies (WFNS) grade 1, 6 were in patients with WFNS grade 2, and 15 were in patients with WFNS grade 3 or above.

Table 1: Location of aneurysms

Location of Aneurysm	Number (%)
Anterior communicating	29 (34.6%)
Posterior communicating	25 (29.8%)
Internal carotid	13 (15.5%)
Middle cerebral	5 (5.9%)
Basilar tip	4 (4.7%)
Posterior inferior cerebellar	4 (4.7%)
Vertebrobasilar	2 (2.4%)
Superior cerebellar	1 (1.2%)
Pericallosal	1 (1.2%)
Total	84

Table 2: Results of follow-up after embolization

Results	All Aneurysms (Total = 70)	Matrix Only Aneurysms (Total = 37)
Stable	39 (55.7%)	21 (56.8%)
Improved	14 (20.0%)	6 (16.2%)
Recanalized	17 (24.3%)	10 (27.0%)
Major recanalization	6 (8.6%)	4 (10.8%)

Aneurysm size ranged from 2.5 to 20 mm with a mean of 6.25 ± 3.23 mm. Forty (47.6%) aneurysms were 5 mm or less, 37 (44.0%) were 5–10 mm, and 7 (8.4%) were 10–20 mm in size. Most aneurysms were in anterior circulation with anterior communicating ($n = 29$) and posterior communicating ($n = 25$) artery aneurysms being most common (Table 1).

At the end of the initial procedure, 47 (56.0%) aneurysms showed complete occlusion (Raymond 1 or R1), 20 (23.8%) showed contrast filling the neck of the aneurysm (Raymond 2 or R2), and 16 (19.0%) showed contrast filling the sac of the aneurysm (Raymond 3 or R3). Postembolization angiogram was not available in 1 patient (1.2%) in whom embolization was not completed because of coil stretching. The patient went for immediate coil retrieval and clipping.

Of the 46 aneurysms that were treated with Matrix coils only, 27 (58.7%) showed R1, 11 (23.9%) showed R2, and 7 (15.3%) showed R3 on angiography after the initial procedure. Postprocedure angiogram was not available in 1 patient (the same patient as mentioned above, whose embolization was not completed and went for immediate clipping).

Of the 70 aneurysms where follow-up angiograms were available, 39 (55.7%) remained stable in appearance (ie, no change in Raymond scale), 14 (20.0%) showed improved occlusion (higher to a lower point on Raymond scale), and 17 (24.3%) demonstrated recanalization. Six (8.6%) demonstrated major recanalization (ie, in which further treatment of the aneurysm was deemed necessary) (Table 2).

Among 46 aneurysms treated with Matrix coils only, follow-up angiograms were available in 37 cases. Of these, 21 (56.8%) showed stable appearances, 6 (16.2%) showed improved occlusion, and 10 (27%) showed recanalization. Major recanalization was seen in 4 (10.8%) (Table 2).

More than 1 follow-up angiogram was available in 21 aneurysms. Of these, 17 either remained stable throughout or improved during the follow-up period. The remaining 4 showed recanalization; only 1 of these aneurysms showed late recanalization between first and second follow-up angiogram from R1 to R2. The other 3 showed recanalization at the first

Table 3: Details of aneurysms with recanalization

	WFNS Grade	Location	Size (mm)	Neck	Coils Used	Postembolism Result	Degree of Recanalization
1	1	AcomA	3.3 × 3.7	S	Matrix only	R1	R1 TO R2
2	2	AcomA	2.5 × 3.5	S	Matrix only	R1	R1 TO R2
3	1	ICA	7.6 × 6.7	S	Mixed	R1	R1 TO R2
4	Unruptured	ICA	3.0 × 2.7	S	Mixed	R1	R1 TO R3
5	1	MCA	7.4 × 6.0	W	Matrix only	R1	R1 TO R2
6	3	MCA	8.0 × 3.5	S	Mixed	R1	R1 TO R2
7	1	PcomA	5.0 × 3.4	W	Matrix only	R1	R1 TO R2
8	1	PcomA	17.5 × 7.8	W	Matrix only	R2	R2 TO R3
9	1	PcomA	6.1 × 5.0	W	Matrix only	R2	R2 TO R3
10	5	PcomA	8.0 × 3.9	S	Mixed	R2	R2 TO R3
11	2	SC	8.5 × 6.0	W	Mixed	R1	R1 TO R3
12	2	AcomA	11.0 × 7.0	W	Mixed	R3	R3 TO R3+ (M)
13	1	PcomA	7.5 × 8.6	W	Matrix only	R3	R3 TO R3+ (M)
14	1	PcomA	8.0 × 6.0	W	Matrix only	R2	R2 TO R3 (M)
15	1	PcomA	5.0 × 3.5	S	Matrix only	R1	R1 TO R3 (M)
16	1	PICA	4.0 × 3.0	W	Matrix only	R3	R3 TO R3+ (M)
17	5	PICA	6.0 × 4.0	W	Mixed	R3	R3 TO R3+ (M)

Note:—R3 M indicates major recanalization; R3+, worse than previous R3 (ie, more contrast filling aneurysm sac); SC, superior cerebellar; S, small neck; W, wide neck; AcomA, anterior communicating artery; ICA, internal carotid artery; MCA, middle cerebral artery; PcomA, posterior communicating artery; PICA, posterior inferior cerebellar artery.

follow-up (ie, at 3 or 6 months postprocedure) and remained stable thereafter.

Follow-up was available on 41 aneurysms with complete occlusion (R1) on the postembolization angiogram, 16 aneurysms with neck remnant (R2), and 13 aneurysms with aneurysm remnant (R3). Of 41 aneurysms with complete occlusion (R1), 32 (78.0%) remained completely occluded, whereas 9 (22.0%) recanalized, including 1 (2.4%) major recanalization. Of 16 aneurysms showing neck remnant after the initial procedure (R2), 8 (50.0%) showed improvement, 4 (25.0%) remained stable, and 4 (25.0%) recanalized, including 1 (6.2%) major recanalization. Of 13 aneurysms that showed aneurysm remnant (R3) after initial procedure, 6 (46.1%) improved, 3 (23.1%) remained stable, and 4 (30.8%) recanalized, all of which were major recanalizations.

Of 48 aneurysms that were followed for 6 months, 25 (52.1%) remained stable, 10 (20.8%) improved, and 13 (27.1%) recanalized, 5 (10.4%) of which were major recanalizations. Of the 22 aneurysms that were followed for 9–22 months, 14 (63.6%) remained stable, 4 (18.2%) improved, and 4 (18.2%) recanalized, 1 (4.5%) of which was a major recanalization.

Thirty-two aneurysms with size ≤5 mm were followed; 17 (53.1%) remained stable, 9 (28.1%) improved, and 6 (18.8%) recanalized, 2 with (6.2%) major recanalization. Another 32 aneurysms with a size between 5 and 10 mm were followed; 21 (65.6%) remained stable, 2 (6.2%) improved, and 9 (28.1%) recanalized, 3 (9.4%) of which were major recanalizations. Six aneurysms measuring 10–20 mm were followed; 1 (16.7%) remained stable, 3 (50.0%) improved, and 2 (33.3%) recanalized, 1 (16.7%) of which was a major recanalization.

Forty-three narrow-necked aneurysms were followed; 27 (62.8%) remained stable, 9 (20.9%) improved, and 7 (16.3%) recanalized, 1 (2.3%) of which was a major recanalization. Twenty-seven wide-necked aneurysms were followed; 12 (44.5%) remained stable, 5 (18.5%) improved, and 10 (37%) recanalized, 5 (18.5%) of which were major recanalizations.

Aneurysms that recanalized ($n = 17$) had a mean diameter of 7.1 mm (compared with 6.2 mm overall) with a range of 3–17.5 mm. Ten (58.8%) were wide-necked and 16 (94.1%) were acutely ruptured; 8 (47.0%) recanalized aneurysms were incompletely packed during the initial procedure and were graded as R2 ($n = 4$) or R3 ($n = 4$). The other 9 (53%) aneurysms that recanalized were completely packed initially (8 went from R1 to R2 and 1 aneurysm went from R1 to R3) (Table 3).

Table 4: Procedural complications including all 84 aneurysms

Complication	Number (%)
Thromboembolic	3 (3.6%)
Aneurysm rupture	4 (4.7%)
Coil stretching	3 (3.6%)
Groin hematoma	1 (1.2%)
Parent vessel occlusion	1 (1.2%)
Coil friction causing incomplete occlusion	1 (1.2%)
Intra-procedural vasospasm	1 (1.2%)
Total	14

Of 6 aneurysms with major recanalization, 4 demonstrated incomplete packing in the postprocedure angiogram and were graded as R3 (Table 3). Five of the 6 aneurysms had a wide neck. Average diameter of these aneurysms was 7.1 mm (compared with 6.2 mm overall).

Procedural complications were noted in 15 patients overall (Table 4). Thromboembolic complication was seen in 3 (3.6%) cases and aneurysm rupture was seen in 4 (4.7%) cases. None of the thromboembolic complications resulted in permanent neurologic deficit. Parent vessel occlusion was noted in 1 (1.2%) case at the first follow-up at 6 months. Coil stretching was seen in 3 (3.6%) cases. One stretched Matrix coil had to be retrieved surgically, and the aneurysm in question was clipped. Coil friction (with Matrix coil) leading to incomplete aneurysm occlusion was noted in 1 case.

There were aneurysm rebleeds in the follow-up period. Both happened in aneurysms that were incompletely packed during the initial procedure (R3). One aneurysm rebled 6 weeks after the initial procedure, whereas another rebleed happened 28 months after the initial procedure. One of the rebleeds resulted in death.

Overall, there were 7 deaths among the patients in this study, 6 of which were related to complications of subarachnoid hemorrhage. Two patients had significant neurologic deficit requiring support in activities of daily life, whereas 4 patients had mild neurologic deficit but did not require support. None of the neurologic deficits were related to procedural complications.

Discussion

Since the ISAT[1] results were published, endovascular treatment of intracranial aneurysms has evolved from a technique that was used in selective cases where either the aneurysm location (eg, basilar tip) or patient profile (eg, poor WFNS grade) was unsuitable for neurosurgical intervention to a technique that was the primary definitive procedure for most aneurysms. Angiographic and clinical follow-up studies of patients undergoing neurosurgical clipping has shown a low incidence of both aneurysm recurrence and rebleeding.[7-9] ISAT has reported a slight excess of postprocedural aneurysm rebleeding with endovascular therapy compared with neurosurgical clipping after 1 year.[1,2] A 5-year study of 317 patients treated with endovascular coiling reported a relatively high risk of rebleeding (7.9%) in recurrent aneurysms compared with the risk (0.4%) in angiographically stable aneurysms.[10] Even with a follow-up regimen for coiled aneurysms, late recurrence and rebleeding are difficult to prevent. In the recent past, a number of new technologies[11-16] have been introduced to prevent aneurysm recurrence, including the so-called bioactive coils.

The bioactive coils are based on the principle of producing a healing response in the neck of the aneurysm that effectively excludes the aneurysm from the circulation. Matrix coils have copolymer (polyglycolic acid/lactide) coating on the surface that has been demonstrated in animal experiments to produce accelerated fibrosis and neointima formation.[5] The same group has reported a cuff of tissue in the aneurysm neck on angiography of embolized aneurysm of human subjects that is believed to represent this fibrous tissue and neointima.[6] Although these reports are encouraging, the final proof of efficacy of such coils is the experience of operators in treating aneurysms with such coils and the long-term efficacy in preventing aneurysm recanalization.

GDCs were introduced for clinical use in 1992, and obtained FDA approval in 1995. They are still the "gold standard" for endovascular coils. The ISAT results are based on the use of bare platinum coils. Efficacy of any new coil, therefore, has to be compared with that of the GDC/bare platinum coil. Recanalization rates after endovascular coil treatments of aneurysms with GDCs have been studied by several groups with varying results.[3,4,17-20] Part of the reason for the variable results, apart from difference in study populations, may be the different definitions of recanalization applied by various authors and the difference in the length of follow-up. Assessment of degree of recanalization is also highly subjective, and this may also lead to variability between studies.

In the current study, recanalization has been defined by worsening of angiographic appearance on the modified Raymond scale. The historical study with GDCs that is most comparable with the current one is by Raymond et al[3]; both studies used the same method of assessment of recanalization. Raymond et al[3] reported an overall recanalization rate of 33.6% compared with 24.3% in the present study. The major recanalization rate of 20.7% quoted by the same study is also higher than 8.6% found in the present study. This difference could be explained in part by use of Matrix coils as opposed to bare platinum coils. However, part of the explanation could be the longer mean follow-up period in the former study that may have resulted in more recurrences being detected. In the current study, stratification of results based on length of follow-up did not show any increase in the rate of recanalization in the group with longer follow-up. Although it may be argued that this may be artifactual because of the relatively small number of cases in the longer follow-up arm, late and progressive recanalization (in cases in which more than 1 follow-up angiogram was available) were also found to be low in the current study.

The mean aneurysm size (9.67 $\pm$ 5.91 mm) in the study by Raymond et al[3] was larger than that in the current study (6.25 $\pm$ 3.23 mm), which may have contributed to the higher recanalization rate in the former. However, that very study highlighted the fact that there is higher incidence of recurrence in acutely ruptured aneurysms compared with unruptured aneurysms. In the current study, 59 out of 70 (84.2%) aneurysms were acutely ruptured, which is higher compared with 54.1% in the study by Raymond et al,[3] which may to some extent counterbalance the effect of aneurysm size.

The proportion of wide-necked aneurysms in the current study (38.6%) was similar to that in the study by Raymond et al[3] (35%). As in the study by Raymond et al,[3] there is a marked difference in recurrence rates between narrow and wide-necked aneurysms. Recanalization rate in wide-necked aneurysms in the current study was 37% and that in narrow-necked aneurysms was 16.3%. In the study by Raymond et al,[3] these rates were 52.3% and 23.7%, respectively.

Achieving complete aneurysm occlusion is just as important with Matrix coils as it is with GDCs in achieving good long-term results. Where initial complete occlusion (R1) was achieved, recanalization rate in the current study was 22% (major recanalization, 2.4%), which is similar to that reported by Raymond et al[3] (20% recanalization, 9% major recanalization). Where there was a neck remnant (R2) after initial embolization, recanalization rate was 25% (major recanalization 6.2%) in the current study compared with 40.1% (major 23.5%) in the study by Raymond et al.[3] Where incomplete occlusion (R3) was achieved initially, recanalization rate in the current study was 30.8% (all major) compared with 51.1% (46.8% major) in the study by Raymond et al.[3]

Gallas et al[20] reported follow-up of 705 intracranial aneurysms treated with GDCs. This included predominantly small- and medium-sized ruptured aneurysms (85% aneurysms less than 10 mm) and reported an initial complete occlusion rate of 72.6%, a recanalization rate of 14.8%, and a retreatment rate of 4.7%. These results, however, are not reflected by 2 other large studies using GDC/bare platinum coils[3,4] that both reported higher rates of recanalization.

Several other groups[21-24] have published their experience with Matrix coils. Most of these studies report a higher recanalization rate compared with the current study[21-23] ranging from 57.4%, reported by Niimi et al,[22] to 36%, reported by Fiorella et al[21] and Kang et al.[23] Taschner et al[24] reported a

lower recanalization rate of 24%, but their study cohort of 25 aneurysms was much smaller than the other studies. Although there are obvious differences in study cohort and design, the higher recanalization rates in the other studies are not easily explainable. The study by Kang et al[23] included a smaller number of aneurysms, greater proportion of unruptured aneurysms, technically easier aneurysms, and a shorter follow-up period, none of which would explain the higher recanalization rate. Two of the studies[21,22] reported a lower initial complete occlusion rate than the current study, which may partly explain the higher recanalization rate. One of the reasons quoted for the low initial occlusion rate is high friction encountered with Matrix coils.[22] This concurs in our experience with Matrix, which certainly seems to have different mechanical properties compared with bare platinum, most probably due to the coating of copolymer. A markedly suboptimal result was obtained in 1 case early in the present series because of coil friction. We have also experienced increased microcatheter movement within the aneurysm and sometimes displacement of the microcatheter outside the aneurysm.

As stressed before, assessment of recanalization, even by using the same methodology, is highly subjective. Although most of the Matrix studies[21-23] have used similar method of assessment of recanalization as the present one, a difference in results could be explained at least in part by the subjective nature of assessment. In addition, although most studies, including ours, have assessed recanalization on the basis of a change in Raymond grade, one group[22] has reported a much higher recanalization rate (57.4%) than worsening of angiographic grade (27.7%), because these authors feel that recanalization can occur without change in angiographic grade.

Murayama et al[4] have studied the difference in recanalization rates in the early period of 5 years (1990–1995) and a later period of 6 years (1996–2002) (beginning with FDA approval of the GDC system and introduction of the balloon remodeling technique). Recanalization rates were 26.1% for the early period and 17.2% for the late period, with an overall recanalization rate of 20.9%. These figures demonstrate the fact that there is a learning curve in the use of any new technology, and this probably applies to the transition from bare platinum coils to coated coils. It also demonstrates that improvement in technology (for example, development of 3D GDCs) can improve long-term results. The current study was entirely performed with the first generation Matrix coils, and a number of coil-handling issues were addressed in development of the second-generation Matrix coils, which have recently become available. This may in future result in further improvement in results.

In the current study, Matrix coils were used alone as well as in combination with other coils. The recanalization rates in the 2 groups are very similar (Table 2). This is probably because in cases in which a combination of coils were used, Matrix constituted most of the coil length, and the small amount of bare platinum coil used in these cases did not result in significant difference in results. Cases treated with HydroCoils were excluded because they are also classified as bioactive coils and may contaminate the effect of Matrix coils on recurrence rate. Cases with Neuroform stents were also excluded because additional effects of stent placement could also contaminate the results.

Fourteen (20%) aneurysms demonstrated improved occlusion in the follow-up study. It is not clear whether this is because postembolization angiograms were done while the patient was still anti-coagulated and contrast filling of the neck/sac of the aneurysm would have promptly disappeared once the heparin effect had worn off. It is certainly true that this phenomenon of improved occlusion is also seen with bare platinum/GDCs[20,21] and is not specific to Matrix coils.

One of the objectives of this study was to assess the safety profile of Matrix coils. As shown in Table 4, the rate of procedural aneurysm rupture and thromboembolic complications were within the range quoted in the literature.[4,18] Coil stretching was noted in 3 cases, all of which were with Matrix coils. This may be due to increased coil friction caused by polyglycolic acid/lactide coating and/or relatively poor stretch resistance of the first-generation Matrix coils. There were 2 rebleeds in the present study, 1 of which was fatal. The fatal rebleed happened 6 weeks after embolization from an incompletely coiled aneurysm (postembolization grade R3). Because 71 patients in this study presented with ruptured aneurysms, the fatal early rebleeding rate in this study is 1.4%, which is comparable with that of the ISAT study.[1,2,25]

There are some obvious limitations of this study. This was a single-center study involving a limited number of operators. There was no control group of aneurysms treated with bare platinum coils in the same center. Comparison was made with historical studies performed in other centers (using both GDC and Matrix); as discussed before, the long-term results of these studies are extremely variable because of the different study cohorts and methods of assessment of recanalization. Even if the same methodology is applied, assessment of recanalization (particularly assessment of major recanalization) is subjective, which also makes comparison with other studies difficult. A multicenter randomized controlled trial comparing Matrix and GDCs would be necessary to address these deficiencies.

Conclusion

Matrix coils are safe to use, and the recanalization rate of aneurysms treated with these coils appears to be at least comparable with historical studies with GDCs. A randomized controlled trial is needed to establish whether the recanalization rates are better than GDC. Overall recanalization rate of 24.3% in the current study is better compared with some other studies with Matrix coils.[21-23] This may be accounted for by the higher rate of complete initial occlusion in this study.

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