Intracranial Aneurysms Coiling With Matrix
Immediate Results in 152 Patients and Midterm Anatomic Follow-Up
From 115 Patients

Michel Piotin, MD, PhD; Laurent Spelle, MD, PhD; Charbel Mounayer, MD; Carolina Loureiros, MD; Askar Ghorbani, MD; Jacques Moret, MD

Background and Purpose—We report our experience using Matrix coils in coiling of cerebral aneurysms.

Methods—Clinical and angiographic outcomes of 152 patients (165 aneurysms) treated exclusively with Matrix coils were retrospectively analyzed.

Results—There were 74 ruptured aneurysms (44.8%) and 91 unruptured (55.2%). After coiling, 84 (50.9%) aneurysms were occluded, 38 (23.0%) aneurysms had a neck remnant, and 43 (26.1%) aneurysms had a sac remnant. Packing ranged from 10% to 49% (mean and median, 27%). Overall treatment-induced morbidity was 6.6% and mortality was 1.3% (10 of 152 to 2 of 152, respectively). One hundred fifteen (69.7%) aneurysms were followed, disclosing 42 (36.5%) recurrences at a mean period of 9 months (median, 6 months; range, 1 to 28 months). The recurrence rate for small aneurysms (<10 mm) was 28 (31.1%) of 90, whereas for larger aneurysms (≥10 mm), the recurrence rate was 14 (56.0%) of 25 (P=0.0336). When packing was ≤25%, the recurrence rate was 44.4%, whereas for aneurysms with packing >25%, the recurrence rate was 29.8% (P=0.1588). Recurrence rate was not correlated to packing. Ruptured aneurysms recurred more frequently than unruptured aneurysms (P=0.0004).

Conclusion—Matrix coils provided no better recanalization rates than those reported previously for bare platinum coils.

Key Words: cerebral aneurysm ■ embolization ■ therapeutic

Recanalization remains a limitation of aneurysm coiling.1–3 Bioactive coils as Matrix (Boston Scientific, Fremont, Calif) were designed to reduce recanalization.4 However, controversy still exists about its clinical efficacy.4–10 Our objective was to evaluate the immediate and midterm clinical and anatomic results in 165 intracranial aneurysms treated with Matrix coils.

Materials and Methods
There were 152 patients (102 women and 50 men; age range, 25 to 84 years; mean, 50 years) with 165 aneurysms (May 2002 to February 2008) treated exclusively with Matrix coils. Coiling was performed under full anticoagulation. Coils were inserted until aneurysm circulatory exclusion or when no more coil could be delivered.

Data Collection and Analysis
Aneurysm location, size, rupture status, degree of occlusion, and complications, including rebleeding, were evaluated. A single reader evaluated all angiograms. Aneurysm occlusion was classified as described by Roy and Raymond.3 At follow-up, an aneurysm was considered recurrent if a previously totally occluded aneurysm had a partial recurrence of the neck and/or the sac. An aneurysm was considered remnant regrowth if a subtotally occluded aneurysm was found to have an increasing neck remnant or residual aneurysm. The recurrence was qualified as sizable if its size would theoretically permit retreatment.

Aneurysm volumes were determined on 3-dimensional images derived from rotational angiography to calculate coil packing (coil volume/aneurysm volume). Follow-up angiograms were reviewed, and aneurysm recurrence was dichotomized as absent or present. Analysis was performed to evaluate the effect of aneurysm size, mode of presentation (ruptured versus nonruptured), and percentage of aneurysm packing. Recurrence rates for subgroups were evaluated for statistical significance using a 2-tailed Fisher exact test. Recurrence rates for subgroups according to initial angiographic results were evaluated for statistical significance using a χ² test for independence. A probability value of <0.05 was considered statistically significant.

Results
Aneurysms Treated
The mean aneurysm size was 7.8 mm and the median was 7.1 mm. There were 74 ruptured aneurysms (44.8%) and 91 unruptured aneurysms (55.2%).

Immediate Angiographic Results
Eighty-four (50.9%) aneurysms were totally occluded, 38 (23.0%) had a neck remnant, and 43 (26.1%) had a sac

Received March 20, 2008; accepted April 16, 2008.
From the Department of Interventional and Functional Neuroradiology, Foundation Rothschild Hospital, Paris, France.
Correspondence to Jacques Moret, MD, Service de Neuroradiologie Interventionnelle et Fonctionnelle, Hôpital de la Fondation Ophtalmologique Adolphe de Rothschild, 25–29 rue Mainin 75940 Paris, Cedex 19, France. E-mail jmoret@fo-rothschild.fr
© 2008 American Heart Association, Inc.

Stroke is available at http://stroke.ahajournals.org DOI: 10.1161/STROKEAHA.108.520866

321
remnant. Packing density ranged from 10% to 49% (mean and median, 27%).

### Treatment-Related Complications

Symptomatic thromboembolic events occurred in 12 cases (7.9% [12 of 152]). Five of them (3.9% [6 of 152]) were transitory. Seven thromboembolic events (4.6% [7 of 152]) were noted at the time of treatment, whereas 5 (3.3% [5 of 152]) occurred in a delayed fashion (1 to 45 days). Intraprocedural perforation with clinically relevant hemorrhage occurred in 5 cases (3.3% [5 of 152]). The overall treatment-induced morbidity and mortality (with abstraction of transient symptoms) were 6.6% and 1.3%, respectively (10 of 152 and 2 of 152, respectively).

### Rebleeding

One patient (0.6% [one of 152]) with a ruptured aneurysm rebled 4 days after endovascular treatment with a fatal outcome. This patient had initial intraparenchymal hematoma.

### Followed Aneurysms

Mean duration of follow-up was 14 months (median, 13 months; range, 1 to 49 months). Overall, 115 (69.7%) aneurysms were followed, disclosing 42 (36.5%) recurrences at a mean period of 9 months (median, 6; range, 1 to 28 months). The mean aneurysm size was 7.7 (median, 7.0 mm; range, 2.7 to 17 mm). There were 46 ruptured aneurysms (40.0%) and 69 unruptured aneurysms (60.0%).

### Delayed Aneurysm Occlusion

Overall, 56.1% (32 of 57) of the aneurysms that were not totally occluded showed angiographic improvement at follow-up. Six (22.2%) of 27 aneurysms with persisting neck opacification after endovascular treatment were totally occluded at follow-up. Eighteen (60.0%) of 30 aneurysms with persisting sac opacification were totally occluded at follow-up, whereas 8 (26.7%) harbored persisting neck opacification.

### Recurrence Rates

The overall recurrence rates are shown in Table 1. The recurrence rate for small aneurysms (<10 mm) was 28 (31.1%) of 90, whereas for large aneurysms (≥10 mm), the recurrence rate was 14 (56.0%) of 25 ($P=0.0336$). When the packing was ≤25%, the recurrence rate was 20 (44.4%) of 45, whereas for aneurysms with packing >25%, the recurrence rate was 20 (29.8%) of 67 ($P=0.1588$). Recurrence rate was not correlated to packing.

### Recurrence Rates According to Initial Angiographic Results

Aneurysms that were initially occluded exhibited minor recurrences, whereas the aneurysms with persisting neck opacification after embolization showed a trend toward more important recanalization. Aneurysms with persisting sac opacification did not have significantly more recurrence suggesting sac thrombosis within the time interval between the end of the endovascular treatment and follow-up angiography (Table 2).

### Recurrence Rate According to Presentation Status

Aneurysms that were not ruptured exhibited minor recurrences, whereas the ruptured aneurysms showed a significant trend toward more important recanalization (Table 3).

### Discussion

Our procedure-related rate (6.6%) of complications was similar to those of previously reported rates.4–8,11 We deplored delayed ischemic complications in 3.3% of the patients. The occurrence of ischemic complications in a delayed fashion has not yet been reported with Matrix or bare platinum coils. A delayed action of the coil covering polymer can be advocated. An experimental study on swine models showed that scarring neck tissue was higher in Matrix-treated than Guglielmi detachable coil-treated aneurysms after 2 weeks.12 This enhanced tissue formation might favor local thrombotic phenomenon leading to focal brain ischemia.

We deplored a rebleeding rate of 0.6%. This rebleeding occurred early after endovascular treatment in a patient who had initial intraparenchymal hematoma. There were no exclusion criteria in our series and, consequently, patients with initial poor clinical grade were not excluded, providing a risk of including patients with initial intraparenchymal hematoma, a known factor of increased risk of rebleeding. Similarly, Murayama et al reported a rebleeding rate of 2%.4 Rebleeding rates in patients treated with Matrix coils after subarachnoid hemorrhage appeared to be similar or even higher than in patients treated with bare platinum coils.13,14

Many aneurysms that were not occluded after endovascular treatment showed angiographic improvement at follow-up. Pierot et al encountered a 30% rate of angiographic improve-

### Table 1. Recurrence Rates for Followed Aneurysms (n=115)

<table>
<thead>
<tr>
<th>Aneurysm Size</th>
<th>Minor (%)</th>
<th>Sizeable (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All aneurysms</td>
<td>22.6 (26/115)</td>
<td>13.9 (16/115)</td>
</tr>
<tr>
<td>Small aneurysms (&lt;10 mm)</td>
<td>24.4 (22/90)</td>
<td>6.7 (6/90)</td>
</tr>
<tr>
<td>Large aneurysms (≥10 mm)</td>
<td>16.0 (4/25)</td>
<td>40.0 (10/25)</td>
</tr>
</tbody>
</table>

### Table 2. Recurrences Rates According to initial Angiographic Results*

<table>
<thead>
<tr>
<th>Class</th>
<th>Recurrence Rates</th>
<th>Minor (%)</th>
<th>Sizeable (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>41.4 (24/58)</td>
<td>34.5 (20/58)</td>
<td>6.9 (4/58)</td>
</tr>
<tr>
<td>2</td>
<td>44.4 (12/27)</td>
<td>3.7 (1/27)</td>
<td>40.7 (11/27)</td>
</tr>
<tr>
<td>3</td>
<td>20.0 (6/30)</td>
<td>16.7 (5/30)</td>
<td>3.3 (1/30)</td>
</tr>
<tr>
<td>Total</td>
<td>36.5% (42/115)</td>
<td>22.6% (26/115)</td>
<td>13.9% (16/115)</td>
</tr>
</tbody>
</table>

*χ² test for independence. Class 1, complete obliteration, including the neck; Class 2, residual neck; Class 3, persisting aneurysm sac opacification.

### Table 3. Recurrences Rates According to Presentation Status

<table>
<thead>
<tr>
<th>Presentation Status</th>
<th>Recurrence Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rupture</td>
<td>56.5% (26/46)</td>
</tr>
<tr>
<td>No rupture</td>
<td>23.2% (16/69)</td>
</tr>
</tbody>
</table>

Significance: $P=0.0004$. 
ment as well. Such improvement might be due to the healing effect of the Matrix coil over time. Conversely, angiographic improvement of subtotally occluded aneurysm with bare platinum coils is a common fact, and it is rather difficult to distinguish between true polymer healing effect and spontaneous thrombosis.

Our recurrence rate of 36.5% is within the range of the previously published series of Matrix. In our series, the rate of sizeable recurrence (13.9%) was higher than in the series of Pierot et al. Fiorella et al found a 23.1% rate of major recanalization urging retreatment. Recent historical series dealing with bare platinum coils showed no superior recanalization rates.

Like with bare platinum coils, the correlation between embolized volume and stability of aneurysm occlusion had been a source of controversy in the literature. In our series dealing with aneurysms exclusively treated with Matrix coils, the percentage of packing density was not a significant factor affecting the recanalization rate.

Our results showed a trend toward more minor recurrence in aneurysms that were initially totally occluded and more major recurrence in aneurysms with an initial residual neck. This finding could be explained by the fact that a great number of initial Class 3 aneurysms transformed into Class 1 in the interval between endovascular treatment and follow-up. Similar delayed angiographic improvement was described with bare platinum coils. Consequently, Raymond et al suggested considering the first angiographic follow-up as the initial result to depict further recurrence. In series with Matrix coils, the fact that this delayed aneurysm occlusion was secondary to Matrix biological effect or due to spontaneous thrombosis remains a matter of debate.

We found a significantly higher recurrence rate in the group of ruptured aneurysms as previously reported with bare platinum coils.

Conclusions
Matrix coils confirmed its procedural safety. We reported the occurrence of delayed ischemic complications supporting the action of a biological process over time. However, its influence was not demonstrated by decreased recurrences. Consequently, there is still no evidence to recommend the use of Matrix over bare platinum coils.

Disclosures
None.

References
Intracranial Aneurysms Coiling With Matrix: Immediate Results in 152 Patients and Midterm Anatomic Follow-Up From 115 Patients
Michel Piotin, Laurent Spelle, Charbel Mounayer, Carolina Loureiros, Askar Ghorbani and Jacques Moret

Stroke. 2009;40:321-323; originally published online November 6, 2008;
doi: 10.1161/STROKEAHA.108.520866

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/40/1/321

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Stroke can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Stroke is online at:
http://stroke.ahajournals.org//subscriptions/