Contributions of the straightening effect of the parent artery to decreased recanalization in stent-assisted coiling of large aneurysms

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OBJECTIVE The durability of embolization of large aneurysms is enhanced by use of the neck-bridging stent. However, it remains unclear what factors contribute to decreased recanalization. The purpose of this study was to demonstrate the contribution of the straightening effect of the parent artery to the durability of stent-assisted coiling for large aneurysms.

METHODS Of the 182 aneurysms treated by embolization since the introduction of the neurovascular stent, 82 consecutive unruptured aneurysms with a diameter greater than 7 mm were selected. There were 52 aneurysms treated with a stent (Group S) and 30 treated without a stent (Group NS). Occlusion status was evaluated 12 months after embolization with digital subtraction angiography. The vascular angle of the parent artery was measured before, immediately after, and 12 months after embolization. The rates of recanalization were compared between Group S and Group NS. In Group S, the rates of recanalization were further compared between those aneurysms with and without a significant angle change.

RESULTS The rate of major recanalization was 9.6% in Group S and 26.7% in Group NS. The volume embolization ratio was 32.6% in Group S and 31.6% in Group NS, with no statistically significant difference. However, the angulation change before and after coiling was significantly higher in Group S (10.6°) than in Group NS (0.9°). The difference in the angulation was more evident 12 months after coiling (19.1° in Group S and 1.5° in Group NS). In Group S, recanalization was found in 14.3% of 35 stented aneurysms without a significant angular change when a significant angular change was defined as more than 20°. In contrast, all 17 aneurysms with ≥20° of angular change remained occluded.

CONCLUSIONS Significant angular change of ≥20° most likely leads to decreased recanalization following stent-assisted embolization of large aneurysms.

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KEY WORDS aneurysm; stent; coil; vascular disorders

ABBREVIATIONS ACoA = anterior communicating artery; BA = basilar artery; CFD = computational fluid dynamics; CO = complete occlusion; DF = dome filling; DSA = digital subtraction angiography; ICA = internal carotid artery; MRA = MR angiography; NR = neck remnant; PGLA = polyglycolic acid/polylactic acid; SAH = subarachnoid hemorrhage; TOF = time of flight; VER = volume embolization ratio; VRD = vascular reconstruction device.


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by neck-bridging stents includes immediate and delayed vascular angle remodeling, i.e., straightening of the parent artery. Recently, vascular geometry change caused by the straightening effect has been shown to significantly alter hemodynamics in both bifurcation- and sidewall-type aneurysms. However, these observations are based on the findings of a computational fluid dynamics (CFD) study, which used only a small number of clinical cases. It remains unclear whether this angular remodeling clinically leads to decreased recanalization.

In the present study, we extracted records of patients from our database with unruptured aneurysms of 7 mm or more in diameter who could be followed with digital subtraction angiography (DSA) 12 months after coil embolization. The rates of recanalization following coil embolization with and without the stent-assisted technique were compared, focusing attention on the angular change of the parent artery. Moreover, the rates of recanalization in the stent-assisted coiled aneurysms with and without significant angular change were further compared to demonstrate whether the straightening effect clinically contributes to decreased recanalization in stent-assisted coiling.

**Methods**

**Study Sample**

In our study, 182 aneurysms were treated with coiling since the Enterprise VRD (Codman), the first approved neurovascular stent, was introduced in Japan in 2010. Of these 182 aneurysms, several were excluded from the present study, including those that were less than 7 mm in diameter (n = 41), those that presented with subarachnoid hemorrhage (SAH; n = 21), those previously treated with coiling (n = 18), and those that did not have 12-month follow-up DSA available (n = 20), to minimize possible bias. The aneurysms less than 7 mm in diameter and those that presented with SAH were excluded because a neck-bridging stent for those aneurysms is an off-label use in Japan. The recanalized aneurysms treated previously with coiling were excluded because accurate volume calculation was difficult due to irregularity of the lumen. Twenty aneurysms with no follow-up DSA were excluded because they were treated less than 12 months before the present study. Finally, 82 unruptured aneurysms with a diameter of 7 mm or more and with 12-month follow-up DSA available were included in the present study (Fig. 1).

These aneurysms were classified into 2 groups according to whether a neck-bridging stent was used at treatment (Group S, n = 52) or not used (Group NS, n = 30; Table 1). A single Enterprise VRD was used in 45 aneurysms, and a single Neuroform EZ was used in 7 aneurysms in Group S. No aneurysm treated with multiple stents was included in the study. Coil embolization was performed exclusively with bare platinum coils. No polyglycolic acid/polyactic acid (PGLA)-coated or hydrogel-coated coils were used in the present series. The pre- and postprocedural antiplatelet regimen was the same for all patients. All patients underwent loading with 100 mg aspirin and 75 mg clopidogrel 1 week before treatment. If a stent was used in the procedure, dual antiplatelet therapy was continued for 6 months and aspirin was continued for another 6 months.

If a stent was not used, clopidogrel was discontinued immediately after treatment and aspirin was continued for 3 months. The patients had been registered in a prospective manner since approval of the neck-bridging stent in 2010. The present study was conducted after the approval of our Institutional Review Committee.

**Narrow-Neck Aneurysms**

Those aneurysms with a narrow neck (< 4 mm), and/or with a small-caliber parent artery (< 3 mm), were generally treated without using a neck-bridging stent. The off-label indication criterion for use of a neck-bridging stent in Japan is an unruptured wide-necked (≥ 4 mm) aneurysm of more than 7 mm in diameter. Because off-label use for smaller (< 7 mm) aneurysms was not approved by our Institutional Review Committee, those aneurysms were excluded from the present study. Moreover, aneurysms with a narrow neck are less likely to recanalize, even without a stent. Delivery of a stent into a small artery is technically more challenging. For these reasons, aneurysms with a narrow neck were initially treated without the use of a neck-bridging stent in the present series.

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**Figure 1.** Patient selection algorithm. Since the first neurovascular stent was approved for use in Japan in 2010, 182 consecutive aneurysms were treated with embolization. Of these aneurysms, those that were less than 7 mm in diameter (n = 41), those that had presented with subarachnoid hemorrhage (n = 21), those that had recanalized (n = 18), and those that had unavailable 12-month follow-up DSA (n = 20) were excluded from the present study. Finally, the data from 82 unruptured aneurysms with a diameter of 7 mm or more and 12-month DSA were extracted in the present study.
Outcome Measurements

The maximum neck size of each aneurysm was measured on 3D-DSA. The aneurysm locations were categorized into 12 sites. Recanalization was evaluated on 12-month follow-up DSA and time-of-flight MR angiography (TOF-MRA). Occlusion status immediately after treatment and at the 12-month follow-up was evaluated and recorded as complete occlusion (CO), neck remnant (NR), or dome filling (DF) according to the Raymond scale by one of the coauthors (H.C.), who was not directly involved in the procedures. Recanalization was defined as an aneurysm with a deterioration of the Raymond scale score and one that needed to be retreated. If no recanalization was recorded at the 12-month follow-up, the aneurysm was further followed by TOF-MRA. Another DS angiogram was indicated if any change was noted on TOF-MRA. Aneurysm volume was calculated by approximating the aneurysm as a sphere or ellipsoid.

The angulation of the parent artery was measured on the working projection of DSA before the procedure, immediately after, and at the 12-month follow-up. If DSA obtained on the same projection was not available, the angulation was measured on the better of either the frontal or lateral view of the parent artery. Using Photoshop CS4 software (Adobe Systems Inc.) the vascular angle of the parent artery was measured using 3 points: the center of the parent artery at the aneurysm neck, and the most distal and proximal edges of the stented artery (Fig. 2). The distal and proximal edges were determined by the distal markers of the deployed stent. The lines were longitudinally drawn from each of the edges to the aneurysm neck. The

### TABLE 1. Aneurysm configuration in Groups S and NS*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group S</th>
<th>Group NS</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>52</td>
<td>30</td>
<td>—</td>
</tr>
<tr>
<td>Mean age ± SEM (yrs)</td>
<td>60.4 ± 1.6</td>
<td>67.1 ± 2.3</td>
<td>0.1867</td>
</tr>
<tr>
<td>Mean max diameter ± SEM (mm)</td>
<td>10.3 ± 0.5</td>
<td>9.8 ± 0.7</td>
<td>0.4811</td>
</tr>
<tr>
<td>Mean neck size ± SEM (mm)</td>
<td>5.8 ± 0.2</td>
<td>4.8 ± 0.3</td>
<td>0.0112†</td>
</tr>
<tr>
<td>Mean follow-up period ± SEM (mos)</td>
<td>22.9 ± 1.5</td>
<td>29.1 ± 4.2</td>
<td>0.7470</td>
</tr>
</tbody>
</table>

- **Aneurysm location (%)**
  - ICA-cavernous (SW) 5.8 3.3
  - ICA-paraclinoid (SW) 38.5 33.3
  - ICA-PCoA (SW) 7.7 13.3
  - ICA-bifurcation (BF) 1.9 0.0
  - MCA (BF) 1.9 0.0
  - A1 (SW) 1.9 0.0
  - ACoA (BF) 9.6 13.3
  - Distal ACA (BF) 0.0 0.0
  - VA (SW) 1.9 6.7
  - BA-SCA (SW) 9.6 10.0
  - BA-bifurcation (BF) 17.3 20.0
  - Others 3.8 0.0

- **ACA** = anterior cerebral artery; **BF** = bifurcation-type; **MCA** = middle cerebral artery; **PCoA** = posterior communicating artery; **SCA** = superior cerebellar artery; **SW** = sidewall-type; **VA** = vertebral artery.

- *Group S includes aneurysms treated with a stent and Group NS includes those treated without a stent.
- † Statistically significant.

*FIG. 2. BA bifurcation aneurysm treated with stent-assisted embolization showing significant angular change. A: Angiography before coiling shows an unruptured aneurysm at the BA bifurcation with a diameter of 19.4 mm and a neck of 5.0 mm. The angle (dashed line) between the upper BA and the right P1 segment was measured at 83° before stent placement. The dashed line was drawn using 3 points: the center of the parent artery at the neck, and the most distal and proximal ends of the artery to be stented. B: Angiography immediately after stent-assisted coiling shows complete occlusion of the aneurysm. A 22-mm Enterprise VRD was placed from the right P1 to the BA. The angle of the parent artery was measured at 118° immediately after stenting. Arrows indicate both stent edges. The parent artery was straightened by the stent. The angulation change was 35°. C: Angiography obtained 12 months after stenting shows the aneurysm remained completely occluded. Note that the parent artery was further straightened by the stent. The angle was measured at 136° and the angulation change from before coiling to measurement at 12 months was 53°. Arrows indicate both stent edges.*
intersection of the 2 lines was determined to be the center of the aneurysm neck. Using these 3 points, the vascular angle was measured semiautomatically with the software. In a nonstented artery, the proximal and distal points were substituted with the centers of the curvature just proximal and distal to the aneurysm. The methodology of vascular angle measurement was essentially similar to the previous study. In the present study, significant angular change immediately after coiling and at the 12-month follow-up was defined as more than 20° compared with the vascular angle in the precoiled status. The rates of recanalization were compared between Groups S and NS. Multiple factors possibly affecting recanalization were also compared between the 2 groups. Moreover, the rates of recanalization in the stented aneurysms with and without significant angular change were compared.

Statistical Analysis
Statistical analysis was conducted using JMP (version 10, SAS Institute). The mean values in all tables are presented with standard errors. Mean age, maximum aneurysm diameter, follow-up period, and angulation change before and after coiling were analyzed using Fisher’s exact test. Aneurysm location and occlusion status were evaluated by use of the chi-square test. The rates of recanalization were analyzed using Fisher’s exact test or the likelihood ratio test. A result with a p value < 0.05 was considered statistically significant.

Results
Baseline Characteristics
The mean ages were 60.4 in Group S and 67.1 in Group NS (Table 1). The maximum aneurysm diameters were 10.3 mm in Group S and 9.8 mm in Group NS. Although neither of the 2 parameters was significantly different, the neck size in Group S was 5.8 mm, significantly larger than that of 4.8 mm in Group NS. The aneurysm locations in each group are shown in Table 1. In both groups, the paraclinoid ICA (38.5% in Group S and 33.3% in Group NS) was the most frequent location, followed by the basilar artery (BA) bifurcation (17.3% in Group S and 20.0% in Group NS). The aneurysm locations were not significantly different.

Occlusion statuses immediately after coiling are shown in Table 2. No significant differences were found in postcoiling occlusion statuses. The mean VER was 32.6% in Group S and 31.6% in Group NS, with no significant difference between groups. The occlusion statuses at the 12-month follow-up were as follows: CO 63.5%, NR 21.2%, and DF 15.4% in Group S; and CO 60.0%, NR 6.7%, and DF 33.3% in Group NS. Major recanalization that needed to be retreated was observed in 9.6% in Group S and 26.7% in Group NS (Table 2). There were statistically significant differences in recanalization between the 2 groups (p = 0.04).

Angulation change of the parent artery before and after coiling was 10.6° in Group S and 0.9° in Group NS (Table 2). The change was found to be further between precoiling measurements and 12-month follow-up: 19.1° in Group S, and 1.5° in Group NS. The angulation changes were both significantly larger in Group S than in Group NS. The change between precoiling measurements and 12-month follow-up were significantly larger than between precoiling and immediate postcoiling measurements, suggesting a persistent straightening effect over time.

When all aneurysms in Group S were classified into either sidewall- or bifurcation-type according to Table 1, the bifurcation-type aneurysms had more extensive angular change than the sidewall-type (Table 3). The angular changes in the bifurcation-type aneurysms in Group S were 18.3° immediately after coiling and 36.3° at 12 months’ follow-up. Those in the sidewall-type aneurysms were 7.4° and 12.2°, respectively. Of all the aneurysm locations, the anterior communicating artery (ACoA) had the largest angular change, followed by the BA bifurcation (Table 3). The ICA-paraclinoid showed the smallest angular change.

Various factors possibly affecting aneurysm durability were compared between occluded versus recanalized aneurysms after stent-assisted embolization (Table 4). There was a statistically significant difference in the neck size, maximum aneurysm diameter, and VER by univariate analysis. In the occluded aneurysms, the mean vascular angle was 11.2° immediately after stenting, which increased to 20.1° at 12 months, while those of the recanalized aneurysms were 4.5 and 9.6°, respectively.

A cutoff value of the vascular angle change related to decreased recanalization was carefully determined.
straightening effect of aneurysm stent

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When a significant angular change was defined as ≥ 20° immediately after coiling or at the 12-month follow-up, 17 of 52 stented aneurysms revealed significant angular change (Table 5). The rates of recanalization in the aneurysms with and without an angular change of ≥ 20° were 0.0% and 14.3%, respectively, with statistically significant differences (Table 5). Representative cases with and without significant angular change are shown in Figs. 2 and 3. Multiple factors possibly affecting recanalization were compared between cases with and without significant angular change in the stented aneurysms. There were no significant differences in maximum diameter, neck size, or VER between the aneurysms with and without angular change, suggesting that angular change most likely clinically contributes to decreased recanalization in stent-assisted coiling.

Discussion

In the present study, stent-assisted embolization was proven to decrease recanalization as shown by other groups in previous studies. The VER was not found to contribute to decreased recanalization. A comparison between Groups S and NS shows that angular change was the only factor with a statistically significant difference that may affect aneurysm recanalization. Moreover, in stent-assisted coiling, those aneurysms with significant angular change were less frequently recanalized than those without. These findings suggest that the angulation change of the parent artery, which is caused by the straightening

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**TABLE 4. Comparison of factors possibly associated with recanalization in occluded and recanalized aneurysms after stent-assisted embolization**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Occluded</th>
<th>Recanalization</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>47</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Smoking (%)</td>
<td>17.2</td>
<td>0</td>
<td>0.3159</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>40.4</td>
<td>60.0</td>
<td>0.3996</td>
</tr>
<tr>
<td>Mean max diameter ± SEM (mm)</td>
<td>9.9 ± 0.6</td>
<td>13.8 ± 1.2</td>
<td>0.0374*</td>
</tr>
<tr>
<td>Mean neck ± SEM (mm)</td>
<td>5.4 ± 0.2</td>
<td>9.1 ± 1.3</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>Mean VER ± SEM (%)</td>
<td>33.7 ± 1.3</td>
<td>22.6 ± 3.6</td>
<td>0.0112*</td>
</tr>
<tr>
<td>Mean angulation ± SEM (°)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After coiling</td>
<td>11.2 ± 2.4</td>
<td>4.5 ± 1.4</td>
<td>0.3678</td>
</tr>
<tr>
<td>At 12-mo follow-up</td>
<td>20.1 ± 3.0</td>
<td>9.6 ± 2.8</td>
<td>0.2694</td>
</tr>
</tbody>
</table>

* Statistically significant.

**TABLE 5. Rates of recanalization of the stent-assisted coiled aneurysms with and without significant angular change (≥ 20°)**

<table>
<thead>
<tr>
<th>Angular Change</th>
<th>0–20°</th>
<th>≥20°</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>35</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Bifurcation type (%)</td>
<td>3 (8.6)</td>
<td>12 (70.6)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Mean max diameter ± SEM (mm)</td>
<td>10.1 ± 0.6</td>
<td>10.9 ± 1.1</td>
<td>0.4654</td>
</tr>
<tr>
<td>Mean neck size ± SEM (mm)</td>
<td>5.8 ± 0.3</td>
<td>5.7 ± 0.4</td>
<td>0.8636</td>
</tr>
<tr>
<td>Mean VER ± SEM (%)</td>
<td>32.6 ± 1.6</td>
<td>32.7 ± 2.2</td>
<td>0.9646</td>
</tr>
<tr>
<td>Recanalization (%)</td>
<td>14.3 (5/35)</td>
<td>0.0 (0/17)</td>
<td>0.0401*</td>
</tr>
</tbody>
</table>

* Statistically significant. The p value of 0.0401 was calculated using the likelihood ratio test.

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**FIG. 3. BA bifurcation aneurysm treated with stent-assisted embolization showing no significant angular change. A: Angiography before coiling shows an unruptured aneurysm at the BA bifurcation with a diameter of 14.3 mm. The angle (dashed line) between the upper BA and the left P1 segment was measured at 90° before stenting. The dashed line was drawn using 3 points: the center of the parent artery at the neck, and the most distal and proximal ends of the artery to be stented. B: Angiography immediately after stent-assisted coiling shows complete occlusion of the aneurysm. A 28-mm Enterprise VRD was placed from the left P1 to the BA. The angle of the parent artery was measured at 97.4° immediately after stenting. Arrows indicate both stent edges. C: Angiography obtained 12 months after stent placement shows the aneurysm was found to be recanalized. The angle was measured at 103.8° and the angulation change from before coiling to measurement at 12 months was 13.8°. Arrows indicate both stent edges.**
effect of the stent, is most likely related to decreased recanalization.

Strategies enhancing the durability of endovascular treatment include: 1) increasing the VER, 2) accelerating clot organization after coiling, and 3) decreasing hemodynamic stress to the aneurysm. Strategy 1 includes the balloon-assisted technique and hydrogel-coated coils. Strategy 2 includes PGLA-coated coils, such as the Matrix \(^2\) coil (Stryker Neurovascular). Strategy 3 uses a flow-diverting stent. Of these strategies, a flow-diverting stent can decrease hemodynamic stress immediately after deployment and has been more and more frequently used in the treatment of large and giant aneurysms. However, aneurysm occlusion is not obtained immediately after treatment with a flow-diverting stent. Slowly progressive thrombosis within the aneurysm occurs over time and finally leads to complete occlusion; it usually takes 6–12 months after treatment.\(^1\) This progressive thrombosis may expose the aneurysm to unstable hemodynamic circumstances and can cause delayed aneurysm rupture before obtaining complete occlusion of the aneurysm.\(^3,6\)

A single deployment of the neck-bridging stent with large porosity does not have the same flow-diverting effect as a flow-diverting stent.\(^6,9,17\) Although there may be favorable biological interactions with the vessel wall, such as intimal covering,\(^12\) it is unpredictable how complete the coverage is. Moreover, excessive intimal hyperplasia, which leads to in-stent stenosis, can cause ischemic complications.\(^4\) Overlapping\(^17\) and Y-configuration\(^11\) deployment of multiple neck-bridging stents have been shown to cause some “flow-diversion” effect in computational fluid dynamics studies. Progressive thrombosis by the use of multiple stents has also been reported in clinical practice.\(^2\) However, complex multiple stent placement carries a high risk of both peri- and postprocedural ischemic complications and requires more aggressive and longer administration of antiplatelet medicines.\(^10\) Instead, the neck-bridging stent has been shown to change the angle of the parent artery over time by the straightening effect, as shown in the CFD study (discussed in the Introduction).\(^6,9\) Gao et al. showed that angular remodeling displaces and attenuates the flow impingement zone at the neck of bifurcation-type aneurysms, leading to decreased hemodynamic stress.\(^6\) The present study suggests that clinically, this effect leads to decreased recanalization. Although this “flow-diversion” effect of the neck-bridging stent is not evident immediately after treatment, the flow into the aneurysm is primarily blocked by coils in the aneurysms immediately after coiling. The straightening effect of a stent occurs over time after treatment and maintains the stoppage of flow into the aneurysm. Progressive delayed thrombosis is known to occur in some cases after deployment of the neck-bridging stent.\(^16\) This phenomenon can be explained by this delayed flow-diversion effect, most probably caused by the vessel straightening.

Although a flow-diverting stent has been proven to overcome recanalization in sidewall-type aneurysms, its use remains controversial in the treatment of bifurcation-type aneurysms. Intrasaccular flow diversion devices have been developed, mainly targeting those aneurysms not indicated for a flow-diverting stent. These devices do not leave any foreign metal material in the parent artery so that long-term administration of antiplatelet medicines is not generally necessary. Although it is very promising, at this point, there is not strong evidence favoring intrasaccular devices over stent-assisted coiling.\(^13\) The present study suggests that stent-assisted coiling remains a good option for those aneurysms that are likely to have significant angular change after stenting, i.e., mostly bifurcation-type aneurysms. In contrast, those aneurysms that are less likely to have significant angular change, mostly sidewall-type aneurysms, should be treated with a flow diventer instead of a neck-bridging stent.

We decided in the present study that the significant vascular angle was 20° for the following reasons. The mean angle change of the occluded aneurysms in Group S was found to be 20.1°. When drawing the receiver operating characteristic curve, the cutoff value was around 17°. When the cutoff value was set at 17°, there was a strong, but not statistically significant, trend in the rate of recanalization. When the value was set at 20°, we found a statistically significant difference in the rate of recanalization. Although the sensitivity was 100%, the specificity was as low as 36.2%, suggesting that multiple factors, including neck size and aneurysm size, were associated with recanalization. This was also supported by the findings that the vascular angles of the occluded aneurysms were not significantly different from those of the recanalized aneurysms (Table 4). However, this also suggests that the aneurysm is more likely to be stable regardless of neck or aneurysm size when a vascular angle change of ≥ 20° is found.

Finally, we note the possible limitations of the present study. First, the difference in neck size between Groups S and NS was significant, most likely because the aneurysms with a narrow neck were intentionally treated without stents. However, this selection bias did not affect the significant decrease in recanalization in Group S, which had larger neck sizes and were more likely to recanalize.\(^14\) Second, aneurysm volume was estimated, rather than measured, with 3D-DSA software. It is possible that this estimation was inaccurate. However, the measurement error was minimized by eliminating irregularly shaped aneurysms such as recanalized ones. Third, the anatomical location of the aneurysms registered in the present study was different from those generally found in clinical practice. We usually selected clipping for those aneurysms amenable to clipping, which may have introduced selection bias. Fourth, in-stent stenosis, one possible factor affecting recanalization following stent-assisted coiling, was not taken into consideration in the present study. Although we found some extent of in-stent stenosis in a few cases, there is not clear evidence at this point what degree of stenosis may affect perianeurysmal hemodynamics. Fifth, angle measurement was performed by a single coauthor. Although the average value of 3 repeated measurements was used, measurement by a single person could be a limitation. Semiautomatic calculation using 2 points, such as the stent markers, was used to minimize this bias. The vascular angle change in Group NS, which was as low as 0.9° ± 0.1°, could be interpreted as measurement error. Finally, the flow-diversion effect associated with vessel straight-
Straitening effect of aneurysm stent

Conclusions
The rates of recanalization were significantly lower in stented versus nonstented unruptured aneurysms with a diameter greater than 7 mm. Although the VERs between the 2 groups were not significantly different, we found statistically significant differences in the parent artery angle immediately after treatment and at follow-up. In stent-assisted coiled aneurysms, those with a significant angular change of more than 20° were significantly less likely to recanalize compared with those with less angular change. The straightening effect of a neck-bridging stent clinically contributes to decreased recanalization.

References

Disclosures
Dr. Ishii reports receiving lecture fees from both Stryker and Johnson & Johnson. This study was not sponsored by any company.

Author Contributions
Conception and design: Ishii. Acquisition of data: Chihara, Kikuchi, Araif, Ikeda. Drafting the article: Ishii. Critically revising the article: Ishii. Reviewed submitted version of manuscript: Ishii. Approved the final version of the manuscript on behalf of all authors: Ishii. Statistical analysis: Ishii. Study supervision: Miyamoto.

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