The endovascular treatment of wide-necked aneurysms can be technically challenging due to distal coil migration or impingement of the parent vessel. In this paper, the authors illustrate an alternative method for the treatment of wide-necked intracranial aneurysms using a dual microcatheter technique.

Methods. The authors’ first 100 consecutive patients who underwent coil embolization of a wide-necked aneurysm using a dual microcatheter technique are reported. With this technique, 2 microcatheters are used to introduce coils into the aneurysm. The coils are deployed either sequentially or concurrently to form a stable construct and prevent coil herniation or migration. Angiographic and clinical outcomes are reported.

Results. The technical success rate of the dual microcatheter technique is 91% with a morbidity and mortality of 1% and 2%, respectively. Clinical outcomes are excellent with 93% of patients demonstrating a modified Rankin Scale score of 0–2 at long-term follow-up regardless of their score at presentation. Retreatment rates are 18%.

Conclusions. The dual microcatheter technique may be a safe and efficacious first line of treatment for wide-necked aneurysms.

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Key Words • dual • microcatheter • wide-necked • aneurysm • outcomes • vascular disorders • interventional neurosurgery

In this paper, we illustrate an alternative method for the treatment of wide-necked intracranial aneurysms using only microcatheters. We describe a dual microcatheter technique and the clinical and radiographic imaging of 100 patients with the following goals: 1) investigate the safety of this approach; 2) calculate the rates of aneurysm occlusion; 3) assess patient functional outcomes; and 4) determine overall predictors of complications, retreatment, and outcome.
Patient Selection

A wide-necked aneurysm was defined as one having a dome-to-neck ratio of less than 2 or a neck diameter greater than 4 mm. During the evaluated period, true saccular aneurysms were treated using this technique, but dissecting or blister aneurysms were not.

Interventional Procedure

Access to the femoral artery is obtained in a standard fashion. The guiding catheter must be able to simultaneously accommodate 2 microcatheters. The microcatheters can be either preshaped or steam-shaped to improve navigability and stability. The first microcatheter is advanced over a microguidewire into the aneurysm under roadmap guidance. At this point, attempts may be made to coil the aneurysm using a single microcatheter. Once it is determined that the dual microcatheter technique will be needed, a second microcatheter is introduced and advanced into the aneurysm. To prevent inadvertent manipulation, the microcatheter that is not in use is covered with a towel. The second microcatheter is usually steam shaped with a curve different from that of the first catheter so that the 2 microcatheters will occupy different parts of the aneurysm. Care must be taken when positioning the second microcatheter, as it can cause the first microcatheter to migrate forward.

Two different general strategies can be described: “interleaving” and “locking.”

Interleaving Technique. This technique is most often used in particularly wide-necked aneurysms. In such aneurysms it may not be possible to place the framing coil into the aneurysm without loops of the coil herniating out of the neck. In these cases, the second microcatheter is placed into the aneurysm and the operator alternates pushing the coils first through one catheter and then through the other, “interleaving” the 2 coils (Fig. 1). Typically the first coil is deployed until a loop begins to herniate. This loop is pulled back into the aneurysm. Then, the second coil is pushed until a loop of the second coil begins to herniate. Thus, the operator alternates pushing the coils first through one catheter then the other until both coils are fully in place in the aneurysm. With patience and careful manipulation, even very wide necked aneurysms can be treated in this fashion. Using the longest available framing coils, it is possible to place 60–100 cm of coil to construct a stable frame prior to detachment of either coil. Once the frame is formed, one of the coils is detached. Typically the smaller coil is detached (if they are different sizes) or the second coil introduced is detached (if they are the same size). One coil is always left attached to the pusher wire while coils are introduced through the second catheter. This maneuver provides additional stability to the construct and helps prevent movement of the frame or herniation of coil loops.

Locking Technique. In some aneurysms it is possible to place an entire framing coil without herniation of loops. In many cases, however, the construct is not entirely stable. Once the coil is detached it may move, and some or all of the coil may herniate into the parent artery. In these situations, we often opt to place a second catheter and introduce a second framing coil into the aneurysm. This second coil provides additional radial tension to the construct and effectively “locks” the first coil in place. Again, large volumes of coils can be placed in the aneurysm, forming a stable frame before either coil is detached. In this situation, the second coil placed is detached, and the first coil is left attached, stabilizing the frame while coiling proceeds.

Aneurysm volumes, coil volumes, and packing densities were calculated using AngioCalc (www.angiocalc.com).

Imaging Assessment

Imaging outcomes were recorded for each case. Immediate treatment outcomes were documented in all cases by digital subtraction angiography. At discharge, patients were scheduled for 6- and 12-month angiographic follow-up with intent to image via CT angiography, MR angiography, or additional angiographic studies at 24 months. Long-term follow-up imaging analysis was performed for those patients with at least 12 months of follow-up (71%). Follow-up imaging was evaluated for stability, recurrence, or progressive/delayed occlusion of the aneurysm. In cases of recurrent or residual aneurysms, the remnant was classified according to the Raymond classification.

Clinical Assessment

Through an exhaustive review of the clinical records, the clinical presentation and outcomes were recorded for each patient. Complete neurological examinations were available for 99 of the 100 patients. Clinical status was scored using the modified Rankin Scale (mRS) with a score of 0–2 considered a good outcome. Major complications were classified as any hemorrhage, infarction, or dissection that was related to the procedure and resulted in permanent morbidity as determined by consensus between the interventional neuroradiologist and the neurosurgeon or neurologist who provided concurrent care to the patient.
Dual microcatheter coil embolization of wide-necked aneurysms

Statistical Analysis

Data are presented as mean and range for continuous variables, and as frequency for categorical variables. Statistical analyses of categorical variables were carried out using the chi-square test, Fisher’s exact test, and the Mantel-Haenszel test for linear association, and comparison of means was carried out using the Student t-test as appropriate. Univariate analysis was used to test covariates predictive of the following dependent variables: major treatment-related complications, any treatment-related complication, intraoperative rupture, retreatment, and favorable outcome (mRS Score 0–2 vs 3–6). The following factors were assessed for predictive value: aneurysm dome diameter, aneurysm neck diameter, dome-to-neck ratio (aneurysm dome diameter/aneurysm neck diameter), parent artery diameter, parent artery-to–aneurysm neck ratio (parent artery diameter/aneurysm neck diameter), presence/absence of subarachnoid hemorrhage, mRS score at presentation, Hunt and Hess score, aneurysm location, packing volume, sidewall versus terminus, volume of cerecyte/hydrogel/platinum coils, and initial occlusion estimates.

Factors predictive in univariate analysis (p < 0.20) were entered into a multivariate logistic regression analysis. Factors deemed relevant (for example, age, sex, and aneurysm size) were included in select multivariate analysis even if not deemed statistically significant. Further expansion analysis was carried out to assess for collinearity and to determine optimal predictors (for example, aneurysm size vs aneurysm neck vs dome-to-neck ratio). Further assessment of interaction and confounding was assessed through stratification and relevant expansion covariates. This may include direct assessment of interaction through addition of relevant variables (for example, size × age along with age in multivariate assessment after assessment with only age or only size); a p value of < 0.05 for the interaction variable is indicative of interaction. Further examples of stratification to assess for confounding include assessment of outcome during a number of stratification models, for example, large versus small aneurysms and ruptured versus unruptured aneurysms; p values of ≤ 0.05 were considered statistically significant. Statistical analysis was carried out with Stata (version 10.0, StataCorp.).

Results

Patient Demographics

Between January 2006 and June 2012, a total of 1314 patients underwent coil embolization of a cerebral aneurysm at our institution. Four hundred fifty-nine of the aneurysms were considered to have a wide neck. Treatment of wide-necked aneurysms at our institution has included single microcatheter techniques, the dual microcatheter technique, stent-assisted coiling, balloon remodeling, use of multiple stents for flow remodeling, and flow diverters. During this time period, 100 patients were treated using the dual microcatheter technique, 138 were treated using stent assistance, and 30 were treated with balloon remodeling. Here, we report the outcomes of 100 consecutive wide-necked aneurysms treated with the dual microcatheter technique. With refinement of the dual microcatheter technique, we began using this technique as our primary treatment option and saving adjunctive techniques for cases in which the dual microcatheter technique failed.

The 100 consecutive patients treated using the dual microcatheter technique were retrospectively enrolled in this study. Seventy-nine were female and 21 were male. The mean age was 58 years (Table 1). The most common presentation was an incidental finding (42 patients). Thirty-two patients presented with a subarachnoid hemorrhage. Other presenting symptoms included a headache without hemorrhage in 18 patients, visual disturbance in 6 patients, stroke or transient ischemic attack in 5 patients, seizure in 4 patients, and other neurological sequelae in 5 patients. Note that there was some overlap in presenting symptoms.

Aneurysm Characteristics

The average diameter of the aneurysm dome, the neck, and the parent artery are provided in Table 1. The most common aneurysm locations were the anterior communicating artery (21 aneurysms), the posterior communicating artery (17 aneurysms), the basilar tip (14 aneurysms), and the middle cerebral artery bifurcation (10 aneurysms).

Endovascular-Related Complications

Treatment-associated morbidity and mortality were 1% and 2%, respectively (Table 2). There was no morbidity (0%) but 1 death (1%) among the 68 patients treated electively. In the 32 patients treated after presenting with subarachnoid hemorrhage, there was 1 major complication (3%) and 1 death (3%). In the only death among the unruptured aneurysms, the microcatheter perforated the aneurysm dome, resulting in extensive hemorrhage and hydrocephalus with patient death within 24 hours. The death among the ruptured aneurysm cohort occurred after the coils fell out of the aneurysm, resulting in obstruction of the parent artery, stroke, and eventually death. The morbidity occurred as a result of sluggish flow in the A1 segment of the anterior cerebral artery during the procedure, resulting in a stroke. Due to the low morbidity and mortality rates, no correlation between patient demographics or aneurysm characteristics and risk of complication were established.

As with any endosaccular approach to brain aneurysm treatment, an important consideration when using 2 microcatheters in an aneurysm is the risk of intraprocedural rupture. In this series, there were 3 intraprocedural ruptures (3%). In 2 of the cases, the rupture was identified early and the aneurysm was successfully coiled. Upon waking, neither patient demonstrated any clinical sequelae of the intraprocedural rupture. In the third case, the rupture resulted in significant bleeding and death, as described above. This rate of intraprocedural rupture is consistent with the rupture rates established in the literature.

Initial Treatment Outcomes

As represented by Fig. 2, the dual microcatheter technique was successful in 91 of the 100 cases (91%).
The 9 unsuccessful cases were due to continuous herniation of the coils into the parent artery. Seven of the 9 patients were successfully treated by stent-assisted coil embolization and the other 2 were successfully treated by staged embolization of the aneurysm through a single catheter. Initial obliteration (> 95%) was achieved in 57 cases (57%). Of the patients with less than 95% immediate occlusion, 21 had at least 12 months of follow-up imaging. Eighteen of these 21 patients (86%) demonstrated progressive occlusion on follow-up studies. The average packing density for all aneurysms was 28.8% ± 18.3% with a range of 0%–129.6%.

Clinical Outcomes

Clinical data were available for 99 of the 100 patients at presentation and discharge, including 67 patients who were treated electively and 32 patients who were treated for a ruptured aneurysm. In total, 87 of the 99 patients (88%) had an mRS score of 0, 1, or 2 at presentation (Fig. 3), including 66 of 67 (99%) treated electively and 21 of 32 (66%) treated after a rupture.

At discharge, 86 of the 99 patients (87%) had an mRS score of 0–2, including 65 of the 67 electively treated patients (97%) and 21 of the 32 patients (66%) with ruptured aneurysms.

Clinical follow-up was available for 82 patients with a mean duration of 20 ± 18 months (range 1–67 months). Good outcomes (mRS score ≤ 2) were achieved in 75 of these 82 patients (91%), including 59 of the 60 unruptured aneurysms (98%) and 16 of the 22 ruptured aneurysms (73%).

A univariate analysis showed that hemorrhage (p < 0.001), neck diameter (p = 0.017), aneurysm diameter (p = 0.007), and packing volume (p = 0.027) were predictive of unfavorable outcomes. Multivariate analysis showed that

### TABLE 1: Patient demographics and aneurysm characteristics treated using the dual catheter technique with a comparison of unruptured and ruptured aneurysms*

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Aneurysms</th>
<th>Unruptured Aneurysms</th>
<th>Ruptured Aneurysms</th>
</tr>
</thead>
<tbody>
<tr>
<td>total no. of aneurysms</td>
<td>100</td>
<td>68</td>
<td>32</td>
</tr>
<tr>
<td>age in yrs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>58 ± 12.1</td>
<td>57.8 ± 11.4</td>
<td>58.6 ± 13.6</td>
</tr>
<tr>
<td>range</td>
<td>27–84</td>
<td>27–77</td>
<td>38–84</td>
</tr>
<tr>
<td>no. of patients w/ mRS score available at presentation</td>
<td>99</td>
<td>67</td>
<td>32</td>
</tr>
<tr>
<td>mRS score at presentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–2</td>
<td>87 (88)</td>
<td>66 (99)</td>
<td>21 (66)</td>
</tr>
<tr>
<td>3–5</td>
<td>12 (12)</td>
<td>1 (1)</td>
<td>11 (34)</td>
</tr>
<tr>
<td>Hunt &amp; Hess grade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>1</td>
<td></td>
<td>(3)</td>
</tr>
<tr>
<td>II</td>
<td>20</td>
<td></td>
<td>(62)</td>
</tr>
<tr>
<td>III</td>
<td>7</td>
<td></td>
<td>(22)</td>
</tr>
<tr>
<td>IV</td>
<td>3</td>
<td></td>
<td>(9)</td>
</tr>
<tr>
<td>V</td>
<td>1</td>
<td></td>
<td>(3)</td>
</tr>
<tr>
<td>anterior circulation</td>
<td>83 (83)</td>
<td>57 (84)</td>
<td>26 (81)</td>
</tr>
<tr>
<td>posterior circulation</td>
<td>17 (17)</td>
<td>11 (16)</td>
<td>6 (19)</td>
</tr>
<tr>
<td>aneurysm diameter in mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>6.9 ± 3.8</td>
<td>6.6 ± 3.6</td>
<td>7.5 ± 4.1</td>
</tr>
<tr>
<td>range</td>
<td>2.5–22.3</td>
<td>2.5–18.3</td>
<td>2.5–22.3</td>
</tr>
<tr>
<td>aneurysm neck in mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>4.2 ± 1.5</td>
<td>4.2 ± 1.5</td>
<td>4.4 ± 1.4</td>
</tr>
<tr>
<td>range</td>
<td>1.9–8.3</td>
<td>1.9–8.3</td>
<td>2.5–8</td>
</tr>
<tr>
<td>parent artery diameter in mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>2.6 ± 0.7</td>
<td>2.6 ± 0.7</td>
<td>2.6 ± 0.7</td>
</tr>
<tr>
<td>range</td>
<td>1.5–4.5</td>
<td>1.5–4.5</td>
<td>1.5–4.5</td>
</tr>
<tr>
<td>dome-to-neck ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>1.7 ± 0.7</td>
<td>1.6 ± 0.6</td>
<td>1.8 ± 0.8</td>
</tr>
<tr>
<td>range</td>
<td>0.7–4.8</td>
<td>1–3.2</td>
<td>0.7–4.8</td>
</tr>
<tr>
<td>parent artery–to–aneurysm neck ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>0.7 ± 0.3</td>
<td>0.7 ± 0.3</td>
<td>0.6 ± 0.2</td>
</tr>
<tr>
<td>range</td>
<td>0.3–1.5</td>
<td>0.3–1.5</td>
<td>0.3–1.1</td>
</tr>
</tbody>
</table>

* Values are number of aneurysms (%) unless stated otherwise. Means are presented with SDs.
increasing age (OR 0.25 [95% CI 0.07–0.88], p = 0.031), ruptured aneurysm (OR 45.33 [95% CI 5.73–407.57], p < 0.001), and increasing aneurysm diameter (OR 1.18 [95% CI 1.02–1.35], p = 0.019) were independent predictors of an unfavorable outcome (mRS Score 3–6).

Radiological Follow-Up

Seventy-one patients presented for at least a 12-month follow-up imaging study with an average follow-up time of 26 ± 14 months (range 12–66 months). Thirteen of the 71 patients (18%) required a retreatment, including 8 of 49 unruptured aneurysms (16%) with at least 12 months follow-up and 5 of the 22 ruptured aneurysms (23%). A multivariate analysis found no statistically significant predictors of retreatment. However, there was a significant decrease in retreatment rates over time as operators gained more experience as shown in Fig. 4 (OR 0.78 [95% CI 0.57–0.99], p = 0.043).

A multivariate analysis showed that ruptured aneurysms (OR 26.6 [95% CI 1.9–372.4], p = 0.015) and packing volume (OR 0.89 [95% CI 0.8–0.9], p = 0.036) were predictive of retreatment. Those patients with a packing density greater than 22% had a retreatment incidence of 2.5%, while those with a packing density less than 22% had a 12% retreatment incidence.

Discussion

Baxter et al. first introduced dual microcatheter embolization as a rescue technique in 2 cases of wide-necked aneurysms. Since then, there have been several case reports and a study of 25 patients describing experiences with the technique. We report 100 consecutive cases with a technical success rate of 91%, morbidity of 1%, mortality of 2%, and a recurrence rate of 18%. We have found that this is a safe and efficacious alternative for treatment of wide-necked aneurysms.

The technique has several advantages over balloon remodeling or stent-assisted embolization. First, it takes advantage of the superior tracking ability of 2 microcatheters, allowing for the embolization of aneurysms in tortuous vasculature or in smaller distal arteries. Second, it does not require temporary occlusion of the parent artery. Third, it does not require the deployment of a permanent device with the subsequent need for prolonged antiplatelet therapy, which may increase the risk of major bleeding events. Fourth, it allows large volumes of coils to be placed in the aneurysm sac forming a stable construct prior to detachment of the coils. Fifth, as a second microcatheter is the only additional item used for this technique, it might provide cost savings to the institution compared with the use of balloons or stents.

An ancillary benefit of this procedure is that, should the dual microcatheter technique prove ineffective, the operator may employ an adjunctive technique, such as balloon remodeling or stent assistance. The dual microcatheter technique was technically successful in 91% of our cases. We subsequently achieved 100% technical success among all 100 reported aneurysms through the use of stents in 7 cases and staged embolization in 2 cases in which the dual microcatheter technique was unsuccessful.

Table 2: Outcomes data for unruptured and ruptured aneurysms treated with the dual catheter technique

<table>
<thead>
<tr>
<th>Variable</th>
<th>All</th>
<th>Unruptured</th>
<th>Ruptured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of aneurysms</td>
<td>100</td>
<td>68</td>
<td>32</td>
</tr>
<tr>
<td>Clinical outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morbidity</td>
<td>1 (1)</td>
<td>0 (0)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Mortality</td>
<td>2 (2)</td>
<td>1 (1)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Immediate treatment outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical success</td>
<td>91 (91)</td>
<td>62 (91)</td>
<td>29 (91)</td>
</tr>
<tr>
<td>Initial occlusion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>17 (17)</td>
<td>9 (13)</td>
<td>8 (25)</td>
</tr>
<tr>
<td>&gt;95%</td>
<td>57 (57)</td>
<td>34 (50)</td>
<td>23 (72)</td>
</tr>
<tr>
<td>Raymond classification (immediate)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>17 (17)</td>
<td>9 (13)</td>
<td>8 (25)</td>
</tr>
<tr>
<td>Aneurysm</td>
<td>45 (45)</td>
<td>32 (47)</td>
<td>13 (41)</td>
</tr>
<tr>
<td>Neck</td>
<td>38 (38)</td>
<td>27 (40)</td>
<td>11 (34)</td>
</tr>
<tr>
<td>Follow-up radiographic outcomes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aneurysms w/ &gt;12 mos FU</td>
<td>71</td>
<td>49</td>
<td>22</td>
</tr>
<tr>
<td>Retreatment</td>
<td>13 (18)</td>
<td>8 (16)</td>
<td>5 (23)</td>
</tr>
<tr>
<td>Progressive occlusion</td>
<td>18 (25)</td>
<td>16 (33)</td>
<td>2 (9)</td>
</tr>
</tbody>
</table>

* FU = follow-up.
The morbidity and mortality rates in this series are 1% and 2%, respectively. Complications were slightly more common in the ruptured group (6% combined morbidity and mortality) than in the unruptured group (1%). For comparison, morbidity rates of 1.4%–21% with an average of 7.1% among 2262 aneurysms following stent-assisted embolization have been reported in the literature.4,6,15,16,22,23,29,31–33,35,44,45,52,53 Among 879 aneurysms treated with balloon remodeling in the literature, the morbidity ranged from 2.2% to 9% with an average of 3.8%.1,7,10,27,28,30,34,36,39,42,43,48,50

Multivariate analysis showed that age, ruptured aneurysms, and either aneurysm dome diameter or packing volume are predictive of unfavorable clinical outcomes (p = 0.019 and 0.013, respectively). However, a review of patients’ mRS scores from presentation to follow-up clinic appointments demonstrates a general trend toward improved clinical outcomes (Fig. 3). The majority of patients who present with an mRS score of 0–2 have a good outcome (86 of 87, 99%).

The use of this technique raises 3 serious concerns. First, placing 2 microcatheters into an aneurysm may increase the risk of rupture.40,49 In this study, the rupture rate using this technique was 3% with only 1 of the 3 cases resulting in any clinical complications, which is similar to the reported incidence of 2.5% for all aneurysms regardless of size or presence of subarachnoid hemorrhage.49 Second, coiling wide-necked aneurysms without a stent or a balloon may increase the risk of coil herniation and parent artery occlusion. In this series, despite an average neck size of 4.2 mm and an average dome-to-neck ratio of 1.7, coil herniation occurred in just 1 patient. Third, coiling wide-necked aneurysms without stents or balloons may lead to decreased packing density and an increased recurrence rate. Indeed, in this study 18% of patients required retreatment, including 16% of unruptured aneurysms and 23% of ruptured aneurysms. On the one hand, this is a high recurrence rate. On the other, all of the aneurysms included in this study were wide-necked aneurysms. Other authors have found similar recurrence rates in large and wide-necked aneurysms. In a prospective collection of cases Raymond et al. found a 20.7% recurrence rate in all treated aneurysms (defined as a recurrence that requires further treatment), and also found that larger aneurysms have as much as a 34%–50% recurrence rate.46 In a similar population of patients treated by stent-assisted coil embolization in the literature, retreatment rates ranged from 10.7% to 20% with an average of 14.4% among 200 aneurysms.4,21,22,53

Retreatment rates following balloon remodeling ranged from 8% to 16.9% with an average of 11.6% among 190 aneurysms reported in the literature.1,10,36,50 It is important to note, though, that while our study includes only wide-necked aneurysms, many of the aneurysms included in the comparison stent and balloon data include all aneurysms. Prior studies have identified a correlation between neck size and recurrence rates, which may account for some of the difference in retreatment rates between our data and data following balloon remodeling in the literature.14,17

The multivariate analysis identified rupture status (p = 0.015) and decreasing packing density (p = 0.036) as predictors of retreatment. Packing density is an often cited predictor of recurrence.5,25,51 In our study, aneurysms with a packing density of less than 22% were significantly more

![Fig. 3. Modified Rankin Scale scores at presentation, discharge, and follow-up for all patients.](image-url)
likely to recur than those with greater than 22% packing density \((p < 0.001)\). The interventionalist must balance the risk of recurrence with the risk inherent in stent-coiling or balloon remodeling. The immediate and long-term complication rates in this series compare favorably to the complication rates reported in series of aneurysms that have undergone stent-assisted coil embolization or balloon remodeling. It has been our practice to err on the side of safety, more lightly packing aneurysms in which the risk of coil herniation is deemed high. This approach takes advantage of the well-known protective effect of coating, allows time for the coil construct to mature, and is chosen with the understanding that retreatment, if necessary, will be safer once the coils have at least partially endothelialized within the aneurysm. None of the patients who presented with a ruptured aneurysm suffered from rebleeding after treatment, and none of the patients who were retreated suffered a complication. Although more recurrences can be expected with this approach, in our estimation treating the occasional recurrence is safer than routine stent-coiling or balloon remodeling.

The major limitation of this study is its retrospective and nonrandomized design. We are not aware of a selection bias related to the location of the aneurysm or the types of coils chosen. However, these factors could play a role in the results described herein.

**Conclusions**

The dual microcatheter technique offers the interventionalist an option for treating wide-necked aneurysms without the use of occlusive balloons or permanent stenting. Morbidity and mortality rates are low at 1% and 2%, respectively. Retreatment rates may be higher with this technique at 18%, though this increase in retreatment rate is in part an expected consequence of a strategy to underpack those aneurysms at highest risk for coil herniation and migration.

**Acknowledgment**

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**Disclosure**

Dr. Evans is a consultant for Covidien, Stryker, Carefusion, and Cook. Dr. Jensen is a consultant for Covidien and Stryker. Dr. Gaughen is a consultant for Covidien, Stryker, and Microvention. The University of Virginia Interventional Neuroradiology fellowship program is partially funded through a grant from Microvention. The other authors have nothing to disclose.

Author contributions to the study and manuscript preparation include the following. Conception and design: Durst, Gaughen. Acquisition of data: Durst, Geraghty, Kreitel, Medel, Demartini. Analysis and interpretation of data: Durst, Starke, Evans. Drafting the article: Durst, Starke. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Durst. Study supervision: Gaughen, Evans.

**References**


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Fig. 4. Learning curve associated with the development of the dual microcatheter technique resulting in less frequent retreatments as the operators gained experience with the technique (OR 0.78 [95% CI 0.57–0.99], \(p = 0.043\)).


38. Moret J, Pierot L, Boulin A, Castaings L: “Remodelling” of...


