Embolization of Intracranial Aneurysms With Hydrogel-Coated Coils Versus Inert Platinum Coils: Effects on Packing Density, Coil Length and Quantity, Procedure Performance, Cost, Length of Hospital Stay, and Durability of Therapy

Ron C. Gaba, MD; Sameer A. Ansari, MD, PhD; Soma Sinha Roy, MD; Franklin A. Marden, MD; Marlos A.G. Viana, PhD; Tim W. Malisch, MD

Background and Purpose—The durability of aneurysm coil embolization is thought to depend on packing density. The expansile property of hydrogel coating on coils increases volumetric packing per coil length. We describe our experience using hydrogel-coated coils (HydroCoils) compared with inert platinum coils in intracranial aneurysm embolization.

Methods—Fifty aneurysms embolized primarily using HydroCoils from 2003 to 2004 were compared with 57 volume- and shape-matched aneurysms treated with standard platinum coils from 2000 to 2003. Outcome measures included volumetric percentage occlusion (VPO), length and number of coils used, procedure time, fluoroscopy time, contrast volume, coil cost, length of hospital stay, and durability of therapy.

Results—Seventeen/26/5 small/medium/large aneurysms treated with HydroCoils were matched with 29/24/4 small/medium/large aneurysms treated with inert platinum. HydroCoil embolization yielded significantly greater VPO (84.8% versus 29.8%; P<0.001), decreased average total coil length used per aneurysm (33.2 versus 44.3 cm), reduced fluoroscopy time (53.2 versus 65.2 minutes; P=0.016), but increased contrast volume used (174.8 versus 112.9 cc; P<0.001). There were no differences in length of hospital stay. Procedure-related morbidity and mortality rates in the HydroCoil cohort were 4% and 0%, respectively. Follow-up angiography at mean 12.3 months revealed lower aneurysm recurrence rates (17% versus 24%; number-needed-to-treat [NNT] 14.3). Initial costs associated with HydroCoil embolization were higher ($5835 versus $4017; P=0.004) but countered by lower retreatment rates (10% versus 17%; NNT 14.3).

Conclusions—HydroCoil embolization achieves greater aneurysm packing density with decreased coil length. Initial durability data favor HydroCoils, with lower recurrence and retreatment rates. (Stroke. 2006;37:1443-1450.)

Key Word: aneurysm ■ embolization ■ hydrogel ■ therapeutic

The durability of endovascular coil occlusion of intracranial aneurysms is thought to depend on density of packing achieved within the aneurysm sac, commonly known as volumetric percentage occlusion (VPO). The HydroCoil Embolic System (MicroVention) is a recently developed coil technology designed to improve packing density. Hydrogel-coated coils (HydroCoils) consist of platinum coils covered with a hydrophilic polymer that swells in blood. Coil swelling in vivo should theoretically result in greater aneurysm filling compared with inert platinum coils and may translate into more durable therapy.

This study aimed to examine the effect of packing density achieved with HydroCoils versus inert platinum coils on durability of aneurysm therapy. The effect of HydroCoil use on total coil number and coil length used, total procedure and fluoroscopy time, contrast volume used per procedure, total coil cost, and length of hospital stay was also evaluated.

Materials and Methods

Patients and Aneurysms
Sixty consecutive aneurysms in 55 patients were treated prospectively using HydroCoils between February 2003 and February 2004. Aneurysm presentations included all clinical grades of acute subarachnoid hemorrhage, remote rupture, discovery after rupture of another intracranial aneurysm, symptoms of mass effect including headache and cranial neuropathy, or incidental finding on MRI or...
magnetic resonance angiography. Aneurysms were situated in a variety of locations in the anterior and posterior circulations and were of various sizes, including small (≤5 mm), medium (6 to 10 mm), large (11 to 20 mm), and giant (>20 mm).

Embolization of aneurysms was performed using standard technique. Selection of endovascular therapy versus microsurgical clipping was made as a consensus decision by interventional neuroradiology and neurosurgery physicians based on amenability to embolization considering factors such as aneurysm size, configuration, neck width, and location. Inclusion criteria consisted of any intracranial saccular aneurysm treated in a constructive manner using HydroCoils as the primary filling coil. Concomitant use of inert platinum coils limited to framing or neck finishing was allowed. Balloon remodeling technique and adjunctive stent placement were performed in selected cases. Exclusion criteria for the HydroCoil group included any treatment approach involving parent artery sacrifice or use of bioactive coil technologies.

A retrospective cohort of intracranial aneurysms treated with inert platinum coils and matched for volume and shape with the HydroCoil data set were identified from a database of aneurysms treated between January 2000 and December 2003 and used as a historical control for comparison with the HydroCoil group.

Patients and data for this study were accrued in compliance with our institutional review board.

**Outcomes**

Primary outcome measures included VPO and durability of therapy. VPO was calculated using the formula: VPO=100×(total coil volume/aneurysm sac volume). Coils were calculated assuming a cylindrical coil shape, using the formula: Coil volume=π×(coil radius)²×(coil length) for each coil. Coils were obtained from coil manufacturers (Boston Scientific; Cordis Neurovascular Inc; MicroVention; Micrus Corporation). Calculations for Hydro-Coils used theoretical final coil volume, assuming full polymer expansion. Aneurysm size was measured using standardized techniques, and aneurysm sac volume was calculated using the formula: Aneurysm sac volume=(4/3)×π×(height/2)×(width/2)×(length/2). Calculated VPOs exceeding 100% were adjusted to 100% for data analysis. Durability of aneurysm occlusion was evaluated angiographically at specified follow-up times (3 to 6 months, 12 to 18 months, and 24 months). Aneurysm recurrence was defined as coil compaction, recanalization through the coil mesh, aneurysm regrowth, or neck enlargement at follow-up angiography. No change in Raymond scale was required.

Secondary outcome measures included total coil number and coil length used, embolization procedure and fluoroscopy time, contrast volume used per procedure, total coil cost, and length of hospital stay. Contrast volume indicates volume (mL) of iohexol (Omnipaque 300; Amersham Health) used. Procedure performance parameters were excluded from analysis if not documented or if >1 aneurysm was treated during a single procedure. List prices from 2004 manufacturer catalogues (manufacturers as listed previously) were used to calculate coil costs. Exclusion criteria for length of hospital stay analysis included therapy (endovascular or surgical) of >1 aneurysm during a single hospitalization, occurrence of a non-neurologic complication accounting for a majority of a hospital admission, early patient death, or outside hospital transfer.

**Statistical Analysis**

Categorical data were analyzed using χ² or Fisher exact tests. The mean of continuous measures for HydroCoils and platinum coils were compared using an independent samples t test or Mann-Whitney rank sum test. Statistical analysis was performed using a commercially available software package (SigmaStat 3.0; SPSS Inc). P<0.05 was considered significant. Binary outcome measures were compared using absolute and relative measures.

Because no appropriate comparison giant aneurysm was found among aneurysms treated with platinum during the historical time period of 2000 to 2003, giant aneurysms treated with HydroCoils were excluded from categorical data calculations. Durability analysis was still performed.

**Results**

**Patients and Aneurysms**

Fifty HydroCoil-treated aneurysms in 45 patients were eligible for the study. Ten patients with 10 aneurysms were excluded. Small, medium, and large aneurysms in the HydroCoil treatment group were compared with a platinum-treated cohort consisting of 57 aneurysms in 57 patients. Patient demographics, aneurysm characteristics, and treatment information for these groups are presented in Table 1. Aside from increased use of balloon remodeling in the platinum group (P=0.019), there were no significant differences in these factors.

**TABLE 1. Patient Demographics, Aneurysm Characteristics, and Treatment Information**

<table>
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<tr>
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<td>Platinum finishing coil</td>
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*Including only small, medium, and large sizes; †statistically significant.
Packing Density
The calculated theoretical VPO for HydroCoil-treated aneurysms was significantly greater than that achieved with platinum coils for all aneurysm size types (Table 2; all P<0.001; small P<0.001; medium P<0.001; large P=0.016). A calculated VPO >100% was seen in 9 of 17 small aneurysms and 15 of 26 medium aneurysms, reflecting the assumption of full polymer expansion in aneurysms. Forty-two of 48 HydroCoil-treated aneurysms had a VPO >50%. No HydroCoil-treated aneurysm had a VPO <30%. Overall, HydroCoils accounted for 90.5% of VPO in HydroCoil-treated aneurysms, with the rest attributable to platinum coils used for framing or neck finishing.

Coil Length and Quantity
Aneurysms treated with HydroCoils required less total coil length for occlusion than those treated with platinum coils (Table 2). Differences were significant for small and medium aneurysms (small P=0.028; medium P=0.006). The number of large aneurysms was too small to achieve statistical significance, although there was a trend in favor of less coil length used. HydroCoils accounted for 71.8% of coil length used over all HydroCoil-treated aneurysms.

A similar number of coils were used in treating aneurysms with HydroCoils compared with platinum coils. No significant differences were seen in the average coil quantity used per aneurysm (Table 2). When the HydroCoil cohort was analyzed by finishing coil, fewer total coils were necessary when HydroCoils were used as the finishing coil compared to when platinum was used for finishing (Table 2), although not statistically significant. HydroCoils accounted for 69.2% of coils used in the HydroCoil cohort.

Procedure Performance
Total procedure times were not significantly different in the treatment groups (Table 2). A significant difference in fluoroscopy time in small aneurysms (Table 2; P<0.001) translated into a significant difference for all aneurysms (Table 2; P=0.016), with 18% less fluoroscopy time in the HydroCoil cohort.

Total contrast volume used was increased in procedures using HydroCoils, and differences were significant for all, small, and medium aneurysms (Table 2; all P<0.001; small P=0.005; medium P<0.001). There remained significant differences in used contrast volume when aneurysms in each treatment group were classified into those in which single-vessel angiograms were performed at the time of embolization and those in which multiple (2 to 4) vessel angiograms were performed. In single-vessel procedures, contrast volume was significantly increased in all and medium aneurysms (Table 2; all P<0.001; medium P=0.018). For multiple vessel procedures, significantly greater mean contrast volume was appreciated in all, small, and medium aneurysms (Table 2; all P<0.001; small P=0.035; medium P=0.017).

Cost
Coil cost was increased when using HydroCoils. Average cost of HydroCoils was greater than platinum coils for each aneurysm size type (Table 3), with a significant difference in medium aneurysms (P=0.033) translating into a significant difference for all aneurysms (P=0.004). There were no significant differences in cost when the HydroCoil cohort was analyzed based on finishing coil used. In particular, a trend
length of hospital stay (d) 13.0 (n 2004 USD)†
Coil cost–Platinum finishing coil
Length of stay–ruptured (d) 16.7 (n 2004 USD)
Coil cost (2004 US dollars)† 5835 4017
Of 45 patients with 50 aneurysms treated with HydroCoils, HydroCoil Cohort
Durability of Therapy
Recurrence requiring retreatment (%)
Follow-up time period
Recurrence (%)
All aneurysms 7 (17%) 4 (11%) 10 (24%)
HES finishing coil
Platinum finishing coil
Platinum finishing coil
Post-traumatic aneurysm.

In the HydroCoil cohort, HydroCoils were used for neck
remnant at follow-up angiography. Mean follow-up time was 12.3 months. Seven (17%) HydroCoil-treated aneurysms (1 small, 3 medium, 2 large, 1 giant) showed recurrence at follow-up angiography, observed at mean 5.9 months. Four (10%) recurrent aneurysms (1 small, 1 medium, 1 large, 1 giant) have been retreated or will need retreatment. Three (7%) aneurysms (2 medium, 1 large) with minimal neck regrowth will not require further treatment because of benign morphology. Of 7 cases of recurrence, 3 were among the first 5 patients treated with HydroCoils, and 1 was a giant post-traumatic aneurysm.

In the HydroCoil cohort, HydroCoils were used for neck finishing in 25 aneurysms (7 small, 14 medium, 2 large, 2
toward greater coil costs in small aneurysms finished with platinum coils compared with HydroCoils was not statistically significant (Table 3; P=0.058).

Length of Hospital Stay
No significant differences in length of hospital stay were appreciated between HydroCoil and platinum treatment groups, including when aneurysms were classified into ruptured and unruptured data sets (Table 3).

Initial Angiographic Results
Initial angiographic results were better in the HydroCoil group, although not statistically significantly different. Complete obliteration was achieved in 29 (58%) HydroCoil-treated aneurysms compared with 30 (55%) in the platinum cohort. A small residual neck was left in 18 (36%) HydroCoil-versus 23 (40%) platinum-treated aneurysms. Residual aneurysm was seen in 3 (6%) HydroCoil- versus 4 (7%) platinum-treated aneurysms.

Durability of Therapy
HydroCoil Cohort
Of 45 patients with 50 aneurysms treated with HydroCoils, 38 (84%) patients with 41 aneurysms underwent follow-up angiography (Table 4). Of 7 patients with 9 aneurysms not undergoing follow-up, 2 presented with poor Hunt and Hess grade and died as a result of initial subarachnoid hemorrhage. Three poor-grade patients survived after embolization but were unavailable for follow-up because of poor clinical status. Two patients were lost to follow-up.

Thirty-four of 41 (83%) aneurysms demonstrated stable complete obliteration or stable appearance of a small neck remnant at follow-up angiography. Mean follow-up time was 12.3 months. Seven (17%) HydroCoil-treated aneurysms (1 small, 3 medium, 2 large, 1 giant) showed recurrence at follow-up angiography, observed at mean 5.9 months. Four (10%) recurrent aneurysms (1 small, 1 medium, 1 large, 1 giant) have been retreated or will need retreatment. Three (7%) aneurysms (2 medium, 1 large) with minimal neck regrowth will not require further treatment because of benign morphology. Of 7 cases of recurrence, 3 were among the first 5 patients treated with HydroCoils, and 1 was a giant post-traumatic aneurysm.

In the HydroCoil cohort, HydroCoils were used for neck finishing in 25 aneurysms (7 small, 14 medium, 2 large, 2
giant), and platinum was used for neck finishing in 25 aneurysms (10 small, 12 medium, 3 large). Use of platinum finishing coils was associated with slightly greater aneurysm recurrence (Table 4), with mean follow-up times of 14.8 and 14.9 months, 11.5 and 12.2 months, and 9.5 and 19 months for HydroCoil- and platinum-finished small, medium, and large and giant aneurysms, respectively. Two recurrent HydroCoil-finished aneurysms and 2 recurrent platinum-finished aneurysms underwent retreatment.

**Inert Platinum Cohort**
Among 57 aneurysms treated with inert platinum, 41 (72%) patients with 41 aneurysms underwent follow-up angiography (Table 4). Of 16 patients with 16 aneurysms not undergoing follow-up, 1 presented with poor Hunt and Hess grade and died as a result of initial subarachnoid hemorrhage. Six poor-grade patients survived after embolization but were unavailable for follow-up because of poor clinical status. Nine patients were lost to follow-up.

Thirty-one of 41 (76%) aneurysms demonstrated stable complete obliteration or stable appearance of a small neck remnant at follow-up angiography. Mean follow-up time was 18.9 months. Ten (24%) platinum-treated aneurysms (5 small, 4 medium, 1 large) showed recurrence at follow-up angiography, observed at mean 16.7 months. Seven (17%) recurrent aneurysms (2 small, 2 medium, 1 large) have been or will need retreatment. Three (7%) aneurysms (1 small, 2 medium) with mild regrowth will not require further treatment because of benign morphology.

**Complications**
The procedure-related complication rate in the HydroCoil cohort was 4% and consisted of 1 symptomatic and 1 asymptomatic event. In 1 case of superior cerebellar artery occlusion during embolization of an unruptured medium right superior cerebellar artery aneurysm, the patient’s resulting neurological symptoms completely resolved within days. One case of intraprocedural aneurysm rupture occurred during placement of a coil into a ruptured medium right posterior communicating artery aneurysm treated using balloon remodeling. The balloon was inflated to protect the aneurysm dome, and the aneurysm was successfully packed with coils. Repeat angiography after balloon deflation showed no further contrast extravasation. There was no change in the patient’s postprocedure neurological status compared with preprocedure baseline.

One delayed asymptomatic event consisted of distal arterial coil migration, evident on 6-month follow-up angiography of a treated small anterior communicating artery aneurysm. The patient remained neurologically asymptomatic throughout her postembolization course.

There were no cases of procedure-related death, postembolization aneurysm rupture, worsened mass effect, or aseptic meningitis among HydroCoil-treated patients.

**Discussion**
Endovascular coil embolization is an effective means of securing intracranial aneurysms and protecting against subarachnoid hemorrhage.8 Although the safety of this procedure is well documented,8 there are few data on durability of coil occlusion. With estimates of retreatment rates ranging from 10% to >30%,8,10–13 there have been increased efforts to delineate factors involved in long-term stability of coiled aneurysms and to develop technologies to improve durability.

Density of coil packing within an aneurysm has been suggested to correlate with durability of treatment.1–4 The VPO of an aneurysm reflects such variables as aneurysm size and neck width, coil technology, and operator experience. Although some authors have suggested a threshold VPO of 25% to 33.3% for durable occlusion,1,2 this level of packing may still not be optimal. In this study, we found that hydrogel-coated platinum coils achieved an average calculated theoretical VPO nearly 3X that seen in a historical cohort of aneurysms treated with inert platinum coils. The high packing density achieved with HydroCoils is related to the ability of the coil to swell and conform to available space within the aneurysm at low pressures. A calculated VPO >100% was seen in more than half of small and medium aneurysms treated with HydroCoils. Other authors explain finding this on the basis of systematic errors in aneurysm measurement and volume calculation.5 The fact that this phenomenon was observed only among HydroCoil-treated aneurysms in this study argues against this. We believe that the assumption of complete HydroCoil expansion is likely faulty in densely packed, small- to medium-sized aneurysms and causes calculation error resulting in theoretical VPOs exceeding 100%. This is supported by the observation that this phenomenon occurred more frequently in small- to medium-sized aneurysms compared with large and giant aneurysms (24 of 43 compared with 1 of 7) because smaller aneurysms are generally packed more densely. Additionally, there was no clinical or radiological evidence for complications expected from HydroCoil overexpansion in this series to support VPOs exceeding 100%. On this basis, we suggest the possibility that HydroCoils do not fully expand if there is not enough space in the aneurysm sac.

The greater packing density attainable per unit length in HydroCoils was associated with use of decreased coil length in treating aneurysms with this technology compared with inert platinum. Overall, HydroCoil-treated aneurysms were packed more densely using ≈25% less total coil length compared with standard platinum. Interestingly, this decrease in coil length did not translate into a significant reduction in total number of coils used per aneurysm in this series. This may be explained by the fact that on average, shorter coils were used in treating aneurysms with HydroCoils (average coil length HydroCoil 6.4 cm; platinum 9.0 cm; P<0.001). This greater use of short coils may be attributable to limited initial commercial availability of HydroCoils >10 cm.

There was no significant difference in embolization procedure times. The reduced fluoroscopy time seen in small HydroCoil-treated aneurysms may be spurious. There were no substantial differences in procedure technique that would affect fluoroscopy time, including positioning of patients, catheters, wires, and coils, between the treatment groups to account for this difference.

Utilization of HydroCoils increased contrast volume used per embolization procedure, a difference present regardless of
whether the procedure consisted of a therapeutic intervention in which a single vessel angiogram was performed or if the embolization was performed at the same setting as the diagnostic 4-vessel angiogram. The increased contrast utilization is probably multifactorial in nature. One contributing factor is a technique used in some earlier HydroCoil embolization procedures, namely obtaining multiple 20-minute delayed angiograms after serial coil insertion to evaluate for full swelling. We no longer consider this technique necessary.

Increased coil cost in the HydroCoil group reflects the more expensive catalogue price of these coils. Because coil cost comprises only a small percentage of embolization procedure cost and total cost incurred during hospitalization for aneurysm therapy, the financial impact of greater HydroCoil cost is minimal. In this study, no significant differences were appreciated in length of hospital stay between the treatment groups. Lengths of hospital stays in this series are comparable to those reported previously for ruptured and unruptured aneurysms.14,15

Data obtained at mean 12.3-month follow-up in the HydroCoil cohort suggests improved durability of therapy in aneurysms treated with HydroCoils compared with platinum coils. Recurrence rates were decreased in the HydroCoil cohort, significantly in small aneurysms (5% versus 17%; $P=0.013$). The 17% overall recurrence rate seen with Hydro-Coils in this series represents a 7% absolute risk reduction and 29% relative risk reduction compared with the platinum cohort. Excluding our institutional HydroCoil “learning curve,” or first 5 patients treated, from this analysis, recurrence rate was 11%. This represents a significant reduction from the platinum recurrence rate ($P=0.026$). Absolute and relative risk reductions were 13% and 54%, respectively. The clinical impact of these risk reductions is reflected in the NNT of 7.7, indicating that for every 8 aneurysms treated with HydroCoils rather than platinum, 1 less recurrence is encountered at mean 12.3-month follow-up. In this series, we did not attempt to differentiate between mechanisms of aneurysm recurrence, of which there are 3 well-accepted types: (1) coil compaction (mechanical failure of the coil pack), (2) recanalization through the interstices of a stable coil pack (“biological” failure of the coil pack), and (3) regrowth of the aneurysm neck or base proximal to a stable coil pack (progression of disease). Retreatment rate was also reduced in the HydroCoil cohort, in which 4 of 7 (57%) of recurrent aneurysms required repeat embolization, compared with 7 of 10 (70%) in the platinum group. Although clinical outcome after coil embolization of aneurysms is most closely related to presence of rupture and clinical grade of subarachnoid hemorrhage at initial presentation,13 it is noteworthy that any treatment that increases durability of therapy and decreases retreatment rates will reduce morbidity and mortality related to retreatment or rebleeding.

There were no differences in aneurysm volume or neck width between recurrent and stable HydroCoil-treated aneurysms. In this series, use of HydroCoils for neck finishing resulted in a reduced aneurysm recurrence rate compared with use of platinum for neck finishing (13% versus 22%), suggesting improved stability when embolization is performed exclusively with HydroCoils.

Figure 1. Giant left internal carotid artery ophthalmic region aneurysm before embolization (A) and after embolization (B) with 20 HydroCoils and 4 platinum coils. Stable obliteration of this aneurysm is evident on 1-year follow-up angiogram (C).
Although the durability data presented are limited by a shorter follow-up time period in the HydroCoil group compared with the platinum cohort, literature addressing the timing of postembolization aneurysm recurrence suggests that this difference may not be significant. Although 12-month follow-up is by no means complete, recent articles describing long-term follow-up of intracranial aneurysms treated with detachable coils have suggested that the majority of aneurysm recurrences occur early in the postembolization course. In surveying 489 aneurysms postembolization, Murayama et al found that most recanalizations occurred within 3 months. Raymond et al reported that \( \sim 65\% \) of recurrences found among 381 aneurysms surveyed after embolization were identified by 12-month follow-up. Gallass et al found that among 571 aneurysms surveyed after embolization, 96% of aneurysms occluded at 12 months remained stable at final follow-up (mean 36 months). These studies indicate that postembolization aneurysm recanalization is generally an early phenomenon, and lack of early recurrence may suggest long-term durability. Our series substantiates these facts. There was only 1 case of recurrence (slight neck remnant progression) observed beyond 12-month follow-up after stability was documented on 12-month angiography in either treatment group (a total of 50 aneurysms followed for \( \geq 12 \) months). Furthermore, the mean follow-up time at which recurrence was observed in the HydroCoil group was 5.9 months, which further supports the view that recurrence is an early phenomenon. Although the mean follow-up time of recurrence of 16.7 months in the platinum group suggests a propensity for late recanalization, this value

Figure 2. Post-traumatic bilobed giant right cavernous internal carotid artery aneurysm before initial embolization (A) and after initial embolization (B) with 17 HydroCoils. Aneurysm regrowth appreciated on 6-month follow-up angiogram (C). After aspirin and clopidogrel pretreatment, patient underwent a second stage of coiling with 14 HydroCoils and stent assistance (D), with subsequent stable complete occlusion on 4-month follow-up angiogram (E).
is falsely elevated by 3 data outliers. Patients with late recurrence observed at 24, 36, and 42 months had missed all previous surveillance angiograms, so it is unclear how long the recurrences had been present. Exclusion of these values lowers the mean platinum coil time of documentation of recurrence to 9.3 months. Thus, although 12-month follow-up is not complete, it is felt to be a sufficient amount of time to formulate early judgments on HydroCoil durability. Although it is possible that some HydroCoil-treated aneurysms may show later recurrence, the sources referenced contend that the likelihood of this occurring is relatively low. Long-term follow-up angiographic data continue to be collected.

Large and giant aneurysms have historically shown significant recurrence rates after embolization, often requiring retreatment procedures. In this series, HydroCoil embolization resulted in superior filling of large and giant aneurysms. The mean VPO of 70.7% obtained represents an improvement on generally recognized endosaccular coil mass volumes traditionally achieved in these aneurysms. Durable occlusion was appreciated on angiographic follow-up in several cases, which warrant description. A giant left internal carotid artery ophthalmic region aneurysm embolized to complete occlusion with HydroCoils demonstrated stable obliteration on subsequent 12-month follow-up angiography (Figure 1). An acute post-traumatic giant right cavernous internal carotid artery aneurysm, which would conventionally likely require a deconstructive approach, sacrificing the artery, was successfully treated with HydroCoils in 2 stages (Figure 2).

Summary
Emerging coil technologies with potential to routinely achieve a VPO of >50%, uncommon among older inert platinum coils, should continue to facilitate our understanding of the relationship between packing density and durability. Although this study is limited by its dependence on a historical control group and slightly shorter mean follow-up period for the HydroCoil treatment group, the 3-fold increase in packing density achieved with HydroCoils appears to provide improved durability, with a one-third decrease in appreciable angiographic recurrence and a one-third decrease in need for retreatment. Although it is reasonable to expect that any technology that increases coil packing density ultimately improves durability of occlusion, long-term angiographic follow-up is necessary.

Acknowledgments
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References
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