Small Intracranial Aneurysm Treatment Using Target® Ultrasoft™ Coils

Gaurav Jindal, MD, Timothy Miller, MD, Moronke Iyohe, MD, MPH, Ravi Shivashankar, MD, Vikram Prasad, MD, and Dheeraj Gandhi, MD
Department of Interventional Neuroradiology, University of Maryland Medical Center, 22 South Greene Street, Baltimore, MD 21201, USA

Abstract

Purpose—The introduction of small, soft, complex-shaped microcoils has helped facilitate the endovascular treatment of small intracranial aneurysms (IAs) over the last several years. Here, we evaluate the initial safety and efficacy of treating small IAs using only Target® Ultrasoft™ coils.

Materials and methods—A retrospective review of a prospectively maintained clinical database at a single, high volume, teaching hospital was performed from September 2011 to May 2015. IAs smaller than or equal to 5.0 mm in maximal dimension treated with only Target® Ultrasoft™ coils were included.

Results—A total of 50 patients with 50 intracranial aneurysms were included. Subarachnoid hemorrhage from index aneurysm rupture was the indication for treatment in 23 of 50 (46%) cases, and prior subarachnoid hemorrhage (SAH) from another aneurysm was the indication for treatment in eight of 50 (16%) cases. The complete aneurysm occlusion rate was 70% (35/50), the minimal residual aneurysm rate was 14% (7/50), and residual aneurysm rate was 16% (8/50). One intraoperative aneurysm rupture occurred. Three patients died during hospitalization from clinical sequelae of subarachnoid hemorrhage. Follow-up at a mean of 13.6 months demonstrated complete aneurysm occlusion in 75% (30/40) of cases, near complete occlusion in 15% (6/40) of cases, and residual aneurysm in 10% (4/40) of cases, all four of which were retreated.

Conclusion—Our initial results using only Target® Ultrasoft™ coils for the endovascular treatment of small intracranial aneurysms demonstrate initial excellent safety and efficacy profiles.

INTRODUCTION

Endovascular coil embolization of intracranial aneurysms (IAs), including small aneurysms, has become a well-established technique for treatment of IAs since its inception in the early 1990s. Although no consensus exists regarding the definition of small or very small IAs, prior reports on the topic have designated aneurysms under 3 mm in diameter as “very small” and aneurysms under 4, 5, 7, or even 10 mm as “small” [1–19]. The International Study of Unruptured Intracranial Aneurysms initially grouped aneurysms by size below and above 10 mm and later grouped aneurysms by size below and above 7 mm [1,2]. Published reporting standards suggest that small IAs are less than 5 mm in maximal size [3]. Very small and small IAs have often been considered challenging to treat from an endovascular perspective [7–12,20]. Intraoperative aneurysm rupture is a well-known complication during treatment of these lesions. In recent years, however, these lesions commonly have been treated via endovascular means with good overall safety and efficacy profiles [14,15,17]. Reported recurrence and retreatment rates of previously coiled small IAs vary in the literature, although are similar to those of larger IAs [8,9,14,15,17].

The introduction of new endovascular devices has helped enable treatment of small IAs previously considered untreatable or difficult to treat by such techniques [12,21,22]. One such advancement is the increasing availability of small, soft microcoils with a complex design such as the Target® 360 Ultrasoft coil (Stryker-Neurovascular, Kalamazoo, Michigan, USA). These coils were first introduced in 2010. The relatively low level of stiffness of these coils compared to previously available technology may assist in safe initial endovascular treatment of small brain aneurysms, including ruptured brain aneurysms. We present our initial results using these coils alone to treat small IAs.
MATERIALS AND METHODS

Institutional review board approval was obtained for a nonrandomized, retrospective study of treatment of intracranial aneurysms performed at a single, high-volume, academic hospital over a 44-month period from September 2011 to May 2015. A search of inventory and a prospectively maintained clinical database was performed to identify patients who received Target® 360 Ultrasoft coils. Inclusion criteria included intracranial aneurysms less than or equal to 5.0 mm in maximal dimension, treatment with only Target® 360 Ultrasoft coils, and intention to fully treat at initial coiling. Exclusion criteria were prior index aneurysm treatment, flow diversion as initial treatment of the index aneurysm, and/or purposely staged index aneurysm treatment. Patient demographics, imaging, devices used during aneurysm embolization, immediate and follow-up angiographic results, complications, and any new documented neurological examination changes were reviewed.

Endovascular treatment

All patients had diagnostic cerebral angiograms performed in multiple angiographic projections, including three-dimensional (3D) angiography on one of two Siemens Artis Zee (Erlangen, Germany) biplane angiography units, during the initial patient workup to characterize the morphology of the target aneurysm. Tri-axial endovascular access, consisting of 80 cm, six French arterial sheaths, guide catheter, and microcatheter, were used in 33 cases, while shorter six French sheaths with a guide catheter and microcatheter were used in 17 cases. All aneurysms were treated using a single microcatheter navigated into the aneurysm sac. All aneurysms were treated until angiographic occlusion was achieved or until it was felt that no further coils could be safely inserted. Adjunctive devices were used in 21 cases, including stents (13/50) and balloons (8/50).

A simple aneurysm volume calculation was used for each aneurysm:

\[
\text{Aneurysm volume} = \frac{\pi \times \text{width} \times \text{depth} \times \text{height}}{6}
\]

The volume of the coils was calculated using the following formula:

\[
\text{Coil volume} = \pi \times (\text{radius})^2 \times (\text{length of coil})
\]

The aneurysm’s packing density was then calculated using this formula:

\[
\text{Packing density} = \frac{\text{coil volume/aneurysm volume}}{} \times 100\%
\]

Coil volume was determined using AngioCalc, LLC software online. Angiographic imaging immediately after treatment and follow-up angiographic imaging were evaluated by two interventional neuroradiologists (Gaurav Jindal and Ravi Shivashankar). Discrepancies were mitigated by consensus.

RESULTS

Between September 2011 and May 2015, 246 patients at our institution underwent brain aneurysm coiling using Target® 360 Ultrasoft coils with or without other coil types. Of these, 50 patients (41 women, nine men; mean age 57.3 years, range 35 to 87 years) met inclusion criteria. Indications for treatment included SAH from index aneurysm rupture in 23/50 cases (46%) and prior history of other brain aneurysm rupture in eight (16%) cases, family history of brain aneurysm rupture in eight cases (16%), and aneurysm morphology and/or location in 11 (22%) cases. Maximal aneurysm diameter ranged from 1.5 mm to 5.0 mm, while minimum diameter ranged from 1.1 mm to 4.5 mm. Mean aneurysm volume was 12.1 mm$^3$.

A complex coil shape was used as the initial framing coil in every case. An average of 3.1 coils were used with mean total length of 7.8 cm. Mean packing density was 40% (range 10–88%). In 39 of 50 (78%) cases, only coils less than or equal to 2.5 mm in diameter were used. In 33 of 50 (66%) cases, only coils less than or equal to 2 mm in diameter were used. In 21 of 50 (42%) cases, only coils less than or equal to 1.5 mm in diameter were used. The immediate complete aneurysm occlusion rate was 70% (35/50), near complete occlusion rate with minimal filling at the base of the aneurysms was 14% (7/50), and residual aneurysm was seen in 16% (8/50) of cases. All cases of residual aneurysm on immediate postembolization angiography had stagnant flow of contrast material within the coils loops.

Follow-up imaging was available for 40 of 50 (80%) cases, consisting of digital subtraction angiography with or without additional contrast-enhanced MR angiography in 29 cases and only contrast-enhanced MR angiography in 11 cases at a mean of 13.6 months (range 4–40 months). Twenty and 33 of 40 patients had follow up imaging at an interval of 12 months or greater and six months or greater, respectively. There was a lack of follow-up imaging at the current time in 10 cases: three cases not yet due for follow-up, three cases currently unwilling or lost to follow-up, and four cases due to death (three deaths related to SAH during initial hospitalization and one death due to myocardial infarction six months after brain aneurysm treatment). No rehemorrhage of the target aneurysm was definitively documen-
intermediate complication rate was 6% (3/50), consisting of one intraoperative aneurysm rupture and two groin hematomas. The intraoperative aneurysm rupture resulted in an anteromedial frontal lobe intraparenchymal hemorrhage during coiling of a small ruptured anterior communicating artery aneurysm. This did not result in a new neurological deficit, and the patient recovered without any significant disability. Two groin hematomas were managed conservatively without further complication. There was no perioperative procedural related clinical evidence of stroke, although routine follow-up brain imaging was not obtained postoperatively. Intraoperative parent vessel platelet aggregation was seen in three cases, all of which occurred in the setting of subarachnoid hemorrhage and all of resolved with intra-arterial infusion of abciximab. One delayed device related complication on a two-month follow-up angiogram manifested as coil migration out of an aneurysm sac and into the parent artery without resultant clinical evidence of stroke. This aneurysm had been initially treated using only a single coil. Interestingly, this aneurysm initially recurred after coil migration but later completely thrombosed; part of this coil remains in the parent vessel.

DISCUSSION

The advent in recent years of new endovascular devices such as flexible distal access catheters, low profile microcatheters, and soft complex microcoils has no doubt helped facilitate safe treatment of small brain aneurysms which previously had been considered challenging to treat [12,21,22]. We report on one such advancement in endovascular coil technology, and our initial data, although somewhat small in power, demonstrates favorable initial safety and efficacy profiles. Our aneurysm occlusion and recanalization rates are similar to those of other recent reports on the treatment of small and very small brain aneurysms [8,9,14,15,18,23–26]. Our complication rates, however, are more favorable than older reports on small brain aneurysm coil embolization and are similar to more recent reports on the topic [8–11,14–17,20,23–26].

Small brain aneurysms have posed significant therapeutic challenges during endovascular coiling. Multiple reports demonstrate an intraoperative risk of aneurysm rupture during coiling of around 10% for small lesions and a correspondingly lower risk of larger lesions [7–13,16,20,27,28] More recent reports, however, demonstrate a more favorable risk profile of coil embolization of small brain aneurysms. For example, Stetler et al and Starke et al demonstrated intraoperative risks of small brain aneurysm rupture during coiling to be only 1.2% in 2015 and 3.7% in 2013, respectively [14,15] (Table 1). Additional reports, while limited in number, also have shown good angiographic and clinical outcomes in the endovascular treatment of small brain aneurysms [13,18,23–26,29,30] In 2012, Chalouhi et al. demonstrated similar long-term outcomes between groups of very small ruptured aneurysms randomized to microsurgical repair or endovascular coiling, despite the fact that procedural complications were higher in the microsurgery group [17]. Our results also demonstrate a favorable risk profile associated with coil embolization of small brain aneurysms. We experienced one intraoperative aneurysm rupture in our series, no perioperative thromboembolic events, and no known deaths directly attributable to endovascular treatment. There were no intraoperative ruptures during treatment of previously unruptured aneurysms. Moreover, the average aneurysmal volume of 12.1 mm³ in our series corresponds to a sphere roughly less than 3 mm in diameter which is at the

<table>
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<th>Authors</th>
<th>Journal, Year</th>
<th>&lt;3 mm (n)</th>
<th>&lt;4 mm (n)</th>
<th>&lt;5 mm (n)</th>
<th>&lt;6 mm (n)</th>
<th>&gt;3, 4, or 6 mm (n)</th>
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<tbody>
<tr>
<td>Piecot et al</td>
<td>Stroke, 2008</td>
<td>3.7 % (434)</td>
<td>0.7% (304)</td>
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<td>Nguyen et al</td>
<td>J Neurosurg, 2008</td>
<td>11.7% (60)</td>
<td>2.3% (622)</td>
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<td>Van Rooij et al</td>
<td>AJNR, 2009</td>
<td>7.7% (196)</td>
<td>3.3% (1099)</td>
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<td>Brinjikji et al</td>
<td>Stroke, 2010</td>
<td>8.3% (493)</td>
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<td>Schuette et al</td>
<td>Neurosurg, 2011</td>
<td>13.5% (74)</td>
<td>2.9% (273)</td>
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<td>Mitchell et al</td>
<td>J Stroke Cerebrovas D, 2013</td>
<td>8.7% (683)</td>
<td>3.9% (683)</td>
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<td>Starke et al</td>
<td>J Neuront Surg, 2013</td>
<td>3.7% (91)</td>
<td>1.2% (85)</td>
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<td>Stetler et al</td>
<td>J Neuroint Surg, 2015</td>
<td>1.2% (85)</td>
<td>2% (50)</td>
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<tr>
<td>Current</td>
<td>Current Series</td>
<td>1.2% (85)</td>
<td>2% (50)</td>
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Aneurysm rupture at presentation serves as an independent predictor of intraoperative aneurysm rupture in endovascular series. Some authors have included both ruptured and unruptured small cerebral aneurysms in their analyses, and the intraprocedural rupture rate in the unruptured cohort is generally less compared to the ruptured cohort [8,9,16,17] (Table 2). Nearly, half of the patients in our series (23/50) presented after index aneurysm rupture, and the only case of intraoperative aneurysm rupture we experienced was during treatment of a ruptured lesion.

An additional challenge associated with small brain aneurysms is that endovascular treatment may at times need to be aborted after attempting treatment, [9,17,20] and some operators have advocated a very low threshold for microsurgical repair of these lesions if endovascular occlusion is expected to be challenging [12]. In the recent report on very small ruptured aneurysms by Chalouhi et al, 10% of cases in the endovascular group were aborted [17]. We use a multidisciplinary approach and convert from endovascular to microsurgical repair or vice versa when deemed appropriate. However, the nature of our study’s retrospective design does not allow us to comment in detail on the number of aborted endovascular cases in this series or in our practice overall, although we believe the number is very small. Notably, only one case in our series was retreated via microsurgical repair.

While recurrence and retreatment rates of previously coiled small IAs vary in previously published reports, these rates are generally similar to those of larger IAs [8,9,14,15,29] (Table 3). Van Rooij et al, however, found a higher re-treatment rate in larger IAs when compared to very small IAs [8]. Additionally, ruptured IAs at presentation have been shown to demonstrate higher rates of recurrence in comparison to unruptured IAs [15,17,31,32]. A small percentage of previously coiled small IAs have demonstrated early/immediate postembolization rehemorrhage and/or need for early/immediate retreatment via microsurgical repair or repeat coil embolization [8,9]. The recurrence and re-treatment rates in our series are similar to previously reported series of small IAs. We report re-treatment rates based only on our available follow-up population. We experienced no early rehemorrhage after embolization, one re-treatment at one month follow-up, and no cases of immediate re-treatment within the first few days after initial treatment.

LIMITATIONS

Limitations of our study include its somewhat small power and retrospective, nonrandomized design. Follow-up in our study is also somewhat limited both in number of patients and in time of follow-up. Greater experience with small intracranial aneurysms in a larger number of patients will be necessary before more definitive conclusions can be drawn and before comparisons between various coil products can be made. To this end and because we have been encouraged by our initial results, we have started a prospective, multicenter registry utilizing only Target® Ultrasoft™ coils for the treatment of small brain aneurysms with longer time of follow-up. Another limitation of our study is lack of data on the number of patients with small aneurysms whose procedures were aborted during attempted coiling, although we believe this number is small based on our experience. While our small, single-center data set demonstrates initial safe deployment of Target® Ultrasoft™ coils in small ruptured and unruptured brain aneurysms with a low risk of major complications and a high rate of occlusion on short-term follow-up imaging, treatment for small brain aneurysms should continue to be individually tailored after careful clinical assessment of the patient and the lesion.

REFERENCES


