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Safety/Efficacy of a Pusher, Thermal Detachment Coil for Ruptured Intracranial Aneurysms: A Multicenter Real-World Study

Antonio Lorenzo[1] | Joaquín Gil[2] | Jose Ignacio Gallego[3] | Alfonso González-Cruz[4] | Fernando Aparici-Robles[5] | Antoni Boscà[1] | Antonio Sagredo[3] | Marc Comas-Cufí[6] | Josep Puig[7]

[1]Interventional Radiology, Hospital General Universitario de Castellón, Valencia, Spain | [2]Radiology, Hospital Clínico Universitario de Valencia, Valencia, Spain | [3]Neuroradiology, Hospital General Universitario de Alicante Dr. Balmis, Alicante, Spain | [4]Interventional Radiology, Consorcio Hospitalario General de Valencia, Valencia, Spain | [5]Interventional Radiology, Hospital Universitario La Fe, Valencia, Spain | [6]Department of Computer Science, Applied Mathematics and Statistics, University of Girona, Girona, Spain | [7]Radiology Department CDI, Hospital Clinic of Barcelona and IDIBAPS, Barcelona, Spain

Correspondence: Antonio Lorenzo (tonilorenzogorriz@gmail.com) | Josep Puig (jpuigmd@gmail.com)

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ABSTRACT

Background and Purpose: Optima coils are a new type of embolic coils with complex and WAVE shape properties and variable degrees of softness. In patients with ruptured intracranial aneurysms, we examined the safety (periprocedural complications) and efficacy (occlusion rate immediately postprocedure) of the Optima coil.

Methods: We studied 103 consecutive patients with ruptured intracranial aneurysms who were treated exclusively with the Optima coil, without the use of accompanying implanted devices, at five centers in Spain. Endovascular techniques included stand-alone or balloon-assisted coiling. Postprocedural occlusion and periprocedural device-related adverse events were the endpoints. Aneurysm occlusion was graded according to the modified Raymond–Roy Occlusion scale.

Results: Of the 103 enrolled patients (70 female; median age 59 years), 59 (57.3%) presented with an IV Fischer Scale grade, and 61 (59.2%) of the ruptured aneurysms were wide-necked. Thirty-eight (36.9%) aneurysms were located in the anterior communicating artery. Simple-coiling and balloon-assisted coiling were performed in 36 (34.9%) and 65 (63.1%) patients, respectively. Raymond–Roy Class I, II, and III were reached in 64 (60.3%), 29 (28.1%), and ten (9.7%) following the procedure. The periprocedural device-related serious adverse event rate was 12 (13.5%), of which eight (7.7%) were due to coil protrusion. Four (3.8%) patients had intraprocedural aneurysm rupture. No early rebleeding or death was reported.

Conclusion: This analysis suggests that the Optima coil is safe and effective for treating ruptured aneurysms, with satisfactory occlusion rates and low rates of periprocedural device-related serious adverse events.

1 | Introduction

Endovascular therapy is the first treatment of choice for intracranial aneurysms, both ruptured and unruptured [1, 2]. The International Subarachnoid Aneurysm Study and the Barrow Ruptured Aneurysm Trial have established the efficacy of coil embolization in the treatment of ruptured intracranial aneurysms [2, 3]. Despite the increasing use of devices in the acute setting

of subarachnoid hemorrhage, coiling remains the most common endovascular technique in this scenario [4–9]. Aneurysm perforation during endovascular sac embolization is one of the most feared events in operator experience. In response to this situation, such as the relatively high rate of recanalization (approximately 20%) in coiled aneurysms, coil technology has advanced substantially in the development of new shapes, an extended range of sizes, and softness, such as coil-surface technology [10–15].

Since the beginning, endovascular treatment has consisted of vessel deconstruction by deploying detachable balloons. The development of detachable coils in the early 1990s enhanced endovascular treatment as the primary treatment for ruptured aneurysms. The first commercially available coil was helical, relatively stiff, and required around 45 min for detachment. Major improvements in coil design include a three-dimensional shape and wider ranges of diameters and lengths. Similarly, the development of late mechanical, electrolytic, and thermal detachment systems has allowed for controlled and instant coil release [16].

Optima coils (Balt, Montmorency, France) are novel, electrically detached, platinum coils made in two different shapes, with varying softness and a wide range of sizes, which permit operators to face a variety of aneurysm shapes and sizes, especially in cases of subarachnoid hemorrhage (SAH). Optima Coil presents a novel pusher design aimed at reaching 1-to-1 transmission of pushability from the operator's hands to the tip of the microcatheter. This pushability perfectly balances the softness of these coils to reduce the impact and high pressure against the aneurysm wall, which may cause aneurysm rupture, particularly in cases of SAH, when the aneurysm wall is highly friable. Although the impact of these coils on the rate of recanalization has not been determined, the Optima Coil System has been set up as a reliable coil for many physicians due mainly to its adaptability to the packing density, and the relationship between the short detachment zone and progressively softer body coil prevents the microcatheter kickback and enhances its stability into the aneurysm sac during embolization.

We aimed to evaluate the safety (procedural complications) and efficacy (occlusion rate immediately postprocedure) of the Optima Coil System in patients with ruptured intracranial aneurysms.

2 | Methods

2.1 | Study Setting

This was a retrospective multicenter study of consecutive patients with ruptured intracranial aneurysms treated exclusively with Optima coils during the acute event between March 2018 and June 2022. Each patient was discussed with a multidisciplinary neurovascular workgroup. At least 24 h before the procedure, patients, or family members were informed about the nature of their disease, the intended treatment, and available alternatives. All participating centers received institutional review board approval from their respective institutions, and patients signed informed consent forms. Therefore, this study has been performed by the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. A retrospective evaluation of the medical records was conducted. The following inclusion criteria were met: (1) patients with aneurysms exclusively treated with Optima coils, (2) patients without accompanying treatment (flow diverter, flow disruptor, surgery), and (3) patients without parent artery occlusion. Patients treated with stent-assisted coiling or those treated with a device other than the Optima Coil System were excluded.

2.2 | The Optima Coil System

To treat intracranial aneurysms and other neurovascular disorders, the Optima coil system consists of an implantable platinum-tungsten bare coil with instant thermal detachment using a detachment controller. With an open-loop structure and a short proximal tail, the Optima coil reduces microcatheter kickback, particularly in aneurysm coiling settings. These coils, which are available in complex and helical shapes, are offered in three distinct configurations based on their softness: standard, soft, and, ultrasoft configurations. They are available in various sizes (1–24 mm).

2.3 | Recorded Data

The following data were collected: demographic information (age and sex), Fisher Scale score, Glasgow scale score, intraparenchymal/intraventricular hemorrhage, and aneurysm characteristics (location, maximum diameter of the sac, and neck). In addition, the following endovascular treatment-related information was collected: coiling technique (stand-alone or balloon-assisted), immediate postoperative occlusion grading, and periprocedural complications (aneurysm rupture, thromboembolic events, coil protrusion, or rebleeding).

2.4 | Endovascular Treatment

At a biplane or single-plane angiosuite, procedures were performed with the patient under general anesthesia. In all patients, the femoral approach was preferred, and access was gained with or without ultrasound guidance. Following diagnostic angiography using standard projections, 3D angiography was performed to measure the aneurysm and parent vessel to obtain working projections. Subsequently, superselective microcatheterization of the aneurysm was performed, and a double-lumen balloon was placed in the parent vessel to cover the aneurysm neck. The diameter and length of the Optima Coil System were selected based on the dimensions of the aneurysm sac. The device was then detached through the microcatheter to the appropriate location to fill the entire aneurysm sac. Specific angiographic projections were selected to identify the occlusion grade when technical issues compelled the completion of the coiling or the desired outcome was achieved. Standard cranial projections were used to detect complications resulting from the procedure. Subsequently, the femoral access was closed using a specific closure device.

2.5 | Anticoagulation Protocol

After the femoral puncture, a loading dosage of 5000 UI of heparin was administered, followed by a maintenance dose of 1000 UI every hour until femoral access closure.

2.6 | Outcomes

The primary outcome was the occlusion rate immediately following the procedure. Raymond-Roy Occlusion classification is used to determine the occlusion categorization of endovascularly treated intracranial aneurysms. The grades were as follows: Grade I indicates complete obliteration. Grade II indicates that some residual neck remains after coiling. Grade IIIa indicates interstitial contrast filling of the sac, which translates to the presence of residual aneurysm still permeable following coiling, which is anticipated to progress to Grade I or II with time. Grade IIIb residual aneurysms are broader and larger than Grade IIIa aneurysms and have a greater retreatment rate. The ideal aneurysm coiling classifications are grades I and II.

2.7 | Statistical Analysis

Distribution normality was assessed using the Kolmogorov–Smirnov test. To compare baseline characteristics and procedural, safety, and clinical outcomes between the groups, we used chi-square or Fisher's exact tests for categorical variables and the Student's t-test or F-test, as appropriate, for continuous data. Statistical significance was set at $p < 0.05$. Analyses were performed using R (version 3.6.1, R Foundation for Statistical Computing, Vienna, Austria, https://www.R-project.org).

3 | Results

Optima coils were used to treat 103 patients with ruptured cerebral aneurysms between March 2018 and June 2022. Two patients treated with stent-assisted coiling were excluded from analysis to avoid selection bias. Their inclusion could improperly favor occlusion rates; conversely, stent deployment in acute subarachnoid hemorrhage is associated with higher thromboembolic and ischemic events. A total of 102 patients were included in this analysis. Table 1 outlines the cohort characteristics. There were 70 (67.96%) women, with a mean age of 59 years (range 53–65 years). A total of 59 (57.28%) patients had an IV Fisher Scale score. Most aneurysms were found in the anterior communicating artery (36.89%), the terminal internal carotid artery (19.42%), and the middle cerebral artery (15.53%). The aneurysms had a median diameter of 6.3 mm (IQR, 5–9 mm) and a wider neck in 59.22% of the cases. Simple and balloon-assisted coiling were performed in 36 (34.95%) and 65 (63.11%) patients, respectively.

3.1 | Postprocedural Occlusion and Endovascular Technique

Raymond–Roy (RR) class I, II, and IIIa/IIIb were achieved in 64 (60.37%) patients, 29 (28.15%) patients, and 10 (9.70%) patients,

TABLE 1 | Main characteristics.

	Whole cohort (n = 103)
Age [years], median (IQR)	59 (53;65)
Female, n (%)	70 (67.96)
Fisher Scale, n (%)	
Grade 0	1 (0.97)
Grade I	2 (1.94)
Grade II	22 (21.36)
Grade III	19 (18.45)
Grade IV	59 (57.28)
Glasgow score, median (IQR)	15 (11;15)
Additional hemorrhage, n (%)	
Absent	42 (40.78)
Intraparenchymal hemorrhage	8 (7.77)
Intraventricular hemorrhage	27 (26.21)
Intraventricular hemorrhage with hydrocephalus	20 (19.42)
Intraparenchymal and intraventricular hemorrhage	6 (5.82)
Localization, n (%)	
Anterior cerebral artery	4 (3.88)
Middle cerebral artery	16 (15.53)
Anterior communicating artery	38 (36.89)
Posterior communicating artery	12 (11.65)
Posterior cerebral artery	1 (0.97)
Basilar artery	2 (1.94)
Posteroinferior cerebellous artery	2 (1.94)
Cavernous segment of ICA	1 (0.97)
Clinoid segment of ICA	3 (2.91)
Ophthalmic segment of ICA	4 (3.88)
Terminal segment of ICA	20 (19.42)
Aneurysm diameter [millimeters], median (IQR)	6.3 (5;9)
Wide neck, n (%)	61 (59.22)
Coiling technique, n (%)	
Stand-alone	36 (34.95)
Balloon-assisted	65 (63.11)
Procedural-related complications, n (%)	12 (13.56)
Absent	87 (86.44)
Aneurysm rupture	4 (3.88)
Coil protrusion	8 (7.77)
Thromboembolic event	2 (1.94)
Early rebleeding	0 (0)

Abbreviations: ICA, internal carotid artery; IQR, interquartile range; n, number of participants.

TABLE 2 | Analysis according to endovascular technique.

	Balloon-assisted coiling (n = 65)	Coiling alone (n = 36)	*p*-value
Age [years], median (IQR)	58.5 (52;64.75)	60.5 (55;67.25)	0.399
Female, n (%)	45 (68.2)	25 (69.4)	0.895
Fisher Scale, n (%)			0.054
Grade 0	0	1 (2.8)	
Grade I	2 (3)	0	
Grade II	18 (27.3)	3 (8.3)	
Grade III	12 (18.2)	7 (19.4)	
Grade IV	34 (51.5)	25 (69.4)	
Glasgow score, median (IQR)	15 (10;15)	15 (13;15)	0.322
Additional hemorrhage, n (%)			0.249
Absent	31 (47)	10 (27.8)	
Intraparenchymal hemorrhage	5 (7.6)	3 (8.3)	
Intraventricular hemorrhage	16 (24.2)	12 (33.3)	
Intraventricular hemorrhage with hydrocephalus	9 (13.6)	10 (27.8)	
Intraparenchymal and intraventricular hemorrhage	4 (6.1)	1 (2.8)	
Localization, n (%)			
Anterior cerebral artery	1 (1.5)	3 (8.3)	0.2
Middle cerebral artery	15 (22.7)	1 (2.8)	0.009
Anterior communicating artery	23 (34.8)	15 (41.7)	0.6
Posterior communicating artery	4 (6.1)	8 (22.2)	0.019
Posterior cerebral artery	0	1 (2.8)	0.4
Basilar artery	2 (3)	0	>0.9
Posteroinferior cerebellous artery	0	2 (5.6)	0.14
Cavernous segment of ICA	1 (1.5)	0	>0.9
Clinoid segment of ICA	2 (3)	1 (2.8)	>0.9
Ophthalmic segment of ICA	3 (4.5)	1 (2.8)	>0.9
Terminal segment of ICA	15 (22.7)	4 (11.1)	0.12
Aneurysm diameter [millimeters], median (IQR)	7 (5.55;9)	5.6 (4;8.77)	0.431
Wide neck, n (%)	47 (71.2)	14 (38.9)	0.001
Modified RRO			0.700
RRO class I	39 (60)	23 (63.9)	
RRO class II/IIIa/IIIb	26 (40)	13 (36.1)	
Procedural-related complications, n (%)	10 (15.2)	6 (16.7)	0.840
Aneurysm rupture	4 (6.1)	0	
Coil protrusion	3 (4.5)	5 (13.9)	
Thromboembolic event	2 (3)	0	
Early rebleeding	0	0	

Abbreviations: ICA, internal carotid artery; IQR, interquartile range; n, number of participants; RRO, modified Raymond–Roy Occlusion scale.

respectively (Table 2). All aneurysms with angiographic results of RR = IIA/IIIb had a wide neck. The majority of MCA and TICA aneurysms are treated using balloon-assisted coiling (Figure 1). In contrast, aneurysms presenting a wide neck were treated more frequently with balloon-assisted coiling than with coiling alone [47 (71.2%) vs. 14 (38.9%) patients; $p = 0.001$]. While almost every MCA aneurysm was embolized using balloon-assisted coiling (15/16), simple coiling was used in eight of the 12 terminal segment aneurysms (Table 2). The grade of occlusion rate was not associated with coiling approaches but was associated with

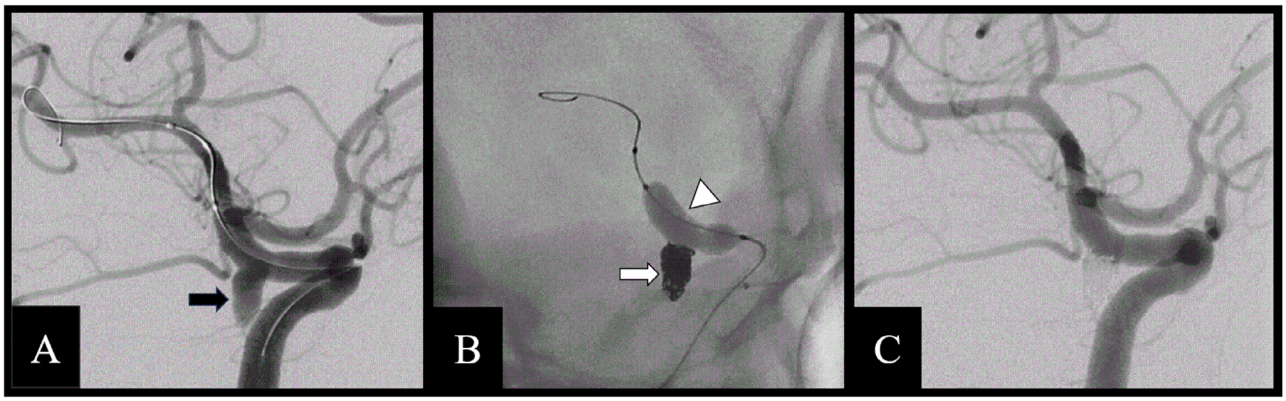

FIGURE 1 | (A) Oblique internal carotid artery angiography showing a wide-neck sacciform aneurysm (black arrow), depending on the terminal segment, (B) Plain radiography showing packing of the aneurysm (white arrow) with Optima coils and an inflated balloon in the parental artery (white arrowhead), and (C) Oblique digital subtraction angiography image showing complete aneurysm occlusion.

the occurrence of procedure-related complications (Table 3). Terminal segment aneurysm embolization had lower complete occlusion rates (5/20; 25%) (Table 3).

3.2 | Periprocedural Device-Related Adverse Events and Fisher Scale

The procedural device-related adverse event rate was 12 (13.56%). Four (3.88%) patients experienced intraprocedural aneurysm perforation and were treated with balloon-assisted coiling, with no further clinical repercussions (Table 3). There were eight cases of coil protrusion, one of which developed carotid bifurcation occlusion and subsequently died. Two cases of thromboembolic events caused moderate-to-severe deficits in the patients. No rebleeding occurred after the procedure (Table 1). Fisher grade did not show a relationship with aneurysm location, occlusion rates, or treatment-related complications (Table 4).

4 | Discussion

In this retrospective multicenter cohort of patients, we found that the Optima coil is safe and effective for the treatment of ruptured intracranial aneurysms, with satisfactory occlusion rates and low device-related serious adverse events. This is congruent with the findings of other coil series studies [1, 2, 17, 18]. In terms of efficacy, the results were comparable to or superior to those published in large randomized studies comparing different types of coils. In the Cerecyte Coil Trial [12], the rates of postoperative complete aneurysm occlusion, neck remnants, and aneurysm remnants were 25.5%, 50.2%, and 11.7%, respectively. However, in the current study, these rates were 60.37%, 28.15%, and 9.70%, respectively. In a recent study by Guerreiro-Simoes et al. [18], Barricade coils (Blockade/Balt, Montmorency, France) were studied for safety and efficacy in the treatment of intracranial aneurysms. These are electrically detached platinum coils of various shapes, softness, and sizes. They reported rates of 83.0, 11.3, and 5.7%, respectively. The Matrix and Platinum Science trial [14] demonstrated postoperative complete aneurysm occlusion in 35.6%, neck remnant in 27.7%, and aneurysm remnant in 37.2% of the bare coil group, as well as the German-French Randomized Endovascular Aneurysm Trial [19], which demonstrated postoperative complete aneurysm occlusion in 52%, neck remnant in 23%, and aneurysm remnant in 24% of the bare coil group.

When comparing occlusion rates to aneurysm localization, we found lower complete occlusion outcomes (RRO I) in terminal segment aneurysms. This may relate to the most used technique in this location, simple coiling, which may contrast with higher occlusion rates obtained with balloon-assisted coiling. Balloon-assisted coiling was predominant in ruptured MCA aneurysms, possibly due to a higher incidence of wide-neck aneurysms in this location. Conversely, simple coiling was mostly used for terminal segment aneurysms, which are usually narrow-neck. Regarding the Fisher scale, grade IV was associated with lower consciousness levels, which literature attributes to intraventricular and/or intraparenchymal hemorrhage [20].

Our sample had 12 periprocedural complications (13.56%). In addition to aneurysm perforation, thromboembolic complications, and rebleeding, coil protrusion was included as a complication because it was not anticipated to be part of the predicted outcome even though it had scarce clinical significance. None of these patients required additional medical therapy. When only aneurysm rupture and thromboembolic events were included as complications, the overall rate of complications was 5.82%, which is modest compared to the 13.5% reported in the ARETA study [21], which included both ruptured and unruptured aneurysms.

Four (3.88%) intraprocedural aneurysm perforations were found in our series, which is comparable to other similar series of ruptured aneurysms reported in the literature (1.44%,[22] 7.0%,[23] 3.61%,[24] 2.5%,[25] and 7.5%[26]). In the CLARITY Study [27], a prospective multicenter study involving 782 patients with ruptured aneurysms revealed an intraprocedural aneurysm perforation rate of 4.34%. This type of complication may be attributable to the softness of the device. Compared with Wang et al. [22] (7.94%), Dinç et al. [25] (9.4%), and the aforementioned CLARITY study [27] (12.53%), thromboembolic events occurred in our sample at a rate of 1.94%. This considerable discrepancy may be attributed to the lack of a stent-assisted coiling approach in our cohort. Nevertheless, the use of this technique in cited studies remains limited. Although coil protrusion is not typically

TABLE 3 | Analysis according to occlusion rate immediately post-procedure.

	Complete occlusion (RRO class I) (n = 64)	Subtotal occlusion (RRO class II) (n = 29)	Incomplete occlusion (RRO class IIIa/IIIb) (n = 10)	*p*-value
Age [years], median (IQR)	59.5 (52;65.75)	58 (54;63)	63 (55.5;70.75)	0.548
Female, n (%)	42 (65.6)	22 (75.9)	6 (60)	0.528
Fisher Scale, n (%)				0.905
Grade 0	1 (1.6)	0	0	
Grade I	1 (1.6)	1 (3.4)	0	
Grade II	12 (18.8)	8 (27.6)	2 (20)	
Grade III	11 (17.2)	6 (20.7)	2 (20)	
Grade IV	39 (60.9)	14 (48.3)	6 (60)	
Glasgow score, median (IQR)	15 (12.75;15)	14 (11;15)	15 (12.5;15)	0.644
Additional hemorrhage, n (%)				0.780
Absent	23 (35.9)	15 (51.7)	4 (40)	
Intraparenchymal hemorrhage	5 (7.8)	2 (6.9)	1 (10)	
Intraventricular hemorrhage	19 (29.7)	4 (13.8)	4 (40)	
Intraventricular hemorrhage with hydrocephalus	13 (20.3)	6 (20.7)	1 (10)	
Intraparenchymal and intraventricular hemorrhage	4 (6.25)	2 (6.9)	0	
Localization, n (%)				
Anterior cerebral artery	1 (1.6)	3 (10)	0	0.2
Middle cerebral artery	11 (17)	4 (14)	1 (11)	>0.9
Anterior communicating artery	29 (45)	7 (24)	2 (22)	0.2
Posterior communicating artery	9 (14)	2 (6.9)	1 (11)	0.5
Posterior cerebral artery	1 (1.6)	0	0	>0.9
Basilar artery	1 (1.6)	1 (3.4)	0	0.6
Posteroinferior cerebellous artery	2 (3.1)	0	0	>0.9
Cavernous segment of ICA	0	0	1 (11)	0.09
Clinoid segment of ICA	2 (3.1)	1 (3.4)	0	>0.9
Ophthalmic segment of ICA	3 (4.7)	1 (3.4)	0	>0.9
Terminal segment of ICA	5 (7.8)	10 (34)	5 (56)	<0.001
Aneurysm diameter [mm], median (IQR)	6 (4.57;8.7)	7 (5.5;8.7)	7.35 (5.82;9)	0.573
Wide neck, n (%)	32 (50)	19 (65.5)	10 (100)	0.004
Coiling technique, n (%)				0.555
Stand-alone	23 (35.9)	8 (27.6)	5 (50)	
Balloon-assisted	39 (60.9)	21 (72.4)	5 (50)	
Procedural-related complications, n (%)				0.562
Absent	56 (87.4)	25 (86.2)	8 (80)	
Aneurysm rupture	1 (1.6)	3 (10.3)	0	
Coil protrusion	5 (7.8)	1 (3.4)	2 (20)	
Thromboembolic event	2 (3.12)	0	0	
Early rebleeding	0	0	0	

Abbreviations: ICA, internal carotid artery; IQR, interquartile range; n, number of participants; RRO, modified Raymond–Roy Occlusion scale; mm, millimeters.

TABLE 4 | Fisher scale score comparison.

	Grade II (n = 22)	Grade III (n = 19)	Grade IV (n = 59)	*p*-value
Age [years], median (IQR)	58 (52;60)	54 (50;65)	61 (55;71)	0.057
Female, n (%)	15 (68)	13 (68)	41 (68)	>0.9
Glasgow score, median (IQR)	15 (15;15)	15 (13;15)	14 (9;15)	0.002
Localization, n (%)				0.9
Anterior cerebral artery	0	1 (5.3)	3 (5.0)	
Middle cerebral artery	3 (14)	3 (16)	10 (17)	
Anterior communicating artery	10 (45)	7 (37)	21 (35)	
Posterior communicating artery	2 (9.1)	3 (16)	7 (12)	
Basilar artery	0	0	2 (3.3)	
Posteroinferior cerebellous artery	0	0	2 (3.3)	
Cavernous segment of ICA	1 (4.5)	0	0	
Clinoid segment of ICA	0	1 (5.3)	2 (3.3)	
Ophthalmic segment of ICA	0	2 (11)	2 (3.3)	
Terminal segment of ICA	6 (27)	2 (11)	11 (18)	
Aneurysm diameter [millimiters], median (IQR)	6 (4.8, 7.6)	6.2 (5, 10)	6.85 (4.8, 9)	0.8
Wide neck, n (%)	10 (45)	14 (74)	37 (62)	0.2
Coiling technique, n (%)				0.555
Stand-alone	4 (18.5)	7 (37)	25 (43.3)	
Balloon-assisted	18 (81.5)	12 (63)	34 (56.7)	
Modified RRO				0.5
RRO class I	12 (55)	11 (58)	39 (66)	
RRO class II	8 (36)	6 (32)	14 (24)	
RRO class IIIa/IIIb	2 (9)	2 (11)	5 (8.5)	
Procedural-related complications, n (%)				0.8
Absent	17 (77)	18 (95)	50 (83)	
Aneurysm rupture	2 (9.1)	0	2 (3.3)	
Coil protrusion	2 (9.1)	1 (5.3)	5 (8.3)	
Thromboembolic event	0	1 (5.3)	1 (1.7)	
Early rebleeding	0	0	0	

Abbreviations: ICA, internal carotid artery; IQR, interquartile range; n, number of participants; RRO, modified Raymond–Roy Occlusion scale.

reported as a complication, Wang et al. [22] reported a coil protrusion rate of 6.13%, similar to the 7.76% rate described in our cohort. In our study, no rebleeding occurred after the endovascular embolization. By contrast, Wang et al. [22] (1.44%) and Kim et al. [28] (2.3%) or Dinç et al. [25] (2.5%) showed low but real rebleeding rates.

The Optima Coil System may be advisable to be present on daily armamentarium because of the high availability of sizes and softness and its usefulness in cases when simple coiling is preferable and there is a need to keep the microcatheter tip stabilized into the aneurysm sac during coil deployment. At the same time as our study development, there is an ongoing single-center prospective investigator-initiated study called APPLY. This single-center study aimed to evaluate the safety and efficacy of the Optima Coils System and may provide additional clinical data and follow-up in cases of embolized aneurysms with Optima coils [29]. This device can be MRI-scanned safely [30].

Several limitations of this study merit discussion. We examined the immediate anatomical results, but not the long-term outcomes. The sample size was modest, and the study design was retrospective. Assessment of the angiographic result may also be subject to operator bias, as there is subjectivity in the conception of residual neck and in the interstitial filling of the aneurysmal sac, which could contribute to revealing the differences in the degrees of occlusion reported in the current literature. Two patients who were treated with stent-assisted coiling were excluded because the number of cases was not representative. However, in cases of subarachnoid hemorrhage, this technique

is associated with a higher rate of complications, particularly thromboembolic events. Nonetheless, these two excluded cases lacked these complications.

In conclusion, according to the results of this multicenter study, the Optima coil is safe and effective for treating ruptured aneurysms, demonstrating satisfactory occlusion rates and low rates of periprocedural device-related complications. A larger study is required to confirm the outcomes of this coil.

Acknowledgments

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

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