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EXPERIMENTAL RESEARCH - VASCULAR

Endovascular coil embolization of unruptured intracranial aneurysms: a Korean multicenter study

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Abstract
Background and objective Endovascular coil embolization has been a major treatment modality for unruptured intracranial aneurysms (UIAs) in South Korea. However, there are still few reports on the outcomes of this procedure. We performed a retrospective, multicenter study to determine how safe and effective coiling for UIA has been over the most recent 3 years in South Korea.
Materials and methods We analyzed a total of 2,180 UIAs in 2,035 patients who were treated by coiling from January 2007 to December 2009 at 22 centers in South Korea, with a focus on patient characteristics, the location and size of the aneurysms, procedural complications, and angiographic and clinical outcomes.
Results Coiling was successful in 98.0 % of the cases (2,137/2,180 aneurysms). Immediate post-procedural angiography demonstrated complete occlusion in 62.6 % (1,337/2,137 aneurysms), residual neck in 32.4 % (692/2,137), and residual sac in 5.0 % (108/2,137) of the cases. The rate of any procedure-related adverse event was 6.9 % (148/2,137 aneurysms). The rates of permanent morbidity and mortality were 1.8 % (39/2,137 aneurysms) and 0.1 % (2/2,137 aneurysms), respectively. Follow-up conventional angiography or MRA at ≥6 months was performed in 85.7 % (1,832/2,137 aneurysms) of cases. Among the eligible aneurysms for follow-up angiographic analysis, major recanalization was noted in 3.9 % (72/1,832 aneurysms, mean follow-up interval, 12 months). Among these, 68 aneurysms (3.7 %) were re-treated. An aneurysm of the middle cerebral artery (MCA) was a risk factor for incomplete occlusion (P=0.049) and major recanalization (P=0.046). During follow-up, no aneurysmal rupture occurred.
Conclusions Endovascular coil embolization of UIAs has been an effective preventive modality with low procedure-related morbidity in South Korea.

Keywords Coiling · Unruptured intracranial aneurysms · South Korea · Multicenter study

Introduction

In South Korea, coil embolization as a treatment of cerebral aneurysms began in 1996 with the introduction of the Guglielmi detachable coil. Since then, the number of aneurysm coiling procedures has rapidly grown. According to the data from the national database of health claims maintained by the Korean Health Insurance Review and Assessment Service (HIRA), at present, approximately 5,000 ruptured and unruptured cerebral aneurysms are treated annually with endovascular coil embolization at approximately 80 centers, performed by approximately 100 neuro-interventionlists. Approximately 45 % of these aneurysms are unruptured aneurysms.

To determine the safety and efficacy of aneurysm coiling, we conducted a retrospective analysis on unruptured intracranial aneurysms (UIA) managed by endovascular coiling in 22 South Korean endovascular centers throughout the country.

Materials and methods

The participating 22 centers were facilities at which at least 50 coil embolizations of cerebral aneurysms per year were

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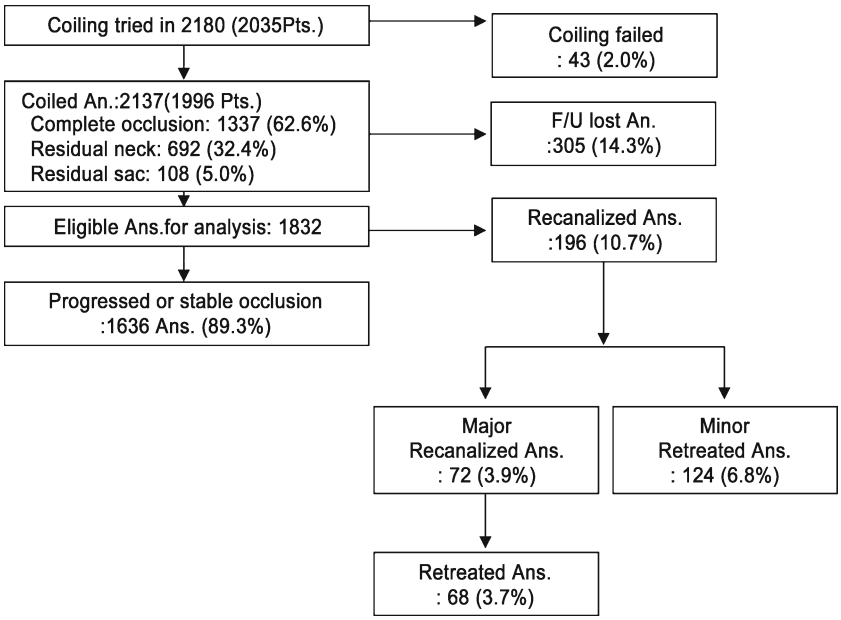

Fig. 1 Algorithm of enrolled aneurysms

performed over 3 years (2007–2009). These institutes are located throughout all the provinces of the country. The study protocol was approved by the institutional review board (IRB) or local ethics committee of each hospital. All consecutive saccular UIAs managed by endovascular coiling between January 2007 and December 2009 were included from each center. Dissecting, fusiform, infectious, or traumatic aneurysms were excluded. Overall, 2,180 intracranial aneurysms in 2,035 patients were reviewed.

Patient demographics, aneurysm characteristics, modalities of endovascular coiling, and angiographic and clinical outcomes were anonymously collected from the medical records and images by one trained researcher who was not involved in the treatment. Data management and statistical analysis were independently conducted by the principal investigators (Kwon SC, Kwon OK).

The treatment indication and selection of endovascular technical modalities were decided at the discretion of the individual physicians of each center.

Any undesirable events and abnormal neuro-angiographic findings related to the procedures were reported, regardless of the symptom development. Clinical neurologic conditions were evaluated according to a modified Rankin Scale (mRS) at discharge and the follow-up visit, based on the medical records [13]. Permanent morbidity was defined as a change in the mRS score associated with the coiling procedure.

The angiographic results including preoperative, immediate post-procedure, and follow-up (conventional angiography, or MRA at ≥6 months) outcomes were collected. The angiographic results were classified using the Raymond classification scale: complete occlusion, residual neck, and residual aneurysm [15].

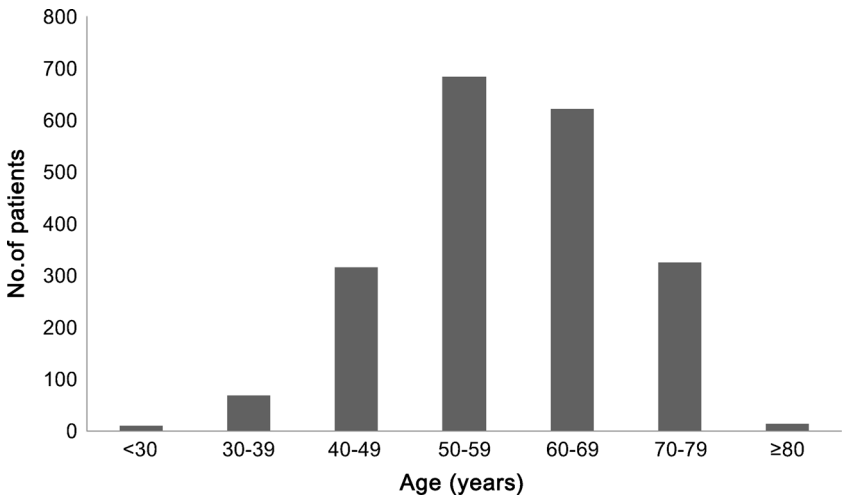

Fig. 2 The age distribution of 2,035 patients

The follow-up angiographic results were classified as 'progressed to occlusion', 'stable', and 'recanalized'. And, recanalization was re-classified into major and minor. Major recanalization was defined as more contrast filling within the aneurysm dome or significant coil compaction compared to an immediate post-procedure angiographic outcome for which the corresponding physician considered retreatment. Minor recanalization was defined as minimal coil compaction at the aneurysmal neck.

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS version 19.0, SPSS Inc., Chicago, IL, USA). Ordinal logistic regression models and simple logistic regression models were used to calculate the odds ratio (OR), corresponding 95 % confidence interval (CI), and p-values. The significance level was set to 0.05.

Results

Patient population, aneurysm characteristics, and modalities of treatment

Among the 2,035 patients, 1,435 (70.5 %) were female. The patient ages ranged from 16 to 90 years (mean: 58.6 years± 10.46). The majority (1,618/2,035, 79.5 %) were between the fourth and sixth decades of age (Figs. 1 and 2). The prevalence of hypertension and diabetes was 39.3 % and 8.3 %, respectively. The demographics of the patients are presented in Table 1.

Among 2,180 aneurysms, there were 1,954 anterior circulation aneurysms (89.7 %) and 226 posterior circulation aneurysms (10.3 %). The ICA (1,320 aneurysms, 60.6 %), especially the paraclinoid ICA (662 aneurysms, 30.4 %), and anterior communicating arteries (337 aneurysms, 15.5 %) were frequent sites. The aneurysm size was 5 mm or smaller in 1,163 aneurysms (1,163/2,180, 53.3 %), 5–10 mm in 784 aneurysms (36.0 %), 10–15 mm in 149 aneurysms (6.8 %), and larger than 15 mm in 84 aneurysms (3.9 %). Coiling failed in 43 aneurysms (2.0 %). The remaining 2,137 aneurysms (98.0 %) were successfully treated. Among 133 patients with multiple UIAs, two aneurysms were coiled during one session in 122 patients, three aneurysms in 10 patients, and four aneurysms in one patient.

Preoperative antiplatelet medication was administered in 1,842 patients (1,842/2,035, 90.5 %). No adverse events related to the preoperative antiplatelet medication were noted. A majority of the aneurysms were coiled under general anesthesia (1,933/2,137, 90.5 %). In terms of the coiling techniques, catheter-based coiling (single microcatheter technique for 982 aneurysms, multiple microcatheter technique for 386 aneurysms) was performed in 1,368 aneurysms (1,368/2,137, 64.0 %). The balloon remodeling technique was used in 312 aneurysms (14.6 %), stent-assisted coil embolization in 354 aneurysms (16.6 %), internal parent artery trapping in four aneurysms (0.2 %), and combined techniques, such as the balloon-in stent technique and multiple catheters with stenting or ballooning, in 99 aneurysms (4.6 %).

Table 1 Baseline demographic data

Characteristics	Value
No. of An.	2,180
No. of pt.	2,035
Sex	
Male	600 (29.5 %)
Female	1,435 (70.5 %)
Age	16–90 (Mean 58.6±10.46)
HTN	800/2035 (39.3 %)
DM	168/2035 (8.3 %)
Multiple An.	133/2035 (6.5 %)
Pre-procedural antiplatelet agent preparation	1,842/2035 (90.5 %)
Location of An. (*N*=2,180)	
ICA	1,320 (60.6 %)
Paraclinoid	662 (30.4 %)
PCoA	304 (13.9 %)
Others	354 (16.2 %)
ACA	403 (18.5 %)
AcoA	337 (15.5 %)
Others	66 (3.0 %)
MCA	231 (10.6 %)
VB	226 (10.4 %)
Size of An. (*N*=2,180)	
An ≤ 5	1,163 (53.3 %)
5 < An ≤ 10	784 (36.0 %)
10 < An ≤ 15	149 (6.8 %)
15 < An	84 (3.9 %)
Anesthesia (*N*=2,137)	
G.A.	1,933 (90.5 %)
L.A.	204 (9.5 %)
Modalities of embolization (*N*=2,137)	
Catheter-based	1,368 (64.0 %)
Balloon-assisted	312 (14.6 %)
Stent-assisted	354 (16.6 %)
Internal trapping	4 (0.2 %)
Combined technique	99 (4.6 %)

No. number; *An*. aneurysm; *pt*. patient; *HTN* hypertension; *DM* diabetes mellitus; *ICA* internal carotid artery; *PCoA* posterior communicating artery; *ACA* anterior cerebral artery; *ACoA* anterior communicating artery; *MCA* middle cerebral artery; *VB* vertebrobasilar; *G.A.* general anesthesia; *L.A.* local anesthesia

Table 2 Statistical analysis between angiographic results and related factors (Total N: 2,137 Ans.)

Factor	Value	Complete	Near complete	Partial	OR	95 % CI	p-value
Age	≤65	974 (72.85 %)	456 (65.9 %)	85 (78.7 %)	Ref.		
	>65	363 (27.15 %)	236 (34.1 %)	23 (21.3 %)	1.221	1.011–1.474	0.038
Multiplicity	Single	1,192 (89.15 %)	576 (83.24 %)	89 (82.41 %)	Ref.		
	Multiple	145 (10.85 %)	116 (16.76 %)	19 (17.59 %)	1.642	1.283–2.102	<0.001
Anesthesia	L.A.	125 (9.35 %)	70 (10.12 %)	6 (5.56 %)	Ref.		
	G.A.	1,212 (90.65 %)	622 (89.88 %)	102 (94.44 %)	1.019	0.757–1.371	0.901
Location	ICA	827 (61.85 %)	401 (57.95 %)	71 (65.74 %)	Ref.		
	ACA	255 (19.07 %)	126 (18.21 %)	13 (12.04 %)	0.927	0.734–1.171	0.526
	MCA	126 (9.42 %)	88 (12.72 %)	11 (10.19 %)	1.326	1.001–7.757	0.049
	VB	129 (9.65 %)	77 (11.13 %)	13 (12.04 %)	1.212	0.910–1.616	0.189
Size	An ≤ 5	729 (54.53 %)	363 (52.46 %)	48 (44.44 %)	Ref.		
	5 < An ≤ 10	473 (35.38 %)	238 (34.39 %)	41 (37.96 %)	1.063	0.880–1.284	0.526
	10 < An ≤ 15	84 (6.28 %)	56 (8.09 %)	8 (7.41 %)	1.342	0.954–1.887	0.091
	15 < An	51 (3.81 %)	35 (5.06 %)	11 (10.19 %)	1.736	1.159–2.601	0.007
Modalities of embolization	Cather-based	859 (64.25 %)	457 (66.04 %)	52 (48.15 %)	Ref.		
	Balloon-assisted	198 (14.81 %)	95 (13.73 %)	19 (17.59 %)	1.009	0.784–1.297	0.946
	Stent-assisted	219 (16.38 %)	105 (15.17 %)	30 (27.78 %)	1.117	0.882–1.415	0.358
	Internal trapping	4 (0.3 %)	0 (0 %)	0 (0 %)	Not Available		
	Complex technique	57 (4.26 %)	35 (5.06 %)	7 (6.48 %)	1.287	0.858–1.930	0.223
D/N	D/N < 1.5	575 (43.01 %)	321 (46.39 %)	52 (48.15 %)	Ref.		
	D/N ≥ 1.5	762 (56.99 %)	371 (53.61 %)	56 (51.85 %)	0.863	0.725–1.027	0.096

OR odds ratio; *CI* confidence intervals; *L.A.* local anesthesia; *G.A.* general anesthesia, *ICA* internal carotid artery; *ACA* anterior cerebral artery; *MCA* middle cerebral artery; *VB* vertebrobasilar; *An.* aneurysm; *Tx.* treatment; *D* dome; *N* neck P-values were computed by ordinal logistic regression analysis

Immediate angiographic outcomes

Complete occlusion was achieved in 1,337 aneurysms (62.6 %), neck remnant (near-complete occlusion) in 692 aneurysms (32.4 %), and aneurysm remnant (partial occlusion) in 108 aneurysms (5.0 %).

The analysis of factors affecting the postoperative angiographic results revealed that age (>65), multiplicity of aneurysms, MCA location, and large size (>15 mm) were related to partial occlusion with a significant difference (Table 2).

Procedural adverse events

Among the 2,137 coiled aneurysms, any procedure-related adverse event was noted in 148 aneurysms (148/2,137, 6.9 %). There were 42 thromboembolic events (42/2,137, 2.0 %), 20 procedural aneurysm ruptures (20/2,137, 0.9 %), 65 coil protrusions or prolapses into the parent vessel (65/2,137, 3.0 %), 11 device-related events (11/2,137, 0.5 %) including unraveling or unintentional detachment of the coil, and 10 femoral access complications (10/2,137, 0.5 %). Most of the events were asymptomatic. From these adverse events, permanent neurologic deficits were noted in 39 patients (39/2,137, 1.8 %). Two patients died due to procedural rupture (2/2,137, 0.1 %).

The occurrence of symptomatic complications was related to the history of diabetes mellitus (P=0.036), and the combined coiling technique (P=0.004) (Table 3).

During the follow-up period, no aneurysmal ruptures were noted.

Follow-up angiographic results

Radiologic follow-up studies (conventional catheter angiography, or MRA) at ≥6 months after coiling were available in 1,832 aneurysms (1,832/2,137, 85.7 %). The mean interval of the follow-up imaging studies was 12 months (12.27± 3.9 months). In terms of the follow-up studies, conventional catheter angiography was performed for 369 aneurysms (369,/2137, 17.3 %), and MRA was performed for 1,463 aneurysms (1,463/2,137, 68.4 %).

The follow-up studies showed progressed occlusion or stable occlusions in 1,636 aneurysms (1,636/1,832, 89.3 %). The recanalizations were noted in 196 aneurysms (10.7 %), minor recanalization in 124 aneurysms (124/1,832, 6.8 %), and major recanalization in 72 aneurysms (72/1,832, 3.9 %). Among these, retreatment was performed in 68 aneurysms by further coiling (68/1,832, 3.7 %). The simple logistic regression analysis revealed that young age (≤65), MCA and VB location, large aneurysms (>10 mm), and initial angiographic

Table 3 Statistical analysis between persistent morbidity and related factors (Total N: 2,137 Ans.)

Factor	Value	Neurologic complications		OR	95 % CI	p-value[a]
		No	Yes			
Age	≤ 65	1,487 (70.88 %)	28 (71.79 %)	Ref.		
	> 65	611 (29.12 %)	11 (28.21 %)	0.956	0.473~1.933	0.901
DM	No	1,925 (91.75 %)	32 (82.05 %)	Ref.		
	Yes	173 (8.25 %)	7 (17.95 %)	2.434	1.059~5.596	0.036
HTN	No	1,260 (60.06 %)	20 (51.28 %)	Ref.		
	Yes	838 (39.94 %)	19 (48.72 %)	1.428	0.758~2.693	0.270
Multiplicity	No	1,829 (87.18 %)	35 (89.74 %)	Ref.		
	Yes	269 (12.82 %)	4 (10.26 %)	1.287	0.454~3.650	0.635
Anti-platelet	No	202 (9.63 %)	2 (5.13 %)	Ref.		
	Yes	1,896 (90.37 %)	37 (94.87 %)	0.507	0.121~2.121	0.352
Anesthesia	L.A.	200 (9.53 %)	1 (2.56 %)	Ref.		
	G.A.	1,898 (90.47 %)	38 (97.44 %)	0.250	0.034~1.829	0.172
Size	An. ≤ 5	1,122 (53.48 %)	18 (46.15 %)	Ref.		
	5 < An. ≤ 10	737 (35.13 %)	15 (38.46 %)	0.503	0.145~1.737	0.277
	10 < An. ≤ 15	145 (6.91 %)	3 (7.69 %)	0.638	0.181~2.244	0.483
	15 < An.	94 (4.48 %)	3 (7.69 %)	0.648	0.128~3.280	0.600
Location	ICA	1,276 (60.82 %)	23 (58.97 %)	Ref.		
	ACA	390 (18.59 %)	4 (10.26 %)	0.569	0.196–1.655	0.301
	MCA	220 (10.49 %)	5 (12.82 %)	1.261	0.474–3.352	0.642
	VB	212 (10.1 %)	7 (17.95 %)	1.832	0.776–4.322	0.167
Modalities of embolization	Catheter-based	1,346 (64.16 %)	22 (56.41 %)	Ref.		
	Balloon-assisted	308 (14.68 %)	4 (10.26 %)	0.795	0.272–2.322	0.674
	Stent-assisted	347 (16.54 %)	7 (17.95 %)	1.234	0.523–2.913	0.631
	Internal trapping	4 (0.19 %)	0 (0 %)	Not available		
	Combined technique	93 (4.43)	6 (15.38)	3.947	1.562–9.973	0.004

[a] P-values were computed by simple logistic regression analysis

incomplete occlusion were significant risk factors related to aneurysmal recanalization (Table 4).

Discussion

Since being introduced in 1996, endovascular coiling has been an important treatment modality for cerebral aneurysms in South Korea. According to the national health-claim database managed by the Korean Unruptured Cerebral Aneurysm Coiling (KUCAC), in 2007, a total of 8,175 cerebral aneurysms were treated with either surgical clipping or endovascular coiling in South Korea. Among them, 3,050 aneurysms (39 %) were managed by endovascular coil embolization. The number of patients treated by coiling increased to 3,583 (41 % of all treated aneurysms) in 2008 and to 4,176 aneurysms (43 %) in 2009. At more than 80 centers throughout the country, approximately 100 neuro-interventionalists (neurosurgeons, neuroradiologists, and neurologists) are actively performing neuro-endovascular procedures. The Korean National Medical Insurance System covers approximately 90 % of the coiling fee. With increasing numbers of patients, the necessity for community-based outcome review has been raised to determine the safety and efficacy of this procedure.

In this study, we hoped to determine the safety and outcomes of the aneurysm coiling procedure itself. Therefore, we only included UIAs. During the target period (from 2007 to 2009), a total of 10,809 aneurysms were coiled at approximately 80 centers in South Korea. Among them, approximately 4,860 aneurysms were unruptured (data from the HIRA). In this study, 2,180 UIAs were included, accounting for 45 % of the coiled UIAs in South Korea during this period.

Our data showed that institutes in South Korea use similar preparations and techniques for endovascular coiling. Most procedures were performed under general anesthesia. Antiplatelet preparation was given for more than 90 % of the patients. The coiling techniques were also approximately the same. More than 85 % of the patients were regularly followed by imaging studies. Complete occlusion was achieved in 1,337 aneurysms (62.6 %), neck remnant (near complete

Table 4 Statistical analysis between recanalization and related factors (Total N: 2,137 Ans.)

Factor	Value	Recanalization		OR	95 % CI	p-value[a]
		No	Yes			
Age	≤65	1,180 (72.13 %)	158 (80.61 %)	Ref.		
	>65	456 (27.87 %)	38 (19.39 %)	0.622	0.430–0.901	0.012
HTN	No	960 (58.68 %)	115 (58.67 %)	Ref.		
	Yes	676 (41.32 %)	81 (41.33 %)	1.000	0.740–1.351	0.999
Location	ICA	1,018 (62.22 %)	98 (50.00 %)	Ref.		
	ACA	303 (18.52 %)	39 (19.89 %)	1.337	0.903–1.980	0.147
	MCA	161 (9.84 %)	25 (12.76 %)	1.613	1.009–2.580	0.046
	VB	154 (9.41 %)	34 (17.35 %)	2.293	1.499–3.509	< 0.001
Size	An. ≤ 5	890 (54.4 %)	80 (40.82 %)	Ref.		
	5 < An. ≤ 10	567 (34.66 %)	74 (37.76 %)	1.452	1.041–2.026	0.028
	10 < An. ≤ 15	110 (6.72 %)	24 (12.24 %)	2.427	1.476–3.991	<0.001
	15 < An.	69 (4.22 %)	18 (9.18 %)	2.902	1.646–5.116	<0.001
D/N	≤1.5	720 (44.01 %)	95 (48.47 %)	Ref.		
	>1.5	916 (55.99 %)	101 (51.53 %)	0.836	0.621–1.124	0.236
Modalities of embolization	Catheter-based	1,040 (63.57 %)	141 (71.94 %)	Ref.		
	Balloon-assisted	245 (14.98 %)	24 (12.24 %)	0.723	0.459–1.138	0.161
	Stent-assisted	269 (16.44 %)	23 (11.73 %)	0.631	0.398–1.000	0.050
	Intenal trapping	3 (0.18 %)	0 (0 %)	Not available		
	Combined technique	79 (4.83 %)	8 (4.08 %)	0.747	0.353–1.578	0.445
Initial	Complete	1,061 (64.85 %)	105 (53.57 %)	Ref.		
Angiographic	Near complete	494 (30.20 %)	81 (41.33 %)	1.657	1.217–2.256	0.001
Outcome	Partial	81 (4.95 %)	10 (5.10 %)	1.248	0.628–2.479	0.528

[a] P-values were computed by simple logistic regression analysis

occlusion) in 692 aneurysms (32.4 %), and aneurysm remnant (partial occlusion) in 108 aneurysms (5.0 %). Although we do not have outcome data for the early years (1996–2006) for comparison, our data show that the technical feasibility and occlusion rates are compatible with other recent reports from other countries [2, 5, 12, 16]. In this study, old age (>65), multiplicity of aneurysms, MCA location, and large size (>15 mm) affected the postoperative angiographic results. We think UIAs in the older patients and less risky aneurysms in cases of multiplicity were not coiled aggressively.

In the recently published multicenter prospective ATENA (Analysis of Treatment by Endovascular Approach of Nonruptured Aneurysms) study, adverse events occured in 15.4 % of patients, and permanent neurologic deficits were seen in 2.6 % of patients [12]. In our study, the rate of any procedural event was 6.9 % per aneurysm (148/2,137 aneurysms), and the rate of procedure-related permanent symptomatic neurologic complications was 1.8 % per aneurysm (39/2,137). Our procedural complication rates appear better than those of other studies [7, 12], but may reflect the rapidly evolving stage of the neuro-endovascular field.

Campi A et al. previously reported that younger age, large aneurysm size, and incomplete initial occlusion were predictors of aneurysm recurrence after endovascular coiling [1]. In this study, the risk factors of aneurysmal recanalization were younger age, MCA and VB location, large aneurysm size, and suboptimal initial angiographic result. We think that the possibility of more follow-up image studies in younger patients, and technical difficulties for MCA and VB location are related to high aneurysmal recanalization.

Several factors should be noted. First, this study showed that the indications for coiling in South Korea might be wider than usual: (1) paraclinoid ICA aneurysms known to have a benign natural course comprised 30.4 % of all aneurysms, and (2) approximately half of the treated aneurysms were less than 5 mm in size. For the 17 years since the introduction of aneurysm coiling in South Korea, reasonable coiling indications for UIAs have been a major issue. As more evidence that reveals the natural risks of unruptured paraclinoid aneurysms and small aneurysms is established [4, 6, 9–11], the current indications of coiling could possibly be narrowed further. Second, the proportion of MCA aneurysms among all coiled aneurysms is approximately 10 %. Given that the incidence of MCA aneurysms is approximately 10 % of all aneurysm locations [8], unruptured MCA aneurysms can be assumed to have been actively treated by endovascular coiling similar

to other locations. Traditionally, MCA aneurysms have been considered challenging for endovascular coiling due to their unfavorable anatomic features, including a wide neck and the involvement of important branches [3]. Our data also showed high risks of incomplete occlusion and recanalization in this location. Therefore, it would be reasonable to be more careful in selecting the MCA aneurysms for coiling. Third, although still lacking robust data to support pre-procedural antiplatelet agent preparation, in community-based practice, single or dual antiplatelet agents were used in more than 90 % of the patients (90.5 %, 1,842/2,035) [14, 17]. Well-organized clinical studies will be necessary to address this issue.

Despite community-based data from many institutes, the high rate (85.7 %) of the radiologic follow-ups after coiling was encouraging. We believe that this rate is due to a well-established medical care environment in South Korea that includes easy access and low medical costs. According to the radiologic follow-up study, the overall recurrence rate was 10.7 % (196/1,832 aneurysms). Minor recanalization occurred in 124 aneurysms (124/1,832, 6.8 %), and major recanalization requiring re-treatment occurred in 72 aneurysms (72/1,832, 3.9 %). We believe that these rates are acceptable.

There are some limitations to this study. First, the clinical and angiographic results were assessed by the treating physician, not by an independent researcher. Second, this study was a retrospective, core lab-adjudicated study, not a prospective, controlled trial. The indications, techniques for coil embolization, and the protocols for follow-up (follow-up time and image modality) could be different in each center. Third, although the mid-term angiographic data appear acceptable, their long-term durability should be further investigated.

Conclusion

This study represents the recent overall community-based results of endovascular coil embolization for UIAs in South Korea. Endovascular coiling was found to be an effective preventive modality with low procedure-related morbidity for UIAs.

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Conflicts of interest None.

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