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Original Article

Practical Feasibility and Packing Density of Endovascular Coiling Using Target® Nano™ Coils in Small Cerebral Aneurysms

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Objective : Based on the use of Nano™ coils, we retrospectively compared the proportion of the coils (≤ 1.5 mm) and packing density in two patient groups with small cerebral aneurysms (< 4 mm diameter) who were treated with or without Nano™ coils.

Materials and Methods : Between January 2012 and November 2013, in 548 cerebral aneurysms treated by endovascular coiling, 143 patients with 148 small cerebral aneurysms underwent endovascular coiling. After March 2013, coiling with Nano™ coils was performed on 45 small cerebral aneurysms (30.4%).

Results : There were no significant differences in the size and locations of the cerebral aneurysms, the age of the patients, and the procedural modalities between the two groups. The proportion of the coil (≤ 1.5 mm) of the group treated with Nano™ coils (53.6%) was higher than the proportion of the coil (≤ 1.5 mm) of the group treated without Nano™ coils (14.7%) with statistical significance ($p < 0.001$). The packing density of the group treated with Nano™ coils (31.3 ± 9.69%) was higher than the packing density of the group treated without Nano™ coils (29.49 ± 7.84%), although the difference was not significant. Procedural complications developed in 3 lesions (2 thromboembolisms and 1 carotid dissection) (2.0%). Treatment-related transient neurological deficits due to thromboembolism developed in 1 lesion, which had not been treated with Nano™ coils. There was no treatment-related permanent morbidity or mortality in either of the groups.

Conclusion : In our series, the small cerebral aneurysms treated with Nano™ coils showed more packing density with no additive procedural risk or difficulty.

Keywords Cerebral aneurysm, Endovascular

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INTRODUCTION

The coil packing density has recently been regarded as one of the important factors for improving the durability of endovascular coiling. Several techniques, such as the balloon remodeling technique,[1)] and materials such as complex shaped platinum coils[2)] or volume expanding coils[3)] have previously been used to increase the packing density in the treatment of cerebral aneurysms.

Recently, newly designed coils such as Nano™ coils (Stryker Neurovascular, Fremont, CA, USA) have been used to treat small cerebral aneurysms. Company bench test was performed by the testing machanism that a nitinol wire is placed through the center of an unfixed loop of coil, Nano™ coils are proved that they are softer than other conventional coils, we hypothesized that endovascular coiling with Nano™ coils in small cerebral aneurysms may require a larger number of coils and longer coil length, resulting in a higher packing density of the coils. We therefore retrospectively compared the proportion of the coils, the packing density between two groups, and procedural complications with intracranial aneurysms smaller than 4 mm that were treated with or without Nano™ coils.

MATERIALS AND METHODS

Patients

Between January 2012 and November 2013, 548 cerebral aneurysms were treated with endovascular coiling at two institutions. A total of 148 small cerebral aneurysms (< 4 mm) were treated with endovascular coiling. After March 2013, endovascular coiling using Nano™ coils was performed in 45 small cerebral aneurysms (30.4%). We retrospectively evaluated 143 patients with 148 small cerebral aneurysms treated with endovascular coiling with or without Nano™ coils.

In our practice, endovascular coiling is selectively performed based on the discussion of vascular and endovascular teams. We generally treated cerebral aneurysms larger than 4 mm without the presence of rupture and the location of the cerebral aneurysm. Ruptured small cerebral aneurysms were treated with endovascular coiling on an emergent basis. For small unruptured cerebral aneurysms, and particularly in cases of bifurcated aneurysms or posterior circulation aneurysms, we recommend treatment if the patient is 70 years old or younger. For small cerebral aneurysms in other locations, the treatment decision should be based on the aneurysm morphology, multiplicity, previous history of subarachnoid hemorrhage, age of the patient, emotional status of the patient, and/or technical feasibility. In cases of cerebral aneurysms smaller than 2 mm, annual follow-up is recommended generally.

Clinical data were obtained by reviewing the patient medical records. Using procedural records and images, the characteristics of the aneurysms, including the aneurysm location, size (width, depth, and height), and neck diameter, as well as vessel incorporation and procedural details, such as the immediate angiographic results and complications, were reviewed.

Endovascular treatment

A simple coiling method using single or multiple microcatheters was primarily used. The multiple microcatheter technique was applied to aneurysms with broad necks or incorporated vessels, following technical details described previously.[4)5)] Stent-assisted coiling was performed in small cerebral aneurysms that were not suitable for simple coiling or following a failed simple coiling. All procedures were performed under general anesthesia using two biplane systems at two institutions (Integris Allura, Phillips Medical Systems, Netherlands or Artis ZEE, Siemens, Germany).

Angiographic findings, including the aneurysm size and degree of occlusion, were interpreted by neurointerventional neurosurgeons or radiologists. Aneurysm size was measured from 3-dimensional angiographic images. The aneurysm width was determined by measuring the longest diameter of the fundus parallel to the axis of the aneurysm neck. The height was determined as the longest diameter of the fundus vertical to the axis of the aneurysm neck. Aneurysm depth was determined by measuring the longest diameter of an aneurysm perpendicular to the axis of the parental artery.

The aneurysm volume was calculated by assuming that the aneurysms were elliptical and using the following formula:

Aneurysm volume = 4π (height/2 × length/2 × width/2)/3

Coil volumes were calculated using the following formula:

Coil volume = π (radius)2 × length

The coil packing density was expressed using the following formula:

Packing density = (coil volume/aneurysm volume) × 100%.

Angiographic outcomes were classified as complete occlusion, residual neck, and partial occlusion according to the Raymond scale.[6]

Statistical analysis

Statistical analysis was performed to evaluate differences in the clinical and radiological outcomes and differences in the packing density for small cerebral aneurysms according to the use of Nano™ coils. Nominal data were analyzed using the χ^2 or Fisher exact test, and numerical data were analyzed using Student's *t*-test or the Mann-Whitney *U* test as appropriate. A two-tailed $p < 0.05$ was defined as statistically significant.

RESULTS

Among 143 patients with 148 small cerebral aneurysms, 114 patients (79.7%) were female, with an age range of 31 to 82 years (median age: 56 years, mean ± SD: 56.5 ± 11.0 years); 13 cerebral aneurysms (8.8%) were ruptured, and 45 small cerebral aneurysms (30.4%) were treated with Nano™ coils.

There were no significant differences in the size and locations of the cerebral aneurysms, the age of the patients, and the procedural modalities between the two groups (Table 1).

In the group treated with Nano™ coils, we used the simple catheter technique in 23, stent-assisted technique in 21, and multiple catheter technique in 1. In the

Table 1. Comparison of demographic and radiological data between small cerebral aneurysms treated with Nano™ coils and without Nano™ coils

	Without Nano™ coils (n = 103)	With Nano™ coils (n = 45)	*p* value
Age	57.4 ± 10.4	54.9 ± 11.6	0.209
Rupture			0.065
Yes	6	7	
No	97	38	
Aneurysm location			0.428
Pericallosal	1	0	
ACoA	17	6	
A1	0	1	
MCA bifurcation	8	3	
M1	3	2	
ICA bifurcation	1	2	
AchA	6	3	
PCoA	11	7	
Dorsal wall	1	2	
Paraclinoid	48	15	
Basilar trunk	2	0	
PICA	1	1	
SCA	2	0	
Basilar bifurcation	1	2	
P1	1	1	
Aneurysm height (mm)	2.86 ± 0.49	2.88 ± 0.50	0.841
Aneurysm width (mm)	2.92 ± 0.54	2.84 ± 0.57	0.449
Aneurysm neck (mm)	2.64 ± 0.63	2.64 ± 0.64	0.981
Aneurysm depth (mm)	2.84 ± 0.53	2.87 ± 0.65	0.772
Aneurysm volume (mL)	0.129 ± 0.005	0.128 ± 0.005	0.912

ACoA = anterior communicating artery; A1 = proximal anterior cerebral artery; MCA = middle cerebral artery; M1 = proximal middle cerebral artery; ICA = internal carotid artery; AchA = anterior choroidal artery; PCoA = posterior communicating artery; PICA = posterior inferior cerebellar artery; SCA = superior cerebellar artery; P1 = proximal posterior cerebral artery

Table 2. Comparison of packing density, procedure modality, radiological outcomes, and procedural complications between small cerebral aneurysms treated with Nano™ coils and without Nano™ coils

	Without Nano™ coils (n = 103)	With Nano™ coils (n = 45)	*p* value
No. of coils	2.37 ± 1.17	2.87 ± 1.29	0.023
Coil length (cm)	7.33 ± 3.52	7.67 ± 3.78	0.612
Coil volume (mL)	0.039 ± 0.017	0.041 ± 0.002	0.553
Proportion of coil ≤ 1.5 mm (%)	14.7 ± 25.2	53.6 ± 28.7	< 0.001
Packing density	29.49 ± 7.84	31.3 ± 9.69	0.228
Coiling technique			0.106
Simple	45	23	
Stent-assisted	48	21	
Double	9	1	
Wire-assisted	1	0	
Radiological outcomes			0.190
Partial	16	4	
Residual neck	18	8	
Complete	69	33	
Procedural complications			0.666
Thromboembolism (symptomatic thromboembolism)	1 (1)	1 (0)	
ICA dissection	1	0	

ICA = internal carotid artery

group treated without Nano™ coils, the endovascular techniques included simple catheter technique in 45, stent-assisted technique in 48, and multiple catheter technique in 9, and wire-assisted technique in 1. There was no significant difference in the endovascular techniques applied between the two groups (Table 2).

The proportion of the coil (≤ 1.5 mm) of the group treated with Nano™ coils (53.6%) was higher than the proportion of the coil (≤ 1.5 mm) of the group treated without Nano™ coils (14.7%) with statistical significance (p < 0.001). The packing density of the group treated with Nano™ coils (31.3 ± 9.69%) was higher than the packing density of the group treated without Nano™ coils (29.49 ± 7.84%), although the difference did not reach statistical significance. The number of coils used in the group treated with Nano™ coils (2.87 ± 1.29) was significantly higher than that in the group treated without Nano™ coils (2.37 ± 1.17, p value = 0.023). The coil length used in the group treated with Nano™ coils (7.67 ± 3.78 cm) was longer (although this difference was not significant) than that used in the group treated without Nano™ coils (7.33 ± 3.52 cm). The coil volume in the group treated with Nano™ coils (0.041 ± 0.002 mL) was higher (although this difference was not significant) than that in the group treated without Nano™ coils (0.039 ± 0.017 mL).

The radiological data of the group treated with Nano™ coils revealed complete occlusion in 33 lesions (73.3%), residual neck in 8 lesions (17.8%), and partial occlusion in 4 lesions (8.9%). In the group treated without Nano™ coils, the radiological outcomes included complete occlusion in 69 lesions (67.0%), residual neck in 18 lesions (17.5%), and partial occlusion in 16 lesions (15.4%). There were no significant differences in the radiological outcomes between the two groups.

Three procedure-related complications (2%) developed in the 148 small cerebral aneurysms treated with endovascular coiling (2 cases of thromboembolism and 1 case of ICA dissection). Transient hemiparesis due to the procedure developed in 1 lesion treated without Nano™ coils. There was no permanent procedure-related morbidity or mortality in either of the two groups.

DISCUSSION

The coil packing density has been considered to be one of the predicting factors in the recurrence of cerebral aneurysms treated with endovascular coiling.[7,8] Several advances, such as balloon or stent remodeling techniques, complex shaped coils, and volume expanding coils have been developed to improve the coil packing density.[1-3,9] We expected that Nano^{TM} coils, which are softer than previous other coils in bench test, would increase the coil packing density during the treatment of small cerebral aneurysms. In our series, although the aneurysm volume of the group treated with Nano^{TM} coils (0.128 mL) was relatively smaller than that of the group treated without Nano^{TM} coils (0.129 mL), the group treated with Nano^{TM} coils required significantly more coils (2.87 ± 1.29) than did the group treated without Nano^{TM} coils (2.37 ± 1.17) (p = 0.023). The coil length (7.67 ± 3.78 cm) of the group treated with Nano^{TM} coils was longer (although this difference was not significant) than that of the group (7.33 ± 3.52 cm) treated without Nano^{TM} coils. The packing density of the group treated with Nano^{TM} coils (31.3 ± 9.69%) was higher than that of the group treated without Nano^{TM} coils (29.49 ± 7.84%); however, this difference was not significant. These results may be due to the use of coils that are shorter in length and smaller size in the group treated with Nano^{TM} coils, resulting in larger numbers of coils packed in the aneurysms. And, the proportion of the coil (≤ 1.5 mm) of the group treated with Nano^{TM} coils (53.6%) was higher than the proportion of the coil (≤ 1.5 mm) of the group treated without Nano^{TM} coils (14.7%); this difference was statistically significant (p < 0.001).

Small cerebral aneurysms less than 3 mm are considered technically challenging because of the increased possibility of procedural aneurysm rupture. Based on several clinical series, small cerebral aneurysms less than 3 mm were also observed to result in a relatively high procedural rupture rate.[10,11] However, in our series, there were no procedural ruptures in the small cerebral aneurysms treated with endovascular coiling. This result can be attributed to the following several factors. Firstly, small cerebral aneurysms were mostly ruptured in previous reports, but approximately 90% of the aneurysms (n = 135) were unruptured in our series. These unruptured cerebral aneurysms are less likely to have thin, fragile walls, unlike ruptured cerebral aneurysms. The possibility of procedural rupture was therefore lower in our series. Secondly, the size criterion in our series (< 4 mm) was larger than those of previous reports. The aneurysm size (≥ 3 mm, < 4 mm) was larger than in previous reports that included 96 lesions. This factor might have influenced the lower incidence of procedural rupture in our series because the larger size of the cerebral aneurysm provides more space in cerebral aneurysms, reducing the risk of procedural rupture due to inadvertent manipulation of the microcatheters or coils.

Procedure-related complications in the group treated with Nano^{TM} coils included 1 thromboembolic lesion (2.1%) that did not result in any neurological deficits. There was no significant difference between the two groups with respect to this result. The incidence of procedure-related complications in the group treated with Nano^{TM} coils was not higher than that of the group treated without Nano^{TM} coils. Accordingly, endovascular coiling using Nano^{TM} coils was not found to increase the procedure-related risk in cases involving small cerebral aneurysms.

Our series has limitations; it is a retrospective, non-randomized, and small sample size study. However, our study may have clinical value because proportion the coil packing density of the group treated with Nano^{TM} coils was higher than that of the group treated without Nano^{TM} coils, although the difference between the two groups was not significant. Additionally, analysis of durability should be evaluated in the small cerebral aneurysm using Nano^{TM} coils.

CONCLUSION

In our series, the group treated with Nano^{TM} coils exhibited a higher proportion of the coil (≤ 1.5 mm) and packing density of the coils. In addition, there were no significant differences between the groups in terms of the procedural complications. Therefore, the small cerebral aneurysms treated with Nano™ coils showed more packing density with no additive procedural risk or difficulty.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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