

Jailing Technique Using a Catheter-based Open-cell Stent System in Internal Carotid Artery Sidewall Aneurysms Unfeasible to Simple Coiling

Sun Geon Yoon¹, Sung-Chul Jin², Seung Hwan Kim², Kyoung Dong Jeon², Doo Young Kim², Sun-Il Lee², Hae Woong Jeong³

¹Department of Neurosurgery, Busan Paik Hospital, Inje University, Busan, Korea

²Department of Neurosurgery, Haeundae Paik Hospital, Inje University, Busan, Korea

³Department of Diagnostic Radiology, Busan Paik Hospital, Inje University, Busan, Korea

Objective : An open cell stent system may offer better apposition of cell struts to vessel wall than a closed cell stent system in acute vasculature. The purpose of this study was to evaluate the feasibility of coiling using the jailing technique with the Neuroform EZ stent system.

Methods : The jailing technique using the open-cell stent system of the Neuroform EZ stent was planned in 22 consecutive patients with 22 cerebral aneurysms. We retrospectively evaluated the technical success of the jailing technique and the occurrence of interference between two microcatheters as well as the factors influencing this interference.

Results : The jailing technique was successful in 19/22 patients (86.4%), and interference between two microcatheters occurred in 6/21 (28.6%). The jailing technique failed in 3/22 patients, with problems that included failure of the stent delivery system to advance into the positioned microcatheter in one, interference between the microcatheters during the advancement of the stent delivery system in one, and failure of microcatheter insertion into the aneurysm sac in the remaining patient. Interference between the two microcatheters developed during the advance of the stent delivery system into the positioned microcatheter in all cases. One factor that influences interference between two microcatheters more than expected by chance is the carotid siphon angle ($p = 0.019$).

Conclusion : The acuteness of the carotid siphon angle influences the interference between two microcatheters. Therefore, the jailing technique using the Neuroform EZ stent should be performed carefully in cerebral aneurysms with an acute carotid siphon angle because the procedure may possibly fail.

J Cerebrovasc Endovasc Neurosurg.
2013 December;15(4):293-298

Received : 27 June 2013

Revised : 7 August 2013

Accepted : 23 October 2013

Correspondence to Sung-Chul Jin

Department of Neurosurgery, Inje University
Haeundae Paik Hospital, 1435 Jwa-dong,
Haeundae-gu, Busan 612-043, Korea

Tel : 82-51-797-0607

Fax : 82-51-703-0434

E-mail : kusmal@hanmail.net

Keywords Carotid siphon, Microcatheter, Neuroform, Jailing

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

INTRODUCTION

The jailing technique is one of the stent-assisted coiling modalities in wide-necked cerebral aneurysms that

are recalcitrant to simple coiling.¹⁾⁴⁾⁵⁾ A major advantage of the jailing technique is strengthening the stability of the microcatheter in cerebral aneurysms into which insertion of the microcatheter might be difficult.

The jailing technique is generally used with closed-cell stent systems, such as the Enterprise stent, in wide-necked cerebral aneurysms. However, in closed-cell stent systems, apposition of the stent strut to the vessel wall may be difficult in cerebral aneurysms with tortuous vasculature. A closed-cell stent system was recently reported to yield “incomplete stent apposition in the tortuous vasculature”.^{2,3)} The Neuroform EZ stent system has an open-cell stent system that employs a microcatheter-based transfer technique. Furthermore, this system is expected to provide good navigability and accessibility in the vessel. We expect the jailing technique using the Neuroform EZ stent system to be a good option for wide-necked aneurysms with tortuous vasculature. In this retrospective study, we evaluated the feasibility of the jailing technique using the Neuroform EZ stent system in cerebral

aneurysms that were unfavorable to simple coiling.

MATERIALS AND METHODS

Starting in June 2011, we developed a jailing technique using the Neuroform EZ stent system, mainly for the coiling of cerebral aneurysms that were unfavorable to simple coiling. From June 2011 to December 2011, the jailing technique using the Neuroform EZ stent system was planned in 22 cerebral aneurysms (Table 1). These lesions were included in our study, which was approved by the Institutional Review Board. The primary techniques used for coil embolization included the jailing technique in 21 lesions and simple coiling in one. In two lesions, we changed the treatment strategy, halting the use of the jailing technique using the Neuroform EZ

Table 1. Characteristics of 22 patients who underwent coil embolization using the Neuroform EZ stent system.

Patient No.	Sex/Age	Aneurysm location	Carotid siphon angle (degree)	Aneurysm size (height × width)	Aneurysm neck size	Initial treatment design	Success of Jailing	Neuroform stent deployment
1	M/52	Cave	60	4.5×4 mm	4 mm	Stent-assisted	Success	Success
2	F/52	Ophthalmic	89	6.2×4.6 mm	4.1 mm	Stent-assisted	Success	Success
3	M/47	Pcoma	104	2.7×2 mm	2 mm	Simple coiling	Success	Success
4	M/56	Cave	109	1.9×3 mm	1.6 mm	Stent-assisted	Success	Success
5	F/50	Ophthalmic	35	3.6×2.3 mm	2.2 mm	Stent-assisted	Failure	Success
6	F/51	Cave	95	3.4×3 mm	3 mm	Stent-assisted	Success	Success
7	F/66	Ventral	96	3.4×3.1 mm	3.2 mm	Stent-assisted	Success	Success
8	F/69	Cave	64	4.5×4 mm	4 mm	Stent-assisted	Success	Success
9	F/77	Pcom	68	3.4×2.1 mm	2.5 mm	Stent-assisted	Success	Success
10	F/65	Sup. hypophyseal	53	3×3 mm	3 mm	Stent assisted	Success	Success
11	M/66	Ventral	39	2×3 mm	3.1 mm	Stent-assisted	Failure	Failure
12	F/48	Pcoma	84	4×3.5 mm	3.5 mm	Stent-assisted	Success	Success
13	F/47	Ventral	76	2.1×3.3 mm	3.7 mm	Stent-assisted	Success	Success
14	F/53	Sup. hypophyseal	133	7.4×6.3 mm	4 mm	Stent-assisted	Success	Success
15	M/54	Cave	45	3.4×4.3 mm	3.8 mm	Stent-assisted	Success	Success
16	F/47	Sup. hypophyseal	70	3.9×3.7 mm	3.7 mm	Stent-assisted	Success	Success
17	F/59	Ophthalmic	116	2.5×2 mm	2 mm	Stent-assisted	Success	Success
18	F/46	Sup. hypophyseal	53	2.5×4 mm	3.8 mm	Stent-assisted	Success	Success
19	F/71	Pcoma	108	4×4.9 mm	3.2 mm	Stent-assisted	Success	Success
20	F/58	Ventral	105	4.2×5.3 mm	4 mm	Stent-assisted	Success	Success
21	F/56	Ventral	35	2×2.2 mm	1.8 mm	Stent-assisted	Failure	Success
22	F/57	Sup. hypophyseal	30	4×4.5 mm	4 mm	Stent-assisted	Success	Success

Acoma= anterior communicating artery; Pcoma= posterior communicating artery; sup= superior

stent system because of failure of the primary treatment plan.

Without developing an initial plan for the coil embolization, such as a single-catheter technique or stent-assisted coiling, we administered aspirin (300 mg) and clopidogrel (300 mg) to the patients with unruptured cerebral aneurysms for at least three hours before the procedure but prescribed the same dose of aspirin and clopidogrel to the patients with ruptured cerebral aneurysms immediately after the procedure via nasogastric tube. Anticoagulation was initiated by the injection of a bolus of 3000 IU heparin intravenously immediately after femoral puncture, followed by intermittent bolus injection of 1000 IU heparin hourly. Coil embolization was performed via a single femoral access in all cases, with a 7 F GuideR guiding catheter (Boston Scientific, Natick, MA, USA). We attempted several variations of the jailing technique to develop a safer and more efficient strategy for the use of this method: 1) A Renegade Hi Flo (Boston Scientific, Watertown, MA, USA) microcatheter was positioned first, and then an Excelsior SL-10 (Boston Scientific, Natick, MA, USA) microcatheter was inserted into the cerebral aneurysm. Finally, a Neuroform EZ stent delivery system was advanced into the Renegade Hi Flo microcatheter ($n = 9$). 2) An Excelsior SL-10 microcatheter was first inserted into the cerebral aneurysm, and then a Renegade Hi Flo microcatheter was positioned distal to the cerebral aneurysm. Finally, a Neuroform EZ stent delivery system was advanced into the Renegade Hi Flo microcatheter ($n = 7$). 3) A Renegade Hi Flo microcatheter was positioned first, and then a Neuroform EZ stent delivery system was advanced into the Renegade Hi Flo microcatheter. Subsequently, an Excelsior SL-10 microcatheter was inserted into the cerebral aneurysm ($n = 6$). In all cases, partial coil packing of the aneurysm was performed to reduce the risk of unexpected rupture of the aneurysm due to interference between the two microcatheters before the advance of the Neuroform EZ stent delivery system into the Renegade Hi Flo microcatheter.

Based on accumulated clinical experience, we suggest that the tortuosity of the vasculature and interference between the microcatheters will be major determinants of the success of the jailing technique using the Neuroform EZ stent system. The carotid siphon angle likely represents the degree of vascular tortuosity. The carotid siphon angle is defined as the angle between the supraclinoid segment of the internal carotid artery and the anterior vertical or horizontal segment of the cavernous internal carotid artery. The measurement of the carotid siphon angle was performed semi-automatically on a lateral view of conventional angiography using the picture archiving and communication system (PACS) software system (Maroview; Marotech, Seoul, KR). Interference between the two microcatheters is defined as the phenomenon in which one microcatheter, which is inserted into the cerebral aneurysm, is contacted and dislodged from its previous position by another microcatheter that is positioned for stent deployment during any step of the jailing technique.

Statistical analysis

The differences in various characteristics between the presence and absence of interference of microcatheters were evaluated using the Fisher exact test for nominal data and the Mann-Whitney U test for numerical data. Null hypotheses of no difference were rejected if p values were less than 0.05.

Ethical statement

The form consent was not obtained because this study was a retrospective analysis. The study protocol was approved by the Institutional Review Boards of the Inje University Busan Paik Hospital (IRB No. 2011-085).

RESULTS

We found that the jailing technique using the Neuroform EZ stent system was successfully accomplished in 19 cerebral aneurysms and failed in three (12.5%), although the Renegade microcatheter was

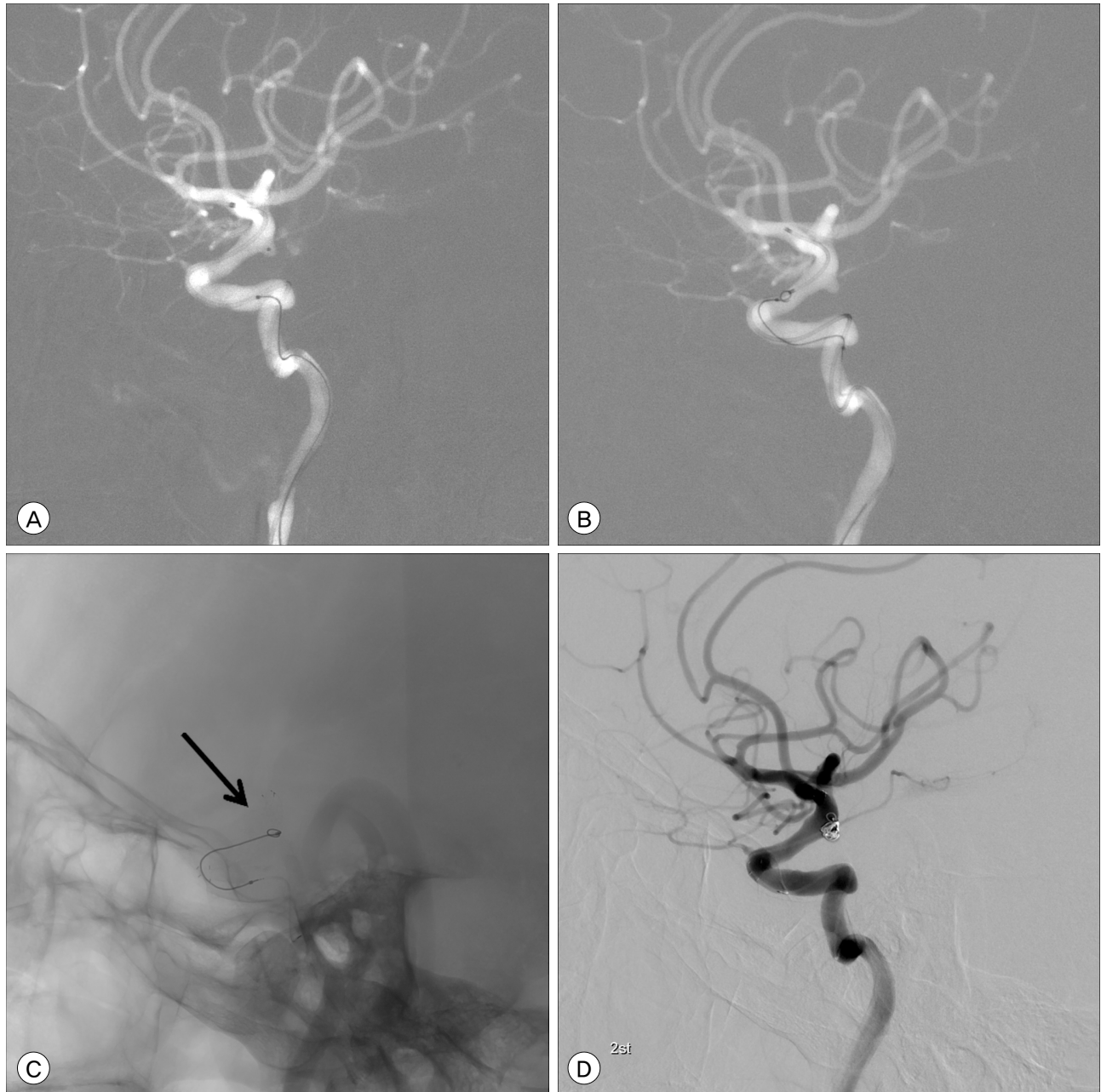


Fig. 1. A case in which the Neuroform stent delivery system failed to advance into the Renegade microcatheter. (A) A working roadmap image shows two well-positioned microcatheters. (B) A working roadmap image shows the dislodging of the microcatheter that was inserted into the aneurysm during the advance of the Neuroform stent delivery system into the Renegade microcatheter. (C) A switch from Neuroform stent-assisted to Enterprise stent-assisted (black arrow) coiling was performed due to the failure of the Neuroform delivery system to advance into the Renegade microcatheter. (D) A final working angiogram shows partial coiling of the aneurysm.

well positioned in all of the lesions. Failure of the jailing technique using the Neuroform EZ stent system developed in three lesions during several steps of the procedure, as follows: 1) the Neuroform EZ stent delivery system failed to advance into the positioned

Renegade microcatheter (Fig. 1); 2) the Excelsior SL-10, which had been inserted into the cerebral aneurysm, was dislodged from the cerebral aneurysm by the advance of the Neuroform EZ stent system into the Renegade microcatheter; and 3) the Excelsior SL-10

Table 2. Factors interfering between microcatheters during jailing technique using the Neuroform EZ stent system.

	Absence of interference	Presence of interference	<i>p</i> value
Carotid siphon angle	88.3 ± 6.0	51.2 ± 11.3	0.019
Steam shaping of Renegade microcatheter			0.420
Steam shaping	4	7	
No steam shaping	2	8	
Strategies of Jailing technique			0.152
1	3	5	
2	1	7	
3	2	3	
Age of patients			0.609
> 60 years	1	5	
≤ 60 years	5	10	

Strategy 1: The Renegade microcatheter is positioned first and then the microcatheter is inserted into the cerebral aneurysm. Finally, the Neuroform EZ stent delivery system is advanced into the Renegade microcatheter. Strategy 2: The microcatheter is first inserted into the cerebral aneurysm, and then the Renegade microcatheter is positioned. Finally, the Neuroform EZ stent delivery system is advanced into the Renegade microcatheter. Strategy 3: The Renegade microcatheter is positioned first, and then the Neuroform EZ stent delivery system is advanced into the Renegade microcatheter. Finally, the microcatheter is inserted into the cerebral aneurysm.

microcatheter failed to insert into the cerebral aneurysm after the Renegade microcatheter had been positioned distal to the aneurysm. The case in which the Neuroform EZ stent delivery system failed to advance into the Renegade microcatheter was switched to a jailing technique using an Enterprise stent system of a closed-cell design (Fig. 1). The other two cases were treated using the conventional sequential technique of stent-assisted coiling with insertion of the microcatheter into the cerebral aneurysm after stent deployment.

Interference between the two microcatheters, possibly a major determinant of the success of the jailing technique, developed in six of 21 cerebral aneurysms (28.6%) excluding one lesion into which the microcatheter was not inserted. Interference between two microcatheters always developed during the step of the procedure in which the Neuroform EZ stent delivery system was advanced into the Renegade microcatheter regardless of which strategy of the jailing technique was used. Analysis of the factors influencing the interference between two microcatheters revealed that the carotid siphon angle is the only statistically significant variable in univariate analysis (Table 2).

Procedural complications developed in four lesions (16.7%), including one thromboembolism, one stretched coil loop, and contrast leakage in two lesions.

Our procedural morbidity and mortality were 8.3% and 0%. None of the cases of procedural morbidity (thromboembolism, *n* = 1; contrast leakage, *n* = 1) resulted in neurological deficits at discharge.

DISCUSSION

Our study demonstrates that the jailing technique using the Neuroform EZ stent system is difficult to apply, especially to cerebral aneurysms with an acute carotid siphon angle. The failure of the jailing technique using the Neuroform EZ stent system is explainable by two influences. One influencing factor in the failure of jailing technique is the Renegade microcatheter itself. A case in which the Neuroform EZ stent delivery system failed to advance into the Renegade microcatheter suggests that crumpling of the microcatheter in the tortuous vasculature and subsequent compromise of the inner lumen adversely influence the jailing technique. Our test of the Renegade microcatheter supported this suggestion that compromise of the inner lumen by crumpling was initiated by curving the microcatheter at approximately 90 degrees and was not restored by the release of the microcatheter in the distal segment. Therefore, compromise of the inner lumen of the Renegade micro-

catheter in tortuous vasculature and a lack of subsequent restoration of the inner lumen after the release of the tension on the Renegade microcatheter are one of the influencing factors in the failure of the jailing technique using the Neuroform EZ stent system. The Excelsior XT-27 microcatheter (Striker neurovascular, Fremont, CA, USA) is used in clinical settings and may overcome the drawbacks of the Renegade microcatheter such as compromise of the inner lumen. This microcatheter should be studied in the acute carotid siphon angle compared with the Renegade microcatheter. Another factor influencing failure of this technique is interference between two microcatheters (one catheter for coiling and another catheter for stent deployment). In our series, all cases of interference between two microcatheters developed during the advance of the Neuroform EZ stent delivery system into the Renegade microcatheter. Therefore, to reduce interference in the jailing technique using the Neuroform EZ stent system, the Renegade microcatheter is first navigated distal to the cerebral aneurysm, and then the Neuroform EZ stent delivery system is advanced into the Renegade microcatheter immediately before unsheathing the stent. Subsequently, the microcatheter is inserted into the cerebral aneurysm. In addition, the carotid siphon angle is the only statistically significant factor affecting the interference between two microcatheters in the jailing technique using the Neuroform EZ stent system. Interference between two microcatheters may be expected to occur in the carotid siphon angle less than 50 degree. Jailing technique may fail if the carotid siphon angle is about 30 degree. Therefore, in the planning of the coiling of cerebral aneurysms with tortuous vasculature (carotid siphon angle less than 50 degree), the conventional sequential technique, which consists of prior deployment of the stent and subsequent insertion of the microcatheter into the cerebral aneurysm, should be considered for stent-assisted coiling using the Neuroform EZ stent system. Furthermore, in the coiling of cerebral aneurysms in which the insertion of the microcatheter

into the aneurysms is expected to be difficult, the jailing technique using a closed-cell stent system, such as the Enterprise stent system, should be considered.

Although our study has a small sample size and is a retrospective design, its significance is focused on the feasibility of the jailing technique using the Neuroform EZ stent system in clinical practice. The jailing technique using the Neuroform EZ stent system should be carefully considered, especially in the coiling of cerebral aneurysms with tortuous vasculatures.

CONCLUSIONS

The jailing technique using the Neuroform EZ stent system showed considerable rates of technical failure due to interference between the microcatheters in cerebral aneurysms that were unfavorable to simple coiling. Therefore, the jailing technique using the Neuroform EZ stent system should be used carefully, especially in cerebral aneurysms with tortuous vasculature.

REFERENCES

1. Biondi A, Janardhan V, Katz JM, Salvaggio K, Riina HA, Gobin YP. Neuroform stent-assisted coil embolization of wide-neck intracranial aneurysms: Strategies in stent deployment and midterm follow-up. *Neurosurgery*. 2007 Sep;61(3):460-8; discussion 468-9.
2. Heller RS, Malek AM. Parent vessel size and curvature strongly influence risk of incomplete stent apposition in enterprise intracranial aneurysm stent coiling. *AJNR Am J Neuroradiol*. 2011 Oct;32(9):1714-20.
3. Heller RS, Miele WR, Do-Dai DD, Malek AM. Crescent sign on magnetic resonance angiography revealing incomplete stent apposition: Correlation with diffusion-weighted changes in stent-mediated coil embolization of aneurysms. *J Neurosurg*. 2011 Sep;115(3):624-32.
4. Spiotta AM, Wheeler AM, Smithason S, Hui F, Moskowitz S. Comparison of techniques for stent assisted coil embolization of aneurysms. *J Neurointerv Surg*. 2012 Sep;4(5):339-44.
5. Wajnberg E, de Souza JM, Marchiori E, Gasparetto EL. Single-center experience with the Neuroform stent for endovascular treatment of wide-necked intracranial aneurysms. *Surg Neurol*. 2009 Dec;72(6):612-9.