

The Interference Phenomenon of Microcatheters in the Jailing Treatment for Internal Carotid Artery Side Wall Aneurysms with an Open Cell Stent System

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Objective : Excelsior XT-27 (Stryker Neurovascular, Fremont, CA, USA) or Rebar 27 (eV3 Covidien, Irvine, CA, USA) microcatheters have recently been used to overcome the limitations of the Renegade Hi-Flo microcatheter such as interference between two microcatheters (one for stent delivery and the other for cerebral aneurysm coiling) during the jailing technique. We evaluated differences and influential factors related to the interference phenomenon according to these two microcatheters group.

Materials and Methods : Between June 2011 and September 2013, the jailing technique was applied to 94 internal cerebral artery (ICA) aneurysms. The jailing technique with the Neuroform EZ stent system was performed using Renegade (n = 22), Rebar (n = 35), and XT-27 microcatheters (n = 37). In the Renegade Hi-Flo microcatheter group, the jailing technique was successful in 19/22 patients (86.4%) and interference between the two microcatheters occurred in 6/21 patients (28.6%). In the Rebar and XT-27 microcatheter group, the jailing technique was successful in 71/72 patients (98.6%) and interference between the two microcatheters occurred in 1/72 patients (1.4%).

Results : There was a significant difference in the interference between the two delivered microcatheters group (p -value < 0.000) and the carotid siphon angle (p -value: 0.004) in the univariate analysis. In the multiple logistic regression analysis, the Rebar and XT-27 microcatheter group (odds ratio [OD] [95% confidence interval (CI)]; 31.277 [3.138-311.729], p -value: 0.003) and the carotid siphon angle (OD [95%CI]; 0.959 [0.922-0.997], p -value: 0.035) were found to be influential factors in the interference phenomenon.

Conclusion : The Rebar 27 and XT-27 microcatheters were more successful and exhibited less interference between the two microcatheters than the Renegade Hi-Flo microcatheter.

J Cerebrovasc Endovasc Neurosurg.
2016 December;18(4):363-368

Received : 22 March 2016

Revised : 1 September 2016

Accepted : 26 November 2016

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Keywords ICA, Open cell stent, Side wall aneurysm, Microcatheter

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INTRODUCTION

The Neuroform EZ stent system may represent a

good option for internal cerebral artery (ICA) sidewall aneurysms due to its good conformation to the vessel curvature, which results in delayed lower thromboembolism.^{2,3)} However, in real practice, the jailing technique using the Neuroform EZ stent system suffers a critical problem related to interference between the two microcatheters used for ICA sidewall aneurysms. In this scenario, the microcatheter that is inserted into the cerebral aneurysm is dislodged from its previous position by the transfer catheter used with the Renegade Hi-Flo microcatheter (Stryker Neurovascular, Watertown, MA, USA), which is positioned for stent deployment during advancement of the Neuroform EZ stent system. Such interference between microcatheters is common (28.6%) and results in the failure of the procedure or the requirement for additional steps to correct this problem.⁷⁾ In our series, the degree of interference between the two microcatheters was significantly different according to the tortuosity of the vessels and the Renegade Hi-Flo microcatheter itself. Recently, stainless steel braided microcatheters, such as the Excelsior XT-27 (Stryker Neurovascular, Fremont, CA, USA) and the Rebar 27 (ev3 Covidien, Irvine, CA, USA) have been widely used to increase the success rate and reduce the interference between two microcatheters, including the Renegade Hi-Flo microcatheter. We hypothesized that there would be no difference in inter-

ference between the two microcatheters according to the deliveries of each microcatheter. In this study, we compared the differences in interference and evaluated the influential factors between the two microcatheters according to each delivery microcatheter.

MATERIAL AND METHODS

Between June 2011 and September 2013, the jailing technique with the Neuroform stent was applied to 94 patients with 94 ICA sidewall aneurysms (n = 71, female; segment of paraclinoid; n = 78, segment of posterior communicating artery; n = 16) (Table 1). The median age was 56.0 years (mean \pm standard deviation, 56.5 \pm 1.1 years; range, 31-83 years). From June 2011 to December 2011, the Neuroform EZ stent system using the Renegade Hi-Flo microcatheter as the delivery catheter was applied to 22 ICA sidewall aneurysms. From May 2012 to September 2013, the Rebar 27 or XT-27 microcatheters were used as the delivery catheters for 72 ICA sidewall aneurysms (Rebar 27 microcatheter, n = 35; XT-27 microcatheter, n = 37). The aneurysms treated with the Neuroform EZ stent system were paraclinoid aneurysms (n = 78) and aneurysms in the posterior communicating artery segment (n = 16).

Without developing an initial plan for the coil em-

Table 1. Comparison of the demographic and aneurysmal characteristics of the Renegade Hi-Flo microcatheter (n = 22) and Rebar 27 or XT 27 microcatheter (n = 72) groups

	Renegade Hi-Flo microcatheter	Rebar 27 or XT 27 microcatheter	pvalue
Gender			0.537
Male	5	18	
Female	17	54	
Age (years)	56.7 \pm 8.8	56.5 \pm 11.1	0.949
Aneurysm location			0.547
Paraclinoid segment	18	60	
p-com segment	4	12	
Carotid siphon angle	75.8 \pm 30.0	84.3 \pm 30.0	0.223
Aneurysm height (mm)	3.6 \pm 1.3	3.7 \pm 1.7	0.667
Aneurysm neck size (mm)	3.2 \pm 0.8	3.7 \pm 1.6	0.179
Aneurysm width (mm)	3.6 \pm 1.1	4.5 \pm 2.3	0.015

Values are presented as number or mean \pm standard deviation

bolization, such as the 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 3 hours before the procedure and administered the same to patients with ruptured cerebral aneurysms immediately after the stent-assisted coiling procedure via a nasogastric tube. Anticoagulation was initiated by the injection of a bolus of 3,000 IU heparin (Green Cross Corp., Yongin, Korea) that was intravenously administered immediately after femoral puncture, followed by an hourly intermittent bolus injection of 1,000 IU heparin. Coil embolization was performed through a single femoral access in all cases with a 7F Guider guiding catheter (Boston Scientific, Natick, MA, USA). Typically, a partial coil packing of an aneurysm was performed to reduce the risk of an unexpected rupture of an aneurysm due to interference between the two microcatheters prior to the advancement of the Neuroform EZ stent delivery system into the delivery microcatheter (e.g., the Renegade Hi-Flo or Rebar or XT-27 microcatheter).

Interference between the two microcatheters was defined as the phenomenon in which the microcatheter that was inserted into the cerebral aneurysm was dislodged from its previous position by another microcatheter that was positioned for stent deployment during any step of the jailing technique. The carotid siphon angle was arbitrarily 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 statistical analyses were performed to evaluate factors that could affect the interference between the two microcatheters. The nominal data were analyzed using the χ^2 or Fisher's exact tests, and the numerical data were examined with Student's *t*-test or the Mann-Whitney *U* test as appropriate. A two-tailed *p* < 0.05 was defined as statistically significant. The influential factors regarding the interference between the two microcatheters were analyzed using multi-

variate logistic regression.

RESULTS

In the renegade Hi-Flo microcatheter group, we found that the jailing technique using the Neuroform EZ stent system was successful in 19/22 cerebral aneurysms (86.4%); however, the Renegade Hi-Flo microcatheter was well positioned in all of the lesions. The failure of the jailing technique using the Neuroform EZ stent system was evident in 3 lesions during the following steps of the procedure: 1) the Neuroform EZ stent delivery system failed to advance into the positioned Renegade Hi-Flo microcatheter; 2) the Excelsior SL-10 microcatheter, which had been navigated into the cerebral aneurysm, was dislodged from the cerebral aneurysm by the advancement of the Neuroform EZ stent system into the Renegade Hi-Flo microcatheter; and 3) the Excelsior SL-10 microcatheter failed to be navigated into the cerebral aneurysm after the Renegade Hi-Flo microcatheter had been positioned distal to the aneurysm. In the Rebar 27 and XT-27 microcatheter group, the jailing technique using the Neuroform EZ stent system was successful in 71 cerebral aneurysms and failed in 1 (1.4%). The failure of the jailing technique was due to dislodgement of the microcatheters from the aneurysm sacs after the deployment of Neuroform stents without interference between the two microcatheters. This factor was likely responsible for the unstable microcatheter positioning into the aneurysm.

In the Renegade Hi-Flo microcatheter group, interference between the two microcatheters occurred in 6 of the 21 cerebral aneurysms (28.6%). One lesion, into which a microcatheter was not inserted, was excluded. In all of these cases, the interference developed during the step in which the Neuroform EZ stent delivery system was advanced into the Renegade Hi-Flo microcatheter, regardless of which jailing technique was used. In the Rebar 27 and XT-27 microcatheter group, there was no interference between the two mi-

Table 2. Univariate analysis of the factors influencing the interference between the two microcatheters during the jailing technique using the Neuroform EZ stent system

	Presence of interference	Absence of interference	<i>p</i> -value
Carotid siphon angle	51.2 ± 27.6	85.4 ± 27.0	0.002
Delivery catheter			0.000
Renegade Hi-Flo	6	15	
Rebar 27 or XT 27	1	71	
Age of patients			0.707
> 60 years	2	32	
≤ 60 years	5	53	

Values are presented as number or mean ± standard deviation

croatheters with the exception of one lesion. In this case, interference between two microcatheters developed during the step in which the Neuroform EZ stent system was advanced into the XT-27 microcatheter.

In the Renegade Hi-Flo microcatheter group, procedural aneurysm rupture developed into two lesions (9.1%) that were stopped by further packing the coils. No other procedural complications, including thromboembolism, were observed. Our procedural morbidity and mortality rates were 9.1% and 0%, respectively. The procedural morbidity resulted in neurological deficits at discharge in none of the cases. In the Rebar 27 and XT-27 microcatheter group, the procedural morbidity, and mortality rates were 0% and 0%, respectively.

There were no significant differences in the demographic or aneurysmal characteristics between the Renegade Hi-Flo and the Rebar 27 or XT-27 microcatheter group, except the aneurysm width. In the univariate analysis, there were statistically significant differences in the interference between the two microcatheter groups according to the carotid siphon angle (*p*-value: 0.002) and the delivery microcatheters (*p*-val-

ue < 0.000) (Table 2). In the multiple logistic regression analysis, the stainless steel braided delivery microcatheter (odds ratio [OR] [95% confidence interval (CI)]; 31.277 [3.138-311.729], *p*-value: 0.003) and carotid siphon angle (OR [95%CI]; 0.959 [0.922-0.997], *p*-value: 0.035) were found to be influencing factors in the interference between the two microcatheters (Table 3).

DISCUSSION

The use of the Neuroform EZ stent system should be technically feasible for general use in the jailing treatment for ICA sidewall aneurysms despite the open cell stent system of the Neuroform EZ stent, which can result in reduced delays in thromboembolic complications compared to closed cell stent systems, such as the Enterprise stent system.⁵⁾ The technical feasibility of stent systems can be evaluated according to the ease of navigating the delivery microcatheter for stent deployment and the lack of interference between the two microcatheters during stent deployment.⁶⁾ Our previous study showed that the jailing technique using the Neuroform EZ stent sys-

Table 3. Multiple logistic regression analysis of the factors influencing the interference between the two microcatheters during the jailing technique using the Neuroform EZ stent system

Factors	Adjusted OR	Adjusted 95% CI	<i>p</i> -value
Carotid siphon angle	0.959	0.922-0.997	0.035
Rebar 27 or XT 27 microcatheter	32.277	3.138-311.729	0.003

OR = odds ratio; CI = confidence interval

tem was difficult to apply, particularly to cerebral aneurysms with acute carotid siphon angles.⁷⁾ The failure of the jailing technique using the Neuroform EZ stent system was attributed to the interference between the two microcatheters; the factors that influenced this interference were the Renegade microcatheter itself and the carotid siphon angle.¹⁾ The microcatheter is a technical factor that can be modified, whereas the carotid siphon angle is an anatomical factor that cannot be modified. Based on our results, we suggest that stainless steel braided microcatheters, such as the Rebar 27 and XT-27 microcatheter, may be more technically feasible than the Renegade Hi-Flo microcatheter.

In the Renegade Hi-Flo microcatheter group, the failure rate of the jailing technique was 13.6%, and the rate of interference between the two catheters was 28.6%. However, in the Rebar 27 and XT-27 microcatheter groups, the failure rate of the jailing technique and the rate of interference between the two microcatheters were 1.4% and 1.4%, respectively. However, there were no procedural morbidities or mortalities in the Rebar 27 and XT-27 microcatheter group. Therefore, the jailing technique with the Neuroform EZ stent system using the Rebar 27 or XT-27 microcatheter as a delivery catheter is more technically feasible and safe than with the use of the Renegade Hi-Flo microcatheter. Additionally, the procedural feasibility and safety of the Neuroform EZ stent system using the Rebar or XT-27 microcatheter was not lower than those of the closed cell stent systems, such as the Enterprise stent.¹⁴⁾ In the multiple logistic regression analysis, the stainless steel braided delivery microcatheter (OR [95%CI]; 31.277 [3.138-311.729], *p*-value: 0.003) and carotid siphon angle (OR [95%CI]; 0.959 [0.922-0.997], *p*-value: 0.035) were found to be influential in the interference between the two microcatheters. Based on the ORs of the microcatheter and carotid siphon angle, the microcatheter exerts a stronger influence on the interference between the two microcatheters. Because the braided characteristics of the delivery microcatheters are different, the Rebar 27 and XT-27 mi-

crocatheters, which are stainless steel and braided, may likely be more resistant to the crumpling of the inner lumen according to angulation than the Renegade Hi-Flo microcatheter, which is fiber braided. And then, the XT-27 microcatheter has a more supportive double helix winding reinforcement compared to the Renegade Hi-Flo microcatheter. This characteristic of the Rebar microcatheter and the XT-27 microcatheter results in less interference between the two microcatheters than with the Renegade microcatheter.

CONCLUSION

The jailing technique with the Neuroform EZ stent system using a Rebar 27 or XT-27 microcatheter may be safer and more feasible than that with the Renegade Hi-Flo microcatheter and may exhibit less interference phenomenon two microcatheters when applied to ICA sidewall aneurysms.

Disclosure

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

REFERENCES

1. Chen YA, Hussain M, Zhang JY, Zhang KP, Pang Q. Stent-assisted coiling of cerebral aneurysms using the Enterprise and the Solitaire devices. *Neurol Res.* 2014 May;36(5):461-7.
2. Heller RS, Malek AM. Parent vessel size and curvature strongly influence risk of incomplete stent apposition in enterprise intracranial aneurysm stent coiling. *ANJR 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. King B, Vaziri S, Singla A, Fargen KM, Mocco J. Clinical and angiographic outcomes after stent-assisted coiling of cerebral aneurysms with Enterprise and Neuroform stents: a comparative analysis of the literature. *J Neurointerv Surg.* 2015 Dec;7(12):905-9.
5. Mangubat EZ, Johnson AK, Keigher KM, Lopes DK. Initial experience with Neuroform EZ in the treatment of wide-neck cerebral aneurysms. *Neurointervention.* 2012

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- Feb;7(1):34-9.
6. 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.
 7. Yoon SG, Jin SC, Kim SH, Jeon KD, Kim DY, Lee SI, et al. Jailing technique using a catheter-based open-cell stent system in internal carotid artery sidewall aneurysms unfeasible to simple coiling. *J Cerebrovasc Endovasc Neurosurg.* 2013 Dec;15(4):293-8.