Permanent Stent Deployment for Preventing Vessel Reocclusion after Mechanical Thrombectomy in Acute Ischemic Stroke

Cheol Su Jwa¹, Jae Hoon Kim², Hee In Kang², In Seok Bae², Deok Ryeong Kim², Byung Gwan Moon²

¹Department of Neurosurgery, National Medical Center, Seoul,

²Department of Neurosurgery, Nowon Eulji Medical Center, Eulji University College of Medicine, Seoul, Republic of Korea

Corresponding author:

Jae Hoon Kim

Department of Neurosurgery,
Nowon Eulji Medical Center, Eulji
University College of Medicine,
68 Hangeulbiseok-ro, Nowon-gu,
Seoul 01830, Republic of Korea
Tel: +82-2-970-8268
Fax: +82-2-979-8268
E-mail: grimi2@eulji.ac.kr

Objective: To evaluate the efficacy of permanent stent deployment (SD) using a Solitaire retrieval stent for flow restoration in the reoccluded vessel after mechanical thrombectomy (MT). **Methods:** We retrospectively investigated 35 acute ischemic stroke patients treated by intra-arterial MT using a Solitaire retrieval stent between September 2013 and August 2016. We compared the recanalization rate and clinical outcome between the simple thrombectomy (ST) group and the permanent SD group. The degree of vessel recanalization was graded using the thrombolysis in cerebral infarction (TICI) grading system. The clinical outcomes were assessed using National Institute of Health Stroke Scale score and modified Rankin Scale (mRS) score at 3 months. **Results:** Ten of the 35 subjects were treated with permanent SD. The mean initial National Institute of Health Stroke Scale (NIHSS) score was 16.6 ± 4.7 in the ST group and 13.0 ± 4.9 in the SD group. The overall successful recanalization rate (TICI grade 2 or 3) was 84% in the ST group and 70% in the SD group ($p=0.381$). Procedure-related complications (symptomatic hemorrhage in 1 case, contrast media leakage in 2 cases) occurred in 3 ST patients during MT. There were no significant differences in favorable outcome (decrement of NIHSS score ≥ 4 after MT and mRS score 0-3 at 3 months) between the ST and SD groups ($p=0.377$ and 0.258 , respectively). **Conclusion:** Permanent SD as a rescue therapy shows high potential for flow restoration in the reoccluded vessel, especially when simple MT has failed.

Key Words: Ischemia; Stents; Stroke; Thrombectomy

Received: April 3, 2020
Revised: April 13, 2020
Accepted: April 20, 2020

INTRODUCTION

Restoration of cerebral blood flow within a short time is the key goal of acute ischemic stroke (AIS) therapy. Although Intravenous or intra-arterial thrombolytic has been shown to be effective for treatment of AIS, due to narrow therapeutic time window, contraindications, risk of symptomatic intracerebral hemorrhage (ICH) and low recanalization rates, endovascular treatment including mechanical thrombectomy (MT) has been widely used as an effective treatment tool for recanalization as it can rapidly improve flow of occluded blood vessels, and promotes recovery of neurological function^{2,8,24}.

Several instruments have been used and developed for MT. In particular, MT using a self-expanding retrieval stent resulted in a higher recanalization rate^{7,23,25,27}. Nonetheless, MT using a retrieval stent fails to achieve recanalization in some cases. Recently, permanent stent deployment (SD) as a rescue therapy showed good recanalization rate and favorable outcomes in AIS^{1,3,4,13,14,16,18-20,26,28,29}. Therefore, in the present study we ex-

amined the efficacy of permanent SD to prevent reocclusion after MT with a retrieval stent, and to maintain recanalization state.

MATERIALS AND METHODS

From September 2013 to August 2016, 35 consecutive patients who underwent MT using a 4 or 6 mm Solitaire (Medtronic, Irvine, CA, USA) retrieval stent for AIS were included. The enrolled patients were divided into the simple thrombectomy (ST) group or the permanent SD group. We compared demographic data (sex and age), clinical data (hypertension, diabetes mellitus, atrial fibrillation, previous cerebrovascular and cardiovascular disease, initial National Institute of Health Stroke Scale (NIHSS) score, location of thrombus, and the use of intravenous recombinant tissue plasminogen activator and post-thrombectomy results (recanalization, ICH, post-thrombectomy NIHSS score, and modified Rankin Scale [mRS] score at 3 months) between the 2 groups. The degree of vessel recanalization

was graded using the thrombolysis in cerebral infarction (TICI) grading system. Successful recanalization was defined as TICI grade 2 or 3. Favorable outcomes were defined as: (1) decrement of NIHSS score ≥ 4 points; and (2) mRS score 0-3 at 3 months.

All MT interventions were performed under local anesthesia. Usually, a 6F Envoy (Codman, Raynham, MA, USA) guiding catheter was placed in the proximal internal carotid artery. Once the microguidewire crossed the occlusion site, Rebar (Medtronic) microcatheter was advanced over the microwire and navigated distal to the clot. The Solitaire stent was then deployed for 5 to 10 min. Under continuous aspiration through the guiding catheter, the stent was retrieved together with the microcatheter. This procedure was repeated 3 to 5 times to

achieve recanalization. When complete reocclusion, distal flow delay, and focal stenotic lesion were found after stent removal, we performed permanent SD. A glycoprotein IIb/IIIa inhibitor (Aggrastat; Merck & Co, Inc., Kenilworth, NJ, USA) was administered intravenously as a loading dose (0.4 mcg/kg) for 30 min, followed by continuous infusion for 24 hr (0.1 mcg/kg/min). Thereafter, dual anti-platelets (acetyl-salicylic acid 100 mg and clopidogrel 75 mg) were given orally.

All continuous variables are presented as the mean $\pm$ standard deviation. We used the Mann-Whitney U test for continuous variables and the Fisher's exact test for categorical variables. A 2-tailed value of $p \leq 0.05$ was considered statistically significant. All statistical analyses were performed using statistical software (SPSS 20.0 for Windows; SPSS Inc., Chicago, IL, USA).

Table 1. Analysis of baseline characteristics of study population according to the thrombectomy method

	ST group (n=25)	SD group (n=10)	p-value
Sex			0.471
Male	14	4	
Female	11	6	
Age (years)	71.3 $\pm$ 8.1	70.4 $\pm$ 12.6	0.872
Hypertension			0.444
Yes	17	5	
No	8	5	
Diabetes mellitus			1.000
Yes	8	3	
No	17	7	
Atrial fibrillation			0.151
Yes	17	4	
No	8	6	
Cardiovascular disease			0.303
Yes	4	0	
No	21	10	
Cerebrovascular disease			1.000
Yes	6	2	
No	19	8	
Initial NIHSS score	16.6 $\pm$ 4.7	13.0 $\pm$ 4.9	0.059
Location of thrombus			0.387
M1	14	7	
M2	1	1	
ICA	10	2	
IV rtPA			0.444
Yes	8	5	
No	17	5	

The data is presented as number or mean $\pm$ standard deviation. ST: simple thrombectomy; SD: stent deployment; NIHSS: National Institute of Health Stroke Scale; M: middle cerebral artery; ICA: internal carotid artery; IV rtPA: intravenous recombinant tissue plasminogen activator.

RESULTS

The demographic and clinical characteristics of the patients are summarized in Table 1. Successful recanalization was achieved in 28 patients (80%) after MT. Ten of the 35 patients were treated with permanent SD. The mean initial NIHSS score was 16.6 $\pm$ 4.7 in the ST group and 13.0 $\pm$ 4.9 in the SD group. The overall successful recanalization rate (TICI grade 2 or 3) was 84% in the ST group and 70% in the SD group ($p=0.381$). Procedure-related complications (symptomatic ICH in 1 case, contrast media leakage in 2 cases) occurred in 3 ST patients during MT. The changes in NIHSS score after MT in each patient

Fig. 1. Dropline graph showing the changes of National Institute of Health Stroke Scale score in each patient before and after mechanical thrombectomy.

are shown in Fig. 1. There were no significant differences in favorable outcomes (decrement of NIHSS score ≥ 4 after MT and mRS score 0-3 at 3 months) between the ST and SD groups ($p=0.377$ and 0.258 , respectively) (Table 2). In subgroup analysis, the reasons for permanent SD in 10 patients were complete reocclusion ($n=4$), focal stenosis ($n=4$), proximal vessel tortuosity with imminent therapeutic window ($n=1$), and distal flow delay with focal stenosis ($n=1$) (Table 3).

DISCUSSION

The use of MT with a retrieval stent was recently reported to have excellent efficacy^{2,5-7,12,15,21-23,25,27}. Furthermore, the safety problems related to the procedure were lower or similar to those of other methods^{2,5,7,15,22,23,27}.

However, MT using a retrieval stent may fail in some patients, resulting in a significant increase in mortality¹¹. Because recanalization of the occluded vessel in AIS treatment is closely

related to good prognosis, recanalization of the occluded vessels is the most important factors for effective treatment^{8,24}.

Repeated MT using a retrieval stent can result in vessel injury, such as perforation or dissection, leading to a symptomatic ICH. Delayed stenosis or reocclusion may also occur due to vascular intimal injury^{9,10}. Furthermore, the migration of thromboembolic fragments may be problematic during retrieval using a stent, while some emboli may not be affected by the thrombolytic agent due to mature and fibrinous consistency, and MT may be difficult if the emboli are firmly attached to the vessel intima. In addition, in cases where a stenotic lesion contains an atherosclerotic plaque, recanalization using simple MT is often difficult.

Thus, permanent stent placement is considered as a rescue therapy when recanalization fails or MT is difficult. Indeed, recent studies have shown that permanent stent placement is effective method in treating AIS^{1,3,4,13,14,16,18-20,26,28,29}.

Permanent stent placement as a rescue therapy has several potential advantages. First, there is no need for multiple repetitive procedures, which allows rapid recanalization and is less likely to damage blood vessels. Second, recanalization can be achieved by compressing and fixing the thrombus to the vessel wall, even if a mature and fibrinous clot exists or a thrombus is strongly attached to the vessel wall. Third, even if there is a stenotic lesion containing an atherosclerotic plaque, recanalization with permanent stent placement is advantageous as it may slightly widen the vessel. Nevertheless, although there was no evidence of in-stent stenosis in patients at 6-month follow-up after permanent stent placement, there are some concerns such as late reocclusion and in-stent stenosis associated with permanent stent placement^{9,17}. Several studies have also reported increased tendency for bleeding because of dual antiplatelet medication after permanent stent placement^{16,19,20}. In this study, symptomatic ICH did not occur in SD group, but there was no statistical significance.

In our study, 35 patients with AIS were enrolled and 10 patients underwent permanent stent placement. It is reasonable to compare the usefulness of permanent SD as a rescue therapy in failed MT group. However, due to small sample size and the changes of MT protocol during study period, we did not directly compare ST group with SD group following failed MT. In subgroup analysis, permanent stent placement was effective, when focal stenosis or complete reocclusion was evident but the thrombus did not come out. In addition, higher rate of permanent SD compared with other studies may be attributed to

Table 2. Analysis of clinical outcomes according to the thrombectomy method

	ST group (n=25)	SD group (n=10)	p-value
Recanalization			0.381
Yes (TICI 2, 3)	21	7	
No (TICI 0, 1)	4	3	
Post-MT NIHSS score	15.3 $\pm$ 10.9	10.9 $\pm$ 11.2	0.131
Δ NIHSS score*	-1.3 $\pm$ 10.2	-2.1 $\pm$ 12.9	0.377
Post-MT hemorrhage			0.542
Yes	3	0	
No	22	10	
Immediate outcome			0.709
Favorable [†]	15	7	
Unfavorable [‡]	10	3	
mRS score at 3 months			0.258
0-3	7	5	
4-6	18	5	

The data is presented as number or mean $\pm$ standard deviation. ST: simple thrombectomy; SD: stent deployment; TICI: thrombolysis in cerebral infarction; MT: mechanical thrombectomy; NIHSS: National Institutes of Health Stroke Scale; mRS: modified Rankin Scale.

* Δ NIHSS score=Initial NIHSS score—Post-MT NIHSS score.

[†]Favorable: NIHSS score improvement ≥ 4 . [‡]Unfavorable: NIHSS score improvement <4 .

Table 3. Analysis of the reasons for permanent stent deployment in 10 patients

Reasons	n	Successful recanalization
Complete reocclusion	4	4
Focal stenosis	4	3
Tortuous proximal vessel with imminent therapeutic window	1	0
Distal flow delay with focal stenosis	1	0

the small sample size. Nevertheless, we found no differences in favorable outcome between the 2 groups, suggesting that the efficacy of permanent stent placement as a rescue therapy after failure of MT may equivalent to patients receiving simple MT.

Our study has several limitations. First, this study was limited by its retrospective nature and small sample size. Second, we did not perform permanent SD in the earlier period of study. During study period, MT protocol was changed to perform permanent SD based on consensus among attending physicians (neurologists and interventionists). Therefore, direct comparison of the degree of recanalization rate and clinical outcomes in this heterogenous group may confound our results. In addition, late reocclusion and in-stent thrombosis caused by permanent stent placement were not evaluated as the follow-up period was short.

CONCLUSION

Permanent SD showed high potential for flow restoration in the reoccluded vessel, especially when simple MT had failed. A long-term follow-up is required to verify the incidence of late complications.

Previous presentation: Oral presentation at Annual Meeting of Society of Korean Endovascular Neurosurgeons, 2016

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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