

## Experimental evaluation and training of stent clot retrieval: the confront clot scrambling method

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### ABSTRACT

The introduction of stent retrievers has changed the methods used for acute intracranial thrombectomy, but the training approach has not been discussed enough. We, therefore, aimed to establish a simple skill up method which can be used to train anytime and anywhere with low costs. Also, we introduce our experimental confront clot scrambling method (CCSM) which makes a profitable visualization in how the stent retriever works. The CCSM involved a sham clot set in the middle of a polyvinyl chloride tube, after which two stent retrievers were navigated from each side before being simultaneously withdrawn with the same force. The stent that removes the sham clot is determined to have stronger clot retrieval ability. Several adjunctive techniques were also compared. The push and fluff adjunctive technique was the most effective among all the stents. Generally, the former deployed stent was stronger than later one. Therefore, the later deployed stent with the push and fluff technique lets us know whether the physician's maneuver worked well or not. CCSM could directly evaluate the ability of adjunctive techniques with each stent retriever and demonstrate the physicians' skills. Because the actual endovascular clot retrieval requires extreme fine maneuvers against invisible vessels, repeat training is very important especially in beginners.

Keywords: acute ischemic stroke, endovascular treatment, experiment, stent clot retriever

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### INTRODUCTION

Fast recanalization is the most effective treatment for acute ischemic stroke due to major cerebral artery occlusion.<sup>1)</sup> Although intravenous thrombolysis with recombinant tissue plasminogen activator is the first-line treatment, it often fails when used in isolation.<sup>2)</sup> Therefore, endovascular approaches for acute ischemic stroke continue to evolve, and new stent retrieval devices now provide immediate restoration of cerebral blood flow. These devices are associated with faster recanalization and higher rates of success compared with previous devices.<sup>3-5)</sup> However, the optimal selection and sequence of stent devices, including the use of adjunctive techniques, is unclear.

In this experimental study, we evaluated the characteristics of currently available stent retrievers and adjunctive techniques and aimed at beginners' training using our confront clot scrambling method (CCSM).

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## METHODS

We evaluated all six standard stent retrievers (three brands) available in Japan as of December 2016. The analyzed stent retrievers are listed in Table 1, but broadly comprised the Trevo ProVue (Stryker, Kalamazoo, Michigan, USA; three sizes), Revive (Codman, Raynham, Massachusetts, USA; one size), and Solitaire 2 (Medtronic, Irvine, California, USA; two size).

**Table 1** List of stent retrievers evaluated in this study

Stent retriever	Size: nominal diameter × length (mm)
Trevo ProVue (Stryker, Kalamazoo, Michigan, USA)	3×20, 4×20, 6×25
Revive (Codman, Raynham, Massachusetts, USA)	4.5×22
Solitaire 2 (Medtronic, Irvine, California, USA)	4×20, 6×30

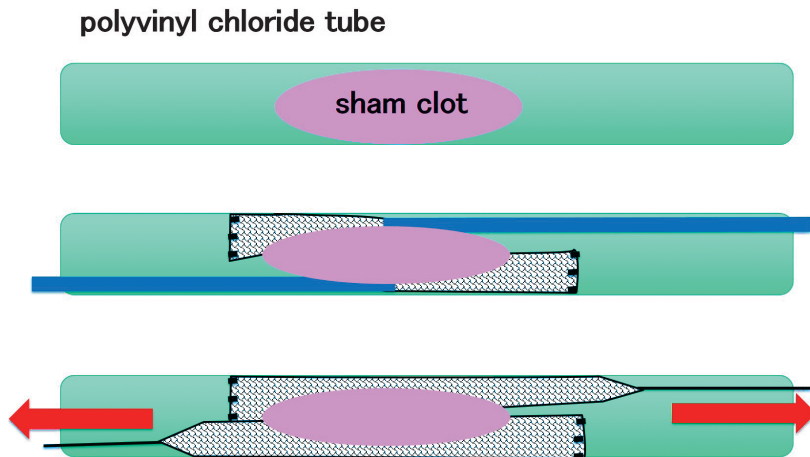
#### *Confront clot scrambling method*

This was an experimental study performed under dry conditions and at room temperature. Konjac was used as a fake thrombus in all experiments. It is a common Japanese food that is made from starch of taro, has a jelly-like consistency, and has a stable and uniform texture. A polyvinyl chloride tube ensuring 5 mm in diameter and 20 cm in length was used as the vascular model. The sham clot was then shaped to 15 mm in length and placed in the middle of the tube. Next, the two stent retrievers to be compared directly were navigated from each side to meet the sham clot. Then, both stents were simultaneously withdrawn with the same force from each end (Fig. 1). The stent that successfully removed the sham clot was determined to have stronger ability for clot retrieval (Fig. 2).

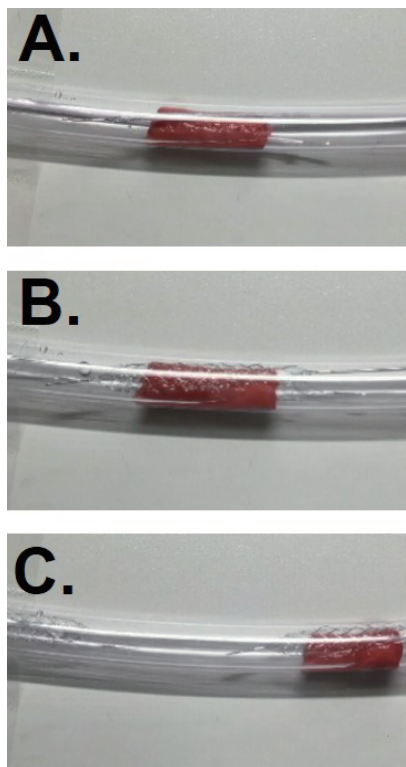
#### *Standard and adjunctive techniques*

We compared several adjunctive techniques per stent, as follows.

1. A standard technique group: standard stent deployment involved positioning a stent retriever across the clot and simply unsheathing it by retracting the delivery microcatheter while immobilizing the microwire.
2. A 5 min waiting group: After deployment of a single stent, that stent was kept with the sham clot for 5 min and warmed by gentle finger contact from outside the tube until retrieval.
3. A 5 s steam group: We further investigated the effect of heat by heating one stent with steam from an electric kettle for 5 s just before delivery and deployment.
4. A push and fluff group: Haussen DC *et al.*<sup>6)</sup> have reported an innovative technique that employs a continued push on the delivery wire to maximize stent expansion during deployment. This technique optimizes wall apposition and cell size/configuration, resulting in higher chances of first-pass reperfusion, fewer passes, better complete reperfusion rates, and better clinical outcomes.



**Fig. 1** Schematic drawing of the confront clot scrambling method showing A sham clot is set in the middle of the tube. Two stent retrievers are then navigated from each side to confront the clot, before each stent is simultaneously withdrawn with the same speed from each end.



**Fig. 2** Photographs of the confront clot scrambling method showing with two Revive device (A) The state before stent deployment. (B) The state after stent deployment. The left sided Revive was deployed as usual, while the right one was deployed with the push and fluff technique. (C) When the both stents were withdrawn with the same speed from each end, the clot was taken by the right Revive device.

## RESULTS

The results of CCSM are shown in Table 2 for the different stent retrievers. Waiting for 5 min after stent deployment was more effective than simple deployment with immediate retrieval for all three stents. Steam for 5 s just before stent delivery was also more effective than the simple technique. When comparing these two groups, waiting for 5 min was preferable to using steam, but the use of the push and fluff technique improved the strength of all retrieval devices most.

Generally, the former deployed stent was stronger than later one. On the other hand, the push and fluff technique was depended on physician's skill. Therefore, the later deployed stent with the push and fluff technique lets us know whether the physician's maneuver worked well or not.

## DISCUSSION

The use of a stent clot retriever for mechanical thrombectomy in case of acute major arterial occlusion has been shown to achieve faster recanalization, more often, and with better outcomes when compared with internal treatments.<sup>7-8)</sup> In two large-scale randomized controlled trials, successful recanalization was reportedly achieved in 79.6% of patients, compared with 49% using the Merci retriever system, indicating the markedly higher efficacy stent clot retrieval devices.<sup>3,9)</sup> Some innovative adjunctive techniques have also recently been developed, such as the push and fluff technique,<sup>6)</sup> with other authors reporting success when using several devices of different sizes.<sup>10)</sup>

Using CCSM, we found several interesting results. First, in all cases, waiting for 5 min after stent deployment was more effective than standard deployment with immediate retrieval. We then wondered if the advantage of waiting was caused by the self-expanding time, body temperature, or both. Secondly, we confirmed that steam for 5 s just before stent delivery was more effective than the standard technique alone, and that heat was favorably associated with better outcomes. Thirdly, we found that the 5 min waiting time was superior to the use of steam heating. Consequently, we thought that longer deployment was probably most advantageous. Fourth, we found that the push and fluff technique added more strength as an adjunctive technique when comparing likewise devices. The push and fluff technique is an established adjunctive technique for closed-cell stents, but we found that it was also effective with the Solitaire stent, which employs a rolled sheet design. In our study, there was no unintentional stent detachment due to forced pushing.

As mentioned above, the former deployed stent was stronger than later one. On the other hand, the push and fluff technique was dependent upon physician's skill. Therefore, the later deployed stent with the push and fluff technique let us know physician's skills. We could evaluate a degree of dilatation of the stent under the direct view. When the pushing force was too strong, the stent was bent or slipped away distally. Because the actual endovascular clot retrieval requires extreme fine maneuvering against invisible vessels, repeat trainings are very important especially in beginners. Generally, the *in vitro* training of neuro endovascular intervention is difficult. For instance, coil embolization and liquid injection cannot be practiced using a simple equipment. In contrast, this CCSM can be performed repeatedly anywhere and anytime using low cost equipments.

A limitation of this study is that CCSM was not performed in a real world setting, and that we cannot explain how much, or indeed whether, our method can be generalized to the clinical setting. We should therefore evaluate other various vascular models and sham clots in the future. Further studies are essential to confirm these initial findings and assess these possibilities.

## Confront clot scrambling method

**Table 2** Results of confront clot scrambling method with stent retrievers

	<b>stent 1</b>	adjunctive	versus	adjunctive	<b>stent 2</b>	
×	Trevo 4×20	none		5 min	Trevo 4×20	○
×	Trevo 4×20	none		steam 5s	Trevo 4×20	○
×	Trevo 4×20	none		P &F	Trevo 4×20	○
○	Trevo 4×20	5 min		steam 5s	Trevo 4×20	×
×	Trevo 4×20	5 min		P & F	Trevo 4×20	○
×	Trevo 3×20	none		P & F	Trevo 3×20	○
×	Trevo 6×25	none		P & F	Trevo 6×25	○
×	Revive 4.5×22	none		5 min	Revive 4.5×22	○
×	Revive 4.5×22	none		steam 5s	Revive 4.5×22	○
×	Revive 4.5×22	none		5 min	Revive 4.5×22	○
○	Revive 4.5×22	5 min		steam 5s	Revive 4.5×22	×
×	Revive 4.5×22	5 min		P & F	Revive 4.5×22	○
×	Solitaire 4×20	none		5 min	Solitaire 4×20	○
×	Solitaire 4×20	none		steam 5s	Solitaire 4×20	○
×	Solitaire 4×20	none		P & F	Solitaire 4×20	○
○	Solitaire 4×20	5 min		steam 5s	Solitaire 4×20	×
×	Solitaire 4×20	5 min		P & F	Solitaire 4×20	○
×	Solitaire 6×30	none		P & F	Solitaire 6×30	○

Abbreviation: P &amp; F, push and fluff

## CONCLUSIONS

In this study, we used CCSM to perform one-to-one competitive analyses of the relative abilities of stent retrievers to capture clots. We are not aware of any other research covering this specific topic in the literature. Although the push and fluff technique was the most effective adjunctive technique, it depended on the physician's skills. However, these are preliminary findings in a model with several important limitations. Further investigations are therefore required to increase our understanding of optimal devices and adjunctive techniques.

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