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Comparison of the Tigertriever and Self-expanding Stent Retrievers for Mechanical Thrombectomy of Acute Ischemic Stroke: A Single-center Experience

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Abstract

Stent retrievers, including the novel Tigertriever, are important in mechanical thrombectomy for acute ischemic stroke due to a proximal large-vessel occlusion within the anterior circulation. We aimed to assess the efficacy and safety of the Tigertriever compared to self-expanding stent retrievers like EmboTrap, Solitaire, Trevo, or Tron. Patients treated at a stroke center for intracranial vessel occlusion in the anterior circulation between August 2022 and August 2024 were evaluated. The primary outcome was a modified first-pass effect, defined as a modified thrombolysis in cerebral infarction grade of 2b-3 after the first pass. Secondary outcomes included the first-pass effect, device-related serious adverse events, embolization in new territory, and hemorrhagic complications within 24 hours post-procedure. Data from 104 hemispheres in 103 patients were analyzed (24 in the Tigertriever group and 80 in the stent-retriever group). The Tigertriever group demonstrated a higher modified first-pass effect (70.8% vs. 52.5%; adjusted odds ratio 3.17; 95% confidence interval 1.06-9.47; p = 0.02). Although not statistically significant, vessel dissection (0% vs. 3.8%), subarachnoid hemorrhage (20.8% vs. 32.5%), and symptomatic intracranial hemorrhage (4.2% vs. 12.5%) within 24 hours post-procedure were lower in the Tigertriever group. No significant differences were observed in the first-pass effect or embolization in the new territory between the 2 groups. The Tigertriever might be effective for anterior circulation intracranial vessel occlusion, achieving a higher rate of modified first-pass effect. It might also be associated with minimal serious procedural complications, indicating its safety profile.

Keywords: acute ischemic stroke, large-vessel occlusion, stent-retriever, manually adjustable Tigertriever, recanalization rate

Introduction

Mechanical thrombectomy (MT) is the standard treatment for acute ischemic stroke due to a proximal large-vessel occlusion within the anterior circulation. Much of the evidence for MT has been established through stent retrievers (SRs).[1,2] Several SRs have been developed and refined over time.

Earlier SRs are made from laser-cut nitinol tubes that are heat-set to a predetermined pattern. Upon deployment from a microcatheter, they expand to their original shape, allowing the stent to adapt to the vessel. The structure and radial force of each device are fixed. The Tigertriever (Rapid Medical, Yokneam, Israel) introduces a novel SR design enabling manual control over diameter and radial force during MT.

In the Multicenter TIGER trial,[3] the Tigertriever demonstrated high efficacy and safety compared with other devices for thrombus removal in patients with large-vessel occlusive stroke. In Japan, Tigertriever has been available since December 2023, but reports on its use remain limited.

We present early treatment outcomes of the Tigertriever compared directly with patients treated using self-

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expanding SRs from a single-center retrospective analysis.

Materials and Methods

Data collection and definitions

Patients treated at our stroke center for intracranial vessel occlusion stroke using Tigertriever or self-expanding SRs, including EmboTrap (Johnson & Johnson MedTech, New Brunswick, NJ, USA), Solitaire (Medtronic, Minneapolis, MN, USA), Trevo (Stryker, Potage, MI, USA) or Tron (JIMRO, Gunma, Japan) between August 2022 and August 2024 were included in the study, following the Fourth and Fifth Edition Guidelines for MT in Japan by the Japan Stroke Society, the Japan Neurosurgical Society, and the Japanese Society for Neuroendovascular Therapy.[4]

The eligibility criteria were 1) MT performed within 24 hours from symptom onset or last known well, 2) anterior circulation occlusions (intracranial internal carotid artery [ICA], middle cerebral artery [MCA] segment 1 [M1], or MCA segment 2 [M2]), 3) patients treated with SR as the first-line thrombectomy device, with first pass using SR alone or combined with an aspiration catheter, excluding first pass with an aspiration catheter or angioplasty balloon.

Eligible patients received intravenous recombinant tissue plasminogen activator (rt-PA; 0.6 mg/kg) according to the Guidelines for Intravenous Thrombolysis (Recombinant Tissue-type Plasminogen Activator), the Third Edition: A Guideline from the Japan Stroke Society.[5]

The institutional review board at Hyogo Medical University (approval number 4815) waived the requirement for written informed consent as the study used clinical data from routine practice, approved in accordance with the Ethical Guidelines for Medical and Health Research Involving Human Subjects in Japan.

Clinical data were collected at our hospital through chart review or by contacting patients or relatives. Periprocedural data and clinical outcomes of both patient groups were retrospectively analyzed. Variables included age, sex as documented in the medical record, pre-onset modified Rankin scale (mRS) score,[6] medical history, prior medication, National Institutes of Health Stroke Scale (NIHSS) score on admission, imaging studies, use of intravenous rt-PA, and onset-to-reperfusion time. Imaging studies assessed ischemic volume on admission using the Alberta Stroke Programme Early computed tomography (CT) Score (ASPECTS) and identified the occluded vessel. We evaluated ASPECTS using non-contrast CT (NCCT) and defined each patient's ASPECTS based on NCCT.[7] The degree of recanalization by MT was classified using the modified thrombolysis in cerebral infarction (mTICI) grading system[8] based on digital subtraction angiography findings post-MT. Vessel occlusion etiology was classified as cardiogenic embolism, other embolic sources (e.g., paradoxical embolism, artery-to-artery embolism, Trousseau syndrome, cryptogenic), or intracranial atherosclerotic disease. NCCT was routinely performed immediately post-MT, and NCCT or magnetic resonance imaging was conducted 7 ± 1 days after MT. Hemorrhagic complications were assessed, including any intracranial hemorrhage such as subarachnoid hemorrhage (SAH) and hemorrhagic transformation. Hemorrhagic transformation was classified according to the European Cooperative Acute Stroke Study II classification, defining symptomatic intracranial hemorrhage as an NIHSS increase of ≥4 points.[9]

Outcomes

The primary outcome of this study was a modified first-pass effect (mFPE), defined as an mTICI grade of 2b-3 after the first pass.

Secondary efficacy outcomes included (1) first-pass effect (FPE), defined as mTICI grade 3 after the first pass;[10] (2) effective recanalization defined as an mTICI grade of 2b-3 after the final pass.

Secondary safety outcomes included (1) serious device-related adverse events, such as vessel perforation and dissection; (2) embolization in a new territory; (3) subarachnoid hemorrhage within 24 hours of MT; (4) symptomatic intracranial hemorrhage within 24 hours of MT, defined as an NIHSS increase of ≥4 points.

Functional outcomes were the rate of patients achieving an mRS score of 0-2, 0-1, and 6 at 90 days after MT.

Statistical analysis

Outcomes were compared between the Tigertriever and self-expanding SR groups. Continuous variables are expressed as means and standard deviations, while categorical variables are presented as frequencies and percentages. Continuous variables were compared using the Student's t-test or Wilcoxon rank-sum test, and categorical variables were assessed using the chi-squared test.

Crude and adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were estimated for the Tigertriever group compared to the self-expanding SR group using a multivariable logistic regression model, adjusted for age, diameter of the occluded vessel,[11] site of main occlusion (internal carotid artery, M1/M2 segment of the middle cerebral artery),[12] stroke etiology (cardioembolic, other embolic source, or intracranial atherosclerotic disease [ICAD]),[13] and rt-PA use.[14]

Subgroup analyses were performed for significant primary or secondary outcomes using multivariate logistic regression models with the same adjusters to estimate adjusted ORs and interaction p-values.

All statistical analyses were conducted using JMP Pro 17 (SAS Institute Inc., Cary, NC, USA). Two-sided tests were used, with $p < 0.05$ considered statistically significant.

Endovascular treatment

MT was performed under local anesthesia using a bi-

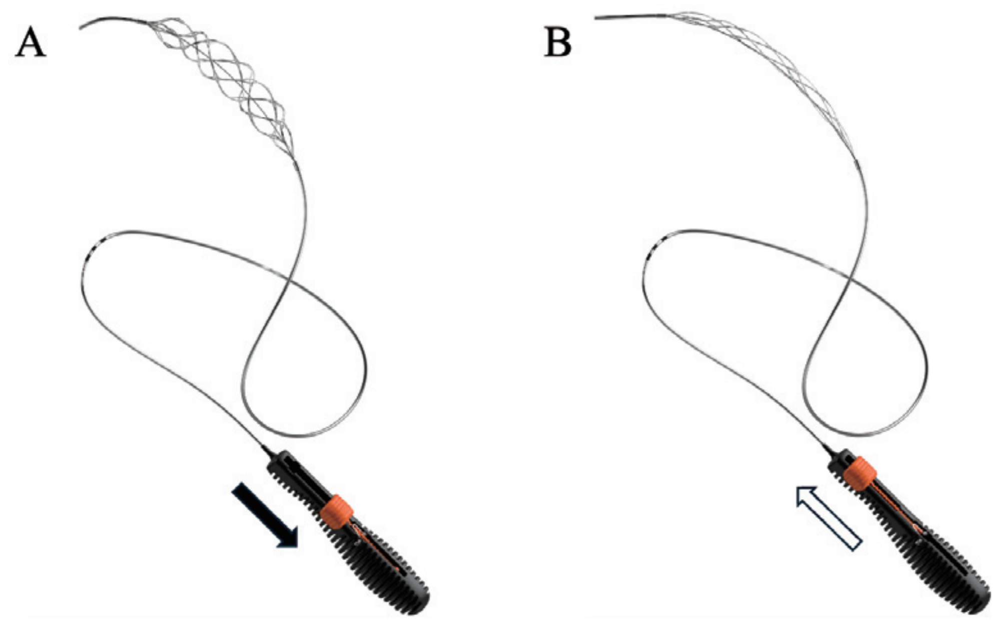


Fig. 1 The structure of the Tigertriever device.
The Tigertriever device can be expanded (A) by pulling the integrated handle slider forward (black arrow) and contracted (B) by pushing the integrated handle slider back to its original position (white arrow).

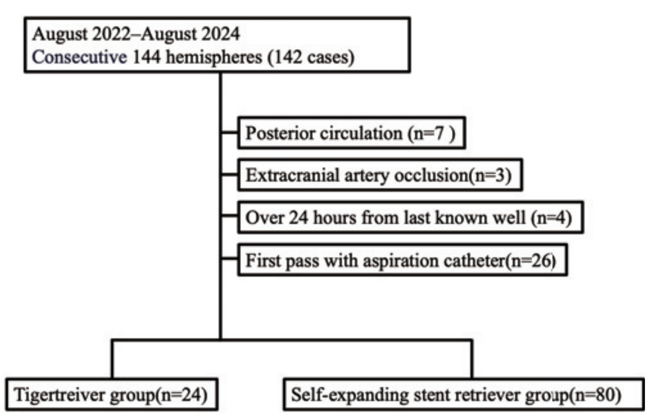


Fig. 2 Study flow chart.

plane or monoplane flat-panel digital subtraction angiography unit. An 8-F or 9-F sheath was placed in the right femoral artery, and an 8-F or 9-F balloon guide catheter was navigated to the target vessel using a 6-F inner catheter. After diagnostic angiography via the balloon guide catheter, a roadmap was created, and a 0.021" microcatheter with a 0.014" microwire was navigated beyond the occlusion site. The operator selected a stent-retriever—EmboTrap, Solitaire, Trevo, Tigertriever, or Tron—to perform a thrombectomy. The stent-retriever was deployed to cover the occlusion site effectively. In the self-expanding stent-retriever group, the operator waited 1-2 min for thrombus integration with the stent-retriever mesh.

The Tigertriever features a braided design with nitinol wires containing a tantalum core and opens when an operator manipulates a handheld slider connected to a control wire fixed at the distal end (Fig. 1). In the Tigertriever group, device expansion was adjusted based on vessel diameter, and the massage technique (repetitive inflation-deflation) was used to engage the thrombus.[15] If strong friction with the vessel wall occurred during retrieval, the Tigertriever was deflated until the friction eased. All procedures incorporated a combined stent-retriever and aspiration catheter technique. Rescue therapy included other MT devices, balloon angioplasty, or intracranial stenting at the operator's discretion.

Results

Patient characteristics

Of the 144 initially enrolled hemispheres (142 patients), 40 were excluded (posterior circulation [n = 7]; extracranial vessel occlusion [n = 3]; >24 hours from last known well [n = 4]; first pass with aspiration catheter [n = 26]). Data from 104 hemispheres (24 in the Tigertriever group and 80 in the self-expanding SR group) were analyzed (Fig. 2). The self-expanding SRs used included EmboTrap (51.6%), Solitaire (11.1%), Trevo (11.1%), and Tron (7.9%). The mean age did not differ significantly between the Tigertriever and self-expanding SR groups (81.1 vs. 79.2 years; p = 0.50). Medical history differences were not significant between the groups. The use of rt-PA prior to MT was also comparable (20.8% vs. 22.5%; p = 0.86). Occlusion sites did not differ significantly (ICA: 20.8% vs. 20.0%, M1: 33.3% vs. 45.0%, M2: 45.8% vs. 35.0%; p = 0.55). Left-sided lesions were more frequent in the self-expanding SR group

(29.2% vs. 52.5%; p = 0.04). The occluded vessel diameter was 2.0 ± 0.5 mm in the Tigertriever group and 2.1 ± 0.6 mm in the self-expanding SR group (p = 0.64). Etiology of vessel occlusion was similar between groups (cardioembolic: 66.7% vs. 55.0%; other embolic source: 12.5% vs. 33.8%; ICAD: 20.8% vs. 11.3%; p = 0.09). Rescue device use was observed in 7 hemispheres (29.1%) in the Tigertriever group and 18 hemispheres (22.5%) in the self-expanding SR group (p = 0.50). Additional balloon angioplasty for ICAD was applied in 4 of 5 hemispheres (80.0%) in the Tigertriever group and 5 of 9 hemispheres (55.6%) in the self-expanding SR group (p = 0.58). Hemorrhagic transformation within 7 days post-MT showed no significant differences between groups (none: 41.7% vs. 36.3%, HI1: 41.7% vs. 26.3%, HI2: 12.5% vs. 23.8%, PH1: 0% vs. 5.0%, PH2: 4.2% vs. 8.8%; p = 0.45) (Table 1).

Outcomes

Primary outcome

The mFPE, defined as an mTICI grade of 2b-3 after the first pass, was significantly higher in the Tigertriever group compared to the self-expanding SR group (70.8% vs. 52.5%; adjusted OR 3.17; 95% CI 1.06-9.47; p = 0.02) (Table 2).

Secondary efficacy outcome

The FPE, defined as mTICI grade 3 after the first pass, did not differ significantly between the Tigertriever and self-expanding SR groups (29.2% vs. 31.3%; adjusted OR 0.91; 95% CI 0.31-2.70; p = 0.29) (Table 2). Effective recanalization after the final pass was 100% in the Tigertriever group and 92.5% in the self-expanding SR group.

Secondary safety outcome

Vessel perforation was 0% in the Tigertriever group and 3.8% in the self-expanding SR group. Vessel dissection was also 0% in the Tigertriever group and 3.8% in the self-expanding SR group; both outcomes had CIs spanning negative to positive values, reflecting estimate instability. Embolism in a new territory was similar between the groups (12.5% vs. 8.8%; adjusted OR 1.55; 95% CI 0.33-7.27; p = 0.92) (Table 2). SAH within 24 hours post-procedure did not differ significantly (20.8% vs. 32.5%; adjusted OR 0.52; 95% CI 0.16-1.71; p = 0.14). Symptomatic intracranial hemorrhage within 24 hours of MT was also comparable (4.2% vs. 12.5%; adjusted OR 0.24; 95% CI 0.03-2.28; p = 0.16) (Table 2).

Functional outcome

Figure 3 shows the distribution of mRS at 90 days after MT. There were no statistically significant differences between the Tigertriever and self-expanding SR groups in the following functional outcomes; mRS score of 0-2, 0-1, and 6 at 90 days after MT (Table 2).

Subgroup analyses

The mFPE-in the Tigertriever group was generally higher than in the self-expanding SR group across all subgroups except for the rt-PA use subgroup (Fig. 4). The incidence of mFPE was significantly higher in the Tigertriever group for patients aged ≥75 years and those with an occluded vessel diameter <2 mm compared to the corresponding self-expanding SR subgroups. The interaction p-value was not significant among any subgroup (Fig. 4).

Discussion

In this study, we compared the performance of the manually adjustable Tigertriever with 4 self-expanding SRs (EmboTrap, Solitaire, Trevo, and Tron). Over the 2-year study period, first-line use of Tigertriever for intracranial vessel occlusion in the anterior circulation was significantly associated with better mFPE. While there were no significant differences in the rate of FPE or effective recanalization after the final pass between the Tigertriever and self-expanding SR groups, incidences of serious device-related adverse events, embolization in new territory, SAH within 24 hours post-MT, and symptomatic intracranial hemorrhage were comparable between the groups. Our study also revealed that there were no statistically significant differences in the distribution of mRS at 90 days after adjusting the cofounder including age, diameter of the occluded vessel, site of main occlusion, stroke etiology, and rt-PA use.

The TIGER trial protocol[3] suggested that after controlled expansion, the device should be relaxed and retrieved after approximately 2 mins. Now, experienced operators[16] recommend using the repetitive inflation-deflation technique to massage the clot.[15] Several prior studies on first-pass effective recanalization rates for first-line Tigertriever use reported rates ranging from 37.7% to 50%.[15,17,18] Our higher rate of 70.8% could be due to the repetitive inflation-deflation technique combined with balloon guide catheter use as a standard.[19] However, FPE rates were not significantly different between groups. The number of Tigertriever handle clicks was operator-dependent and often unrecorded. Studies suggest that larger SRs enable more effective procedures with fewer passages and higher FPE than smaller SRs.[20,21] In cases where few handle clicks were used, Tigertriever performance may have been suboptimal. Jankowitz[16] highlighted optimal maximum expansion at a 90° angle at the device's apex.

Studies on the relationship between vessel diameter and effective recanalization. Mönch et al.[22] reported no difference between large- and small-vessel diameter, while Saber et al.[11] reported a superior effective recanalization with a smaller vessel diameter than a large one. The recent introduction of medium-vessel occlusion-specific SRs may have changed the results. Based on the result of subgroup

Table 1 Patient characteristics

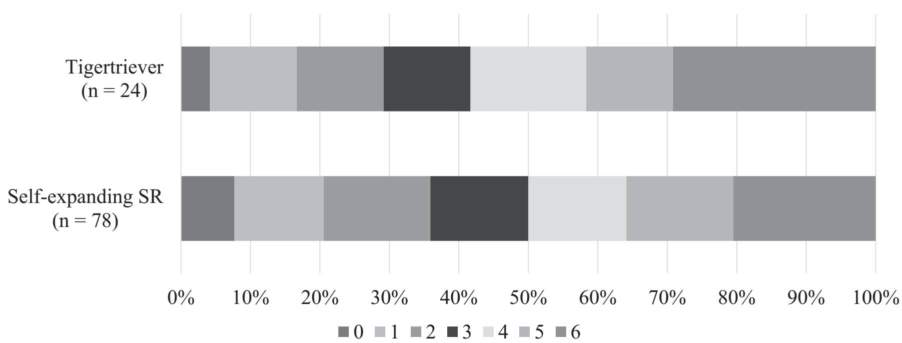
	Tigertriever (n=24)	Self-expanding retriever (n=80)	p-value
Baseline demographics and medical history			
Age (years), mean (SD)	81.1 (10.3)	79.2 (12.8)	0.50
Men, n (%)	11 (45.8)	36 (45.0)	0.94
Medical history			
Hypertension, n (%)	19 (79.2)	67 (83.8)	0.60
Diabetes mellitus, n (%)	8 (33.3)	15 (18.8)	0.13
Hyperlipemia, n (%)	10 (41.7)	41 (51.3)	0.41
Atrial fibrillation, n (%)	15 (62.5)	46 (57.5)	0.66
Malignancy, n (%)	6 (25)	19 (23.8)	0.90
Coronary artery disease, n (%)	1 (4.2)	7 (8.8)	0.68
Previous ischemic stroke, n (%)	3 (12.5)	17 (21.2)	0.55
Current smoking, n (%)	5 (20.8)	6 (7.5)	0.06
Antiplatelets, n (%)	1 (4.2)	17 (21.3)	0.07
Anticoagulants, n (%)	8 (33.3)	18 (22.5)	0.28
Current stroke event			
NIHSS score on admission, median (IQR)	17 (8-25)	16 (9-24)	0.96
CT ASPECTS, median (IQR)	7 (6-9)	8 (5-9)	0.70
Diameter of occluded artery (mm), mean (SD)	2.0 (0.5)	2.1 (0.6)	0.64
Pre-stroke modified Rankin Scale score, n (%):			0.21
0	9 (37.5)	32 (40.0)	
1	1 (4.2)	13 (16.3)	
2	1 (4.2)	9 (11.3)	
3	5 (20.8)	14 (17.5)	
>3	8 (33.3)	12 (15.0)	
Intravenous recombinant tissue plasminogen activator, n (%)	5 (20.8)	18 (22.5)	0.86
Occlusion site, n (%):			0.55
ICA	5 (20.8)	16 (20.0)	
M1	8 (33.3)	36 (45.0)	
M2	11 (45.8)	28 (35.0)	
Tandem lesion	2 (10.4)	8 (11.1)	0.70
Occlusion side: Left, n (%)	7 (29.2)	42 (52.5)	0.04
Etiology, n (%):			0.09
Cardiogenic embolism	16 (66.7)	44 (55.0)	
Embolism of other sources	3 (12.5)	27 (33.8)	
Intracranial atherosclerotic disease	5 (20.8)	9 (11.3)	
Last known well to puncture time (min), median, IQR	411 (304-644)	370 (237-596)	0.89
Hemorrhagic transformation within 7 days, n (%):			0.45
None	10 (41.7)	29 (36.3)	
HI1	10 (41.7)	21 (26.3)	
HI2	3 (12.5)	19 (23.8)	
PH1	0 (0)	4 (5.0)	
PH2	1 (4.2)	7 (8.8)	

Abbreviation; NIHSS, National Institutes of Health Stroke Scale; IQR, Interquartile range; CT, Computed Tomography; ASPECTS, Alberta Stroke Program Early CT Score; SD, standard deviation; ICA, Internal carotid artery

Table 2 Outcomes

	Tigertriever Group (n=24)	Self-expanding stent retriever (n=80)	Crude OR (95% CI)	P Value	Adjusted OR (95% CI)	P Value
Efficacy outcomes	n=24	n=80				
Successful first pass recanalization mTICI 2B/3, n (%)	17 (70.8)	42 (52.5)	2.20 (0.82-5.88)	0.11	3.17 (1.06-9.47)	0.02
Successful first pass recanalization mTICI 3, n (%)	7 (29.2)	25 (31.3)	0.91 (0.33-2.46)	0.85	0.91 (0.31-2.70)	0.29
Successful final pass recanalization mTICI 2B/3, n (%)	24 (100)	74 (92.5)	NA	NA	NA	NA
Safety outcome	n=24	n=80				
Perforation, n (%)	0 (0)	3 (3.8)	NA	NA	NA	NA
Dissection, n (%)	0 (0)	3 (3.8)	NA	NA	NA	NA
Embolism in new territory, n (%)	3 (12.5)	7 (8.8)	1.49 (0.35-6.27)	0.59	1.55 (0.33-7.27)	0.92
Subarachnoid hemorrhage, n (%)	5 (20.8)	26 (32.5)	0.55 (0.18-1.63)	0.26	0.52 (0.16-1.71)	0.14
Symptomatic intracranial hemorrhage, n (%)	1 (4.2)	10 (12.5)	0.30 (0.04-2.51)	0.20	0.24 (0.03-2.28)	0.16
Functional outcome	n=24	n=78				
mRS 0-2 at 90 days, n (%)	7 (29.2)	28 (35.9)	0.74 (0.27-1.99)	0.54	0.59 (0.17-2.02)	0.40
mRS 0-1 at 90 days, n (%)	4 (16.7)	16 (20.5)	0.78 (0.23-2.59)	0.68	0.73 (0.16-3.29)	0.68
mRS 6 at 90 days, n (%)	7 (29.2)	16 (20.5)	1.60 (0.57-4.50)	0.38	1.63 (0.44-6.01)	0.46

mTICI, modified thrombolysis in cerebral infarction; OR, odd ratio; CI, confidential interval



	mRS at 90 days	0	1	2	3	4	5	6
Tigertriever (n = 24)	n (%)	6 (7.7)	10 (12.8)	12 (15.4)	11 (14.1)	11 (14.1)	12 (15.4)	16 (20.5)
Self-expanding SR (n = 78)	n (%)	1 (4.2)	3 (12.5)	3 (12.5)	3 (12.5)	4 (16.7)	3 (12.5)	7 (29.2)

Fig. 3 Distribution of mRS at 90 days after mechanical thrombectomy.
mRS: modified Rankin scale

analysis in our study, it suggests that the Tigertriever has a superior mFPE for occluded vessels <2 mm. Although device-related intracranial hemorrhage and dissection are concerns with small-diameter vessels, the incidence of dissection, SAH, and symptomatic intracranial hemorrhage within 24 hours post-MT was lower in the Tigertriever group, without statistical significance. This may indicate that the Tigertriever's deflation technique, when encountering resistance, is not a decisive factor in reducing such complications.

Age has not significantly impacted recanalization rates or procedure times in previous studies.[23] However, our findings suggest higher mFPE in older patients aged 75 years with the Tigertriever. This, combined with its safety profile, might make the Tigertriever a beneficial option for MT in older adults.

Limitations

This study had a retrospective design in a single center and included a small number of patients, leading to several limitations that must be considered when interpreting the findings. First, the control group of self-expanding SRs included 4 different SRs due to the relatively small number of individual stent cases. Each of these stents has distinct

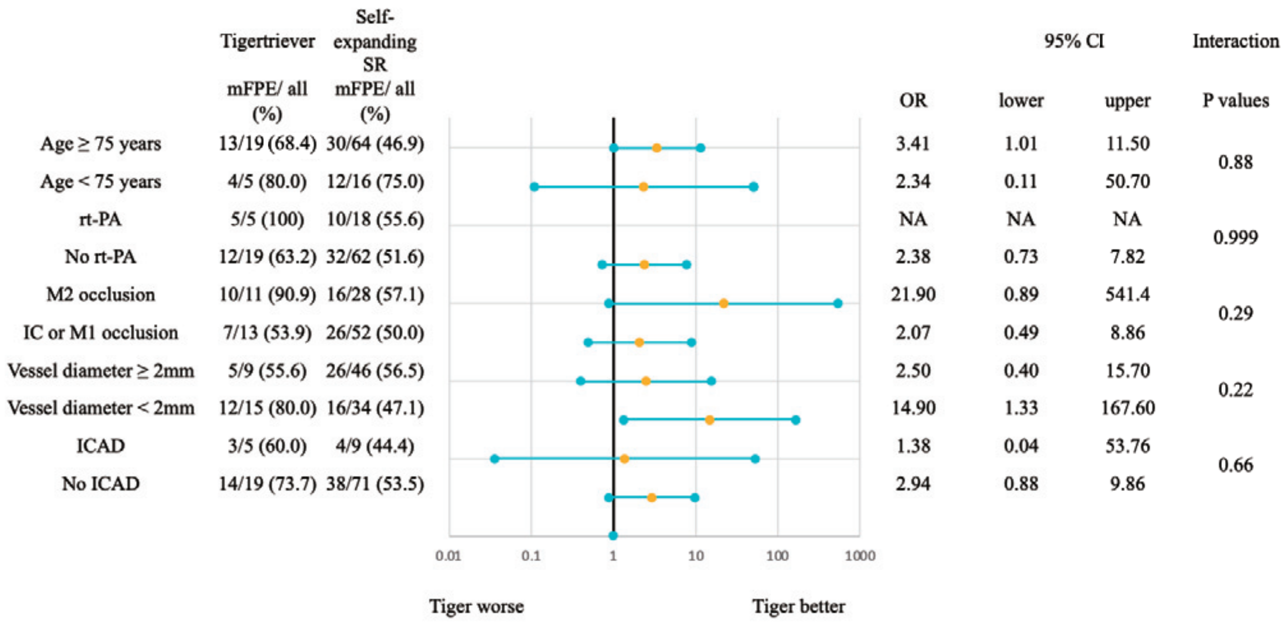


Fig. 4 Forest plots for mFPE, defined as an mTICI grade of 2b-3 after the first pass.
CI: confidential interval; ICAD: intracranial atherosclerotic disease; mFPE: modified first-pass effect; mTICI: modified thrombolysis in cerebral infarction; OR: odd ratio; rt-PA: recombinant tissue plasminogen activator

structures that could have influenced the outcomes. Second, only short-term perioperative outcomes of the SRs were evaluated, and long-term follow-up in the Tigertriever group was inadequate; therefore, differences in long-term outcomes at 90 days could not be assessed. Third, the study was conducted in Japan, where the ratios of risk factors and etiologies for ischemic stroke may differ from those in other countries.[24] Thus, caution should be exercised when generalizing these findings to other geographical regions.

Conflicts of Interest Disclosure

All authors have no conflict of interest.

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