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ORIGINAL ARTICLE

One-year single-center experience with the Aperio thrombectomy device in large vessel occlusion in the anterior circulation: safety, efficacy, and clinical outcome

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Abstract

Background and purpose The Aperio thrombectomy device (Aperio) is a stent retriever designed to achieve rapid and substantial flow restoration in acute ischemic stroke due to large-vessel occlusions (LVOs). We evaluated the safety and efficacy of the Aperio device and compared it with published data of established stent retrievers.

Methods We retrospectively analyzed institutional data of consecutive stroke procedures in patients with LVO in the anterior circulation that were treated between January 2017 and December 2017 with the Aperio. Reperfusion rate regarding to the extended thrombolysis in cerebral infarction scale (eTICI), procedural times, early clinical outcome, and complications were documented.

Results Eighty-two patients were treated by using the Aperio in LVO in the anterior circulation. Median age was 77 (± 12) years (w = 59.8%). Median Baseline National Institutes of Health Stroke Scale (NIHSS) score was 14. Fifty-three (64.6%) patients received intravenous thrombolysis. Successful recanalization (eTICI≥2b) was achieved in 85.3%. Mean time from groin puncture to final recanalization was 52.3 ± 34.8 min. Embolization to new territories occurred in one case. Symptomatic intracranial hemorrhage within 24 h was observed in six patients (7.3%). Twenty-eight (41.2%) out of 68 patients available for assessment of functional outcome at 3 months achieved favorable outcome (mRS 0–2).

Conclusion The Aperio stent retriever mechanical thrombectomy device demonstrated high rates of successful reperfusion and a good safety profile in patients with acute ischemic stroke due to LVO in the anterior circulation.

Keywords Ischemic stroke · M1 segment occlusion · Aperio thrombectomy device · Thrombectomy · Clinical outcome

Introduction

Major acute ischemic stroke trials have demonstrated the clinical benefit and superior reperfusion efficacy of endovascular therapy using stent retriever thrombectomy devices compared to medical treatment [1–4]. Presently, stent retrievers are considered as the standard of care for treatment of acute ischemic stroke secondary to large-vessel occlusion [5]. The first-generation devices for thrombectomy (TE) included the Merci Retriever system (Stryker, Kalamazoo, MI, USA) and the Penumbra aspiration system (Penumbra Inc., Alameda, CA, USA). Second-generation treatment devices included modern endovascular stent retrieval devices, such as the Solitaire (ev3/Covidien, Irvine, CA, USA) and the Trevo (Stryker), which demonstrated high rates of successful recanalization and good neurological outcome. The purpose of this single-center case series was to evaluate the technical effectiveness of the Aperio device in achieving revascularization of anterior circulation large-vessel occlusions (LVOs) in comparison with the results of the major stent retriever trials.

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Material and methods

Our study was approved by our hospital's institutional review board. We retrospectively analyzed our institutional neurointerventional database to examine the radiological and clinical outcomes in all consecutive patients with LVO in the anterior circulation who were treated with TE using the Aperio stent retriever between January 2017 and December 2017. Patients were informed about the approach, benefits, and risks of the planned procedure in the emergency setting, and the informed consent was obtained prior to intervention. The current cohort is part of a larger study group in which written informed consent for retrospective data analysis was obtained from all patients or their next of kin. When patients passed away during hospitalization, the requirement for written informed consent was waived.

Inclusion criteria

The study enrolled adults with occlusion of the M1 segment of the middle cerebral artery (MCA), tandem occlusion (internal carotid artery (ICA) and carotid-T or ICA and M1/M2 occlusion), proximal M2 segment occlusion, carotid T-occlusion, and intracranial ICA occlusion receiving stent retriever thrombectomy as first-line endovascular treatment; no age limit, no baseline National Institutes of Health Stroke Scale (NIHSS) score limit at admission, and no time limit from symptom onset to treatment were applied to restrict study inclusion. Standardized stroke imaging at our institution included non-contrast-enhanced cranial computed tomography (NECCT), CT perfusion (CTP), and CT angiography (CTA). If the time from symptom onset to admission was uncertain, patients were scanned with magnetic resonance imaging (MRI), applying diffusion-weighted imaging (DWI), MR perfusion scanning, and fluid-attenuated inversion recovery (FLAIR) image to discern between salvageable and terminally infarcted tissue. Patients received intravenous thrombolysis (IVT), if eligible, according to the guidelines of the German Society of Neurology. Extensive early ischemic signs or hemorrhage were excluded in pre-interventional imaging by CT or MRI on a case-by-case basis. Treatment of patients was not restricted in regard to ASPECTS. Eligibility for thrombectomy, as established in CTA or TOF-MRA, was determined individually for each patient in consensus between neurologists and neurointerventionalists. The decision is primarily based on the infarct-core/penumbra mismatch, stroke severity, estimated procedural risk, probability of recanalization by IVT, contraindication for IVT, comorbidities, and social and medical pre-stroke conditions. Exclusion criteria were intracranial hemorrhage.

Interventional procedure

The interventional procedures were performed under analgesia (1–2 g novaminsulfone as short infusion) and local anesthesia of the groin. General anesthesia was performed in patients with Glasgow coma scale < 8 or in case of extreme agitation. After local anesthesia of the groin, access was performed using a long 8F sheath or additional guiding catheter positioned in the distal ICA. Stent retriever thrombectomy (Aperio 4.5 × 40 mm, 4.5 × 30 mm, or 3.5 × 28 mm) combined with local thromboaspiration via 5F or 6F intracranial intermediate catheter (SOFIA®, MicroVention, Düsseldorf, Germany) at the proximal occlusion site was performed. After passing the clot with a 0.014 microwire, a microcatheter was advanced beyond the distal end of the clot and the position was verified by angiographic control run via the microcatheter. The Aperio was advanced through the microcatheter until its distal markers were lined up beyond the occlusion. The aim was an overlap of the stent retriever and the clot to catch the lost embolic fragments. The Aperio was deployed by withdrawing the microcatheter by gently pushing the stent retriever to improve expansion into the clot. Subsequently, the stent retriever was removed into the intracranial intermediate catheter under manual local aspiration via a 20-ml syringe (termed the Solumbra technique) [6]. A resistance during retraction of the stent retriever into the intermediate catheter (IMC) indicated a mismatch between clot size and lumen of the IMC. In these cases, the entire assembly (IMC and stent retriever with the trapped clot as one unit) was locked and carefully withdrawn under continuous distal and proximal manual aspiration into the long 8F sheath or guiding catheter referring to the currently described SAVE technique [7]. Biplane follow-up angiograms were performed to document final revascularization results. In case of persistent thrombus, the procedure was repeated. Arterial puncture sites were closed by vascular closure devices (Angio-Seal™, Terumo, Tokyo, Japan).

The time from symptom onset to stroke imaging, to groin puncture, and to recanalization was captured. Devices and medication used during the interventional procedures, the duration, and intraprocedural complications were evaluated from the treatment protocols. After the intervention, patients were admitted to the stroke unit of our hospital and treated according to in-house standard operating procedures.

Device description

The Aperio thrombectomy device (Aperio; Acandis, Pforzheim, Germany) is a further innovative self-expanding thrombectomy device with a hybrid cell design aiming to facilitate a good vessel wall apposition, clot interaction, and efficient clot retention. The repeating functional segments allow adapting the working length to the thrombus length with retained functionality also in tortuous vessels (Fig. 1). The

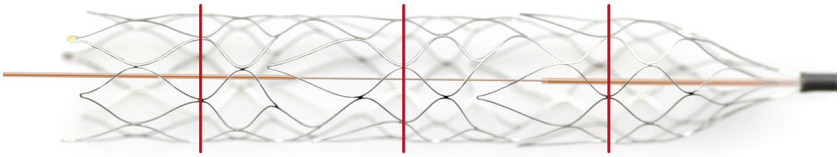

Fig. 1 The Aperio device. Photograph (with kind permission of Acandis). Functional segment (between red lines): small closed cells, large open cells; repeating functional segments allowing adaption of working length to thrombus length

device has two wire markers to support the positioning of the device and three distal device markers to indicate the distal device end and the grade of expansion under fluoroscopy (Fig. 2).

Imaging data

The location of the occlusion was assessed on CT or MR angiographic images. Collateral supply of the occluded MCA territory from pre-interventional CTA scans was scored based on collateral grading system of Tan et al. on a scale of 0–3 [8]. Pretreatment cerebral infarction, according to the Alberta Stroke Program Early CT score (ASPECTS), was assessed by CCT or according to the DWI-ASPECTS by MRI. Posttreatment ASPECTS and intracerebral hemorrhage (ICH), according to the European Cooperative Acute Stroke Study classification (ECASS: not space occupying hemorrhagic infarction (HI1, HI2), space occupying parenchymal hematoma (PH1, PH2)) [9], were assessed by follow-up imaging CCT that was routinely performed 6–24 h after treatment.

Clinical and angiographic assessment, complications

For each patient, a neurological examination was performed at admission by the attending neurologist in the emergency department, including detailed assessment of NIHSS, modified Rankin Scale (mRS) scores. Postinterventional NIHSS and mRS were assessed by the treating neurologist at discharge. mRS at 3-month follow-up was assessed by a standardized telephone interview by one investigator (D.W.). The time from symptom onset to start of angiography (groin puncture) and the time to final recanalization (TTFR) were captured. Angiographic outcome was graded by the extended thrombolysis in cerebral infarction scale (eTICI, in the following abbreviated as TICI) that includes TICI 2c grade referring to near complete perfusion except for slow flow in a few distal cortical vessels, or presence of small distal cortical emboli [10, 11]. Revascularization success was evaluated independently by two experienced neuroradiologists (MGK and JC) in a blinded imaging reading. In case of differing results, consensus reading was performed. Number of device passes to successful recanalization (TICI≥2b) and grade of revascularization TICI 2b, TICI 2c, and TICI 3 after first device pass (FP) were obtained. Complications such as embolization in a previously uninvolved territory on angiogram (embolization to new territories (ENT)), symptomatic intracranial hemorrhage (sICH), and procedure-related mortality rate were assessed.

Results

In 97 stroke patients with the predefined occlusion patterns of the anterior circulation a mechanical TE was performed between January 2017 and December 2017 with ICA occlusion in 3 (3.1%), carotid-T in 2 (2.1%), M1 in 63 (64.9%), tandem occlusion in 14 (14.4%), and proximal M2 segment occlusion in 15 (15.5%). Of 97 patients, 82 (85.6%) underwent TE using the Aperio stent retriever. Detailed occlusion patterns of patients that were treated with the Aperio are given in Table 1. First-line intention to treat (ITT) with the Aperio stent retriever was in 88 patients. There were 6 cases of first-line ITT with the Aperio in that the device was not deployed. In one patient, after extracranial carotid stent deployment, intracranial occlusion of

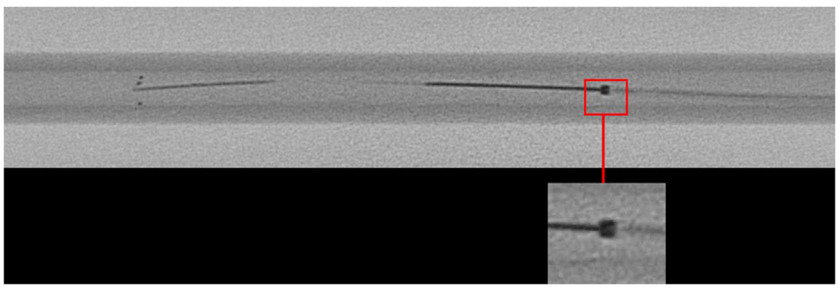

Fig. 2 Fluoroscopy image of the complete released Aperio device (with kind permission of Acandis). Visible parts from proximal to distal are (1) tip of the microcatheter (red frame); (2) + (3) proximal and distal transport wire marker makes total length visible; (4) three distal device markers indicating complete expansion

Table 1 Baseline data, angiographic results, clinical outcome, and complications

	Overall patients treated with Aperio	Patients with follow-up	Patients without follow-up	Patients with failed intention to treat with Aperio
Sample size	*n* = 82 patients	*n* = 68 patients	*n* = 14 patients	*n* = 6 patients
Age (mean ± SD)	77 ± 12	76 ± 12	78 ± 14	75 ± 12
Sex (*n*)	w = 49, m = 33	w = 43, m = 25	w = 6, m = 8	w = 3, m = 3
Medical history, *n* (%)				
Hypertension	66 (80.5)	54 (79.4)	12 (85.7)	5 (83.3)
Diabetes mellitus	22 (26.8)	19 (27.9)	3 (21.4)	0 (0)
Atrial fibrillation	49 (59.8)	40 (58.8)	9 (64.3)	1 (16.7)
Dyslipidemia	37 (45.1)	30 (44.1)	7 (50)	4 (66.7)
Smoking	17 (20.7)	15 (22.1)	2 (14.3)	1 (16.7)
Previous ischemic stroke/transient ischemic attack	14 (17.1)	11 (16.2)	3 (21.4)	0 (0)
IVT	53 (64.6)	42 (61.8)	11 (78.6)	6 (100)
NIHSS pre, median	14	14	14	7
mRS pre, median	5	5	5	5
Prestroke imaging				
CTA-collateral score (0–3), median	1	1	1	2
ICA occlusion, *n* (%), right/left	0 (0)/1 (1.2)	0 (0)/1 (1.5)	0 (0)/0 (0)	0 (0)/1 (16.7)
Carotid T-occlusion n(%), right/left	1 (1.2)/1 (1.2)	1 (1.5)/1 (1.5)	0 (0)/0 (0)	0 (0)/0 (0)
M1-occlusion, *n* (%), right/left	29 (35.4)/33 (40.2)	27 (39.7)/26 (38.2)	2 (14.3)/7 (50)	0 (0)/0 (0)
Tandem (ICA + carotid-T/M1/M2) occlusion, *n* (%), right/left	5 (6.1)/4 (4.9)	5 (7.4)/4 (5.9)	0 (0)/0 (0)	4 (66.7)/0 (0)
Proximal M2 occlusion, *n* (%), right/left	3 (4.7)/5 (6.1)	0 (0)/3 (4.4)	3 (21.4)/2 (14.3)	0 (0)/1 (16.7)
ASPECTS, median	10 (range 6–10)	10 (range 6–10)	10 (range 7–10)	10 (range 10–10)
Procedural data				
Onset to groin puncture (min), mean ± SD	204.9 ± 94.3	211.9 ± 105.3	190 ± 68.7	111.0 ± 45.5
Time from groin puncture to final recanalization (min), mean ± SD	52.3 ± 34.8	47.9 ± 35.5	65.6 ± 32.8	47.3 ± 16.3
Number of passes, mean ± SD	2.6 ± 1.7	2.6 ± 1.7	2.8 ± 1.4	NA
Number of device passes to TICI 2b-3 recanalization, median (range)	2 (1–6)	2 (1–6)	2 (1–4)	NA
Rate of recanalization after stent retriever first pass:				
TICI 2b, *n* (%)	22 (26.8)	18 (26.5)	5 (35.7)	NA
TICI 2c, *n* (%)	4 (4.9)	4 (5.9)	0 (0)	NA
TICI 3, *n* (%)	10 (12.2)	8 (11.8)	2 (14.3)	NA
IA tPA, *n* (%)	25 (30.5)	22 (32.4)	3 (21.4)	2 (33.3)
Final angiographic and postprocedural imaging outcomes				
TICI 0, *n* (%)	3 (3.7)	2 (2.9)	1 (7.1)	2 (33.3)
TICI 2a, *n* (%)	9 (11)	8 (11.8)	1 (7.1)	1 (16.7)
TICI 2b, *n* (%)	25 (30.5)	21 (30.9)	4 (28.6)	2 (33.3)
TICI 2c, *n* (%)	18 (21.9)	19 (27.9)	0 (0)	0 (0)
TICI 3, *n* (%)	27 (32.9)	18 (26.5)	8 (57.1)	1 (16.7)
ASPECTS, median	6	6	6	8
Clinical outcome				
Mortality (30 days), *n* (%)	14 (17.1)	14 (20.5)	NA	2 (33.3)
3-month mRS (median)	3	3	NA	6 (*n* = 5 patients available for follow-up)
n of patients (%) of mRS $\leq$ 2 (at 3-month follow-up)	28 (34.1)	28 (41.2)	NA	2 (40.0)
n (%) mRS 0	11 (13.4)	11 (16.2)	NA	1 (20.0)
n (%) mRS 1	9 (11.0)	9 (13.2)	NA	1 (20.0)

Table 1 (continued)

	Overall patients treated with Aperio	Patients with follow-up	Patients without follow-up	Patients with failed intention to treat with Aperio
n (%) mRS 2	8 (9.8)	8 (11.8)	NA	0 (0)
n (%) mRS 3	6 (7.3)	6 (8.9)	NA	0 (0)
n (%) mRS 4	13 (15.9)	13 (19.1)	NA	0 (0)
n (%) mRS 5	6 (7.3)	6 (8.8)	NA	0 (0)
Mortality (3-month), *n* (%) mRS 6	15 (18.3)	15 (22.1)	NA	3 (60.0)
Complications				
Emboli to new territories (ENT), *n* (%)	1 (1.2)	1(1.5)	0 (0)	0 (0)
sICH within 24 h, *n* (%)	6 (7.3) (PH Typ2)	4(5.9) (PH Typ2)	1 (7.1) (PH Typ2)	0 (0)
Serious adverse device events, *n* (%)	0 (0)	0(0)	0 (0)	NA
Procedure-related serious adverse events, *n* (%)	0 (0)	0(0)	0 (0)	NA

NA not available

M1 was already recanalized; in two patients with tandem occlusion, ICA was occluded over a long distance and aspiration TE was performed as FP, resulting in full recanalization of ICA and M1 segment occlusion; and in two patients (one ICA occlusion, one M2 occlusion), TE had to be terminated because supra-aortal access failed due to anatomic and technically reasons. In one patient, Aperio was not deployable because of kinking of the M2 segment with small diameter. In one case, a solitaire stent retriever was used for FP and in another case, an ERIC stent retriever for FP of M1 segment occlusions; in both cases, choice of the device used was at the discretion of the operator.

In seven patients, sole aspiration was intended and performed as FP, in one patient due to a long-segment extra- and intracranial ICA occlusion without M1 occlusion, and in six patients with M2 occlusions due to the curved vessel anatomy with small vessel diameter.

Fifty-three patients (64.6%) of the stent retriever group received intravenous tissue plasminogen activator (IVT) prior to endovascular procedure. Mean age of the patients was 77 years (SD ± 12); 59.8% were women. Median baseline NIHSS was 14, and median pretreatment mRS was 5. Baseline median ASPECTS was 10, and median collateral score was 1. The mean time from symptom onset to groin puncture was 204.9 ± 94.3 min (Table 1).

There were no noticeable differences in the baseline data of the medical history between patients with 3-month follow-up (FU) compared to patients without FU with exception of a higher IVT rate in patients without FU (78.6% vs. 61.8%). Prestroke imaging revealed higher M1 occlusion rates in patients in the FU group than in patients without FU (77.9% vs. 64.3%), but proximal M2 occlusion was markedly higher in patients without FU (35.7% vs. 4.4%). Overall baseline median collateral score was 1.

Technical success

Major revascularization (TICI≥2b) was achieved in 85.3%. Detailed final and FP TICI recanalization grade is summarized in Table 1. Cohen's kappa demonstrated a high interrater reliability for TICI scoring (kappa 0.9422). Overall mean time to final recanalization (TTFR) proceeding from femoral access to final revascularization was 52.3 ± 34.8 min. Median ASPECTS after treatment was 6. Mean of stent retriever passes was 2.6. FP final recanalization (TICI2b-3) was achieved in 43.9% (36/82). In all cases, the Aperio was the first-line stent retriever device without using more than one stent retriever device. Aperio devices with a size of 4.5 × 40 mm were used in 42 patients, 4.5 × 30 mm in 37 patients, and of 3.5 × 28 mm in 3 patients.

Median of device passes to TICI 2b/3 revascularization was 2. IA tPA rate was higher in patients with follow-up examination compared to those without (32.4% vs. 21.4%). Final TICI≥2b rate was comparable in patients with and without available FU (85.3% vs. 85.7%), but patients without FU demonstrate a markedly higher rate of TICI 3 revascularization (57.1% vs. 26.5%). Final TICI≥2c was achieved in 54.9%. The posttreatment median ASPECTS was 6 (Table 1).

Clinical outcome and complications

Out of 82 patients, 68 (82.9%) were available for a follow-up after 3 months. A favorable clinical outcome according to the mRS scale (mRS 0–2) was achieved in 41.2% (28/68) patients (Table 1). Overall early mortality was 17% (14/82). Overall mortality after 3 months was 22.1% (15/68). There was no procedure-related death. Postprocedure sICH due to hemorrhagic infarction occurred in six patients (7.3%). Asymptomatic hemorrhagic transformation or parenchymal hematoma (HI1, HI2, PH1) was observed in 15 patients

(18.3%) and asymptomatic SAH in 6 patients (7.3%). Embolization of previously unaffected territories by fragmented or lost clots was observed in one case (1.2%). In one patient, bleeding due to perforation of the right femoral communicating artery after groin puncture occurred. Temporary balloon occlusion resulted in a successful hemostasis without occurrence of clinical complications. The overall rate of sICH was 7.3%. Patients with failed ITT had a high rate of good clinical outcome (66.6%, [2/6]) despite a low rate of favorable recanalization rates (TICI≥2b = 50%) due to bias from the small sample size.

Discussion

The aim of this single-center trial was to evaluate efficacy, safety, and clinical outcome of treatment with the Aperio thrombectomy device in stroke patients with LVO in the anterior circulation. In this retrospective, single-center trial, the Aperio achieved high rates of reperfusion among patients with LVO in the anterior circulation, with substantial reperfusion (85% TICI2≥b) that is remarkably higher as compared with the HERMES (71% TICI2≥b) and SEER (77% TICI2≥2b) individual patient data pooled analyses and in line with results of the current ASTER stent retriever arm (83% TICI2≥2b) [12–14]. The DAWN trial, and TRACK Registry in which Trevo devices were used, reported TICI≥2b recanalization in 84% and 80% of patients, respectively (Table 2) [15, 16]. In a recent retrospective single-center study, Yi et al. compared the Trevo stent retriever and the Solitaire stent retriever in 200 patients receiving neurothrombectomy. Rates of successful recanalization (TICI2≥2b) in the Solitaire group were 82.3% vs. 89.7 in the Trevo group [17]. Rates of successful recanalization in our study were also comparable with the reported rates (84.6%) of a recent core laboratory-audited single-center experience evaluating the performance of the EmboTrap [18].

The rate of excellent final reperfusion (TICI≥2c) achieved in 54.8% of the cases in the present study is superior to the outcome data of excellent reperfusion (TICI3) in the Trevo2 [19] trial (14%), and Trevo and Solitaire device retrospective registries (TRACK [16], 45%, and SEER [13], 36%, respectively) and is comparable with the stent retriever arm of the ASTER trial (56.6% achieving final TICI≥2c) [14]. First-pass complete recanalization rates of the EmboTrap in the recently published ARISEII trial (51.5% TICI≥2b, 40.1% TICI≥2c) were higher than in our study [20]. Use of a balloon guiding catheter (BGC) was reported with a rate of 47.3% in the TRACK registry [16]. However, compared to TRACK, we achieved a higher rate of near complete to TICI3 revascularization (54.9%) using a local lesional aspiration technique omitting a BGC. Mean number of passes was 2.6 and in line with results from nonrandomized trials for Trevo (mean 2.1, IQR 1–6) and Solitaire (mean 2.9, IQR 1–8) [17]. In no case more than one Aperio device was used due to lack of success with the initial one. Rescue maneuvers were not required.

There is only one non-trial case series available that evaluated the Aperio device in a clinical setting. One hundred nineteen patients from nine centers, where 42% had the occlusion site in the M1 segment, were treated. Rates of TICI2b-3 of 71% were slightly inferior to the present study, but rates of

Table 2 Clinical and angiographic outcome of selected randomized major stent retriever trials

Study	Endovascular treatment (*n*)	Device	Baseline NIHSS (Median)	TICI2b-3 (%)	%mRS ≤ 2	Mortality (%)	sICH (%)
MR Clean [1]	233	Various	17	59	33	19	8
ESCAPE [12]	165	Solitaire	17	76	52	10	4
REVASCAT [12]	103	Solitaire	17	66	44	18	2
SWIFT Prime [12]	98	Solitaire	17	88	60	12	0
EXTEND-IA [12]	35	Solitaire	15	86	71	7	0
HERMES [12]	634	Various	17	71	46	15	4
ENDOSTROKE [22]*	309	Various	16	77	41	27	15
NASA [23]	354	Solitaire	18.1#	72.5	42	30.2	9.9
TREVOII [19]	88	Trevo	19	68	40	29	4
ASTER [14] (stent retriever arm)	189	Various	16.1#	83	50	33	7
DAWN [15]	107	Trevo	17	84	49	19	6
Current study	82	Aperio	14	85.3	41.2	22.1	7.3

*Number of patients for whom TICI scoring was available

Mean value

TICI3 recanalization were achieved in 53% of patients and favorable comparable to our cohort. The reported rate of stent retriever passes (median 2, range 1–6) was similar to the present study [21]. The rate of 3-month favorable clinical outcome (mRS 0–2) achieved in 41.2% of our patient sample was comparable to Endostroke Registry [22] (41%), NASA Registry [23] (42%), Trevo2 [19] (40%), and HERMES [12] (46%). The rate of favorable outcome was also comparable to the reported results of the Solitaire group (mRS 0–2, 42.1%) in a current published non-trial stent retriever case series [17]. Higher rates of 3-month favorable outcome for the anterior circulation are reported in the TRACK [16] Registry for the Trevo devices with a rate of 51.4%. The SEER [13] meta-analysis for Solitaire devices (54%) and a recent non-trial study for the EmboTrap device reported 3-month mRS rates of 54% and 52.8%, respectively [18]. The safety of the Aperio device in the current study was within the range of recent stent retriever trials. The rate of 7.3% for sICH was slightly higher compared to 4% in the HERMES [12] data, 5% in the ARISE II trial [20], and 2% and 4% sICH rates in SWIFT [24] and Trevo2 [19], respectively. The risk of clot fragment embolization to previously unaffected territories appears low as reported in the literature and occurred in one patient in our study [1]. The all-cause mortality rate at 90 days was 22.1%, which is comparable with the HERMES data [12], the ASTER (19%) [14], and DAWN (19%) [15] trials and was lower compared to Endostroke (27%), NASA [23], and Trevo2 [19] at 30.2% and 29%, respectively. These safety results support an acceptable benefit–risk profile for the device. The major limitations of this study are the non-randomized retrospective nature, a missing reference group, and the relatively small sample. A further limitation is the lost to FU rate of 17.1%, which harbors a potential bias. To attain homogeneity in the procedure, (i) we only used Aperio stent retrievers and (ii) thrombectomies were performed by five neurointerventionalists. Three interventionalists had an experience of 4 years. Two interventionalists had an experience of 1 year each and performed thrombectomies under the supervision of a neurointerventionalist with more than 15 years of experience; (iii) the same local aspiration techniques for clot retrieval described above were used.

The hybrid design of the Aperio with small closed cells to attain a good vessel wall apposition and improve expansion into the clot, and large open cells with integrated anchoring elements to assure efficient clot retention are the features of the device that are supposed to result in favorable recanalization rates. In the present study, a local aspiration technique with stent-retriever retrieval was used; however, a combination also of BGC or aspiration have been shown to facilitate stent-retriever retrieval in addition to "only" BGC or "only" distal aspiration [25, 26]. It is conceivable that the additional use of the Aperio with BGC combined with lesional local aspiration techniques might increase the rate of excellent reperfusion after first device pass [27]. This again might result in an increased rate of good functional outcome and needs to be proven in further studies.

Conclusion

This single-center experience demonstrated that the Aperio device achieved high rates of successful reperfusion in LVO in the anterior circulation with local aspiration techniques in the setting of acute stroke. Absence of device-related procedural complications demonstrated an adequate safety profile. These promising results should be confirmed by further randomized trials.

Contributors All authors contributed to the conception of the work and the acquisition, analysis, and interpretation of data. They edited, revised, and finally approved the manuscript version to be published. They agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. BT received personal fees from Acandis outside the submitted work.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Patients were informed about the approach, benefit, and risks of the planned procedure in the emergency setting, and informed consent was obtained prior to intervention. Consent for retrospective data analysis was waived.

Ethics approval The study was approved by the local ethics committees.

Provenance and peer review Not commissioned; externally peer reviewed.

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