

Thai J Neurological Surg 2026: 17(1): 55-68

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Efficacy of Endovascular Treatment Versus Surgical Clipping for Rupture Intracranial Aneurysms

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ABSTRACT

Background: Treatment options for intracranial aneurysms include surgical clipping and endovascular techniques such as coiling, stenting, and flow diversion. While clipping has been the traditional standard, it is associated with greater morbidity, whereas endovascular methods provide favorable perioperative outcomes but raise concerns regarding long-term durability. This study compares outcomes of these two modalities in ruptured intracranial aneurysms.

Methods: A retrospective cohort study was conducted at Udonthani Hospital, Thailand, including 114 patients treated for ruptured intracranial aneurysms between 2022 and 2024. Patients were divided into surgical clipping (n=43) and endovascular treatment (n=71). Survival, perioperative factors, complications, and one-month functional outcomes were analyzed using Kaplan-Meier survival analysis and logistic regression.

Results: Endovascular treatment showed superior one-month survival (91.55% vs. 58.14%, $P < 0.001$) and better functional recovery (median mRS 1 [0–3] vs. 3 [1–4], $P = 0.019$). Clipping required longer operative time (170 ± 37.8 vs. 73.14 ± 30.77 minutes, $P < 0.001$) and higher blood loss (350 mL vs. 30 mL, $P < 0.001$). Complication rates, including infarction, vasospasm, and hemorrhage, were comparable. Poorer outcomes correlated with higher Fisher grades, particularly grade 4. Logistic regression confirmed endovascular treatment as an independent predictor of favorable outcome (OR 1.38, $P = 0.019$).

Conclusions: Endovascular therapy provides better short-term survival and functional outcomes than surgical clipping for ruptured intracranial aneurysms, supporting its role as a preferred first-line approach in appropriate patients. Prospective studies are needed to evaluate long-term results and optimize treatment strategies.

Keywords: Ruptured intracranial aneurysm, endovascular treatment, surgical clipping, functional outcome, survival analysis.

Received: January 8, 2026 | Revised: March 26, 2025 | Accepted: March 27, 2026

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Introduction

Intracranial aneurysms (IA) are a major cause of morbidity and mortality in patients with subarachnoid hemorrhage (SAH), accounting for approximately 85% of cases of SAH¹. Surgical management of IA has evolved significantly over the years, with two main approaches commonly utilized: conventional craniotomy with aneurysm clipping and less invasive endovascular interventions such as endovascular coiling², stent or flow diverter. The choice between these treatment options depends on various factors, including the aneurysm's size, location, and the patient's overall health condition^{3,4}.

Conventional craniotomy with aneurysm clipping has been the gold standard for many decades and is considered highly effective for the treatment of many aneurysms, particularly those in accessible locations^{5,6}. However, this approach is associated with significant morbidity, including prolonged recovery times and a higher incidence of neurological deficits^{7,8}. In contrast, endovascular intervention, which involves the insertion of coils into the aneurysm through a catheter, is less invasive and offers a faster recovery with potentially fewer complications^{9,10}.

Although endovascular treatment has been shown to be effective for certain types of aneurysms, concerns regarding the long-term durability of coiling and its suitability for complex or wide-necked aneurysms have persisted^{11,12}. Recent studies have sought to compare the efficacy, prognosis, and long-term outcomes between these two approaches, with varying conclusions depending on the study's design, aneurysm characteristics, and patient population^{13,14,15,16}. This study aims to compare the effectiveness of neurovascular intervention and conventional craniotomy with

aneurysm clipping, with a focus on efficacy, prognosis, and overall clinical outcomes.

Materials and Methods

A retrospective data collection was performed on patients diagnosed with ruptured intracranial aneurysm (RIA) and treated between 2022 and 2024 utilizing medical records of patients underwent either endovascular treatment or conventional craniotomy with aneurysm clipping. Inclusion criteria consisted of patients aged 18 years or older, diagnosed via clinical assessment and imaging such as CTA scans, and treated with one of the two occlusion interventions. Patients with unruptured aneurysms or those who underwent alternative treatments were excluded. The collected data included demographic characteristics, aneurysm characteristics, treatment modality, and clinical outcomes—such as neurological deficits, functional recovery (particularly the modified Rankin Scale [mRS], with good functional outcomes defined as scores of 0 to 2 and poor outcomes as scores of 3 to 6), and post-treatment complications. Statistical analysis involved T-tests and Mann-Whitney U tests for numerical data, Chi-square tests for categorical data, and Cox regression hazard analysis for survival outcomes. Kaplan-Meier survival analysis was performed to compare survival rates and functional outcomes between treatment groups. Data analysis was conducted using Stata software version 17 (StataCorp, College Station, TX, USA).

Results

The demographic comparison between patients undergoing surgical clipping and endovascular treatment for IA shows that 58.77% of the total 114 patients were female and 41.23% were male,

with a higher proportion of males in the clipping group (46.51%) compared to the endovascular group (38.03%), though the difference was not statistically significant ($P = 0.372$). The average age was slightly higher in the clipping group (57.65 ± 11.46 years) than in the endovascular group (53.90 ± 11.61 years), but this difference was also not significant ($P = 0.100$). Regarding underlying conditions, diabetes mellitus (DM) was present in 7.89% of patients, with similar rates between groups ($P = 0.778$), while hypertension (HT) was more prevalent in the clipping group (69.77%) than in the endovascular group (53.52%), approaching statistical significance ($P = 0.087$). Chronic kidney disease (CKD) was observed only in the clipping group (4.65%), with none in the endovascular group ($P = 0.067$). Clinically, paralysis was more frequent in the clipping group (11.63%) compared to the endovascular group (2.82%), nearing statistical significance ($P = 0.058$), while altered consciousness and headache had similar prevalence in both groups. Neurologically, median Glasgow Coma Scale (GCS) scores were slightly lower in the clipping group, but differences were not statistically significant.

Similarly, Fisher grade and World Federation of Neurosurgical Societies (WFNS) scores were comparable, indicating similar severity levels between treatment groups. (Table 1)

The analysis compares aneurysm locations and characteristics between patients who underwent clipping versus neurovascular intervention. The anterior communicating artery was the most common site (33.33%), with significantly more cases managed by clipping (58.14%) than intervention (18.31%) ($P < 0.001$). The right-sided aneurysms were more frequently treated with intervention ($P = 0.042$), while aneurysms without a specific site were significantly more common in the clipping group ($P = 0.005$). Although other locations showed varying distributions, none reached statistical significance. Neck size and maximal aneurysm size did not differ significantly between groups ($P = 0.243$, $P = 0.107$, respectively). Complications such as hydrocephalus (41.23%), intraventricular hemorrhage (45.61%), and intracerebral hemorrhage (0.88%) were also comparable between treatment groups, with no statistically significant differences. (Table 2)

Table 1: Demographic Comparison of Endovascular vs. Surgical Clipping for Intracranial Aneurysms

Variables	Total (n=114)	Clipping (n=43)	Endovascular (n=71)	P-value
Gender, n (%)				
Male	47(41.23)	20 (46.51)	27(38.03)	0.372
Female	67(58.77)	23(53.49)	44(61.97)	
Age(year), Mean $\pm$ SD	55.32 $\pm$ 11.65	57.65 $\pm$ 11.46	53.90 $\pm$ 11.61	0.100
Underlying disease, n (%)				
Diabetes mellitus	9 (7.89)	3(6.98)	6(8.45)	0.778
Hypertension	68(59.65)	30 (69.77)	38(53.52)	0.087
Chronic kidney disease	2 (1.75)	2(4.65)	0(0.00)	0.067
Cerebrovascular disease	1 (0.88)	0(0.00)	1(1.41)	0.434

Table 1: Demographic Comparison of Endovascular vs. Surgical Clipping for Intracranial Aneurysms (Cont.)

Variables	Total (n=114)	Clipping (n=43)	Endovascular (n=71)	P-value
Clinical Presentation, n (%)				
Paralysis	7 (6.14)	5(11.63)	2(2.82)	0.058
Alteration of consciousness	74 (64.91)	28 (65.12)	46 (64.79)	0.972
Headache	95 (83.33)	35 (81.40)	60 (84.51)	0.666
Seizure	9 (7.89)	3(6.98)	6(8.45)	0.777
Glasgow Coma Scale, median (IQR)	14 (8,15)	12 (6,15)	14(9,15)	0.189
E, Eye opening	4 (3,4)	4(1,4)	4(3,4)	0.314
V, Verbal command	5(T,5)	4(T,5)	5(T,5)	0.197
M, Motor respond	6 (5,6)	5(5,6)	6(5,6)	0.063
Pupil reaction, n (%)	114 (99.12)	42(97.67)	71 (100)	0.197
Grading Classification, median (IQR)				
Fisher grade	3(1,3)	3(1,4)	3(1,3)	0.646
World Federation of Neurosurgical Societies	1(1,4)	3(1,5)	1(1,4)	0.164

Table 2: Comparison of Aneurysm Radiographic CT Scan Findings Between Endovascular Intervention and Surgical Clipping for Ruptured Intracranial Aneurysms

Variables	Total (n=114)	Clipping (n=43)	Endovascular (n=71)	P-value
Location, n (%)				
Anterior communicating artery	38(33.33)	25(58.14)	13(18.31)	<0.001
Middle cerebral artery	12 (10.53)	7(16.28)	5(7.04)	
Posterior communicating artery	28 (24.56)	10(23.26)	18(25.35)	0.801
Basilar trunk	1 (0.88)	0 (0.00)	1(1.41)	0.540
Internal carotid artery	8(7.02)	1(2.33)	7(9.86)	0.127
Vertebral artery	2 (1.75)	0 (0.00)	2 (2.82)	0.267
Basilar tip	6 (5.26)	0 (0.00)	6 (8.45)	0.050
Side, n (%)				
Left side	37 (32.46)	12 (27.91)	25 (35.21)	0.419
Right side	34 (29.82)	8 (18.60)	26 (36.62)	0.042
No site	45 (39.47)	24 (55.81)	21 (29.58)	0.005

Table 2: Comparison of Aneurysm Radiographic CT Scan Findings Between Endovascular Intervention and Surgical Clipping for Ruptured Intracranial Aneurysms (Cont.)

Variables	Total (n=114)	Clipping (n=43)	Endovascular (n=71)	P-value
Diameter (mm), mean ± SD				
Neck size	2.58±1.09	2.42±0.63	2.67±1.29	0.243
Maximal size	4.74±2.22	4.30±1.82	5.00±2.41	0.107
CT Finding, n (%)				
Intracerebral hemorrhage	1 (0.88)	1 (2.33)	0 (0.00)	0.197
Intraventricular hemorrhage	52 (45.61)	22 (51.16)	30 (42.25)	0.355
Hydrocephalus	47 (41.23)	19 (44.19)	28 (39.44)	0.618

We identified potential confounding factors in our data, including age, hypertension, chronic kidney disease, internal carotid artery aneurysms, basilar tip aneurysms, maximal aneurysm size, and intracerebral hemorrhage. These variables will be included in the multivariable analysis for adjustment.

Operative datas based on modality of surgery demonstrate that clipping is associated with significantly longer operative times (170 ± 37.80 min vs. 73.14 ± 30.77 min, OR 1.94, 95% CI 1.88-2.17,

$P < 0.001$) and greater blood loss (350 mL [IQR: 200–500] vs. 30 mL [IQR: 20–40], OR 1.03, 95% CI 1.02-1.04, $P < 0.001$) compared to neurovascular intervention. Despite these differences, complication rates, including vasospasm (5.26%), infarction (10.53%), and perforation (1.75%), did not significantly differ between the groups. These findings remained consistent after adjusting for potential confounding factors such as age, hypertension, chronic kidney disease, internal carotid artery aneurysms, basilar tip aneurysms, maximal aneurysm size, and intracerebral hemorrhage. (Table 3)

Table 3. Comparison of Surgical Operation Details Between Conventional Craniotomy with Clipping and Endovascular Treatment

Variables	Total (n=114)	Clipping (n=43)	Endovascular (n=71)	OR	95%CI	P-value
Operative time (minutes), mean (SD)	110±57.88	170± 37.80	73.14±30.77	1.94	1.88-2.17	<0.001
Blood loss (mL), median (IQR)	40 (30,250)	350 (200,500)	30 (20,40)	1.03	1.02-1.04	<0.001
CSF diversion	29 (25.66)	11 (26.19)	18(25.35)	0.87	0.32-2.31	0.774
Complication, n (%)						
Perforation	2 (1.75)	0(0.00)	2(2.82)	N/A	N/A	N/A
Vasospasm	6 (5.26)	2(4.65)	4(5.63)	0.82	0.13-4.92	0.818
Infarction	12 (10.53)	6(13.95)	6(8.45)	1.81	0.46-7.08	0.395

The post-treatment outcomes indicate that patients who underwent neurovascular intervention had a significantly higher survival rate (91.55% vs. 58.14%, OR 0.12, 95% CI 0.04–0.37, $P < 0.001$) compared to those who underwent conventional craniotomy with clipping. However, the rates of complete aneurysm occlusion were similar between groups (94.37% vs. 88.37%, OR 0.31, 95% CI 0.06–1.56, $P = 0.156$). There were no significant differences in pneumonia ($P = 0.806$), sepsis ($P = 0.806$), urinary tract infection ($P = 0.438$), or seizure ($P = 0.595$) between treatment groups. The median length of hospital stay was comparable (14 [7,16] days for clipping vs. 13 [7,14] days for intervention, OR 1.04, 95% CI 0.98–1.09, $P = 0.213$). Regarding functional outcomes, the median modified Rankin

Scale (mRS) score before treatment was the same in both groups (5 [4,5]). However, at the one-month follow-up, the neurovascular intervention group showed a trend toward better early recovery (mRS 3 [3, 4] vs. 4 [3, 4]; OR 1.29, 95% CI 0.94-1.76, $P = 0.117$). (Table 4)

Kaplan-Meier survival analysis in Figure 1A revealed a hazard ratio (HR) of 3.29 (95% confidence interval [CI]: 1.12–9.62, $P = 0.030$) in clipping group, indicating that patients undergoing clipping have a significantly higher risk of mortality compared to those treated with endovascular intervention. Figure 1B illustrates the percentage of patients achieving good functional outcomes over time. The endovascular group again demonstrates a better prognosis, with a higher proportion

Table 4. Posttreatment Outcomes Comparison Between Conventional Craniotomy with Clipping and Endovascular Treatment

Variables	Total (n=114)	Clipping (n=43)	Endovascular (n=71)	OR	95%CI	P-value
Length Hospital stay (Days), median (IQR)	14 (7,16)	14(11,20)	13 (7,14)	1.04	0.98-1.09	0.213
Survived, n (%)	90 (78.95)	25 (58.14)	65 (91.55)	0.12	0.04-0.37	<0.001
Complete obliteration, n (%)	105 (92.11)	38(88.37)	67 (94.37)	0.31	0.06-1.56	0.156
Incomplete obliteration, n (%)	9 (7.89)	5 (11.63)	4(5.63)	3.20	0.64-15.99	0.156
Medical complication, n (%)						
Pneumonia	4(3.51)	2(4.65)	2(2.82)	0.70	0.04-11.92	0.806
Septicemia	4 (3.51)	2(4.65)	2(2.82)	0.70	0.04-11.92	0.806
Urinary tract infection	5 (4.39)	3(6.98)	2(2.82)	2.28	0.28-18.22	0.438
Seizure	9(7.89)	3(6.98)	6(8.45)	0.63	0.11-3.49	0.595
Functional Outcomes, median (IQR)						
Modified rankin scale Prior treatment	5 (4,5)	5 (4,5)	5 (4,5)	1.00	0.75-1.32	0.981
30 days in hospital Posttreatment Modified rankin scale	4 (3,4)	4 (3,4)	3 (3,4)	1.29	0.94-1.76	0.117

of patients achieving favorable functional outcomes compared to the clipping group. The HR for improvement in the clipping group is 0.67 (95% CI: 0.44–1.02, $P = 0.063$), suggesting a trend toward worse functional outcomes, though not reaching statistical significance.

A comparison of the proportion of patients achieving good functional outcomes over time based on the Fisher grading system, along with Kaplan-Meier failure analysis of improvement, reveals the following: Fisher grade 2 has a hazard ratio (HR) for improvement of 1.03 (95% confidence interval [CI]: 0.47–2.23), suggesting a similar likelihood of functional recovery compared to Fisher grade 1. Fisher grade 3 has a lower HR for improvement at 0.71 (95% CI: 0.45–1.12), indicating a trend toward worse functional outcomes. Fisher grade 4 shows the lowest HR for improvement at 0.50 (95% CI: 0.28–0.88), reflecting significantly poorer functional

outcomes compared to the reference group. (Figure 2)

Discussion

Ruptured intracranial aneurysms (RIAs) remain a significant cause of morbidity and mortality worldwide, demanding timely and appropriate intervention to minimize neurological damage and improve survival. Two primary treatment modalities—microsurgical clipping and endovascular coiling—are widely employed, each with distinct advantages and limitations. More recently, flow diversion has emerged as an additional option for aneurysms not amenable to traditional treatments. The selection of the optimal intervention is multifactorial, influenced by aneurysm size and location, patient neurological status, available institutional resources, and surgical expertise^{17,18}.

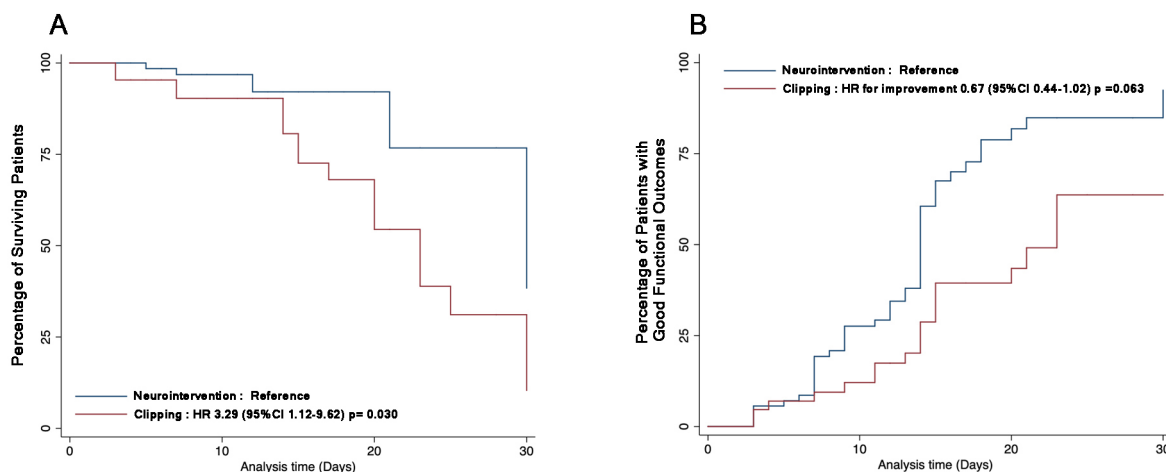


Figure 1. Kaplan–Meier survival analysis comparing neurointervention (blue line) with conventional craniotomy and aneurysm clipping (red line). Panel A shows the percentage of surviving patients over time, while Panel B illustrates the percentage of patients achieving good functional outcomes, defined as a modified Rankin Scale score of 0–2, at the 1-month follow-up

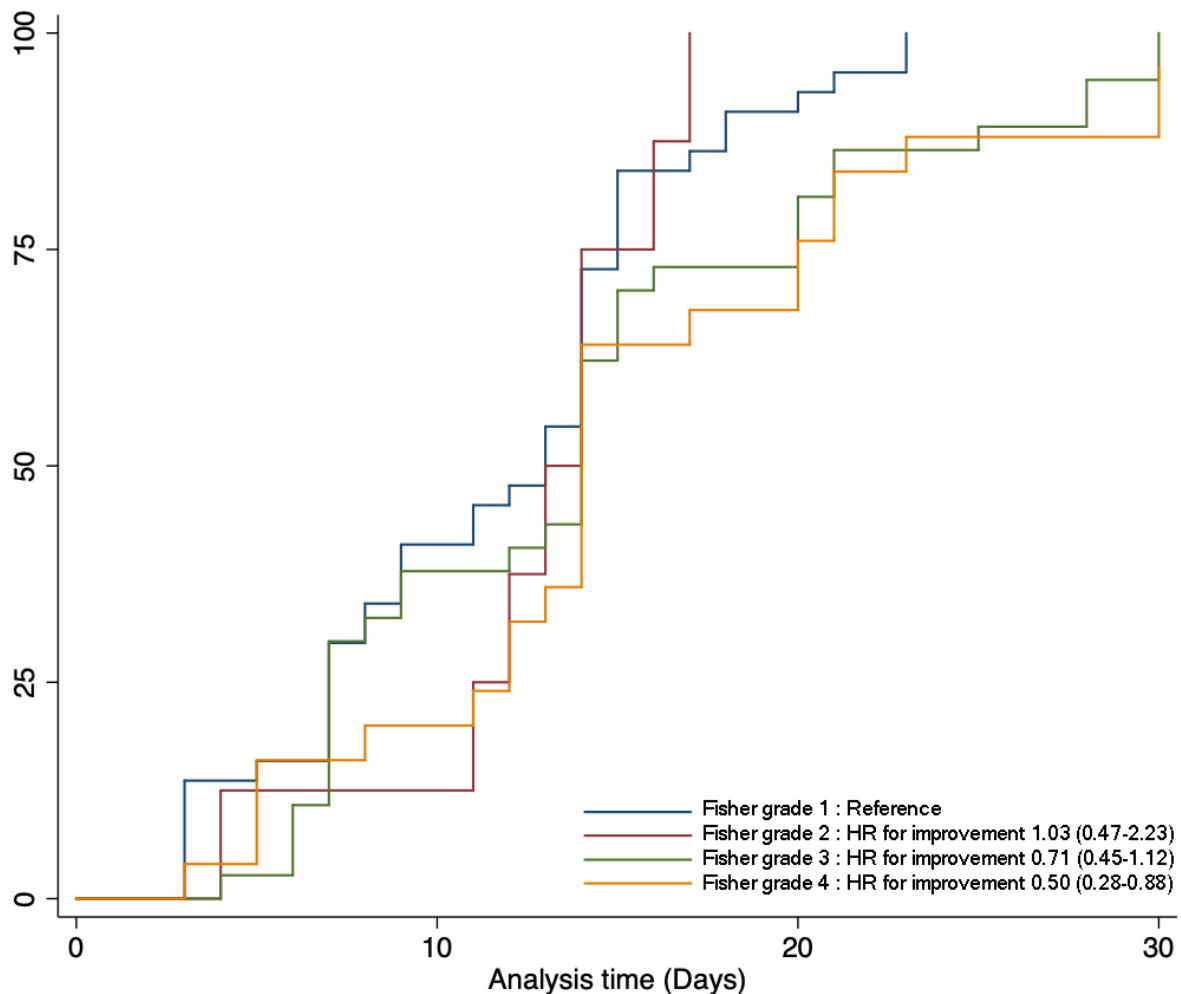


Figure 2. Kaplan–Meier analysis of good functional outcomes—defined as a modified Rankin Scale score of 0–2—at 1 month after treatment, comparing patients across different Fisher grade classifications.

Recent reviews and consensus papers show that both microsurgery and endovascular intervention remain important in intracranial aneurysm management, with each approach offering distinct advantages^{19,20,21,22}. Microsurgical clipping is still valued for its ability to provide immediate and durable aneurysm exclusion, particularly in complex, wide-necked, calcified, or branch-incorporating aneurysms, and it can be especially useful when long-term angiographic stability is a priority^{19,22}. In contrast, endovascular intervention offers a less invasive option, with lower surgical trauma, faster recovery, and growing utility for many ruptured and unruptured aneurysms through advances such as coiling, stent assistance, and flow diversion^{21,22}.

Overall, contemporary literature emphasizes individualized treatment selection based on aneurysm anatomy, rupture status, patient condition, and institutional expertise rather than choosing a single superior modality for all cases^{19, 22,23}.

Microsurgical clipping, once the mainstay of aneurysm treatment, offers durable aneurysm occlusion and is particularly effective in younger patients or in complex aneurysm morphologies¹⁸. However, it is associated with higher rates of procedural morbidity due to the invasive nature of craniotomy and surgical dissection²⁴. In contrast, endovascular coiling has become increasingly favored, especially following the landmark International Subarachnoid Aneurysm Trial (ISAT),

which demonstrated significantly better short-term clinical outcomes and reduced disability at one year among patients treated with coiling compared to clipping¹. The ISAT findings have been corroborated by several other studies^{25,26}, although they also highlighted a higher incidence of aneurysm recurrence and need for retreatment in the coiling group^{13,26,27}.

Our study reinforces these prior observations, demonstrating that endovascular coiling is associated with improved short-term functional outcomes and a trend toward enhanced survival compared to conventional clipping. Interestingly, the difference in favorable outcomes on the modified Rankin Scale (mRS) at one month reached borderline statistical significance ($P = 0.063$), with the overall trend favoring endovascular treatment. The significant survival advantage aligns with prior studies indicating lower perioperative morbidity and mortality with endovascular therapy in treating aneurysmal subarachnoid hemorrhage^{28,29}. The functional outcome trend also supports prior literature suggesting that endovascular coiling yields better long-term functional recovery, though some studies indicate that clipping may offer superior durability in specific aneurysm subtypes³⁰. However, given the borderline significance in functional outcomes, further studies with larger sample sizes may be needed to confirm this trend.

This aligns with the results of a meta-analysis by Ogilvy CS et al.³, which reported lower perioperative morbidity and superior early functional recovery in the coiling group. Additionally, a pooled analysis of 28 studies found that patients undergoing endovascular therapy had better one-year outcomes (mRS 0–2) compared to those receiving surgical clipping^{31,32}, highlighting the growing preference for less invasive strategies in contemporary neurosurgical practice.

No statistically significant differences were found in the rates of post-procedural complications—including pneumonia, urinary tract infections, or seizures—between the two treatment groups. These findings are consistent with Lv X et al.⁴, which suggested that although the two procedures differ technically, the systemic complication profiles are largely similar. This suggests that the primary driver of outcome differences lies in the direct neurological impact of the intervention rather than systemic complications.

The prognostic significance of Fisher grade, a widely used radiological scale to assess the burden of subarachnoid hemorrhage (SAH), was also confirmed in our analysis. Patients with Fisher grade 4—characterized by diffuse thick SAH with intraventricular hemorrhage—had significantly worse functional outcomes, consistent with previous literature^{33,34,35}. Studies have shown that a higher Fisher grade correlates with an increased risk of cerebral vasospasm, delayed cerebral ischemia, and hydrocephalus, all of which contribute to poor neurological recovery^{34,35}. While grades 2 and 3 demonstrated a trend toward poorer outcomes compared to grade 1, only grade 4 reached statistical significance in our dataset, reinforcing its role as a key prognostic factor in the management of aneurysmal SAH.

Endovascular intervention demonstrates superior short-term functional outcomes, significantly lower operative time, and reduced blood loss compared to surgical clipping. It should be considered the preferred initial treatment strategy, particularly for patients where a less invasive approach is vital for early recovery, and for those presenting with aneurysm locations such as the Basilar tip location, which were more frequently managed with intervention in this cohort. Additionally, while

endovascular therapy is effective across various severities, patients with lower Fisher grades (1–3) have a significantly higher likelihood of achieving favorable functional recovery compared to those with grade 4. Therefore, endovascular treatment is highly appropriate for patients prioritized for rapid perioperative stabilization and those with posterior circulation or right-sided vascular access advantages.

The limitations of this study must be considered. First, the retrospective design introduces the potential for selection bias, although baseline demographic and clinical characteristics, including Glasgow Coma Scale (GCS), Fisher grade, and WFNS classification, were similar between treatment groups. Furthermore, we employed multivariable regression analysis to account for confounding variables. Second, the technical outcomes and complication rates for both modalities may have been influenced by the specific experience level and learning curve of the performing neurosurgeons and neurointerventionists. Variations in operator proficiency can significantly impact procedural success and patient prognosis, a factor that was not explicitly controlled for in this retrospective analysis. Third, the lack of long-term follow-up—restricted by the structure of the referral-based healthcare system—limited our ability to assess outcomes beyond the one-month mark. Nevertheless, the short-term functional outcomes still provided valuable insight into early recovery and the relative effectiveness of each treatment modality.

Several areas warrant further investigation. Large-scale, prospective, multicenter studies are essential to assess the long-term durability of endovascular coiling and its effectiveness in preventing aneurysm recurrence. Efforts should also focus on refining patient selection algorithms by

integrating clinical and radiological factors, such as aneurysm morphology, to guide individualized treatment strategies. As neurointerventional technologies continue to evolve, innovations such as flow-diverting stents, intrasaccular devices, and advanced biomaterials for aneurysm occlusion offer promising avenues for improving outcomes^{23,36}. Moreover, the application of artificial intelligence and predictive modeling in clinical decision-making may further enhance risk stratification, optimize therapeutic planning, and support precision medicine approaches in aneurysm management.

Conclusions

Endovascular intervention demonstrates superior short-term functional outcomes and lower perioperative morbidity compared to surgical clipping, supporting its role as the preferred initial treatment strategy for appropriately selected patients with ruptured intracranial aneurysms. Specifically, it is most appropriate for patients requiring rapid perioperative stabilization due to significantly shorter operative times and minimal blood loss, as well as those with posterior circulation or right-sided aneurysms. While microsurgical clipping retains a role in specific anatomical contexts due to its long-term durability, endovascular intervention offers a less invasive alternative with comparable rates of systemic complications and improved early recovery. Additionally, the association between higher Fisher grades—particularly grade 4—and poorer neurological outcomes underscores its utility as a prognostic marker. Further prospective studies are warranted to assess the long-term durability of endovascular approaches, optimize patient selection, and validate these findings across diverse clinical settings.

Abbreviations and Acronyms

CKD: Chronic kidney disease

DM: Diabetes mellitus

GCS: Glasgow Coma Scale

HR: Hazard ratio

HT: Hypertension

IA: Intracranial aneurysm

ISAT: International Subarachnoid Aneurysm Trial

mRS: modified Rankin Scale

RIA: Ruptured intracranial aneurysm

SAH: Subarachnoid hemorrhage

UTI: Urinary tract infection

WFNS: World Federation of Neurosurgical Societies

Conflicting interests

The authors confirmed that there are no potential conflicts of interest regarding the research, authorship, or publication of this article.

Funding

The authors did not receive any financial backing for the research, writing, or publication of this article.

Ethics approval

All procedures followed ethical standards set by the institutional and national research committees, in line with the 1964 Helsinki Declaration and its amendments. Approval was granted by the Udonthani Hospital Ethics Committee.

Consent to participate

Patient consent was not required as the data were anonymized, and the study assessed standard patient management practices.

Clinical trial number:

not applicable.

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