Research Square

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Complete reperfusion benefits cognitive recovery in MCA occlusion after patients receiving thrombectomy

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Abstract

Purpose

Acute ischemic stroke (AIS) caused by middle cerebral artery (MCA) occlusion often leads to severe long-term cognitive impairment. Although endovascular mechanical thrombectomy (MT) is the standard treatment for large-vessel occlusion, the impact of reperfusion degree on long-term cognitive outcomes in isolated MCA occlusion remains unclear, especially in multicenter real-world populations. This study aimed to evaluate the effect of complete versus partial reperfusion on long-term cognitive function and safety after MT.

Methods

A multicenter retrospective study enrolled 390 patients with unilateral anterior circulation MCA occlusion undergoing MT, divided into complete reperfusion group (n = 203) and partial reperfusion group (n = 187). Baseline characteristics, 6-month MoCA cognitive scores, complications, mRS prognosis, and predictive factors of cognitive impairment were analyzed.

Results

Baseline characteristics were well balanced ($P > 0.05$). At 6 months, the complete reperfusion group had higher total MoCA scores, with significant improvements in attention, language, and executive function (all $P < 0.05$). Complication rates were similar between groups ($P > 0.05$). Six-month mRS favorable rates showed no significant difference ($P > 0.05$). Complete reperfusion, preoperative NIHSS ≤ 15, age < 65 years, and normal baseline cognition were independent protective factors for normal long-term cognition (all $P < 0.05$).

Conclusion

Complete reperfusion after MT for MCA occlusion significantly improves long-term core cognitive function without increasing major complications. It is an independent protective factor against cognitive impairment, supporting efforts to achieve complete reperfusion in clinical practice.

Introduction

Acute ischemic stroke (AIS) due to middle cerebral artery (MCA) occlusion represents a major cause of long-term disability, cognitive impairment, and mortality globally[1, 2]. The MCA perfuses eloquent cortical areas responsible for attention, language, executive function, memory, and orientation; thus, its occlusion frequently leads to severe and persistent cognitive deficits that compromise daily independence and quality of life. Despite advances in acute recanalization therapies, post-stroke

cognitive decline remains highly prevalent and is increasingly recognized as a critical endpoint in neurointerventional care[3–5].

Endovascular mechanical thrombectomy (MT) is now the gold-standard treatment for acute anterior circulation large-vessel occlusion, validated by a series of landmark randomized controlled trials including MR CLEAN, ESCAPE, EXTEND-IA, SWIFT PRIME, and REVASCAT. These studies uniformly confirmed that complete reperfusion is associated with superior 90-day functional outcomes and lower mortality compared with partial reperfusion or best medical management[6–9]. However, the majority of early investigations prioritized motor recovery and activities of daily living measured by the modified Rankin Scale (mRS), while long-term cognitive effects were under-evaluated, inconsistently reported, or limited to global cognitive scores rather than domain-specific analysis.

In recent years, emerging observational studies have suggested that the degree of reperfusion may influence post-stroke cognitive recovery. Several single-center series reported better Montreal Cognitive Assessment (MoCA) scores and lower dementia rates in patients with complete reperfusion[10–12]. Nonetheless, these studies are limited by small sample sizes, single-center design, lack of comprehensive cognitive subdomain assessment, and inadequate adjustment for key confounders such as baseline cognition, age, and initial stroke severity. Furthermore, safety concerns persist regarding whether complete reperfusion may increase the risk of symptomatic intracranial hemorrhage and malignant cerebral edema, which could counteract cognitive benefits. To date, large-scale multicenter evidence specifically evaluating long-term cognitive outcomes across multiple cognitive domains after MT for isolated MCA occlusion remains scarce.

To address these critical gaps, the present multicenter retrospective study was conducted across 5 clinical centers, enrolling 390 patients with unilateral anterior circulation MCA occlusion treated with MT. Patients were categorized into complete and partial reperfusion groups, with well-balanced baseline characteristics. We systematically compared 6-month MoCA total and subdomain scores, postoperative complications, and 6-month mRS outcomes, and performed multivariate logistic regression to identify independent factors associated with long-term cognitive function.

This investigation provides robust real-world evidence that complete reperfusion significantly enhances attention, language, and executive function at 6 months without increasing the risk of severe complications. Additionally, we identified young age (< 65 years), low baseline NIHSS score (≤ 15), and preserved preoperative cognitive function as independent protective factors for maintaining normal cognition. These findings carry important clinical implications: they reinforce the importance of achieving complete reperfusion during MT not only for functional recovery but also for cognitive protection; they enable early risk stratification and targeted cognitive intervention; and they support personalized prognostic counseling and treatment decision-making. By clarifying the cognitive benefits and safety profile of complete reperfusion, this study strengthens the evidence base for optimizing both functional and cognitive outcomes in patients with MCA occlusion undergoing mechanical thrombectomy.

Material and methods

Study Design and Ethical Approval

This was a multicenter, retrospective, observational cohort study conducted across 5 clinical centers specializing in cerebrovascular disease and neuro intervention. The study was performed in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) or Ethics Committee of each participating center. Due to the retrospective, non-interventional nature of the study, the requirement for written informed consent was formally waived by all ethics committees. Patient information was anonymized and de-identified prior to analysis to protect privacy and confidentiality.

Study Population and Enrollment Criteria

Patients with acute ischemic stroke (AIS) who underwent endovascular mechanical thrombectomy (MT) were consecutively enrolled between January 2023 and December 2025 in accordance with uniform predefined inclusion and exclusion criteria. Inclusion criteria were as follows: age ≥ 18 years old; diagnosis of acute ischemic stroke confirmed by non-contrast computed tomography (NCCT), computed tomography angiography (CTA) or magnetic resonance angiography (MRA); occlusion located in the unilateral anterior circulation middle cerebral artery (MCA, M1 or M2 segment); treated with standard endovascular mechanical thrombectomy within the guideline-recommended time window; definitive evaluation of postoperative angiographic reperfusion grade; and completed 6-month standardized follow-up with valid MoCA and mRS data. Exclusion criteria were as follows: intracranial hemorrhage, vascular malformation, tumor, inflammatory or demyelinating diseases at onset; bilateral cerebral infarction, posterior circulation infarction, or multiple vascular territory infarctions; severe cognitive impairment, dementia, psychiatric disorder, or major neurodevelopmental disorder prior to stroke; severe hepatic, renal, cardiac or respiratory failure, active malignancy, or life expectancy < 6 months; missing key baseline, surgical, or follow-up data; and lost to follow-up or withdrawal during the study period. A total of 390 eligible patients were finally enrolled and assigned to the partial reperfusion group (n = 187) and the complete reperfusion group (n = 203) according to postoperative angiographic reperfusion grading.

Data Collection and Baseline Assessment

Two trained independent researchers blinded to grouping and outcomes collected data retrospectively from electronic medical records, imaging systems, and follow-up databases, and all data were double-checked to ensure accuracy and completeness. Collected variables included demographic characteristics (age, gender), vascular risk factors (hypertension, type 2 diabetes mellitus, atrial fibrillation, hyperlipidemia, long-term smoking [≥ 1 year], excessive alcohol drinking [≥ 2 standard drinks per day]), preoperative neurological function assessed by the National Institutes of Health Stroke Scale (NIHSS) score on admission by trained neurologists, preoperative cognitive function evaluated by the Montreal Cognitive Assessment (MoCA) total score before surgery or within 24 hours after surgery, and

surgical indicators including the number of thrombectomy attempts and total procedural time from puncture to final angiography.

Endovascular Procedure and Reperfusion Grading

All endovascular mechanical thrombectomy procedures were performed by senior neuro interventionalists with at least 5 years of experience following current international clinical guidelines, using standard stent-retriever and/or aspiration thrombectomy techniques under general anesthesia or conscious sedation. All procedures were conducted in dedicated digital subtraction angiography (DSA) suites, with routine heparinization to maintain an activated clotting time (ACT) of 250–300 seconds during the operation. Postoperative reperfusion status was evaluated using the modified Treatment in Cerebral Ischemia (mTICI) scale by two independent, experienced neuroradiologists blinded to clinical data and patient outcomes, and discrepancies were resolved by consensus or adjudication by a third senior reviewer. Complete reperfusion was defined as mTICI 2b–3, and partial reperfusion was defined as mTICI 0–2a.

Follow-up and Outcome Measures

All patients underwent standardized 6-month follow-up via combined outpatient face-to-face assessment and telephone interview. The primary outcome was long-term cognitive function assessed by MoCA total score and subdomain scores at 6 months, including attention, language function, executive function, orientation, and episodic memory. Secondary outcomes included early postoperative complications within 7 days and long-term neurological prognosis at 6 months; early postoperative complications consisted of symptomatic intracranial hemorrhage (SICH, defined as imaging-confirmed intracranial hemorrhage accompanied by neurological deterioration with an NIHSS increase ≥ 4 points) and secondary cerebral edema (defined as space-occupying edema detected on follow-up NCCT/MRI), while long-term neurological prognosis was evaluated by the modified Rankin Scale (mRS) score with a favorable prognosis defined as mRS 0–2 and an unfavorable prognosis defined as mRS 3–6.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics 26.0 software. Continuous variables with normal distribution were presented as mean ± standard deviation (Mean ± SD) and compared using independent-samples t-test, while non-normally distributed data were expressed as median (interquartile range, IQR) and compared using Mann–Whitney U test. Categorical variables were reported as number (percentage, n/%) and compared using χ^2 test or Fisher exact test when appropriate. Univariate analysis was used to screen potential factors associated with long-term cognitive impairment, and variables with $P < 0.10$ were entered into the binary multivariate Logistic regression model to identify independent protective factors for normal long-term cognitive function. Results were reported with odds ratios (OR),

95% confidence intervals (95% CI), and P values, and a two-sided $P < 0.05$ was considered statistically significant.

Results

Comparison of General Clinical Data and Surgery-Related Indicators

This was a retrospective clinical study conducted jointly by 5 clinical centers. Patients were uniformly screened in a multicenter manner in strict accordance with the predefined inclusion and exclusion criteria. Finally, a total of 390 patients with acute ischemic stroke caused by unilateral anterior circulation middle cerebral artery occlusion who underwent endovascular mechanical thrombectomy were enrolled. According to the postoperative vascular reperfusion grading criteria, they were divided into two groups: 187 patients in the partial reperfusion group and 203 patients in the complete reperfusion group.

Baseline demographic data, past medical history, personal lifestyle, baseline preoperative neurological and cognitive function, and intraoperative surgery-related clinical indicators were systematically compared between the two groups. These indicators included age distribution, gender ratio, prevalence of common cerebrovascular risk factors such as hypertension, type 2 diabetes mellitus, atrial fibrillation and hyperlipidemia, proportion of unhealthy lifestyles including long-term smoking and excessive drinking, National Institutes of Health Stroke Scale (NIHSS) score for neurological deficit immediately on admission before surgery, overall Montreal Cognitive Assessment (MoCA) score before surgery, number of endovascular thrombectomy attempts and total operation time.

The responsible occluded vessel in all enrolled patients was the middle cerebral artery, and there was no difference in the distribution of vascular occlusion sites between the two groups. Statistical analysis showed that there were no statistically significant differences in all the above baseline data and intraoperative surgery-related indicators between the two groups ($P > 0.05$), indicating that the baseline clinical characteristics of the two groups were well balanced, with few confounding factors between the multicenter enrolled cases, and the subsequent comparison results of various outcome indicators were scientifically comparable. Detailed baseline data are shown in Table 1.

Table 1
Baseline clinical characteristics by reperfusion status

Variable	Partial reperfusion (n = 187)	Complete reperfusion (n = 203)	Test statistic	P value
Demographic baseline characteristics				
Age (years, mean ± SD)	62.38 ± 8.75	61.92 ± 9.13	t = 0.512	0.609
Male, n (%)	112 (59.89%)	121 (59.61%)	χ^2=0.178	0.673
History of pre-existing disease				
Hypertension, n (%)	102 (54.55%)	115 (56.65%)	χ^2=0.315	0.575
Type 2 diabetes mellitus, n (%)	42 (22.46%)	48 (23.65%)	χ^2=0.079	0.779
Atrial fibrillation, n (%)	38 (20.32%)	45 (22.17%)	χ^2=0.259	0.611
Hyperlipidemia, n (%)	95 (50.80%)	108 (53.20%)	χ^2=0.301	0.583
Coronary heart disease, n (%)	22 (11.76%)	25 (12.32%)	χ^2=0.045	0.832
History of ischemic stroke, n (%)	28 (14.97%)	32 (15.76%)	χ^2=0.195	0.659
Adverse lifestyle history				
Long-term smoking, n (%)	65 (34.76%)	75 (36.95%)	χ^2=0.189	0.664
Excessive alcohol consumption, n (%)	32 (17.11%)	38 (18.72%)	χ^2=0.248	0.618
Preoperative neurological and cognitive baseline				
Preoperative NIHSS score (mean ± SD)	12.35 ± 3.21	11.89 ± 3.47	t = 1.342	0.180
Preoperative MoCA global cognitive score (mean ± SD)	22.47 ± 4.12	22.81 ± 3.95	t = 0.826	0.409
Intraoperative procedure-related clinical indicators				
Number of endovascular thrombectomy passes (mean ± SD)	2.15 ± 0.87	2.08 ± 0.92	t = 0.783	0.434
Total procedure duration (min, mean ± SD)	92.64 ± 28.75	89.37 ± 30.12	t = 1.091	0.276
Early postoperative complications				
Symptomatic intracranial hemorrhage, n (%)	10 (5.35%)	16 (7.88%)	χ^2=0.972	0.324

Note: Continuous variables are presented as mean ± SD; categorical variables are presented as n (%).

Variable	Partial reperfusion (n = 187)	Complete reperfusion (n = 203)	Test statistic	P value
Demographic baseline characteristics				
Secondary cerebral edema, n (%)	14 (7.49%)	21 (10.34%)	χ^2=1.087	0.297
Overall complication rate, n (%)	24 (12.83%)	37 (18.23%)	χ^2=2.125	0.145
Note: Continuous variables are presented as mean ± SD; categorical variables are presented as n (%).				

Comparison of Long-Term Cognitive Function (MoCA Score at 6 Months After Surgery)

All enrolled patients completed standardized combined outpatient and telephone follow-up at 6 months postoperatively. The Montreal Cognitive Assessment (MoCA) scale was uniformly employed to quantitatively assess the long-term global cognitive function of the patients. The study cohort and endpoint architecture of the study are presented in Fig. 1.

The results of overall cognitive function showed that at the 6-month follow-up, the overall MoCA cognitive score of the complete reperfusion group was higher than that of the partial reperfusion group, with a statistically significant difference between the two groups ($P < 0.05$) (Fig. 2).

Further stratified subgroup comparative analysis of each cognitive dimension of the MoCA scale was performed, and the quantitative results were as follows: Attention: complete reperfusion group (7.12 ± 1.05) vs. partial reperfusion group (5.86 ± 1.13), with a statistically significant difference between the two groups ($P = 0.027$); Language function: complete reperfusion group (6.89 ± 0.97) vs. partial reperfusion group (5.24 ± 1.01), with a statistically significant difference between the two groups ($P = 0.015$); Higher executive function: complete reperfusion group (5.93 ± 0.88) vs. partial reperfusion group (4.67 ± 0.92), with a statistically significant difference between the two groups ($P = 0.031$).

Orientation: complete reperfusion group (5.74 ± 0.76) vs. partial reperfusion group (5.61 ± 0.80), with no statistically significant difference between the two groups ($P = 0.426$); Episodic memory: complete reperfusion group (5.35 ± 0.69) vs. partial reperfusion group (5.22 ± 0.73), with no statistically significant difference between the two groups ($P = 0.518$) (Fig. 3).

The results confirmed that complete vascular reperfusion for middle cerebral artery occlusion can significantly improve core cognitive impairments such as attention, language and executive function in post-stroke patients, but has limited effects on improving basic orientation, memory and comprehension. Detailed cognitive scores of each dimension are shown in Table 2.

Table 2
Comparison of MoCA scores at 6 months between groups

MoCA measure	Complete reperfusion	Partial reperfusion	t value	P value
MoCA total score	26.84 ± 3.25	23.12 ± 3.58	10.627	< 0.001
Attention	7.12 ± 1.05	5.86 ± 1.13	11.582	0.027
Episodic memory	5.35 ± 0.69	5.22 ± 0.73	1.805	0.518
Executive function	5.93 ± 0.88	4.67 ± 0.92	13.926	0.031
Orientation	5.74 ± 0.76	5.61 ± 0.80	1.673	0.426
Language	6.89 ± 0.97	5.24 ± 1.01	16.874	0.015
Note: MoCA, Montreal Cognitive Assessment; data are presented as mean ± SD.				

Comparison of Postoperative Complications and 6-Month Overall Neurological Prognosis

Incidence of Early Postoperative Complications: Vital signs, neurological symptoms and cranial imaging reexamination results of patients were closely monitored after surgery. Research data from the 5 centers were collectively summarized, and the incidence of common severe postoperative complications in the two groups was statistically analyzed. Among 203 patients in the complete reperfusion group, 16 cases had postoperative symptomatic intracranial hemorrhage, with a complication rate of 7.88%, and 21 cases had secondary cerebral edema, with an incidence rate of 10.34%. Among 187 patients in the partial reperfusion group, 10 cases had postoperative symptomatic intracranial hemorrhage, with a complication rate of 5.35%, and 14 cases had secondary cerebral edema, with an incidence rate of 7.49%.

The data showed that the risk of postoperative symptomatic intracranial hemorrhage in the complete reperfusion group was higher than that in the partial reperfusion group. However, statistical tests showed that there were no statistically significant differences in the individual and overall incidence rates of the two major postoperative adverse complications (symptomatic intracranial hemorrhage and secondary cerebral edema after ischemia) between the two groups ($P > 0.05$), indicating that in the multicenter enrolled patients with middle cerebral artery occlusion undergoing thrombectomy, although complete reperfusion showed a trend of higher bleeding risk, it did not reach a statistically significant level (Fig. 4, Table 3).

Table 3
Six-month mRS functional outcome and early postoperative complications by group

Variable	Complete reperfusion (n = 203)	Partial reperfusion (n = 187)	P value
6-month mRS functional outcome			
mRS 0–2	155 (76.35%)	133 (71.12%)	
mRS 3–6	48 (23.65%)	54 (28.88%)	
Early postoperative complications			
Symptomatic intracranial hemorrhage, n (%)	16 (7.88%)	10 (5.35%)	0.324
Secondary cerebral edema, n (%)	21 (10.34%)	14 (7.49%)	0.297
Overall complication rate, n (%)	37 (18.23%)	24 (12.83%)	0.145
Note: Only dichotomized mRS data (0–2 vs 3–6) were available; itemized mRS 0–6 distributions were not available.			

6-Month Overall Neurological Prognosis After Surgery

The modified Rankin Scale (mRS) score at 6 months after surgery was used as the criterion for evaluating long-term daily living ability and overall neurological prognosis. A mRS score of 0–2 was defined as favorable functional recovery, and 3–6 as unfavorable recovery. Statistical results showed that 155 patients in the complete reperfusion group had favorable 6-month mRS prognosis, with a favorable rate of 76.35%; 133 patients in the partial reperfusion group had favorable 6-month mRS prognosis, with a favorable rate of 71.12%. There was no statistically significant difference in the favorable rate of long-term overall neurological prognosis between the two groups ($P > 0.05$) (Fig. 5).

Multivariate Logistic Regression Analysis of Factors Affecting Long-Term Cognitive Impairment in Stroke Patients

To identify the independent risk and protective factors for long-term cognitive impairment after mechanical thrombectomy in patients with acute ischemic stroke caused by middle cerebral artery occlusion enrolled jointly by the 5 centers, multivariate regression model analysis was conducted in this study, with the dependent variable defined as long-term cognitive impairment (assigned as a positive outcome, MoCA score < 26 at 6 months after surgery) and normal cognitive function (assigned as a negative outcome, MoCA score ≥ 26), and the independent variables including four core indicators—vascular reperfusion mode, preoperative NIHSS neurological deficit score on admission, patient age group, and baseline cognitive function level on admission before surgery—which were initially screened

by univariate correlation analysis for potential correlation (P < 0.1) and then included in the multivariate regression model.

A binary multivariate Logistic regression model was constructed for stepwise adjustment of confounding factors. The final regression results confirmed that complete postoperative vascular reperfusion, preoperative NIHSS score ≤ 15 on admission, age at onset < 65 years, and normal baseline cognitive function on admission (preoperative MoCA score ≥ 26) were all independent protective factors for maintaining normal long-term cognitive function after surgery in such patients. All the above indicators were statistically significant (all P < 0.05) (Fig. 6). These results can provide objective data evidence for early clinical prediction of long-term cognitive prognosis, formulation of individualized reperfusion treatment plans and risk prevention and control strategies in patients with middle cerebral artery occlusion in multiple centers. Detailed regression assignment, OR values, 95% CI and P values are shown in Table 4.

Table 4
Multivariable logistic regression for factors associated with long-term cognitive impairment

Factor	Coding	β	SE	Wald χ^2	OR	95% CI	P value
Reperfusion status	0 = partial reperfusion; 1 = complete reperfusion	-0.892	0.215	17.246	0.409	0.268–0.625	< 0.001
Preoperative NIHSS score at admission	0 = > 15; 1 = ≤ 15	-0.765	0.242	10.012	0.465	0.290–0.747	0.002
Age at onset	0 = ≥ 65 years; 1 = < 65 years	-0.683	0.237	8.315	0.505	0.318–0.802	0.004
Baseline preoperative cognitive status	0 = preoperative MoCA < 26 (cognitive impairment); 1 = preoperative MoCA ≥ 26 (normal cognition)	-0.927	0.228	16.583	0.396	0.254–0.617	< 0.001
Note: OR < 1 indicates a lower risk of long-term cognitive impairment.							

Discussion

Acute ischemic stroke caused by middle cerebral artery (MCA) occlusion is frequently accompanied by severe long-term cognitive impairment, which significantly affects functional recovery, quality of life, and social reintegration. Endovascular mechanical thrombectomy has become the standard of care for acute anterior circulation large-vessel occlusion, with abundant high-level evidence confirming that complete reperfusion predicts favorable short-term neurological outcomes[13–15]. However, evidence regarding the long-term cognitive effects of different reperfusion grades, especially in patients with isolated MCA occlusion, remains limited. The present multicenter retrospective study enrolled 390 patients with

well-balanced baseline characteristics to investigate whether complete reperfusion improves 6-month cognitive function, safety profiles, and neurological prognosis. Our findings provide real-world evidence that complete reperfusion significantly enhances global cognition and core cognitive subdomains without increasing major complication rates, and we identified independent protective factors for long-term cognitive preservation.

In the current study, patients with complete reperfusion exhibited significantly higher total MoCA scores at 6 months than those with partial reperfusion. Subgroup analysis further demonstrated that complete reperfusion specifically improved attention, language function, and executive function, whereas no significant differences were observed in orientation or episodic memory. These results are consistent with recent neurocognitive studies showing that the MCA supplies cortical regions closely associated with attention, semantic processing, working memory, and executive control. Prompt and complete reperfusion reduces ischemic damage to the frontal-parietal-temporal network, thereby preserving higher-order cognitive function. In contrast, basic orientation and episodic memory rely more on the limbic system and posterior circulation structures, which are less affected by MCA occlusion, explaining the lack of between-group differences. Our study extends previous single-center observations by confirming that cognitive benefits are domain-specific and reproducible in a large multicenter cohort.

Regarding safety, complete reperfusion was associated with a numerically higher rate of symptomatic intracranial hemorrhage and secondary cerebral edema, but these differences did not reach statistical significance. This finding is consistent with major randomized trials such as MR CLEAN and ESCAPE, which indicated that successful reperfusion does not substantially increase complication risks. Although reperfusion injury remains a theoretical concern, our data suggest that the cognitive and functional benefits of complete reperfusion outweigh the potential safety risks in clinical practice. Importantly, the 6-month favorable neurological prognosis (mRS 0–2) was numerically higher in the complete reperfusion group, although the difference was not statistically significant. This may reflect the relatively long follow-up period and the influence of rehabilitation, comorbidities, and vascular risk control. Nevertheless, the clear cognitive advantage supports the importance of pursuing complete reperfusion beyond conventional functional endpoints.

Multivariate logistic regression identified four independent protective factors for normal long-term cognitive function: complete reperfusion, preoperative NIHSS score ≤ 15, age < 65 years, and normal baseline cognition. These findings are clinically meaningful for risk stratification and personalized decision-making. Younger patients with mild initial neurological deficits and preserved baseline cognition are most likely to maintain cognitive function after complete reperfusion. For older patients or those with severe baseline deficits, more intensive cognitive monitoring and early rehabilitation may be necessary. To our knowledge, this is one of the few multicenter studies to establish a predictive model for cognitive outcomes after mechanical thrombectomy for isolated MCA occlusion.

The present study has several strengths, including a large multicenter sample, rigorous baseline balancing, standardized cognitive assessment, and comprehensive adjustment for confounders.

However, several limitations should be acknowledged. First, this is a retrospective design, which may introduce selection bias despite strict inclusion criteria. Second, follow-up was limited to 6 months; longer-term cognitive trajectories remain unclear. Third, we did not explore plasma biomarkers or imaging markers of microvascular disease, which may provide mechanistic insights. Future prospective studies with longer follow-up and integrated neuroimaging are warranted to validate our findings.

In conclusion, complete vascular reperfusion after mechanical thrombectomy for acute MCA occlusion significantly improves 6-month attention, language, and executive function without increasing major postoperative complications. Complete reperfusion, lower baseline NIHSS score, younger age, and intact preoperative cognition are independent protective factors against long-term cognitive impairment. These results highlight the importance of achieving complete reperfusion to protect post-stroke cognitive function and support individualized prognostic evaluation and clinical decision-making.

Declarations

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All authors have read and agreed to the published version of the manuscript

Author contributions:

Concept: K.Y., Y.B.W.; Design: K.Y., Y.B.W., C.Q.C.; Supervision: J.L., D.X.Q.; Resource: Y.B.W., C.Q.C., D.X.Q.; Data Collection and/or Processing: K.Y., Y.B.W., C.Q.C.; Analysis and/or Interpretation: J.L., D.X.Q.; Literature Search: K.Y., C.Q.C.; Writing: K.Y., Y.B.W., C.Q.C., J.L., D.X.Q.; Critical Reviews: J.L., D.X.Q.

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Data availability:

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate:

Patient consent was waived because of the retrospective nature of this study.

Competing interests:

The authors declare no competing interests.

Clinical trial number:

Not applicable.

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Figures

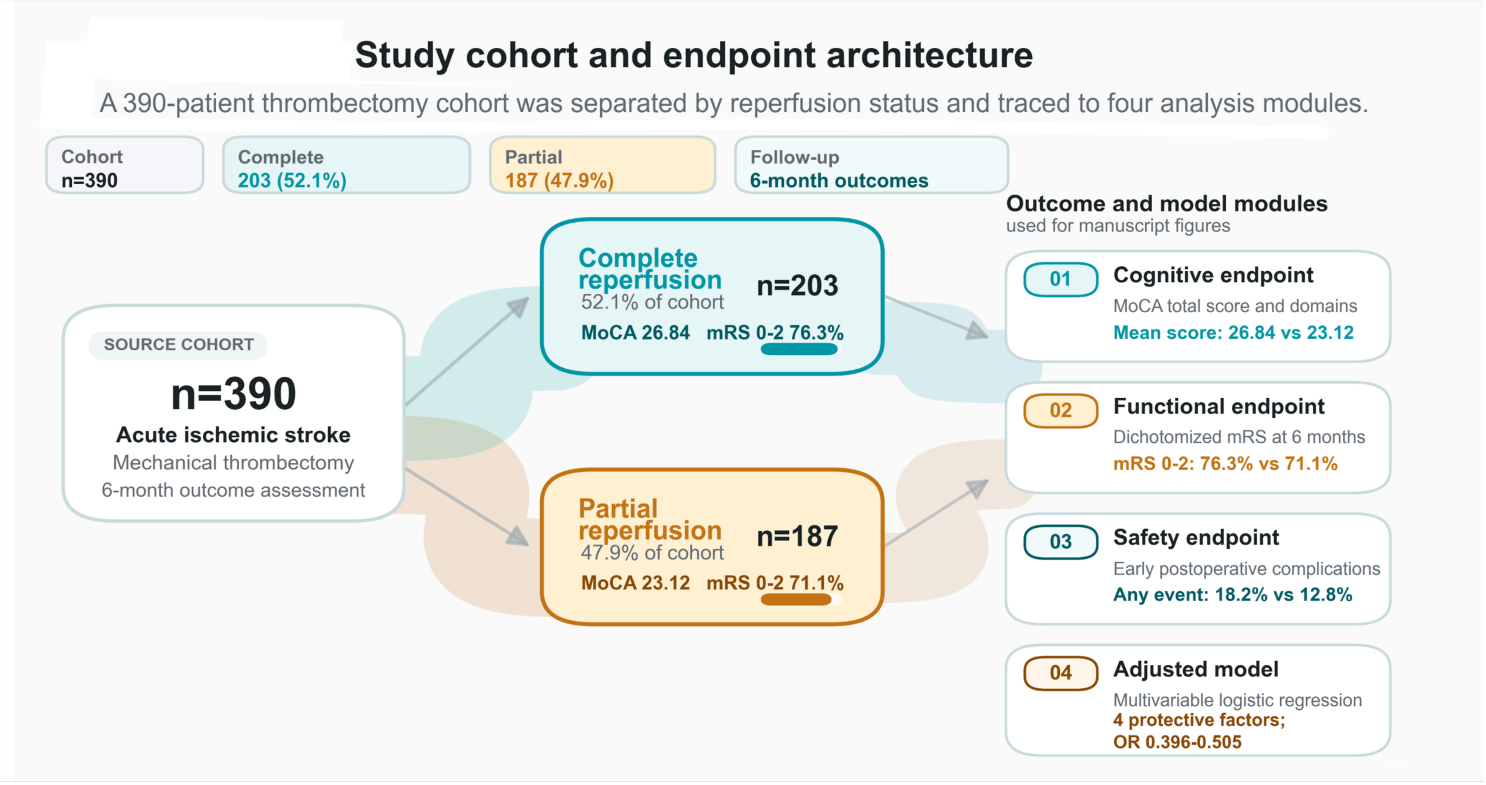
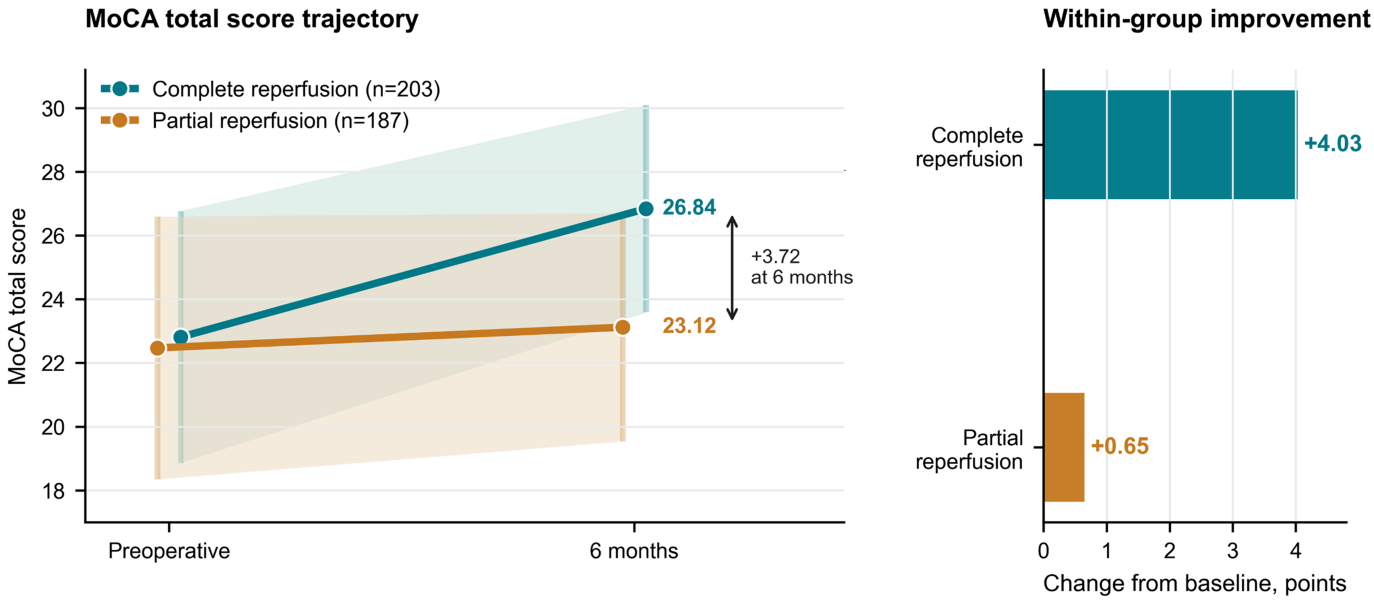


Figure 1

Study flow diagram and analysis modules. The 390-patient thrombectomy cohort was divided into complete (n=203) and partial (n=187) reperfusion groups, with follow-up at 6 months. Four key analyses

were performed: cognitive recovery (MoCA), functional outcome (mRS), safety (complications), and adjusted predictors of cognitive impairment.



Group	n	Preoperative	6 months	Change
Complete reperfusion	203	22.81 +/- 3.95	26.84 +/- 3.25	+4.03
Partial reperfusion	187	22.47 +/- 4.12	23.12 +/- 3.58	+0.65

Values are mean +/- SD. Baseline comparison P=0.409.

Key contrast

Change diff.	**+3.38 points**
6-mo diff.	**+3.72 points**
6-mo P	**<0.001**

Figure 2

Cognitive recovery (MoCA scores) at 6 months by reperfusion status. Patients with complete reperfusion (n=203) showed significantly greater improvement in MoCA total scores from baseline to 6 months (+4.03 points) compared to those with partial reperfusion (n=187, +0.65 points, between-group difference: +3.38 points). At 6 months, the mean MoCA score was 26.84 vs. 23.12 in the complete vs. partial reperfusion groups, respectively (P<0.001).

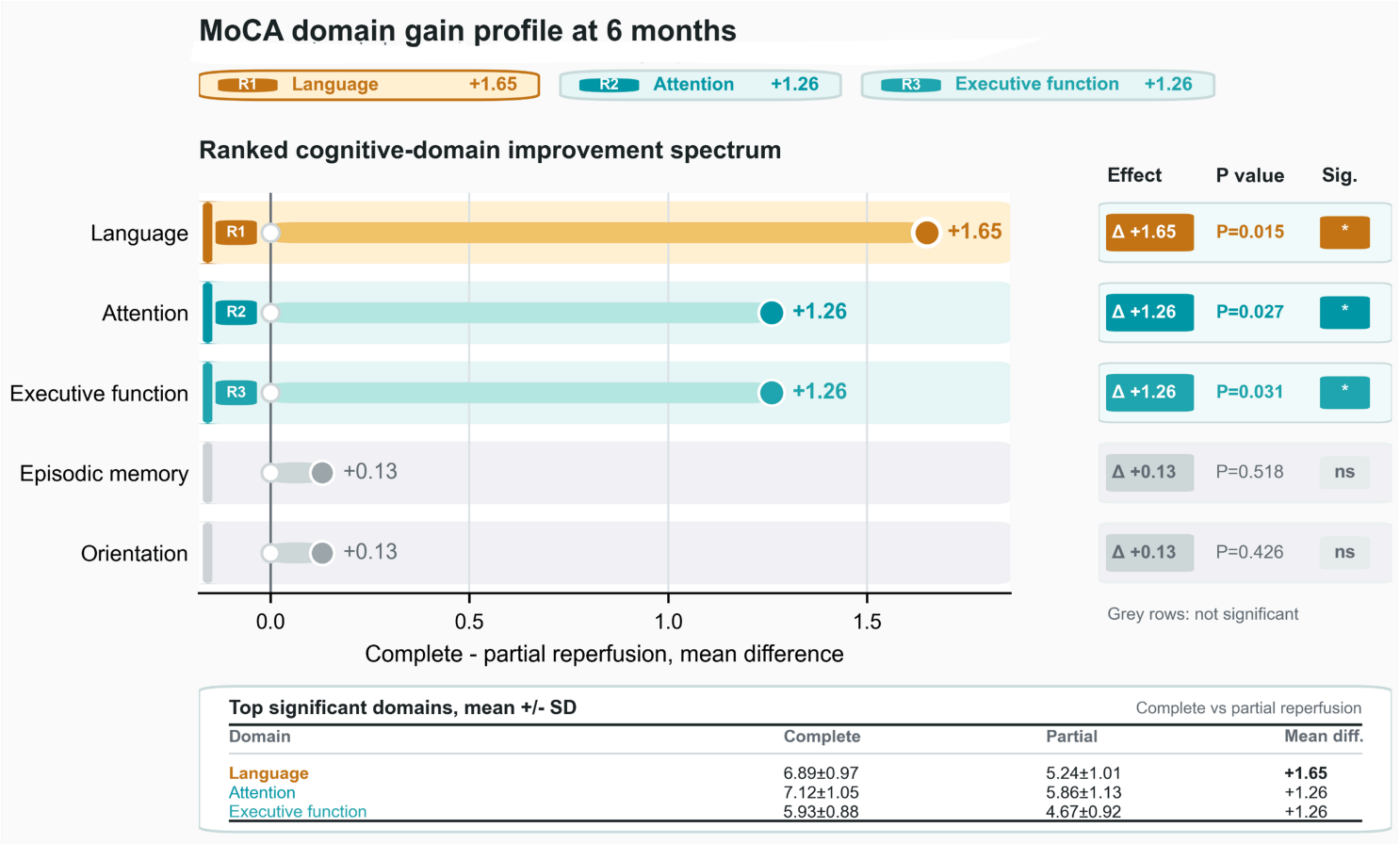


Figure 3

MoCA domain-specific cognitive gains at 6 months, comparing patients with complete vs. partial reperfusion. Mean differences in improvement are ranked from highest to lowest. Significant gains were observed in language (+1.65, P=0.015), attention (+1.26, P=0.027), and executive function (+1.26, P=0.031), while episodic memory and orientation showed no significant between-group differences (P>0.05). Data are presented as mean ± SD.

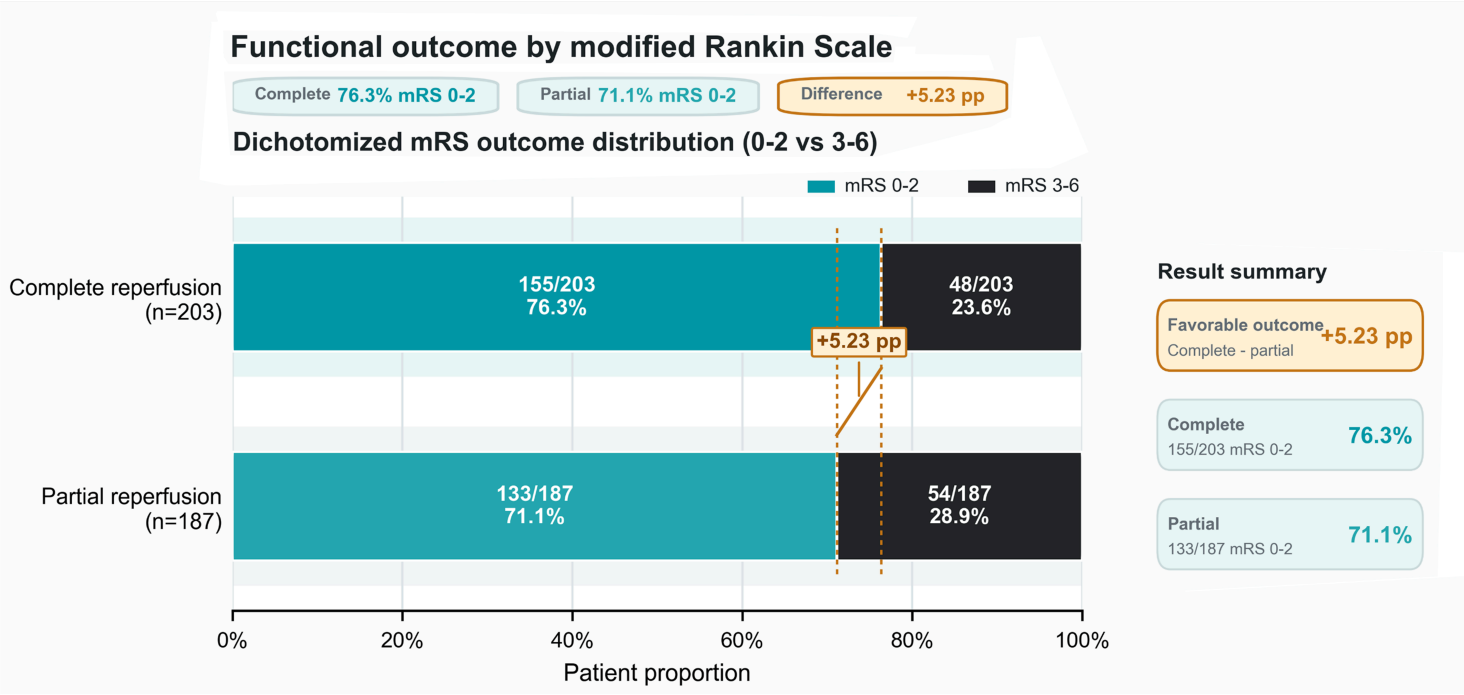


Figure 4

Dichotomized mRS 0–2 functional outcomes at 6 months by reperfusion status. Patients with complete reperfusion (n=203) had a favorable outcome rate of 76.3%, compared to 71.1% in the partial reperfusion group (n=187), a difference of 5.23 percentage points. There was no statistically significant difference in the favorable rate of long-term overall neurological prognosis between the two groups.

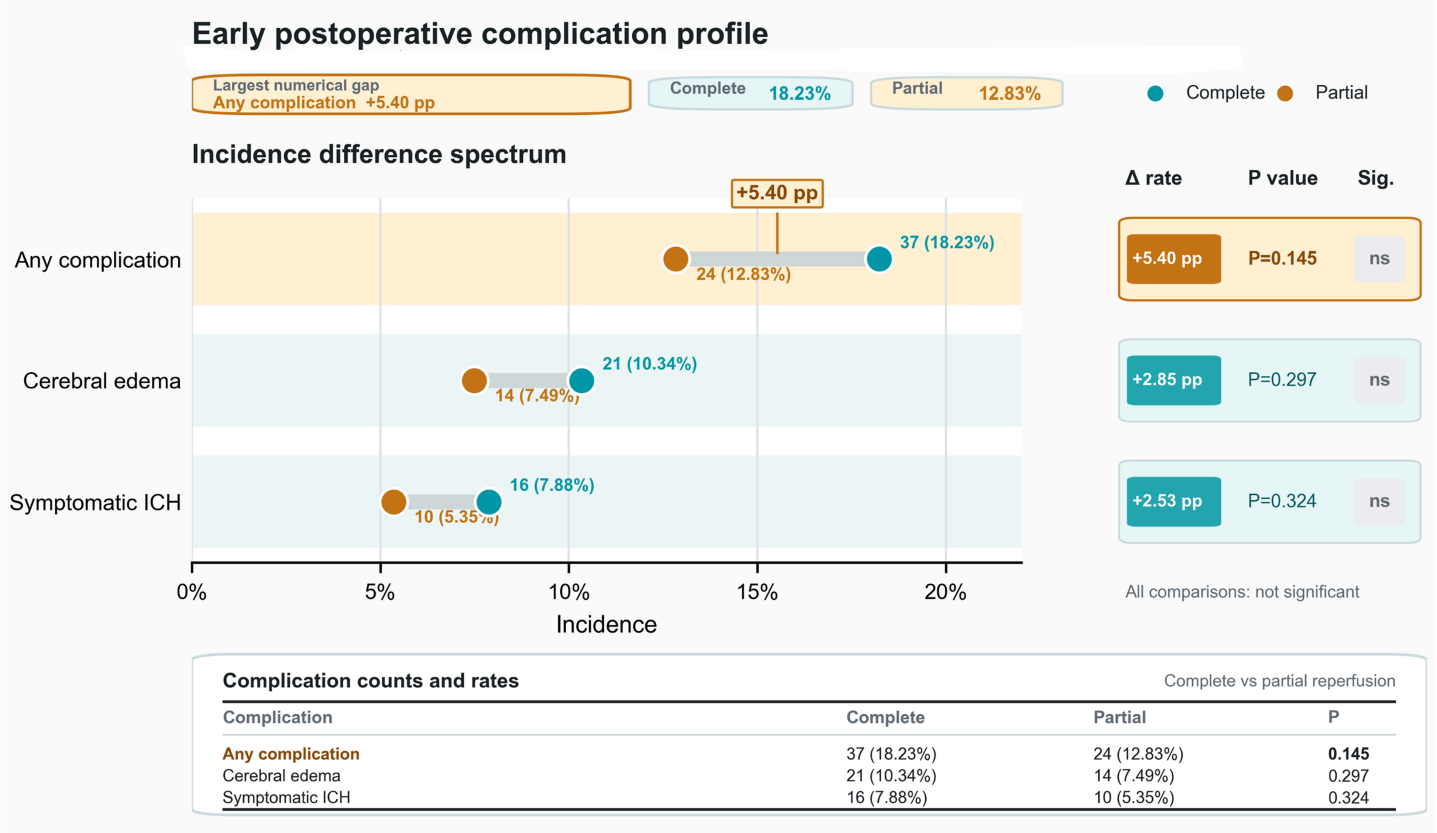


Figure 5

Early postoperative complication profile in patients with complete vs. partial reperfusion. The incidence of any complication was numerically higher in the complete reperfusion group (18.23% vs. 12.83%, difference = +5.40 percentage points), but this difference was not statistically significant (P=0.145). Similarly, rates of cerebral edema (10.34% vs. 7.49%, P=0.297) and symptomatic intracerebral hemorrhage (sICH; 7.88% vs. 5.35%, P=0.324) were higher in the complete reperfusion group, though all comparisons failed to reach statistical significance.

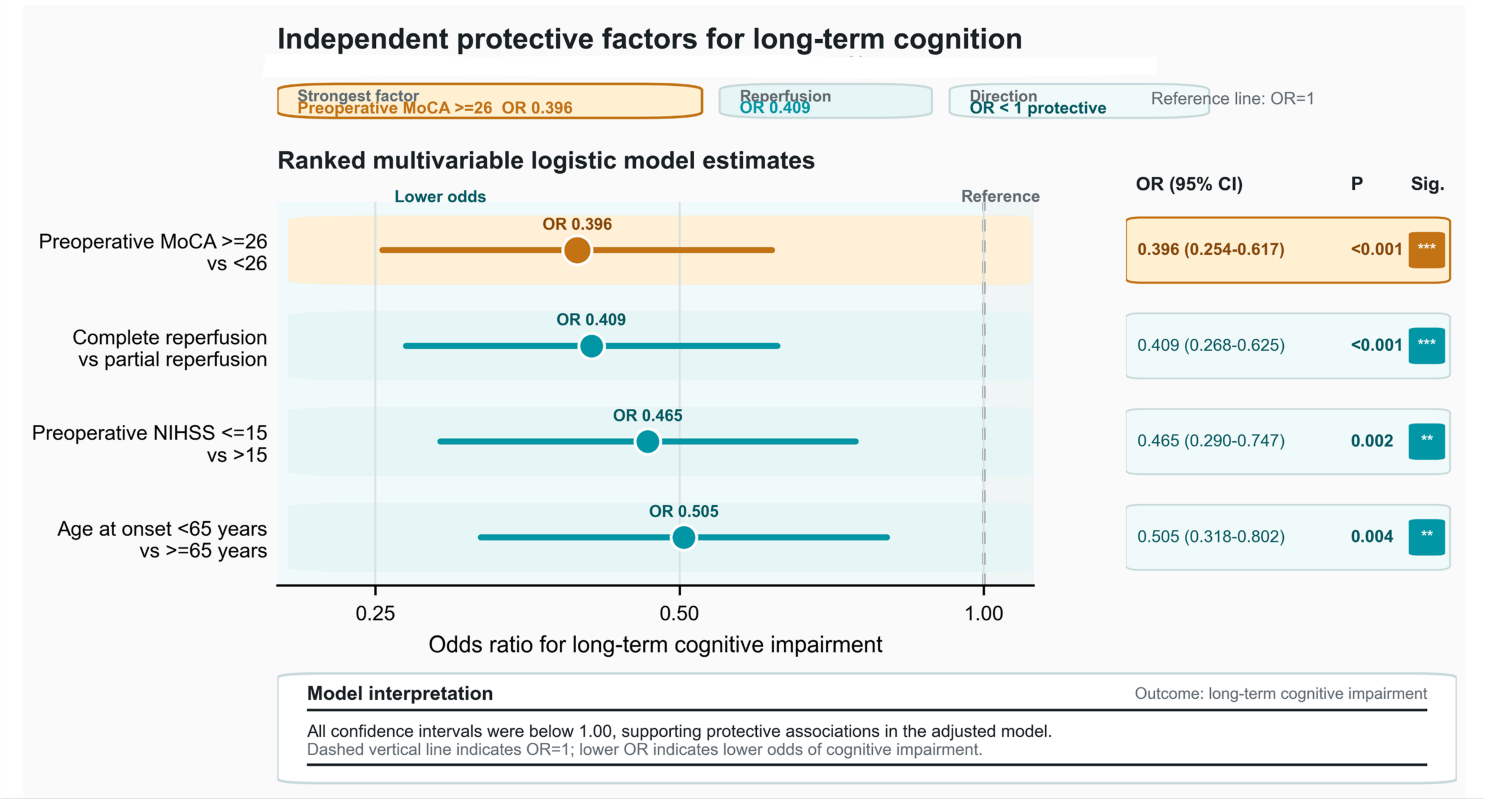


Figure 6

Multivariable logistic regression analysis of independent protective factors for long-term cognitive impairment. Forest plot showing adjusted odds ratios (ORs) with 95% confidence intervals (CIs). Preoperative MoCA ≥26, complete reperfusion, lower baseline NIHSS, and younger age were all significantly associated with reduced odds of cognitive impairment at 6 months (all P<0.01).