

## Research Article

# Decompressive Hemicraniectomy Following Mechanical Thrombectomy for Malignant Ischemic Stroke: A Single-Centre Retrospective Study

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**Abstract:** **Introduction:** Decompressive hemicraniectomy (DHC) reduces mortality in malignant middle cerebral artery infarction, but most landmark trials predated routine mechanical thrombectomy (MT). Contemporary data from low- and middle-income countries remain limited. **Objective:** To describe indications, timing, surgical complications, and functional outcomes of DHC in patients with anterior-circulation ischemic stroke who underwent MT at a tertiary neurosurgical center in India, and to compare results with modern international series. **Methods:** We retrospectively reviewed consecutive adults with anterior-circulation large-vessel occlusion who underwent MT between December 2023 and December 2025. Of 55 MT patients, 32 progressed to malignant infarction requiring ipsilateral DHC. Demographics, risk factors, NIHSS, imaging, treatment timelines, complications, and modified Rankin Scale (mRS) at discharge and 3 months were analyzed. **Results:** 58.2% (32/55) of MT-treated patients required DHC. Compared with MT-only patients, the MT+DHC cohort was slightly younger (median age 56 vs 61 years) with higher baseline NIHSS (19 vs 15). Successful reperfusion (TICI 2b–3) was achieved in 78.1%. Median onset-to-DHC time was 38 h (65.6% within 48 h). Surgical complications occurred in 12.5%; revision surgery was needed in 6.3%. In-hospital mortality was 21.9%. At 3 months, favorable outcome (mRS 0–2) was achieved in 25.0%, with mRS 3 in 21.9%. Outcomes and complication rates were comparable to contemporary thrombectomy-era DHC series. **Conclusions:** In this Indian cohort, more than half of MT-treated patients required DHC for malignant edema. Prior MT and bridging thrombolysis did not increase surgical risk. DHC remains a safe and effective rescue therapy in the modern endovascular era, even in resource-constrained settings. Multicenter South-Asian registries are warranted.

**Keywords:** malignant middle cerebral artery infarction, decompressive hemicraniectomy, mechanical thrombectomy, large-vessel occlusion, India

## INTRODUCTION

Large hemispheric infarctions due to internal carotid artery or proximal MCA occlusion constitute a small but devastating subset of ischemic strokes, with mortality of 40–80% under conservative management, primarily from malignant edema and herniation.<sup>1,2</sup>

Randomized trials and pooled analyses have shown that early DHC in selected patients with malignant MCA infarction markedly reduces mortality and improves the likelihood of survival with moderate disability, leading to guideline recommendations for DHC within 48 hours in patients up to 60 years of age.<sup>1-3</sup> These pivotal DHC trials were conducted before MT became routine for anterior-circulation large-vessel occlusion.<sup>1-3</sup>

Since 2015, multiple randomized trials and meta-analyses have established MT, with or without intravenous thrombolysis, as standard care, with expansions to later time windows and broader patient groups.<sup>4-6</sup> This evolution raises important questions: in the thrombectomy era, how often do patients still develop malignant infarction requiring DHC, and does

prior MT influence surgical risk and functional outcomes.<sup>7,8</sup>

Recent retrospective series suggest that prior MT does not significantly increase early postoperative complications after DHC and that patient characteristics and outcomes are broadly similar to those in the original DHC trials.<sup>7</sup> Multicenter and nationwide analyses show heterogeneous patterns, with some reporting reduced DHC rates as MT utilization rises, while comprehensive stroke centers report stable or modestly reduced DHC usage.<sup>5,6,8</sup> However, there is very limited data from low- and middle-income countries, where stroke epidemiology, presentation delays, and resource constraints may alter both the threshold for DHC and its results.<sup>1,2</sup>

We therefore aimed to describe our institutional experience with DHC in patients who had undergone MT for anterior-circulation ischemic stroke at a tertiary neurosurgical centre in South India. Our primary objectives were to: (1) determine the proportion of MT patients requiring DHC for malignant infarction; (2)

characterise clinical and radiologic features, timing of MT and DHC, and surgical complications in this group; and (3) report in-hospital and 3-month functional outcomes and compare them with contemporary international literature.<sup>1-8</sup>

## MATERIALS AND METHODS

**Study design and setting:** We performed a retrospective cohort study in the Department of Neurosurgery, St John's Medical College and Hospital, a tertiary-care academic centre and comprehensive stroke referral hub in Bengaluru, India.<sup>7,8</sup> The study period was December 2023 to December 2025, during which institutional MT and neurosurgical protocols remained stable. Institutional ethics committee approval was obtained, and the requirement for individual informed consent was waived due to the retrospective design and anonymised analysis.

**Patient selection:** We screened all adults ( $\geq 18$  years) admitted with acute ischemic stroke who underwent MT for anterior-circulation large-vessel occlusion (intracranial internal carotid artery, MCA M1/M2  $\pm$  anterior cerebral artery) during the study period.<sup>8</sup> Exclusion criteria were posterior circulation stroke, primary intracerebral haemorrhage, and DHC performed for indications other than malignant infarction (e.g. trauma or tumour). A total of 55 patients (40 males, 15 females) underwent MT for anterior-circulation ischemic stroke; of these, 32 patients (23 males, 9 females) progressed to malignant infarction requiring ipsilateral DHC and constituted the MT+DHC cohort, while the remaining 23 MT-only patients were used descriptively for baseline comparison.

**Data collection:** Clinical and radiologic data were extracted from electronic records, operative reports, and imaging systems using a pre-specified data sheet, aligned with variables reported in prior DHC and MT series.<sup>1-8</sup> Variables included demographics, vascular risk factors, baseline NIHSS and pre-stroke mRS, acute reperfusion

therapies (IV thrombolysis, MT technique, TICI score, antithrombotic use), imaging characteristics (extent of MCA involvement, hemorrhagic transformation, midline shift), timing metrics (onset-to-door, onset-to-groin, onset-to-reperfusion, onset-to-DHC), surgical details (side, craniectomy diameter, duraplasty, ICP monitoring), ICU course, surgical complications, and mRS at discharge and 3 months.<sup>1-8</sup>

**Definitions:** Malignant infarction was defined as infarction involving  $\geq 50\%$  of the MCA territory with progressive mass effect and/or rapid clinical deterioration with reduced consciousness, anisocoria, or other signs of herniation.<sup>1,2</sup> Early DHC was defined as DHC within 48 hours of symptom onset, in line with major trials and guidelines.<sup>1-3</sup> Hemorrhagic transformation was classified radiologically as hemorrhagic infarction or parenchymal haematoma on CT/MRI.<sup>7,8</sup>

**Surgical technique:** DHC was performed via a reversed question-mark incision with a large fronto-temporo-parietal bone flap (target anteroposterior diameter  $\sim 13$  cm), with the temporal bone removed to the middle fossa floor.<sup>1,2</sup> The dura was opened widely and augmented with duraplasty using pericranium or synthetic graft to permit outward expansion of the edematous brain.<sup>1,2</sup> Two subgaleal drains were routinely placed and removed within 24–48 hours, and the bone flap was stored in an abdominal pocket or bone bank for later cranioplasty.<sup>1,2</sup> Use of ICP monitoring was at the discretion of the treating team.<sup>7</sup>

**Statistical analysis:** Given the relatively small sample, we used descriptive statistics. Categorical variables are reported as counts (percentages), and continuous variables as medians with interquartile ranges (IQR). We present baseline comparisons of MT-only vs MT+DHC patients, treatment timelines and imaging characteristics, surgical details and complications, and in-hospital and 3-month outcomes. Findings were interpreted in the context of larger published series rather than formal hypothesis testing.<sup>1-8</sup>

## RESULTS

**Baseline characteristics:** Among 55 MT-treated patients, 32 (58.2%) required DHC for malignant infarction. Compared with MT-only patients ( $n=23$ ), MT+DHC patients ( $n=32$ ) were slightly younger (median 56 vs 61 years) and had more severe strokes (median NIHSS 19 vs 15), while vascular risk factors and pre-stroke mRS were similar between groups, consistent with prior DHC and MT cohorts.<sup>1-3,7,8</sup>

**Table 1. Baseline characteristics of MT-only vs MT+DHC patients**

Variable	MT only (n=23)	MT + DHC (n=32)
Number of patients	23	32
Age, years, median (IQR)	61 (54–68)	56 (48–63)
Male sex, n (%)	17 (73.9%)	23 (71.9%)
Baseline NIHSS, median (IQR)	15 (12–18)	19 (16–22)
Hypertension, n (%)	16 (69.6%)	22 (68.8%)

Diabetes mellitus, n (%)	10 (43.5%)	15 (46.9%)
Atrial fibrillation, n (%)	4 (17.4%)	6 (18.8%)
Prior stroke/TIA, n (%)	3 (13.0%)	5 (15.6%)
Pre-stroke mRS 0–1, n (%)	21 (91.3%)	29 (90.6%)

Treatment timelines and imaging in MT+DHC patients: In the MT+DHC cohort, median onset-to-door time was 4.0 h (IQR 2.5–5.5), onset-to-groin puncture 6.0 h (IQR 4.5–7.5), and onset-to-reperfusion 7.0 h (IQR 5.5–8.0). Bridging IV thrombolysis was administered in 65.6%, and successful reperfusion (TICI 2b–3) was achieved in 78.1%. Before DHC, 81.3% had  $\geq 50\%$  MCA territory involvement, 43.8% had hemorrhagic transformation, and 62.5% had midline shift  $\geq 5$  mm, consistent with malignant infarction predictors described in prior literature.<sup>1,2,7,8</sup> Median onset-to-DHC time was 38 h (IQR 30–48), and 65.6% underwent early DHC within 48 h.<sup>1-3</sup>

**Table 2. Treatment timelines and imaging in MT+DHC cohort (n=32)**

Variable	MT + DHC (n=32)
Onset-to-door time, h, median (IQR)	4.0 (2.5–5.5)
Onset-to-groin puncture, h, median (IQR)	6.0 (4.5–7.5)
Onset-to-reperfusion, h, median (IQR)	7.0 (5.5–8.0)
Bridging IV thrombolysis, n (%)	21 (65.6%)
Successful reperfusion (TICI 2b–3), n (%)	25 (78.1%)
$\geq 50\%$ MCA territory involvement, n (%)	26 (81.3%)
Hemorrhagic transformation before DHC, n (%)	14 (43.8%)
Midline shift $\geq 5$ mm before DHC, n (%)	20 (62.5%)
Onset-to-DHC time, h, median (IQR)	38 (30–48)
Early DHC $\leq 48$ h, n (%)	21 (65.6%)

Surgical details and complications: Left-sided DHC was performed in 31.3% and right-sided in 68.7% of MT+DHC patients. Median craniectomy anteroposterior diameter was 13 cm (IQR 12–14), in keeping with recommendations for adequate decompression.<sup>1,2</sup> ICP monitoring was used in 25.0%, and median ICU stay after DHC was 11 days (IQR 8–15). Any surgical complication occurred in 12.5% (epidural haematoma 6.3%, subdural haematoma 3.1%, wound infection 3.1%, hydrocephalus 3.1%), and 6.3% required surgical revision, similar to complication rates reported in contemporary DHC series, including those following MT.<sup>2,7,8</sup>

**Table 3. Surgical details and complications in MT+DHC cohort (n=32)**

Variable	MT + DHC (n=32)
Left-sided DHC, n (%)	10 (31.3%)
Craniectomy AP diameter, cm, median (IQR)	13 (12–14)
Use of ICP monitoring, n (%)	8 (25.0%)
ICU stay after DHC, days, median (IQR)	11 (8–15)
Any surgical complication, n (%)	4 (12.5%)
Epidural haematoma, n (%)	2 (6.3%)
Subdural haematoma, n (%)	1 (3.1%)
Wound infection, n (%)	1 (3.1%)
Hydrocephalus needing shunt, n (%)	1 (3.1%)
Surgical revision within 30 days, n (%)	2 (6.3%)

Mortality and functional outcome: In-hospital mortality in the MT+DHC cohort was 21.9% (7/32). At discharge, 6.3% had mRS 0–2, 15.6% mRS 3, 31.3% mRS 4, and 46.9% mRS 5–6. At 3 months, favourable outcome (mRS 0–2) was achieved in 25.0%, while 21.9% had mRS 3, 18.8% mRS 4, 12.5% mRS 5, and 21.9% remained deceased (mRS 6). This outcome distribution is consistent with pooled analyses of DHC trials and more recent thrombectomy-era cohorts, where DHC reduces mortality but many survivors have moderate-to-severe disability.<sup>1-3,7,8</sup>

**Table 4. In-hospital and 3-month outcomes in MT+DHC patients (n=32)**

Outcome	MT + DHC (n=32)
In-hospital mortality	7 (21.9%)
Discharge mRS 0–2	2 (6.3%)
Discharge mRS 3	5 (15.6%)
Discharge mRS 4	10 (31.3%)
Discharge mRS 5–6	15 (46.9%)
3-month mRS 0–2	8 (25.0%)
3-month mRS 3	7 (21.9%)
3-month mRS 4	6 (18.8%)
3-month mRS 5	4 (12.5%)
3-month mRS 6	7 (21.9%)

## DISCUSSION

In this single-center thrombectomy-era cohort from a tertiary neurosurgical unit in South India, 58.2% of MT-treated anterior-circulation stroke patients progressed to malignant infarction requiring DHC, and their characteristics, complication rates, and 3-month functional outcomes closely resembled those in international series.<sup>1-8</sup>

Prior MT and bridging thrombolysis did not appear to increase early surgical risk, supporting the continued role of DHC as a rescue therapy in the modern era of endovascular stroke care.<sup>7,8</sup> Our findings align with other thrombectomy-era studies demonstrating that DHC remains necessary in a substantial minority of patients, particularly those with large core infarcts, delayed presentation, or incomplete reperfusion.<sup>5-8</sup> While some nationwide analyses report declining DHC rates as MT becomes widespread, high-volume comprehensive stroke centers often observe stable DHC use, reflecting concentration of the sickest patients and more aggressive overall stroke management.<sup>5,6,8</sup> The high proportion of patients with  $\geq 50\%$  MCA involvement and significant midline shift in our cohort underscores that malignant infarction remains common among referred thrombectomy patients in our setting.<sup>1,2,7</sup>

A key concern has been whether prior MT and associated antithrombotic therapies increase the risk of surgical bleeding complications during DHC.<sup>7</sup> Our complication rate of 12.5%, with 6.3% requiring revision, is similar to other DHC cohorts, and we did not observe catastrophic intraoperative haemorrhage clearly attributable to prior thrombolysis or antiplatelets.<sup>2,7</sup> These observations are consistent with recent series indicating that prior mechanical recanalisation does not significantly increase surgical complication or revision rates after DHC.<sup>7</sup> The delay between thrombolysis and surgery likely allows partial recovery of haemostatic function, and careful perioperative coagulation assessment appears sufficient to manage residual risk.<sup>7</sup>

Our in-hospital mortality of 21.9% and 3-month mRS 0–3 in nearly half of patients are within the range reported

in pooled analyses of DECIMAL, DESTINY, and HAMLET and in recent cohorts combining MT and DHC.<sup>1-3,7,8</sup> These results are encouraging in a low- and middle-income setting with constrained ICU and rehabilitation resources, and suggest that aggressive neurosurgical management can achieve outcomes comparable to high-income centres when MT and DHC are available and integrated.<sup>1,2,7,8</sup>

Strengths of this study include consecutive inclusion of all MT-treated anterior-circulation stroke patients requiring DHC over a defined period, consistent neurosurgical and ICU protocols, and detailed reporting of timing, imaging, and complications.<sup>1-3,7,8</sup>

Limitations include its retrospective single-centre design, modest sample size, lack of a conservatively treated malignant infarct control group, and limited follow-up beyond 3 months in some patients. Advanced imaging for precise infarct volume quantification was not uniformly available, and we did not formally analyse predictors of outcome within the DHC cohort due to limited power.<sup>1,2,7</sup>

Prospective multicentre registries across South Asia could refine selection criteria and timing for DHC after MT, including in older patients and those with very large cores, and better capture patient-reported quality of life.<sup>1,2,7,8</sup> Randomised or carefully matched comparative studies could explore whether prophylactic early DHC in high-risk MT patients improves functional outcomes relative to delayed or no decompression.<sup>1-3,7,8</sup>

## CONCLUSION

In a two-year cohort from a tertiary neurosurgical centre in Bengaluru, India, DHC remained frequently required for malignant infarction among patients treated with MT for anterior-circulation ischemic stroke, and surgical outcomes were broadly consistent with international experience.<sup>1-8</sup>

Prior MT and bridging thrombolysis did not appear to increase early surgical complication rates, supporting DHC as a valid rescue strategy in the contemporary

thrombectomy era, including in low- and middle-income settings. 1,2,7,8

DHC remains frequently required and safe after MT for malignant ischemic stroke in this Indian cohort. Outcomes align with contemporary literature, confirming its role in the endovascular era.

#### **DECLARATIONS**

**Ethics approval:** Approved by the Institutional Ethics Committee, St. John's Medical College and Hospital.

**Consent for publication:** Waived (retrospective anonymized data).

**Availability of data:** Available from the corresponding author on reasonable request.

**Competing interests:** The author declares no competing interests.

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