

Impact of Timing of Decompressive Craniectomy on Outcomes in Pediatric Traumatic Brain Injury in a Tertiary Care Hospital

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Abstract

Background: Severe traumatic brain injury (TBI) in children frequently leads to elevated intracranial pressure (ICP) unresponsive to first-tier therapies. Decompressive craniectomy (DC) is used as a second-tier measure, but the optimal timing (early vs. late) and role of postsurgical drains in pediatric TBI remain unclear. **Material and Methods:** We retrospectively analyzed 35 pediatric patients (<18 years) who underwent DC for moderate to severe TBI between August 2023 and January 2025 at a tertiary care hospital. Patients were grouped as acute (<24 h; n=27) or subacute (>24 h; n=8) based on surgery timing. Clinical, radiological, surgical details, complications, and outcomes were analyzed. Primary outcomes were GOS scores at discharge, 3 and 6 months, while postoperative drain use and complications were also assessed. **Results:** The mean age was 8.07 ± 4.04 years with slight male predominance. Road traffic accidents were the most common cause, followed by falls and assaults. The acute group had a lower preoperative GCS (6.67 vs. 8.88), but postoperative improvement was similar. At 6 months, 75% of survivors achieved favorable outcomes (GOS ≥ 4), with no significant difference between early and delayed DC. Mortality was 31.4%. Complications included CSF leak (14.3%), infection (22.9%), hydrocephalus (8.6%), and hygroma (8.6%). Drains were used in most patients (77.1%) and external ventricular drains in 14.3%. **Conclusion:** Decompressive craniectomy is effective in severe pediatric TBI, yielding 75% favorable outcomes at six months. Surgical timing did not affect recovery, complications were acceptable with low hydrocephalus rates, and larger studies are needed to refine indications and management.

Keywords: Pediatric traumatic brain injury; Decompressive craniectomy; Surgical timing; Early vs. late DC; Intracranial pressure; Glasgow Outcome Scale; Neurological recovery; Postoperative complications; Hydrocephalus; Surgical drains.

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INTRODUCTION

Traumatic brain injury (TBI) is a major cause of death and disability in children.^[1] Severe TBI often leads to raised intracranial pressure (ICP), which, if uncontrolled, results in cerebral ischemia, herniation, and poor outcomes.^[2,3] Initial management involves first-tier therapies such as sedation, hyperosmolar agents, and cerebrospinal fluid (CSF) drainage.^[4] When these measures fail, decompressive craniectomy (DC) is considered. DC lowers ICP by removing a portion of the skull to allow brain expansion; however, the optimal timing of this procedure—whether performed early (within 24 hours) or late—remains unclear, especially in pediatric patients.^[2,5] While early DC may limit secondary injury, it could also increase the risk of complications.^[6] Current literature offers limited and conflicting evidence, and most guidelines are extrapolated from adult studies rather than pediatric populations, leading to uncertainty in evidence-based decision-making. Moreover, common postoperative complications such as post-traumatic hydrocephalus (PTH) and subdural hygroma may delay recovery, and the role of postsurgical drains (e.g., external ventricular or subgaleal drains) in preventing these complications is still controversial.^[7] There is a need to clarify the impact of surgical timing and

perioperative management strategies on outcomes in pediatric TBI. Therefore, this study aims to compare clinical outcomes between early and late DC, determine the incidence of PTH and hygroma, assess whether the use of postsurgical drains reduces postoperative complications in pediatric TBI patients.

MATERIALS AND METHODS

This retrospective study was conducted following approval from the Institutional Review Board. We reviewed medical records of pediatric patients, aged less than 18 years, who underwent decompressive craniectomy (DC) for moderate to severe traumatic brain injury (TBI) at our tertiary care hospital over a 1.5-year period between August 2023 and January 2025. All patients included in the study had undergone DC specifically as

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a therapeutic intervention for elevated intracranial pressure secondary to TBI. Patients with polytrauma or incomplete medical records, those with pre-existing neurological disorders, bleeding disorders, prior TBI were not included in our study.

Clinical, radiological, and surgical data were systematically collected and analyzed. Neurological status at admission was recorded, including Glasgow Coma Scale (GCS) score, pupillary reactivity, and the presence of any focal neurological deficits. Preoperative imaging was assessed using computed tomography (CT). Preoperative data were obtained from documentation immediately prior to surgery, while postoperative data were derived from clinical records within 24 to 48 hours following surgery, based on the earliest available documentation.

Information on the type and timing of DC was also recorded. The timing of surgery was classified as acute (performed within 24 hours of injury) or subacute (performed after 24 hours). The indications for surgery included clinical deterioration, radiological evidence of cerebral swelling, midline shift or herniation, elevated intracranial pressure refractory to medical therapy, and the presence of space-occupying mass lesions. Treatment modalities administered prior to surgery, such as sedation, osmotic therapy, and CSF drainage.

Postoperatively, all patients were monitored for complications such as cerebrospinal fluid (CSF) leaks, infections, development of hydrocephalus, subgaleal or subdural fluid collections, and progression or appearance of new intracranial hematomas. These were identified through

imaging studies and neurosurgical documentation. The use of surgical drains, including external ventricular drains (EVD) and subgaleal drains, was noted when applicable.

Outcome was assessed using Postoperative GCS and Glasgow Outcome Scale (GOS). GOS scores were evaluated at the time of hospital discharge and again at follow-up at 3 and 6 months post-surgery.

All decisions regarding the need for and timing of DC were made by the attending neurosurgical team using a multifactorial clinical decision-making process, guided by both the patient’s neurological condition and radiological findings.

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and compared between groups using the independent t-test or Mann–Whitney U test, depending on data distribution. Categorical variables frequencies and percentages and compared using the Chi-square test or Fisher’s exact test as appropriate. A p-value < 0.05 was considered statistically significant.

RESULTS

The total cohort consisted of 35 pediatric patients with a mean age of 8.07 ± 4.14 years. Most patients were between 6–10 years (40%), followed by 1–5 years (34.29%). Adolescents aged 11–15 years accounted for 20%, while the 16–18 years group represented the smallest proportion (5.71%) [Table 1]. There was a slight male predominance, with 18 of the 35 patients being male.

Table 1: Age distribution of patients

Age (years)	Total	Percent (%)
1–5	12	34.29
6–10	14	40.00
11–15	7	20.00
16–18	2	5.71

Analysis of the mode of injury revealed that road traffic accidents (RTA) were the most common cause of severe traumatic brain injury, accounting for 15 patients (57.7%) [Table 2]. Falls from height were the second most frequent cause, observed in 8 patients (30.8%). Assault-related

injuries were noted in 3 patients (11.5%), while a single case (3.8%) resulted from a gunshot wound. These findings indicate that high-velocity trauma, particularly road traffic accidents, remains the predominant cause of severe head injury in the pediatric population studied.

Table 2: Mode of Injury

MOI	Number of patients (%)
RTA	15(57.7%)
Fall from height	8(30.8%)
Assault	3(11.5%)
Gun shot	1(3.8%)

Table 3: Pupil at the time of admission

	Total	Acute	Subacute
Isocoric	27	19	8
Anisocoric	5	5	0
Fixed and dilated	3	3	0

Pupillary examination at the time of admission showed that the majority of patients (27 out of 35) had isocoric pupils [Table 3]. Among these, 19 were operated within 24 hr and 8

were operated after 24 hr. Anisocoria was observed in 5 patients, all of whom were in the acute group. Additionally, 3 patients presented with fixed and dilated pupils, all

belonging to the acute group, indicative of severe brain injury or herniation syndromes. Notably, no patient in the subacute group had either anisocoric or fixed dilated pupils at admission, which reflect these patients were operated on urgent basis.

All patients underwent emergent CT scans at admission, which revealed diffuse cerebral edema of varying severity in every case. Associated intracranial lesions were frequently observed. Depressed skull fractures were identified in 10 patients, including both displaced and undisplaced types.

Among the intracranial hemorrhagic lesions, acute subdural hematoma was the most common in 13 patients, followed by intracerebral hematoma, subarachnoid hemorrhage, and multiple cerebral contusions. Several patients presented with multiple concurrent lesions, where combined parenchymal, extra-axial, and bony injuries often coexist following high-impact trauma. There were 27 (77.14%) patients who underwent an acute procedure, whereas 8 (22.16%) underwent a subacute procedure.

Table 4: In hospital Mean GCS, Mean GOS at discharge and at Follow ups

GCS	Total	Acute	Subacute
Pre surgery	7.17 ± 2.42	6.67 ± 2.35	8.88 ± 1.89
Post surgery	9.26 ± 3.37	9.48 ± 3.42	9.38 ± 3.42
GOS			
At Discharge	2.83 ± 1.44	2.85 ± 1.43	2.75 ± 1.58
At 3 months	3.03 ± 1.52	3.04 ± 1.48	3 ± 1.77
At 6 Months	3.34 ± 1.76	3.37 ± 1.74	3.25 ± 1.98

The mean Glasgow Coma Scale (GCS) score for the entire cohort prior to surgery was 7.17. When stratified by surgical timing, patients in the acute group had a lower preoperative mean GCS of 6.67 compared to 8.88 in the subacute group, suggesting more severe neurological impairment in those requiring early intervention [Table 4]. Following surgery, the mean postoperative GCS improved across both groups, reaching 9.48 in the acute group and 9.38 in the subacute group, with a combined cohort mean of 9.26. This reflects a general trend of neurological improvement postoperatively in both groups, although the degree of improvement was more substantial in those operated acutely. Subacute patients had significantly higher preoperative GCS compared to the acute group (8.88 ± 1.89 vs. 6.67 ± 2.35). However, postoperative GCS did not differ significantly between acute and subacute decompressive craniectomy (9.48 ± 3.19 vs. 9.22 ± 3.42), indicating comparable neurological improvement despite worse initial status in the acute group. The Glasgow Outcome Scale (GOS) at discharge showed a

mean score of 2.83 for the overall population, with the acute group having mean score of 2.85 and the subacute group 2.75. At the 3-month follow-up, mean GOS improved to 3.03 in the total cohort, with gradual gains in both subgroups (3.04 in acute and 3.0 in subacute). By the 6-month follow-up, continued improvement was observed with a mean GOS of 3.34 overall. However, the acute group had a mean of 3.37 and the subacute group 3.25, indicating that although functional recovery progressed over time, the overall long-term outcomes remained better in the total cohort, potentially influenced by initial severity and timing of surgical intervention. Notably, despite having a better initial GCS, the subacute group did not demonstrate a proportionally greater improvement in GOS over time. There was no statistically significant difference in 6-month GOS outcomes between the acute and subacute decompressive craniectomy groups (p > 0.05), indicating that long-term functional recovery was comparable regardless of timing of surgery.

Table 5: Complications between acute and subacute groups

Complication	Total	Acute	Subacute
Hydrocephalus	3	3	0
Subgaleal fluid collection	1	1	0
Subdural fluid collection	3	2	1
Infection	8	6	2
CSF leak	5	4	1

Postoperative management often required surgical drains or external ventricular devices (EVD) for cerebrospinal fluid (CSF) diversion and intracranial pressure control. Among the 35 patients, 24 received a subgaleal or subdural drain alone (19 acute, 5 subacute), while 3 required both EVD and drain (2 acute, 1 subacute), and 2 had only an EVD (both acute). Postoperative complications occurred in 37.14% of patients but were largely manageable. Hydrocephalus developed in 3 acute cases, and subgaleal fluid collection was noted in 1 acute case. Infection was the most frequent complication, affecting 8 patients (6 acute, 2 subacute), and was mostly associated with CSF leak or subgaleal/subdural fluid

collections [Table 5]. CSF leak occurred in 5 patients (4 acute, 1 subacute), with only one case of infection occurring independently. Subdural fluid collections were reported in 3 patients (2 acute, 1 subacute). EVD use correlated with higher infection rates, prolonged drain duration increased CSF leak risk, and multiple EVDs were linked to subdural collections. Overall, no single complication dominated the clinical course in either group.

Out of the total 35 patients included in the study, there were 11 deaths, resulting in an overall mortality rate of 31.4%. Mortality was higher in the acute group, with 9 of the 27 patients (33.3%) succumbing to their injuries, compared to 2 deaths among the 8

patients (25%) in the subacute group.

DISCUSSION

Decompressive craniectomy (DC) for severe pediatric traumatic brain injury (TBI) remains controversial due to limited high-quality evidence in children. Although historically used to relieve brain swelling by removing part of the skull, its acceptance has varied. Most data come from adult studies, while pediatric research is scarce. However, available evidence shows that DC effectively lowers refractory intracranial pressure (ICP) and improves cerebral perfusion, which is associated with better long-term neurological outcomes. In our pediatric cohort, DC was an effective strategy for managing severe TBI and elevated ICP, regardless of the timing of surgery. Among the survivors, 75.0% achieved favorable outcomes—defined as a Glasgow Outcome Score (GOS) of 4 or 5—at the six-month follow up and observed overall mortality rate of 31.4% aligned with findings from previous studies. Notably, we recorded a significantly lower incidence of post-traumatic hydrocephalus at 8.57%, compared to the higher rates of 29–42% commonly cited in the literature.^[7-17]

Our study involved 35 pediatric patients with severe traumatic brain injury (TBI) who underwent decompressive craniectomy (DC), aimed at evaluating the impact of early surgical intervention on clinical outcomes. Most patients received unilateral DC, and it emerged as a cost-effective option compared to more intensive medical approaches like barbiturate-induced coma. Among these cases, the leading cause of TBI was road traffic accidents (RTA), followed by falls from height and assaults, with only one case attributed to a gunshot injury. Children from low-income backgrounds and those with impulsive or risk-taking behaviors were more prone to injury. CT imaging guided surgical planning, including craniectomy site and need for duraplasty or lesion resection. Poor outcomes correlated with brain herniation, low initial Glasgow Coma Scale (GCS) scores, and abnormal pupillary reactions. Long-term outcomes were assessed using the original Glasgow Outcome Scale (GOS), a standard tool to evaluate functional recovery, including independence, return to school, and performance in daily activities. The role of timing in DC—whether performed acutely (<24 hours) or subacutely (>24 hours)—remains debated in pediatric patients. Our data showed minimal difference in six-month GOS scores between early and delayed DC groups. While studies by Mhanna et al,^[8] and Josan & Sgouros,^[9] advocate for early DC to control intracranial pressure (ICP) and improve outcomes, their comparisons were against patients who did not receive surgery, not those with delayed DC. In agreement with our findings, Amer Jaradat et al,^[10] reported no significant impact of surgical timing on GOS outcomes among pediatric patients. The absence of a strong association between early DC and improved outcomes in our study could be attributed to other influencing factors, particularly the mechanism of injury. For instance, Paul et al,^[11] demonstrated that non-accidental TBI significantly raised the risk of mortality—by as much as twelvefold—compared to other causes. In contrast, our cohort primarily included

patients with accidental injuries like RTAs and falls. Non-accidental injuries often present later and with more extensive associated trauma, potentially skewing outcomes irrespective of surgical timing. Despite many of our patients presenting with severe clinical status, three-quarters (75%) of survivors achieved favorable six-month outcomes (GOS 4 or 5), reaffirming findings from previous literature,^[9] that DC can be a powerful intervention to mitigate secondary brain injury and improve recovery in pediatric TBI cases.

A statistically significant correlation was also observed between abnormal pupillary findings and lower GOS scores, supporting the notion that pupillary abnormalities can serve as valuable prognostic indicators. This aligns with the conclusions of Taylor HG et al,^[12] who found that pupillary dysfunction was associated with poor outcomes. However, it is worth noting that Güresir et al,^[2] also reported that favorable recovery could still occur in pediatric TBI patients even with pupillary mydriasis, highlighting the complex and multifactorial nature of outcome prediction.

In terms of postoperative complications, our patient cohort experienced several issues commonly reported following DC, such as superficial wound infections, subdural and subgaleal hygromas, hydrocephalus, and cerebrospinal fluid (CSF) leaks. Complication rates for DC vary widely in the literature—ranging from 0% to 100%—though most fall between 14% and 40%.^[13,14] Our observed complication rate was 37.14%, which fits within this range. Specifically, our infection rate of 22.8% closely mirrors the 18.8% reported by Ballesterio et al,^[15] indicating consistency with broader trends.

Post-traumatic hydrocephalus (PTH), although prevalent in many studies, was relatively rare in our cohort, occurring in just 8.57% (3 patients). This rate is significantly lower than the 21–40% commonly reported.^[16] One possible explanation for this reduced incidence is our consistent use of postoperative drainage systems. In our series, 14.3% of patients received an external ventricular drain (EVD), while 77.14% had either subdural or subgaleal drains. Many other studies fail to detail the exact use of such drains, making direct comparisons challenging. However, our findings suggest that careful use of drains may contribute meaningfully to the prevention of PTH.

The development of hygromas—collections of CSF in the subdural space—is often considered a precursor to PTH. Pechmann et al,^[17] reported that all cases of PTH in their study were preceded by subdural hygromas. Despite some studies citing hygroma incidence rates as high as 83%, our cohort showed a much lower rate of just 8.57%. Again, this may be attributed to our standardized use of subgaleal and ventricular drainage systems during postoperative care.

Regarding drain management, we exercised caution to prevent overdrainage of CSF, which could lead to complications such as slit ventricle syndrome. EVDs were carefully calibrated to avoid excessive drainage, and adjustments were made when needed. Subgaleal drains were used in conjunction to maintain a balanced CSF outflow, minimizing the risk of ventricular collapse and subsequent failure of the drainage system.^[18] This approach may offer an additional advantage in optimizing postoperative outcomes and minimizing complication.

This retrospective study with a small sample size (n=35) is prone to selection bias and limited statistical power, especially between

acute and subacute groups. The absence of a non-surgical control group restricts comparisons with conservative management. Variations in injury severity (initial GCS, pupillary changes, herniation) may have acted as confounders. Follow-up was limited to six months, potentially missing delayed cognitive or functional effects.

CONCLUSION

This study demonstrates that decompressive craniectomy (DC) is an effective intervention for managing severe traumatic brain injury in pediatric patients, with 75% of survivors achieving favorable outcomes at six months. The timing of surgery, whether performed within 24 hours (acute) or after 24 hours (subacute), did not significantly influence neurological recovery. The overall complication rate was within expected ranges, and the incidence of post-traumatic hydrocephalus was notably lower, possibly due to the consistent use of external ventricular and subgaleal drains. These findings support the role of DC as a valuable tool in pediatric neurotrauma, though larger prospective studies are needed to refine indications, timing, and postoperative management strategies.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Adamo MA, Drazin D, Smith C, Waldman JB. Comparison of accidental and nonaccidental traumatic brain injuries in infants and toddlers: Demographics, neurosurgical interventions, and outcomes. *J Neurosurg Pediatr* 2009;4:414-9.
- Elsawaf Y, Anetsberger S, Luzzi S, Elbabaa SK. Early decompressive craniectomy as management for severe traumatic brain injury in the pediatric population: A comprehensive literature review. *World Neurosurg* 2020;138:9-18.
- Güresir E, Schuss P, Seifert V, Vatter H. Decompressive craniectomy in children: Single-center series and systematic review. *Neurosurgery* 2012;70:881-8.
- Kochanek PM, Tasker RC, Bell MJ, Adelson PD, Carney N, Vavilala MS, et al. Management of pediatric severe traumatic brain injury: 2019 consensus and guidelines-based algorithm for first and second tier therapies. *Pediatr Crit Care Med* 2019;20:269-79.
- Manfiotto M, Beccaria K, Rolland A, Paternoster G, Plas B, Boetto S, et al. Decompressive craniectomy in children with severe traumatic brain injury: A multicenter retrospective study and literature review. *World Neurosurg* 2019;129:e56-62.
- Nagy L, Morgan RD, Collins RA, Kharbat AF, Garza J, Belirgen M. Impact of timing of decompressive craniectomy on outcomes in pediatric traumatic brain injury. *Surg Neurol Int.* 2023 Dec 22;14:436. doi: 10.25259/SNI_472_2023. PMID: 38213457; PMCID: PMC10783660.
- Pechmann A, Anastasopoulos C, Korinthenberg R, van Velthoven-Wurster V, Kirschner J. Decompressive craniectomy after severe traumatic brain injury in children: Complications and outcome. *Neuropediatrics* 2015;46:5-12.
- Mhanna, Maroun & Mallah, Wael & Verrees, Margaret & Shah, Rajiv & Super, Dennis. (2015). Outcome of children with severe traumatic brain injury who are treated with decompressive craniectomy. *Journal of neurosurgery.* Pediatrics. 16. 1-7. 10.3171/2014.10.PEDS14117.
- Josan VA, Sgouros S. Early decompressive craniectomy may be effective in the treatment of refractory intracranial hypertension after traumatic brain injury. *Childs Nerv Syst* 2006;22:1268-74.
- Amer Jaradat, Mohammed M. Al Barbarawi, Mohammad Jamous, Sultan Jarrar, Suleiman S. Daoud, Saif Aldeen Rawabdeh, Sleem Ra'id Almasanat, Atef F. Hulliel, Shaden Tashtoush, Omar A. Ahmad, Early versus Late Decompressive Craniectomy in Pediatrics with Traumatic Brain Injuries: A Retrospective Study, *World Neurosurgery*, Volume 196, 2025, 123827, ISSN 1878-8750, <https://doi.org/10.1016/j.wneu.2025.123827>.
- Paul, Alexandra R., & Matthew A. Adamo. "Non-accidental trauma in pediatric patients: a review of epidemiology, pathophysiology, diagnosis and treatment." *Translational Pediatrics [Online]*, 3.3 (2014): 195-207. Web. 16 Sep. 2025.
- Taylor HG, Swartwout MD, Yeates KO, Walz NC, Stancin T, Wade SL. Traumatic brain injury in young children: postacute effects on cognitive and school readiness skills. *J Int Neuropsychol Soc.* 2008; 14:734-745.
- Jagannathan J, Okonkwo DO, Dumont AS, Ahmed H, Bahari A, Prevedello DM, et al. Outcome following decompressive craniectomy in children with severe traumatic brain injury: A 10-year single-center experience with long-term follow up. *J Neurosurg.* 2007;106:268-75. doi: 10.3171/ped.2007.106.4.268.
- Kan P, Amini A, Hansen K, White GL, Jr, Brockmeyer DL, Walker ML, et al. Outcomes after decompressive craniectomy for severe traumatic brain injury in children. *J Neurosurg.* 2006;105:337-42. doi: 10.3171/ped.2006.105.5.337.
- Ballesterio MF, Furlanetti LL, Augusto LP, Chaves PH, Santos MV, de Oliveira RS. Decompressive craniectomy for severe traumatic brain injury in children: Analysis of long term neuropsychological impairment and review of the literature. *Childs Nerv Syst* 2019;35:1507-15.
- Carballo-Cuello C, de Jesus O, Fernandez-de Thomas RJ, Garcia M, Vigo-Prieto J, de Jesus-Espinosa A. Posttraumatic hydrocephalus in pediatric patients after decompressive craniectomy. *World Neurosurg.* 2020;136:e690-4. doi: 10.1016/j.wneu.2020.01.153.
- Pechmann A, Anastasopoulos C, Korinthenberg R, van Velthoven-Wurster V, Kirschner J. Decompressive craniectomy after severe traumatic brain injury in children: Complications and outcome. *Neuropediatrics* 2015;46:5-12.
- Sood S, Kumar CR, Jamous M, Schuhmann MU, Ham SD, Canady AI. Pathophysiological changes in cerebrovascular distensibility in patients undergoing chronic shunt therapy. *J Neurosurg* 2004;100:447-53.