Short-term Outcome of Mini craniotomy Verses Conventional Craniotomy for Extradural Hematoma

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ABSTRACT

Background: Extradural hematoma (EDH) is a neurosurgical emergency; mini craniotomy offers a less invasive alternative to conventional craniotomy, potentially reducing surgical trauma and operative time, especially in resource-limited settings, with this study comparing their short-term outcomes. **Methods:** This RCT (Randomized Controlled Trail) at Dhaka Medical College (Apr 2023–Oct 2024) enrolled 56 EDH patients (15–60 y); 28 had mini craniotomy (Group A) and 28 conventional (Group B), comparing GCS, hematoma volume, midline shift, operative time, pain, and complications using SPSS 26 with chi-square, t-test, and Pearson correlation. **Results:** Baseline characteristics including age, cause of injury, preoperative GCS, hematoma volume, MLS, and time to surgery were comparable between the groups ($p>0.05$). The mean operative time was significantly shorter in the mini craniotomy group (84.82±11.50 minutes) compared with the conventional group (105.18±11.59 minutes) ($p<0.05$). Postoperative pain scores were significantly lower in the mini craniotomy group (4.43±0.79 vs 5.11±0.83, $p<0.05$) with reduced analgesic requirement. Postoperative residual hematoma volume was slightly higher in the mini craniotomy group (5.59±4.63 cm^3 vs 3.21±2.13 cm^3, $p<0.05$), but postoperative GCS scores, MLS, and complication rates were comparable between groups. All patients achieved good recovery (GOS 5) at 30-day follow-up. **Conclusion:** Mini craniotomy is a safe and effective alternative to conventional craniotomy for EDH evacuation, offering shorter operative time and reduced postoperative pain while achieving comparable neurological and radiological outcomes. Although slightly higher residual hematoma volume was observed, it did not affect short-term clinical outcomes.

Keywords: *Acute Extradural Hematoma; Mini-Craniotomy; Conventional Craniotomy; Glasgow Coma Scale; Midline Shift; Operative Time; Postoperative Pain; Randomized Controlled Trial.*

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INTRODUCTION

Traumatic brain injury (TBI) continues to be one of the most problematic challenges around the world [1]. Road traffic accidents (RTA) are the leading cause of acute epidural/extradural hematoma (AEDH), accounting for 53% (range: 30%–86%) of all AEDH [2]. This is followed by other causes such as falls, assaults and injuries sustained in sports and other activities.

The AEDH is reported to be in the range of approximately 2%–4% [3,4], and it occurs in 14%–35% of individuals who have sustained a severe TBI [5]. The most common cause of AEDH is a skull fracture accompanied by a rupture of the middle meningeal artery (MMA) or one of its branches [6]. This causes blood to accumulate between the skull and the dura mater. The average age of someone who has AEDH is between 20 and 40 years, but the occurrence is most common in younger people. Adults over the age of 65 rarely experience AEDH, although their mortality rate is much greater [7].

The Brain Trauma Foundation has prepared an informative guideline on the therapy of AEDH. According to this guideline, regardless of where the patient falls on the Glasgow Coma Scale (GCS), surgical evacuation should be performed on all patients whose AEDH volume is more than 30 cm^3 [8]. Although the literature shows a decreasing mortality rate in EDH patients compared to previous studies [9], ongoing brain compression and brainstem herniation have shown unfavorable outcomes [8], which necessitates rapid identification and intervention. Thus, prompt surgical evacuation of AEDH is a realistic gold standard that frequently anticipates a favorable clinical outcome. In modern neurosurgery, the surgical therapy of choice for AEDH is major craniotomy.

The trauma flap is created during this craniotomy by performing substantial scalp dissection using either a curvilinear incision, the question-mark incision, or its reverse, depending on the circumstances. This is followed by the creation of a wide window in the skull bone. Because of this, in the majority of cases, it should be carried out while the patient is under general anesthesia and supported by multimodal physiological monitoring of varied degrees of sophistication. However, several mitigating conditions may make it impossible to rapidly carry out this significant neurosurgery operation. Patients who are fast deteriorating are one example of this; others are multiple trauma patients awaiting at surgical queue in a busy, high turnover rate hospital, emergencies occurring in remote sections of a country, or as a result of operational demands in military battle zones [10]. The conventional method of surgical therapy has involved making rather large craniotomies, to expose the hematoma's margin and then tack the dura mater back together. This technique can clear the hematoma successfully; nevertheless, it is linked to a larger postoperative wound, a longer operating time, a larger skull defect, and more problems [11]. It has been observed that the complication rates of conventional methods range from 0% to 34%, but the fatality rates of surgical procedures range from 0% to 24% in studies [12].

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Moreover, in certain urgent circumstances, the necessary knowledge and facilities to carry out a craniotomy may not be immediately available [13]. It would be of great importance to have an alternative approach for quick and effective clot evacuation in situations where speed and effectiveness of evacuation are important to save lives. As a result, there is an urgent requirement for research into developing a more effective surgical technique.

There are few publications available on the effective applications of mini craniotomy for evacuating and draining hematomas in adult patients in the context of an emergency setting. Using this method, one can obtain an adequate and excellent surgical corridor to the hematoma for rapid decompression. It also offers enough exposure to permit dural tack-ups, a vital technique to prevent reaccumulation of blood in the extradural space. The tack-ups are performed by suturing the separated dura against the inner table of the skull. The conventional craniotomy procedure is almost always carried out under general anesthesia (GA), and as a result, it commonly necessitates the presence of an intensive care unit (ICU), particularly in populations of elderly people [14].

By a smaller incision and smaller bone window compared to conventional craniotomy, mini craniotomy has the potential to allow the whole process to be performed even under regional scalp block and total intravenous anesthesia (TIVA), thus reducing anesthetic exposure hazard [15,16]. When it comes to the evacuation of extradural hematomas, the authors believe that the idea of mini craniotomy is an effective balance between the minimally invasive burr hole and the aggressive, big craniotomy [17].

Research is still ongoing to establish a standard method of minimally invasive procedure to efficiently remove extradural hematoma, as there is logic both for and against a big craniotomy. Therefore, the present study will be useful to evaluate the comparison of short-term outcomes of extradural hematomas treated by mini craniotomy and conventional craniotomy.

METHODS & MATERIALS

This randomized controlled trial was conducted at the Department of Neurosurgery, Dhaka Medical College Hospital over an 18-month period (July-2023 to December-2025) following ethical approval to compare the short-term outcomes of mini craniotomy and conventional craniotomy for extradural hematoma (EDH). Patients aged 15–60 years diagnosed with isolated EDH on CT scan and requiring surgical evacuation were screened according to predefined inclusion and exclusion criteria. The calculated sample size was 56 patients (28 in each group), based on the formula for comparison of two proportions using values derived from previous literature (p_1=39%, p_2=9%, α=0.05, power=80%). Participants were enrolled by systematic random sampling, where the first patient was allocated by lottery and subsequent patients were alternately assigned to Group A (mini craniotomy) or Group B (conventional craniotomy). Preoperative variables including demographic characteristics, cause of injury, admission Glasgow Coma Scale (GCS), hematoma volume, and midline shift were recorded from initial CT scans using ImageJ software; hematoma volume was calculated by the ellipsoid formula (AP × LAT × HT / 2). All patients underwent surgery under general anesthesia following standard neurosurgical protocols. In the mini craniotomy group, a 5-cm diameter bone flap was created through a 7–9 cm incision with a single burr hole, whereas in the conventional craniotomy group a ≥6 cm bone flap was created using 3–4 burr holes through a ≥15 cm incision. Hematoma evacuation, hemostasis, and dural tack-up sutures were performed in both groups, followed by bone flap replacement and subgaleal drainage. Operative time was recorded from skin incision to closure. Postoperative management included standardized analgesia with intravenous paracetamol and per-rectal tramadol, with ketorolac as rescue analgesic. Postoperative CT scan on the first postoperative day assessed residual hematoma volume and midline shift. Clinical outcomes included GCS on postoperative days 3 and 30, postoperative pain on day 3 measured by the Verbal Numeric Rating Scale, postoperative complications, and functional outcome using the Glasgow Outcome Scale on day 30. Data were analyzed using Statistical Package for Social Sciences (SPSS), Version-27.0. Continuous variables were summarized using mean±SD or median (range), while categorical variables were expressed as frequencies and percentages. Comparisons between groups were performed using independent t-test for continuous variables and chi-square test for categorical variables, and correlations among hematoma volume and midline shift were assessed using Pearson correlation, where $p<0.05$ was considered as the level of significance. Ethical approval was obtained from the Institutional Ethical Review Committee (IERC) of Dhaka Medical College, Dhaka, Bangladesh.

RESULTS

Table I shows total of 56 patients were included in this study, with 28 patients undergoing mini craniotomy (Group A) and 28 undergoing conventional craniotomy (Group B). The majority of patients in both groups were in the 15–30 years age range, accounting for 25 patients (89.3%) in Group A and 23 patients (82.1%) in Group B. In the 31–45 years age group, 2 patients (7.1%) were observed in each group, while patients aged 46–60 years comprised 1 patient (3.6%) in Group A and 3 patients (10.7%) in Group B. The mean age of patients was 23.79 ± 9.08 years in Group A and 25.64 ± 11.79 years in Group B, with age ranges of 15–58 years and 15–54 years, respectively. The difference in age between the two groups was not statistically significant (p = 0.512), suggesting comparable baseline demographics. Regarding gender distribution, males constituted the majority in both groups, with 26 patients (92.9%) in Group A and 25 patients (89.3%) in Group B, while females accounted for 2 patients (7.1%) in Group A and 3 patients (10.7%) in Group B. Overall, there was no statistically significant difference in age or gender distribution between the two groups (p = 0.582).

Table I
Baseline demographic characteristics of the study patients (*n* = 56).

Parameter	Group A (Mini Craniotomy) (n=28)	Group B (Conventional Craniotomy) (n=28)	P value
Age groups (years)	n (%)	n (%)	0.582 ns
15–30	25 (89.3)	23 (82.1)	
31–45	2 (7.1)	2 (7.1)	
46–60	1 (3.6)	3 (10.7)	
Mean age ± SD	23.79 ± 9.08	25.64 ± 11.79	0.512 ns
Range (min–max)	15–58	15–54	
Gender			
Male	26 (92.9)	25 (89.3)	
Female	2 (7.1)	3 (10.7)	

Table II presents the etiology of injury was similar across both groups. Road traffic accidents were the most common cause, observed in 15 patients (53.6%) in Group A and 12 patients (42.9%) in Group B. Physical assault was the second most frequent cause, affecting 8 patients (28.6%) in Group A and 7 patients (25.0%) in Group B. Fall from height was reported in 4 patients (14.3%) in Group A and 9 patients (32.1%) in Group B. Fall of a heavy object was the least common, seen in 1 patient (3.6%) in Group A, with no cases in Group B. Overall, the difference in etiology between the two groups was not statistically significant (p = 0.344) .

Table II
Etiology of injury among study patients (*n* = 56).

Causes	Group A (n=28)	Group B (n=28)	P value
	n (%)	n (%)	0.344 ns
Road traffic accident	15 (53.6)	12 (42.9)	
Physical assault	8 (28.6)	7 (25.0)	
Fall from height	4 (14.3)	9 (32.1)	
Fall of heavy object	1 (3.6)	0 (0)	

Table III shows the mean interval from injury to surgery was 24.29 ± 22.51 hours in Group A and 30.50 ± 24.62 hours in Group B, ranging from 6 to 82 hours in the mini craniotomy group and 6 to 120 hours in the conventional craniotomy group, with no significant difference between the groups (p = 0.329). In contrast, the mean operative time was significantly shorter in Group A at 84.82 ± 11.50 minutes compared to 105.18 ± 11.59 minutes in Group B. The operative time ranged from 60 to 105 minutes for mini craniotomy and 80 to 135 minutes for conventional craniotomy, and this difference was statistically significant (p = 0.000).

Table III
Timing of surgery and operative characteristics (*n* = 56).

Parameter	Group A (n=28)	Group B (n=28)	P value
Time from event to surgery (hours)			
Mean ± SD	24.29 ± 22.51	30.50 ± 24.62	0.329 ns
Range (min–max)	6 – 82	6 – 120	
Operative time (minutes)			
Mean ± SD	84.82 ± 11.50	105.18 ± 11.59	0.000 s
Range (min–max)	60 – 105	80 – 135	

Table IV shows neurological status, assessed using the Glasgow Coma Scale (GCS), was comparable between the groups at all measured time points. The mean preoperative GCS was 12.82 ± 2.79 in Group A and 12.86 ± 2.86 in Group B, with no significant difference (p = 0.962). On the first postoperative day, mean GCS improved to 13.93 ± 1.74 in Group A and 14.32 ± 1.39 in Group B (p = 0.355). By the third postoperative day, further improvement was observed with mean GCS of 14.39 ± 1.26 in Group A and 14.82 ± 0.61 in Group B (p = 0.111). At the 30th postoperative day, all patients achieved near-normal neurological function, with mean GCS of 15.00 ± 0.00 in Group A and 14.96 ± 0.19 in Group B (p = 0.322).

Table IV
Comparison of neurological status using Glasgow Coma Scale (GCS) (*n* = 56).

Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	P value
Pre-operative GCS	12.82 ± 2.79	12.86 ± 2.86	0.962 ns
Range	7 – 15	6 – 15	
1st POD GCS	13.93 ± 1.74	14.32 ± 1.39	0.355 ns
Range	10 – 15	10 – 15	
3rd POD GCS	14.39 ± 1.26	14.82 ± 0.61	0.111 ns
Range	10 – 15	12 – 15	
30th POD GCS	15.00 ± 0.00	14.96 ± 0.19	0.322 ns
Range	15 – 15	14 – 15	

Table V presents radiological parameters, including hematoma volume and midline shift, were assessed pre- and post-operatively. The mean preoperative hematoma volume was 56.60 ± 23.48 cm^3 in Group A and 53.67 ± 20.28 cm^3 in Group B, showing no significant difference (p = 0.619). Postoperative hematoma volume significantly decreased in both groups, with 5.59 ± 4.63 cm^3 in Group A and 3.21 ± 2.13 cm^3 in Group B (p = 0.016). Preoperative midline shift was 7.37 ± 2.61 mm in Group A and 6.83 ± 2.18 mm in Group B (p = 0.403), which reduced postoperatively to 2.82 ± 1.40 mm and 2.86 ± 1.52 mm, respectively, with no significant difference (p = 0.919).

Table V
Radiological parameters of hematoma and midline shift (n = 56).

Parameter	Group A (Mean ± SD)	Group B (Mean ± SD)	P value
Pre-operative hematoma volume (cm³)	56.60 ± 23.48	53.67 ± 20.28	0.619 ns
Range	29.31 – 103.50	28.66 – 109.13	
Post-operative hematoma volume (cm³)	5.59 ± 4.63	3.21 ± 2.13	0.016 s
Range	0 – 15.93	0 – 8.50	
Pre-operative midline shift (mm)	7.37 ± 2.61	6.83 ± 2.18	0.403 ns
Range	2.61 – 12.02	3.90 – 11.78	
Post-operative midline shift (mm)	2.82 ± 1.40	2.86 ± 1.52	0.919 ns
Range	0.80 – 5.33	0.77 – 7.35	

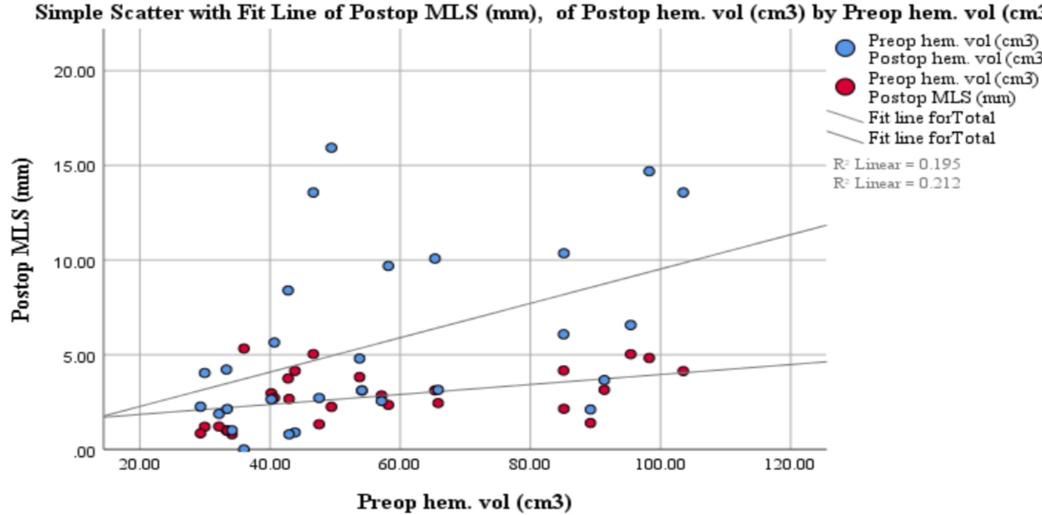

Figure 1 Scatter plot shows the relationship between pre-operative hematoma volume and post-operative midline shift in patients undergoing mini-craniotomy and conventional craniotomy(n=56).

Figure 1 demonstrates a weak positive correlation between preoperative hematoma volume and postoperative midline shift (R^2 = 0.195 and 0.212), indicating that larger hematomas were slightly associated with greater residual midline shift, though the relationship was not strong.

Table VI shows postoperative pain assessment showed better outcomes in the mini craniotomy group. On the first postoperative day, 5 patients (17.9%) in Group A required no additional analgesia, while all patients in Group B required some form of pain management. Intravenous ketorolac as needed (PRN) was required in 14 patients (50.0%) in Group A versus 10 patients (35.7%) in Group B, and regular IV ketorolac every 8 hours was needed in 9 patients (32.1%) in Group A compared to 18 patients (64.3%) in Group B (p = 0.013). Mean pain score on the third postoperative day, assessed using the Verbal Numerical Scale (VNS), was significantly lower in Group A at 4.43 ± 0.79 compared to 5.11 ± 0.83 in Group B (p = 0.003), demonstrating superior postoperative pain control in the mini craniotomy group.

Table VI
Postoperative pain assessment (n = 56).

Parameter	Group A (n=28)	Group B (n=28)	P value
Ketorolac requirement for breakthrough pain (1st POD)	n (%)	n (%)	0.013 s
None	5 (17.9%)	0 (0%)	
I/V stat dose + PRN	14 (50.0%)	10 (35.7%)	
I/V 8 hourly	9 (32.1%)	18 (64.3%)	
Pain score on 3rd POD (VNS)			
Mean ± SD	4.43 ± 0.79	5.11 ± 0.83	0.003 s

Table VII presents postoperative complications were minimal in both groups. Re-exploration was required in 1 patient (3.57%) in Group A, while none were reported in Group B (p = 0.313). Skin or soft tissue infection occurred in 2 patients (7.14%) in Group B, with no cases in Group A (p = 0.150). No cases of meningitis, brain abscess, subdural empyema, or cerebrospinal fluid (CSF) leak were observed in either group. Functional outcomes assessed at the 30th postoperative day using the Glasgow Outcome Score (GOS) revealed excellent recovery in all patients, with a score of 5 in 28 patients (100%) in both groups, and no patients experienced moderate or severe disability, persistent vegetative state, or death.

Table VII
Postoperative complications and functional outcome (*n* = 56).

Parameter	Group A (n=28)	Group B (n=28)	P value
Postoperative complications	n (%)	n (%)	
Re-exploration	1 (3.57)	0 (0)	0.313 ns
Skin/soft tissue infection	0 (0)	2 (7.14)	0.150 ns
Meningitis / meningoencephalitis	0	0	–
Brain abscess / subdural empyema	0	0	–
CSF leak	0	0	–
Glasgow Outcome Score (30th POD)			
Good recovery (5)	28 (100)	28 (100)	–
Moderate disability (4)	0	0	
Severe disability (3)	0	0	
Persistent vegetative (2)	0	0	
Death (1)	0	0	

DISCUSSION

This randomized controlled trial compared the short-term outcomes of extradural hematoma (EDH) treated by mini craniotomy and conventional craniotomy. A total of 56 patients with CT-confirmed EDH requiring surgical evacuation were included over an 18-month period, with 28 patients undergoing mini craniotomy (Group A) and 28 undergoing conventional craniotomy (Group B). Most patients in both groups were aged 15–30 years, and the mean age did not differ significantly between the groups. EDH is known to occur more frequently in younger and middle-aged individuals, while other intracranial hemorrhages such as subdural or subarachnoid hemorrhage are more common in elderly patients [18]. Acute EDH in older patients is relatively uncommon and often associated with poorer outcomes [19,20]. A marked male predominance was also observed in this study, which is consistent with epidemiological data indicating that males are more frequently affected by traumatic brain injury due to greater exposure to high-risk activities and occupational hazards [21,22].

Road traffic accidents were the most common cause of injury, followed by assault and falls. This pattern is consistent with global epidemiological studies identifying road traffic accidents as the leading cause of traumatic brain injury, particularly in low- and middle-income countries [23,24]. The mean time from injury to surgery did not differ significantly between the groups. Previous studies have reported that surgical timing may not significantly influence outcome when patients with a wide range of GCS scores are included, although early surgical intervention remains essential in patients with severe neurological deterioration [25,26].

Current guidelines recommend surgical evacuation for EDH larger than 30 cm³ regardless of neurological status, while smaller hematomas without significant mass effect may be managed conservatively under close monitoring [26]. However, hematoma size alone should not be considered an absolute indication for surgery, and clinical and radiological findings must be assessed together [27].

In the present study, preoperative GCS scores were comparable between the two groups, and both groups showed progressive neurological improvement after surgery. No significant differences were observed in GCS scores on postoperative day 3 or day 30, indicating that mini craniotomy provides effective decompression comparable to conventional craniotomy. Preoperative hematoma volume and midline shift were also similar between groups. Previous studies have reported that larger hematoma volumes and greater midline shift may correlate with poorer outcomes, although some studies have suggested that these parameters may not independently influence prognosis when timely surgical intervention is performed [25,28–30].

The postoperative residual hematoma volume was slightly higher in the mini craniotomy group, possibly due to the smaller bone window and limited surgical exposure. However, this difference did not result in significant differences in postoperative neurological status or midline shift. A significant finding of this study was the shorter operative time in the mini craniotomy group, which was approximately 20 minutes less than in the conventional craniotomy group. Similar findings have been reported in previous studies demonstrating reduced operative duration with minimally invasive techniques for EDH evacuation [31,32]. In addition, patients in the mini craniotomy group experienced significantly lower postoperative pain scores and required less rescue analgesia, likely due to the smaller incision and reduced soft-tissue dissection. Postoperative complications were minimal in both groups. One patient in the mini craniotomy group required re-exploration due to hematoma reaccumulation, while two patients in the conventional craniotomy group developed superficial wound infection. No intracranial infections or cerebrospinal fluid leaks were observed. Functional outcomes assessed by the Glasgow Outcome Scale showed good recovery in all patients at 30-day follow-up, consistent with previous reports demonstrating favorable outcomes after timely surgical evacuation of EDH [33].

Correlation analysis showed a positive relationship between preoperative hematoma volume and postoperative residual hematoma volume and midline shift in the mini craniotomy group. These findings suggest that larger hematomas may be associated with greater residual mass effect, and conventional craniotomy may be preferable in selected cases with very large hematomas. Overall, the results indicate that mini craniotomy is an effective alternative to conventional craniotomy for EDH evacuation. It offers advantages such as smaller incision, shorter operative time, and reduced postoperative pain while achieving comparable neurological and radiological outcomes. Careful patient selection and meticulous surgical technique remain essential, particularly in cases with large or complex hematomas.

CONCLUSION

This study which was undertaken to compare the short-term outcome of extradural hematoma treated by mini craniotomy and conventional craniotomy found that mini craniotomy can provide smaller incision, lesser operative time, lesser post-operative pain, better wound healing yet achieve similar post-operative GCS scores and MLS correction. Significant postoperative residual volume was noted in the mini craniotomy group which could be overcome by rationalizing conventional craniotomy over mini craniotomy in selected cases, keeping in mind the prerequisite of effective EDH evacuation and the goal of satisfactory radiological and clinical recovery.

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