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ORIGINAL ARTICLE

Comparison between Early Post-Operative Outcome of Two Surgical Techniques of In- window Craniotomy with or without Duroplasty for the Management of Traumatic Brain Injury Patients

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ABSTRACT

Background: *Raised Intracranial pressure (ICP) is a major cause of death and disability following severe Traumatic Brain Injury (TBI). Decompressive craniectomy (DC) is commonly performed to relieve elevated ICP and prevent secondary brain injury. A newer technique, in-window craniotomy, allows outward movement of the swollen brain without the need for later cranioplasty. This study was undertaken to determine which in-window craniotomy technique with or without duroplasty provides better outcomes in managing severe TBI.* ***Methods & Materials:*** *A total of 40 adult TBI patients with raised ICP who required unilateral fronto-temporo- parietal decompression were included by purposive sampling and divided into two groups: Group A (in-window craniotomy with duroplasty) and Group B (in-window craniotomy without duroplasty). Patients were followed for three weeks postoperatively.* ***Results:*** *The mean age was 39.4 ± 14.7 years in Group A and 42.3 ± 19.6 years in Group B, with male predominance in both groups. No significant difference in GCS improvement, midline shift correction, or complication rates (30% vs 25%) was found between the groups. However, the mean surgical time was significantly shorter in Group B (128 ± 22.9 min) compared to Group A (174.5 ± 18.1 min) (p<0.001).* ***Conclusion:*** *Both techniques were effective in improving neurological outcomes and radiological parameters in severe TBI. However, in-window craniotomy without duroplasty reduced surgical time without increasing complications, suggesting it may be a preferable option in critically ill patients. Further multicenter studies with longer follow-up are recommended.*

Keywords: *Traumatic Brain Injury, In-window Craniotomy, Duroplasty, Decompressive Craniectomy, Intracranial Pressure*

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INTRODUCTION

Raised intracranial pressure (ICP) is the most frequent cause of death and disability after severe traumatic brain injury (TBI) [1]. Raised intracranial pressure, which is typically caused by cerebral edema, is an important secondary insult. So, lowering the elevated ICP is one of the main goals in the treatment of patients with severe head and brain injury. Decompressive craniectomy (DC) has been performed as a lifesaving surgical procedure that involves removal of part of the skull to accommodate brain swelling. There are currently various decompressive craniectomy methods and technical improvements that have progressed the treatment of TBI. Now a days in-window technique for craniotomy in severe traumatic brain injury is safe, promising and offers a lower rate of complications with no need for additional bone replacement surgery [1]. Usually in-window craniotomy is performed together with dural opening or closing, with the notion that dural opening could maximize brain expansion [2]. To avoid excessive extra calvarial herniation of the brain, here loosely bind a bone on the side where dura mater is opened, using in-window craniotomy technique described established that, in-window craniotomy without duroplasty had a decreased surgical time by 31 minutes on average, which can be beneficial in critically ill patients, especially in victims of severe TBI [3]. Because, the faster surgical procedures focusing on the restoration of physiological parameters, known as damage control surgery. In-window craniotomy without duroplasty has a potential role in the surgical management of TBI/stroke, found adequate cerebral decompression in the majority of reported cases with reduced complications and economic savings. Currently, the optimal management of the opened dura during in-window craniotomy remains controversial. This study aims to compare the early postoperative outcomes of in-window craniotomy with and without duroplasty in patients with TBI and describe a method of duroplasty for improved cerebral decompression.

METHODS & MATERIALS

Study Design

The present study was a hospital-based prospective interventional comparative study conducted over a period of 18 months from October 2022 to March 2024 in the Department of Neurosurgery, Dhaka Medical College Hospital. The study population comprised patients admitted with clinico-radiological indications for decompressive craniectomy due to Traumatic Brain Injury (TBI) with features of raised Intracranial Pressure (ICP).

Sample size estimation

Sample size was calculated using the formula for comparing two proportions, considering p_1 = 17.9% (proportion of complications in duroplasty group) and p_2 = 14.8% (proportion of complications in without duroplasty group) from [4], with Zα = 1.96 at 5% significance level and Zβ = 0.84 at 80% power. The minimum sample size was estimated as 13 per group. Considering the study period and for better outcomes, 20 patients were included in each group, making a total sample of 40 patients.

Sampling technique and selection criteria

Purposive sampling technique was employed to select the study participants. Adults aged above 18 years with Traumatic Brain Injury (TBI) and features of raised Intracranial Pressure (ICP) admitted to the Department of Neurosurgery, Dhaka Medical College Hospital who required unilateral fronto-temporo-parietal decompressive surgery were included in the study. Patients with peroperative severe brain swelling where the bone flap could not be placed, those without consent, patients with bilateral fixed pupils, bifrontal contusions requiring bifrontal decompressive craniectomy, a Glasgow Coma Scale (GCS) score <5, and those lost to follow-up after surgery were excluded.

Data collection procedure

Prior to the study, ethical clearance was obtained from the Ethical Review Board of Dhaka Medical College Hospital. All eligible Traumatic Brain Injury (TBI) patients with raised Intracranial Pressure (ICP) undergoing in-window craniotomy during the study period were approached. After explaining the study's aim and procedures, a total of 40 patients fulfilling the inclusion criteria were enrolled, and informed written consent was obtained from their parents or legal guardians.

Surgical procedure

A large semicircular skin incision was made starting from the midline and extending to the posterior parietal area, ending at the level of the tragus. A wide fronto-temporo-parietal craniotomy (approximately 15×12 cm) with beveled bone cuts was performed, along with anterior temporal craniectomy to relieve temporal lobe pressure. In Group A, the dura was opened in a 'C-shaped' manner and watertight expansile duroplasty was performed using preserved pericranium and 4-0 Polyglactin 910 absorbable sutures. In Group B, the dura was opened in a 'crisscross' manner without duroplasty, and the bone flap was divided into two hinged window lids secured with Polypropylene sutures. A drainage tube was placed and removed after 24–48 hours. Postoperative evaluation included CT scan after 72 hours, Glasgow Coma Scale (GCS) assessment on the 7th postoperative day, and follow-up up to 3 weeks to monitor recovery and complications.

Data processing and analysis

Data were checked, coded, and analyzed using SPSS version 26 (IBM Corp., Armonk, NY). Categorical variables were summarized as frequencies and percentages. Continuous variables were expressed as mean and standard deviation. Independent t-test was used for comparing continuous variables, Fisher's exact test for categorical variables, and paired sample t-test for comparing pre- and post-operative GCS scores and midline shift. A p-value <0.05 was considered statistically significant.

Ethical considerations

Ethical approval was obtained from the Ethical Review Board of Dhaka Medical College Hospital. Informed written consent was taken from the patient's guardians after explaining the objectives, benefits, and voluntary nature of the study. Confidentiality was maintained, and participation did not affect the patients' treatment.

RESULTS

This comparative study included a total of 40 patients with traumatic brain injury (TBI) and features of raised intracranial pressure (ICP) who underwent in-window craniotomy. Patients were divided equally into Group A (in-window craniotomy with duroplasty, n=20) and Group B (in- window craniotomy without duroplasty, n=20). All patients completed postoperative follow-up according to the study protocol.

The mean age of patients in Group A was 39.4 ± 14.7 years, while in Group B it was 42.3 ± 19.6 years. The age distribution between the groups was not statistically significant (p=0.606). In Group A, 45% of patients were aged 20–30 years, 35% were 41–50 years, and 20% were above 50 years. In Group B, 35% were aged 20–30 years, 20% were 31–40 years, 15% were 41–50 years, and 30% were above 50 years. Male patients predominated in both groups, with 55% in Group A and 60% in Group B, whereas female patients comprised 45% and 40%, respectively. There was no statistically significant difference in gender distribution (*p*=1.00) (**Table I**)

Table – I: Distribution of Patients According to Age and Gender (*n*=40)

Variable	Group A n (%)	Group B n (%)	p-value
Age (years)			
20–30	9 (45)	7 (35)	0.606
31–40	0 (0)	4 (20)	
41–50	7 (35)	3 (15)	
>50	4 (20)	6 (30)	
Gender			
Male	11 (55)	12 (60)	1.00
Female	9 (45)	8 (40)	

Both surgical techniques led to significant improvement in Glasgow Coma Scale (GCS) score and midline shift after surgery. In Group A, the mean preoperative GCS was 9.2 ± 1.7, which developed to 11.4 ± 1.5 postoperatively (p<0.001). The mean

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midline shift decreased from 10.1 ± 2.2 mm preoperatively to 4.5 ± 1.3 mm postoperatively (p<0.001). Similarly, in Group B, the mean preoperative GCS score was 10.2 ± 1.9, improving to 11.9 ± 1.4 postoperatively (p<0.001). Midline shift decreased from 9.1 ± 2.5 mm to 3.7 ± 1.3 mm (p<0.001). When comparing between groups, the differences in postoperative GCS and midline shift were not statistically significant (p=0.279 for GCS and p=0.061 for midline shift). Similarly, the mean midline shift correction was 5.6 ± 1.3 mm in Group A and 5.6 ± 1.8 mm in Group B, showing no significant difference (p=0.905) (**Table II**).

Table – II: Improvement of GCS Score and Midline Shift in Each Group (*n*=20)

Parameter	Preoperative Mean ± SD	Postoperative Mean ± SD	p-value
Group A			
GCS	9.2 ± 1.7	11.4 ± 1.5	<0.001
Midline shift (mm)	10.1 ± 2.2	4.5 ± 1.3	<0.001
Group B			
GCS	10.2 ± 1.9	11.9 ± 1.4	<0.001
Midline shift (mm)	9.1 ± 2.5	3.7 ± 1.3	<0.001

Postoperative complications occurred in both groups but without statistically significant differences. In Group A, 14 patients (70%) experienced no complications, while 4 patients (20%) developed meningitis and 2 patients (10%) developed subgaleal CSF collection. In Group B, 15 patients (75%) had no complications, and 5 patients (25%) developed subgaleal CSF collection. No patient in either group developed CSF leak (**Table III**).

Table – III: Postoperative Complications (*n*=40)

Complication	Group A n (%)	Group B n (%)	p-value
None	14 (70)	15 (75)	1.00
Meningitis	4 (20)	0 (0)	0.106
Subgaleal CSF collection	2 (10)	5 (25)	0.407
CSF leak	0 (0)	0 (0)	-

The mean surgical time was significantly longer in Group A (174.5 ± 18.1 minutes) compared to Group B (128 ± 22.9 minutes, p<0.001), reflecting the additional time required for duraplasty (**Table IV**).

Table – IV: Comparison of Surgical Time

Group	Mean ± SD (minutes)	p-value
Group A (with duroplasty)	174.5 ± 18.1	<0.001
Group B (without duroplasty)	128 ± 22.9	

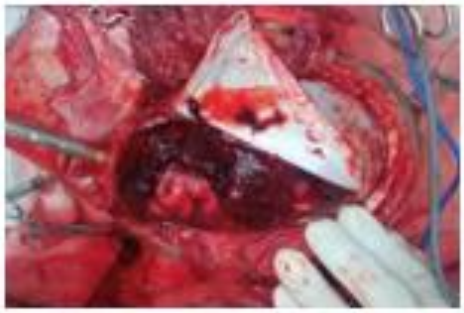

Figure – 1: Dura was opened in 'C shaped' manner in group A patient

Figure 1 shows compares the method of dural opening in both groups ASA and ASI, that a wide fronto-temoro-parietal bone flap is already made (Group A). An extensive C-shaped incision is made in the dura and the dural flap reflected.

Figure – 2: Photograph showing the procedure of water tight duroplasty

Figure 2 shows the closure of dura after C-shaped durotomy, by watertight expansile duroplasty that was performed in Group A.

Figure – 3: Dura was opened in'crisscross' manner in group B patients

Figure 3 This figure demonstrates the method of dural opening used for group B; in which dura is opened in crisscross (X-shaped) style.

Figure – 4: Photograph showing the procedure of in-window craniotomy

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Figure 4 This illustrates that the bone flap is made into hinged "window" sections and is not completely removed. It is lightly tied to allow swelling of the brain tissue. Advantages of the supraorbital bone flap lifting technique are for one that it means decompression can be performed without having to perform a cranioplasty at the later stage.

DISCUSSION

Traumatic brain injury (TBI) remains a major cause of morbidity, mortality, and economic burden, especially in developing countries, often leading to temporary or permanent disability [5]. Decompressive craniectomy (DC) is a well-established neurosurgical intervention aimed at alleviating raised intracranial pressure (ICP) and preventing secondary brain injury. Postoperative cerebrospinal fluid (CSF) leaks, however, remain a concern, as they can lead to severe complications such as meningitis or brain abscess [6]. Selecting the optimal surgical technique is therefore critical to minimize complications and improve patient outcomes. In this study, 40 patients with TBI and raised ICP underwent in-window craniotomy, divided equally into Group A (with duroplasty) and Group B (without duroplasty). The mean age of patients was comparable between the two groups (39.4 ± 14.7 vs 42.3 ± 19.6 years), with no significant difference, consistent with previous studies reporting similar age distributions in TBI patients undergoing decompressive craniectomy [4, 7, 8]. Male predominance was observed in both groups (55% vs 60%), reflecting the higher exposure of males to risk-prone activities and injuries, in line with prior literature [3, 7], Both surgical techniques significantly improved postoperative Glasgow Coma Scale (GCS) scores and reduced midline shift. In Group A, mean GCS improved from 9.2 ± 1.7 to 11.4± 1.5, while in Group B it improved from 10.2 ± 1.9 to 11.9 ± 1.4. Corresponding midline shift reductions were 10.1 ± 2.2 mm to 4.5 ± 1.3 mm in Group A and 9.1 ± 2.5 mm to 3.7 ± 1.3 mm in Group B. These results demonstrate that both in-window craniotomy techniques are effective in early postoperative recovery, without significant differences between the groups, consistent with prior reports [3,4]. Surgical duration was significantly longer in the duroplasty group (174.5 ± 18.1 minutes) compared to the without-duroplasty group (128 ± 22.9 minutes), highlighting a potential advantage of avoiding duraplasty in critically ill patients where time-efficient interventions are essential. This finding aligns with previous studies reporting shorter surgical times in patients undergoing decompression without duraplasty [4,9,10]. Postoperative complications were relatively low in both groups. In Group A, 70% of patients experienced no complications, while 10% developed subgaleal CSF collection and 20% developed meningitis. In Group B, 75% of patients experienced no complications, with 25% developing subgaleal CSF collection and no cases of meningitis. No CSF leaks were observed in either group. The overall complication rates were not significantly different, supporting the safety of in-window craniotomy without duraplasty, as suggested in previous studies [4,11]. Overall, both techniques proved feasible and effective for the early management of TBI. While in-window craniotomy with duroplasty provides dural protection and may reduce specific risks such as postoperative infection, in-window craniotomy without duroplasty offers shorter surgical time and comparable clinical outcomes, making it a practical option in selected patients. Further multicenter studies with larger sample sizes and longer follow- up are recommended to confirm these findings and guide surgical decision-making.

LIMITATIONS

This study was conducted at a single center with a small sample size and short follow-up. Purposive sampling without randomization may introduce selection bias. These factors limit the generalizability of the findings.

CONCLUSION

Both in-window craniotomy techniques significantly improved GCS scores and corrected midline shift. In-window craniotomy without duroplasty had slightly fewer complications and a shorter surgical time, suggesting it may be a faster and safe alternative. Further multicenter studies with larger samples and longer follow-up are recommended.

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