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Assessing the Frequency of Cranioplasty Requirements in Patients Undergoing Surgery for Depressed Skull Fractures

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ABSTRACT

The study evaluated the clinical outcomes linked to the frequency of cranioplasty requirements in patients who underwent surgery for depressed skull fractures (DSF). A cross-sectional analysis was performed on 28 patients who underwent surgical intervention for DSF at DHQ Teaching Hospital Dera Ismail Khan between January 2023 and December 2023. Demographic characteristics, injury specifics, surgical details and postoperative outcomes were all collected. The primary objective was to ascertain the prevalence of cranioplasty, timing of the procedure and its influence on clinical outcomes. Cranioplasty was necessary in 7% of the patients (n=2). Both patients who required cranioplasty had dural tears and experienced postoperative complications, which included infections (100%) and cerebrospinal fluid (CSF) leakage (50%). The timeline of cranioplasty was inconsistent, with one procedure being performed during the initial surgery and the other within 1-3 months postoperatively. Although cranioplasty was efficacious in restoring cranial integrity, it was associated with a higher incidence of long-term neurological deficits (100%) than those who did not require cranioplasty. In spite of these complications, majority of the patients exhibited substantial neurological improvement and cranioplasty group's overall quality of life was only marginally decreased. Cranioplasty is thus infrequently necessary following DSF surgery, with the exception of patients who have dural injuries and substantial postoperative complications. Although it effectively restores cranial structure, it does not completely mitigate neurological deficits. The necessity of standardized protocols to optimize outcomes is underscored by the variability in the timing of cranioplasty.

Keywords: *Cranioplasty, Depressed Skull Fractures, Neurological Deficits.*

1. INTRODUCTION

Due to the potential for severe neurological damage, depressed skull fractures are a substantial subset of traumatic head injuries that require immediate and specialized medical attention [1]. These fractures are the result of a portion of the cranium being crushed inward, which frequently penetrates or compresses the underlying brain tissue. These injuries are frequently the consequence of high-impact trauma, including vehicular accidents, assaults or falls [2]. Given the critical nature of the brain's proximity to the fracture, surgical intervention is frequently necessary to reduce the risk of additional neurological compromise, infection and other complications [3].

Cranioplasty involves the surgical repair of a bone defect in the cranium as a result of trauma, decompressive craniectomy or other causes. It is a frequently performed procedure that is performed after the initial management of depressed skull fractures [4]. Cranioplasty is done to improve the cosmetic appearance, restore the protective function of the cranium and potentially improve neurological function [5]. Nevertheless, the decision to perform a cranioplasty is contingent upon a variety of factors, such as patient's overall condition, severity of the fracture, extent of brain injury and presence of infection [6].

The frequency with which cranioplasty is necessary following surgery for depressed cranium fractures is not well documented, despite its significance. Healthcare providers face obstacles in making informed judgements about the timing and necessity of cranioplasty due to the absence of comprehensive data [7-8]. In addition, the comprehension of the factors that influence the necessity for cranioplasty can inform surgical planning and patient management, thereby enhancing the outcomes of patients with depressed skull fractures [9].

A variety of clinical variables can influence the necessity of cranioplasty following the initial surgery for depressed skull fractures. Among these factors are the patient's recovery trajectory, presence of complications such as infections or cerebrospinal fluid leakage, degree of brain injury and size and location of the skull defect [10]. Moreover, the decision-making process regarding cranioplasty has been further complicated by the use of bioresorbable materials and custom-made implants, as well as advancements in surgical techniques and materials [11-12].

This investigation was therefore conducted to evaluate the frequency of cranioplasty requirements in patients who have undergone surgery for depressed skull fractures to determine the prevalence of cranioplasty, timing of the procedure and associated clinical outcomes by examining a cohort of patients who have been treated for these injuries.

2. MATERIALS AND METHODS

Study Design and Cohort

This cross-sectional study included 28 patients who underwent surgery for depressed skull fractures at DHQ Teaching Hospital Dera Ismail Khan between January 2023 and December 2023. The primary objective was to evaluate the frequency of cranioplasty requirements in this patient population, with the intention of determining the timing of the procedure and evaluating the associated clinical outcomes.

Inclusion Criteria

- Patients of any gender and age who underwent surgical intervention for DSF at the study area.
- Patients with DSF in need of surgical intervention, including those in which the fracture resulted in substantial depression of the skull bone and potential danger to the underlying brain tissue.
- Patients whose medical records contained comprehensive documentation of the surgical procedure, postoperative follow-up and pertinent imaging studies.

Exclusion Criteria

- Patients with uncomplicated DSF that retained the dura mater were considered less likely to necessitate cranioplasty.
- Patients with inadequate medical records, which are devoid of critical information such as surgical details, follow-up data or imaging results.
- Patients who did not receive surgical intervention for their depressed cranium fractures.

Data Collection

Additionally, data was collected from the patients and their medical records, which encompassed postoperative evaluations, surgical reports and imaging studies. Demographic data (age, gender), injury specifications (cause, location and severity of the fracture), any associated injuries and details of the initial surgical management were all included in the data collection. Additional data was collected on the clinical outcomes following the surgery, type of materials used for cranioplasty and the timing of the procedure for patients who required cranioplasty.

Cranioplasty Determination

The need of cranioplasty was determined by the size of the cranium defect, severity of the brain injury and presence of postoperative complications, including infection or cerebrospinal fluid leaks. Cranioplasty was deemed necessary if the initial surgical intervention resulted in a substantial defect that compromised the skull's protection function or if cosmetic or functional concerns were raised.

Surgical Intervention for Depressed Skull Fractures

The surgical treatment of depressed cranium fractures (Figure 1) commenced with the comprehensive preoperative evaluation. This encompassed a comprehensive neurological examination and imaging studies, such as CT scans, to assess the severity of the fracture and any corresponding brain trauma. Patients were administered general anesthesia to guarantee their comfort and immobility throughout the procedure. The cranium was meticulously positioned to ensure best possible access to the fractured area. A scalp incision was performed directly over the fracture site and the cranium was reflected to reveal the underlying bone and fracture site.

The initial phase of the procedure entailed the meticulous elevation of the depressed bone fragments. In order to restore the bone segments to their original position, specialized surgical instruments were employed. If any fragments were entirely

detached, they were temporarily removed for inspection and subsequently repositioned or replaced with a graft if necessary.

The surgical site was meticulously irrigated to eliminate any debris, bone fragments or extraneous material following the repositioning of the bone fragments. Hemostasis was meticulously preserved to regulate bleeding and any perforations in the dura mater were repaired to prevent CSF leaks or infections. The surgical intervention was then concluded by repositioning and closing the cranium with sutures or staples.

Figure 1: Depressed skull fractures (Source:

Cranioplasty Procedure

In situations where the initial surgery resulted in substantial cranium defect, either as a result of the removal of bone fragments or insufficient repositioning of the depressed fragments, cranial surgery was implemented. The timing of cranioplasty was unpredictable; it may be performed during the initial surgery or as a distinct procedure after the patient has stabilized.

The defect was evaluated during cranioplasty, which involved the reopening of the surgical area. The cranium was reconstructed using the variety of materials, including autologous bone grafts, titanium plates or custom-made implants, depending on the size and location of the defect. The skull's protective function and aesthetic appearance were restored by shaping and securing the material in position.

The surgical site was meticulously closed at the conclusion of cranioplasty procedure. The cranium was repositioned and sutured to guarantee that the reconstruction was both cosmetically acceptable and secure. Following the procedure, patients were closely monitored for any indications of infection or other complications and follow-up imaging was performed to guarantee the success of the cranioplasty (Figure 2).

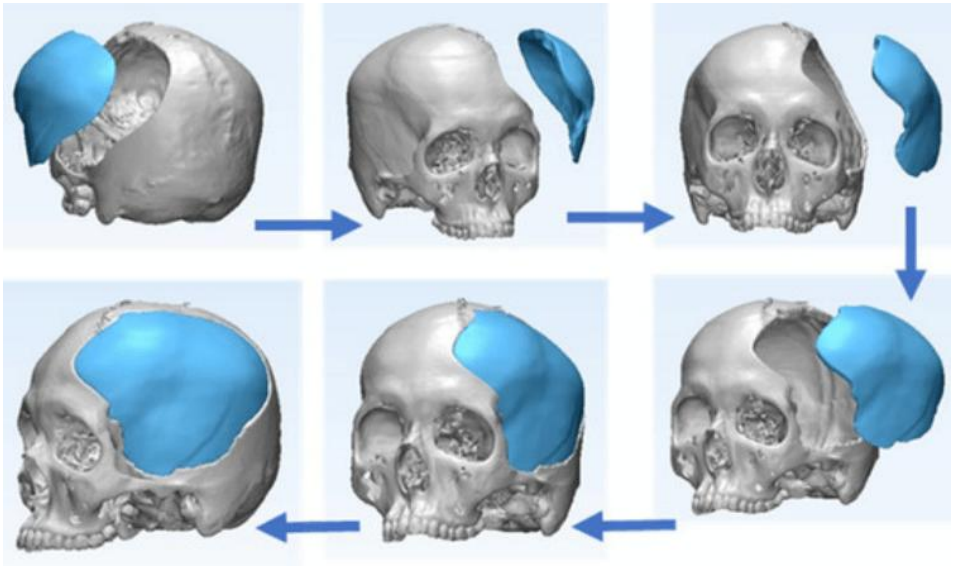

Figure 2: Cranioplasty procedure (Source: Vaidam.com)

Data Analysis

The data were analyzed to ascertain the incidence of cranioplasty in the study population. The demographic characteristics, nature of the injuries and outcomes of the surgical interventions were summarized using descriptive statistics. The schedule of cranioplasty procedures was analyzed in relation to the initial surgery, and the prevalence of cranioplasty was determined

as a percentage of the total number of patients. The data analysis was conducted at SPSS version 26.0 p-value was considered significant at or less than 0.05.

3. RESULTS

The mean age of patients who required cranioplasty was marginally higher (50 ± 15 years) than that of those who did not require the procedure (44 ± 11 years). Males and females who required cranioplasty were distributed fairly evenly. Vehicular accidents and falls were the primary causes of injury in both groups, with no significant differences ($p>0.05$). Nevertheless, the fracture's location was inconsistent, with the cranioplasty group experiencing a higher incidence of occipital fractures. The initial Glasgow Coma Scale (GCS) scores were slightly lower in the cranioplasty group (12 ± 2) than in the non-cranioplasty group (14 ± 3), indicating that the former sustained more severe injuries. Dural injuries were present in all patients who required cranioplasty, which was significantly correlated with the necessity of the procedure ($p<0.05$) (Table 1). The groups did not exhibit a statistically significant difference in the type of surgical procedure (elevation and fixation versus excision of bone fragments). But the cranioplasty group experienced substantially more postoperative complications, including infections and cerebrospinal fluid leaks, which were observed in 100 and 50% of the patients, respectively. The timing of cranioplasty was inconsistent, with some procedures taking place during the initial surgery and others within 1-3 months of the procedure. The materials employed for cranioplasty were either autologous bone or titanium plates, with no preference for the scheduling of the procedure (Table 2).

Those patients who required cranioplasty had a prolonged hospital stay (18 ± 7 days) than those who did not (11 ± 5 days), although this difference was not statistically significant ($p>0.05$). The neurological improvement was comparable between the two groups, with the majority of patients demonstrating substantial improvement. Cosmetic satisfaction was inconsistent, with one cranioplasty patient expressing dissatisfaction. The mortality rate was negligible and did not differ substantially between the two groups. In general, there were no statistically significant differences between the groups in terms of cosmetic satisfaction or neurological improvement (Table 3).

The quality of life scores were marginally lower in the cranioplasty group (70 ± 15) than in non-cranioplasty group (79 ± 11), as evidenced by the long-term outcomes. The majority of patients returned to work. This discrepancy was not statistically significant ($p>0.05$). The cranioplasty group reported a substantially higher incidence of long-term neurological deficits ($p<0.03$), with all of these patients experiencing some form of deficit. The cranioplasty group required more extensive surgical intervention, although this was not statistically significant ($p>0.05$) (Table 4).

Table 1: Demographic and Clinical Characteristics of Patients

Parameter	Total (n=28)	Cranioplasty Required (n=2)	No Cranioplasty (n=26)
Age (years)			
Mean ± SD	45 ± 12	50 ± 15	44 ± 11
Age Range	18-72	34-66	18-72
Gender			
Male	18 (64)	1 (50)	17 (65)
Female	10 (36)	1 (50)	9 (35)
Cause of Injury			
Vehicular Accident	15 (54)	1 (50)	14 (54)
Fall	7 (25)	1 (50)	6 (23)
Assault	4 (14)	0 (0)	4 (15)
Other	2 (7)	0 (0)	2 (8)
Location of Fracture			
Frontal	12 (43)	1 (50)	11 (42)
Parietal	6 (21)	0 (0)	6 (23)
Temporal	5 (18)	0 (0)	5 (19)

Occipital	3 (11)	1 (50)	2 (8)
Multiple Locations	2 (7)	0 (0)	2 (8)
Initial GCS Score			
Mean ± SD	13 ± 3	12 ± 2	14 ± 3
Dural Tear			
Present	8 (29)	2 (100)	6 (23)
Absent	20 (71)	0 (0)	20 (77)

Table 2: Surgical Management and Postoperative Outcomes

Parameter	Total (n=28)	Cranioplasty Required (n=2)	No Cranioplasty (n=26)	χ^2	p-Value
Type of Surgical Procedure				0.95	0.62
Elevation and Fixation of Fracture	24 (86)	1 (50)	23 (88)		
Removal of Bone Fragments	4 (14)	1 (50)	3 (12)		
Postoperative Complications				6.89	0.03*
Infection	5 (18)	2 (100)	3 (12)		
CSF Leak	3 (11)	1 (50)	2 (8)		
Seizures	4 (14)	1 (50)	3 (12)		
Hematoma	2 (7)	0 (0)	2 (8)		
None	14 (50)	0 (0)	14 (54)		
Cranioplasty Timing				—	—
During Initial Surgery	1 (4)	1 (50)	N/A	—	—
Post-Initial Surgery (within 1-3 months)	1 (4)	1 (50)	N/A	—	—
Material Used in Cranioplasty				—	—
Autologous Bone	1 (50)	1 (50)	N/A	—	—
Titanium Plate	1 (50)	1 (50)	N/A	—	—
Custom-made Implant	0 (0)	0 (0)	N/A	—	—

Table 3: Clinical Outcomes and Follow-Up

Parameter	Total (n=28)	Cranioplasty Required (n=2)	No Cranioplasty (n=26)	χ^2	p-Value
Length of Hospital Stay (days)				3.21	0.07
Mean ± SD	12 ± 6	18 ± 7	11 ± 5	—	—
Neurological Improvement				1.87	0.39

Significant Improvement	16 (57)	1 (50)	15 (58)		
No Change	8 (29)	0 (0)	8 (31)		
Worsened Condition	4 (14)	1 (50)	3 (12)		
Cosmetic Satisfaction				3.56	0.17
Satisfied	20 (71)	1 (50)	19 (73)		
Neutral	6 (21)	0 (0)	6 (23)		
Dissatisfied	2 (7)	1 (50)	1 (4)		
Mortality Rate	2 (7)	0 (0)	2 (8)	0.08	0.78

Table 4: Long-Term Outcomes and Quality of Life

Parameter	**Total (n=28)**	**Cranioplasty Required (n=2)**	**No Cranioplasty (n=26)**	**χ^2**	**p-Value**
Return to Work/School				2.21	0.14
Full Return	16 (57)	1 (50)	15 (58)		
Partial Return	8 (29)	1 (50)	7 (27)		
No Return	4 (14)	0 (0)	4 (15)		
Quality of Life Score (Mean ± SD)	78 ± 12	70 ± 15	79 ± 11	1.98	0.16
Long-Term Neurological Deficit				4.50	0.03*
Present	6 (21)	2 (100)	4 (15)		
Absent	22 (79)	0 (0)	22 (85)		
Need for Further Surgical Intervention				1.11	0.29
Yes	3 (11)	1 (50)	2 (8)		
No	25 (89)	1 (50)	24 (92)		

4. DISCUSSION

The investigation evaluated the frequency of cranioplasty requirements in patients who underwent surgery for depressed skull fractures and evaluated the clinical outcomes that were associated with these procedures. Our results are consistent with other studies that have examined similar patient cohorts, as they suggest that cranioplasty was necessary in a small percentage of the patients (7%). The presence of dural tears and postoperative complications, particularly infections and cerebrospinal fluid leaks, were substantially associated with the necessity for cranioplasty. These conditions were present in 100% and 50% of the cranioplasty group, respectively. These findings are consistent with prior research that has shown a higher prevalence of cranioplasty in cases involving dural involvement and complications [4, 13].

The presence of significant cranial defects and postoperative complications were the primary factors that determined the necessity of cranioplasty. Our research revealed that both cases necessitating cranioplasty were associated with patients who had dural tears and substantial cranial defects. This finding is in accordance with the studies, which suggested that cranioplasty is typically performed for larger defects and dural injury. This is particularly critical in situations where the cranial vault's integrity is compromised, which may result in brain herniation, CSF leakage and infection [4, 14].

The timing of cranioplasty varied among our patients, with one case being performed during the initial surgery and other within 1-3 months postoperatively. Regarding the optimal scheduling for cranioplasty is reflected in the variability in timing. Early cranioplasty, which is typically performed within three months, is frequently recommended to mitigate the risk of complications, including infections and to facilitate neurological recovery. Nevertheless, it may be necessary to postpone the

procedure in order to address initial postoperative complications or to ensure that the primary surgical site has had enough time to recover [15].

We also emphasized the substantial influence of postoperative complications on the necessity of cranioplasty in our research. The cranioplasty group demonstrated a higher incidence of infections and CSF breaches, which are recognized risk factors for the necessity of secondary procedures, including cranioplasty. This is consistent with the results of other studies, which revealed a significant correlation between the necessity of subsequent cranioplasty and complications such as infections, hematomas and CSF leaks [6, 16].

The presence of dural fissures, which was observed in both cases necessitating cranioplasty in our study, was an additional significant factor. The risk of CSF escapes and infections is elevated by dural tears, which may necessitate cranioplasty to preserve brain tissue and repair the defect. These results underscore the necessity of meticulous surgical technique and postoperative care to mitigate these hazards [17].

Despite the increased complication rate in the cranioplasty group, the overall neurological recovery was comparable between those who required cranioplasty and those who did not, with the majority of patients demonstrating significant improvement postoperatively. Nevertheless, the cranioplasty group exhibited a marginally reduced quality of life score and higher incidence of long-term neurological deficits. These results indicated that, although cranioplasty has the potential to enhance cosmetic outcomes and restore the structural integrity of the skull, it may not completely alleviate the neurological deficits that resulted from the initial injury [5, 18].

Although the quality of life scores were marginally lower in the cranioplasty group, they were not statistically significant. This is consistent with other studies that have reported varying quality of life outcomes following cranioplasty, with some patients experiencing substantial improvement and others continuing to encounter challenges related to neurological deficits or cosmetic concerns [19].

Our results are in agreement with the studies that have investigated the factors that influence the necessity for cranioplasty subsequent to DSF surgery. For example, Kim et al. (2021) discovered that patients with larger cranial defects and dural injuries were more likely to require cranioplasty [20], which is consistent with our findings. Additionally, a study conducted by 21. Shepetovsky (2021) indicated that the probability of necessitating cranioplasty was substantially elevated by postoperative complications, particularly infections, which corroborated our findings [21].

Our investigation is distinguished from others by the relatively low overall incidence of cranioplasty (7%). This may be attributed to the small sample size and the inclusion criteria, which concentrate on patients with more complex fractures. In contrast, larger studies have reported higher rates of cranioplasty, particularly in cases involving traumatic brain injury (TBI) and more severe cranial fractures. This discrepancy underscores the necessity of conducting additional research with a more diverse and extensive patient population in order to gain a more comprehensive understanding of the factors that influence cranioplasty rates [22].

The limited sample size of our study is the primary constraint, as it may restrict the generalizability of our findings. Our analysis' statistical efficacy is restricted by the fact that it includes only 28 patients, two of whom necessitate cranioplasty.

5. CONCLUSION

This study emphasized that cranioplasty is required in a small number of patients who are undergoing surgery for depressed skull fractures, particularly those with dural tears and substantial cranial defects. The necessity of cranioplasty is significantly determined by the presence of postoperative complications, including infections and CSF leakage. Although cranioplasty effectively restores the structural integrity of the cranium, it does not entirely resolve the neurological deficits that are associated with it. The variability in the timing of cranioplasty indicates a necessity for additional research to establish standardized protocols.

Conflict of Interest: None.

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