



Clinical Significance of Long-Term Follow-Up of Children with Posttraumatic Skull Base Fracture

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■ **OBJECTIVE:** To assess the incidence of cerebrospinal fluid (CSF) leak and meningitis, and the need for prophylactic antibiotics, antipneumococcal vaccination, and surgical interventions, in children with a skull base fracture.

■ **METHODS:** We reviewed the records of children with a skull base fracture who were admitted to our tertiary care center between 2009 and 2014.

■ **RESULTS:** A total of 196 children (153 males), age 1 month to 18 years (mean age, 6 ± 4 years), were hospitalized with skull base fracture. Causes of injury were falls ($n = 143$), motor vehicle accidents ($n = 34$), and other ($n = 19$). Fracture locations were the middle skull base in 112 patients, frontal base in 62, and occipital base in 13. Fifty-four children (28%) had a CSF leak. In 34 of these children (63%), spontaneous resolution occurred within 3 days. Three children underwent surgery on admission owing to a CSF leak from an open wound, 3 underwent CSF diversion by spinal drainage, and 4 (2%) required surgery to repair a dural tear after failure of continuous spinal drainage and acetazolamide treatment. Twenty-eight children (14%) received prophylactic antibiotic therapy, usually due to other injuries, and 11 received pneumococcal vaccination. Two children developed meningitis, and 3 children died. Long-term follow up in 124 children revealed 12 children with delayed hearing loss and 3 with delayed facial paralysis.

■ **CONCLUSIONS:** This is the largest pediatric series of skull base fractures reporting rates of morbidity and long-term outcomes published to date. The rate of meningitis following skull base fracture in children is low, supporting

a policy of not administering prophylactic antibiotics or pneumococcal vaccine. Long-term follow up is important to identify delayed complications.

INTRODUCTION

Traumatic brain injury is a leading cause of death in children. Skull fractures are relatively common following head trauma in children, with 4%–20% of such fractures occurring at the base of the skull. Main causes of head trauma in children include motor vehicle accidents, falls from heights, and blunt trauma. Skull base fractures are less common in the pediatric population than in adults; thus, the management and treatment of these fractures in children have been less well studied and are based mainly on currently accepted treatment protocols for adults.^{1–5}

In the pediatric population, skull base fractures are not always apparent on routine computed tomography (CT) scans performed in the emergency department; thus, clinical examination is the most important first step in diagnosis.⁶ Delay in diagnosis can lead to severe complications, including meningitis, cerebrospinal fluid (CSF) leak, cranial nerve injury, and even death.^{4,7–10} Nonetheless, previous studies have shown that children with a normal neurologic examination and no brain injury on CT are at low risk for complications and can be managed as outpatients.⁶

CSF leak, a known complication of skull base fractures, can present as rhinorrhea or otorrhea. This complication, which occurs in 10%–30% of cases, results from tearing of the dura in the area of the fracture. The leak usually occurs (55%–80%) within the first 48 hours after injury.^{5,6,10,11} Because most leaks stop

Key words

- Meningitis
- Prophylactic antibiotics
- Skull base fracture
- Traumatic brain injury
- Vaccination

Abbreviations and Acronyms

- CSF:** Cerebrospinal fluid
CT: Computed tomography
GCS: Glasgow Coma Scale
GOS: Glasgow Outcome Score

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spontaneously, initial treatment is conservative; continued leakage under conservative treatment often indicates the need for surgical intervention.^{5,7,11} Among adults, the risk of CSF leak leading to meningitis increases with the duration of the leak, at an incremental rate of 10%–50%.^{7,10,12}

In this study, we characterized the clinical course and overall outcomes of children who sustained skull base fractures and assessed the incidence of CSF leak and meningitis, the need for surgical intervention, and the risk of subsequent neurologic deficits. Our findings provide information regarding the need for prophylactic antibiotics and antipneumococcal vaccination.

PATIENTS AND METHODS

We reviewed the charts of patients age <18 years presenting at Hadassah Medical Center between January 2009 and December 2014 with a skull base fracture following an isolated traumatic brain injury. Children with multiple traumatic injuries were excluded from this study. We recorded demographic data, mechanism of injury, neurologic status, and findings of neuroimaging studies (e.g., brain CT) on presentation. As is routine in our department, patients were monitored for the development of CSF leak and meningitis during the course of hospitalization, and the neurologic outcome at the day of discharge was evaluated using the Glasgow Outcome Scale (GOS). The GOS is a 5-point scale that rates a patient's postinjury level of function (1, dead; 5, normal activity with minor motor or mental disabilities). The rate of rehospitalization in a neurology or neurosurgery department and the duration of hospitalization were evaluated as well.

Subgroups of patients were compared using the Pearson χ^2 and Fisher exact tests. Further statistical analyses were performed on the following clinical variables: age, location of fracture, Glasgow Coma Scale (GCS) score at presentation, mechanism of injury, intracranial bleeding status, and duration of hospitalization. Each of these variables was entered into a univariate logistic regression analysis model. The dependent variable was the experience (yes/no) of a CSF leak. The level of statistical significance was set at $P < 0.01$.

RESULTS

Between January 2009 and December 2014, 196 children (153 males [78%], mean age, 6.4 ± 4.3 years; median age, 5 years [range, 1 month to 18 years]) were hospitalized in our pediatric neurosurgical unit with skull base fracture. The duration of hospitalization ranged from 1 to 38 days (median, 4 days; mean, 5.4 ± 4.8 days). **Table 1** summarizes the demographic and clinical characteristics of the cohort.

Blunt trauma was the mechanism of injury in 98% of cases, whereas 2% suffered penetrating injury. The main cause was a fall from height, occurring in 143 children (73%), followed by motor vehicle accident ($n = 34$; 17%) and other means (e.g., falling heavy object, physical violence; $n = 19$; 10%). The most common fracture location was the middle of the skull base ($n = 112$; 57%), followed by the frontal base ($n = 62$; 32%), and occiput ($n = 13$; 7%). Among children with minor head trauma (GCS 14–15), the most common fracture site was the middle of the skull base; in those with moderate head trauma, frontal fractures were most common. The rate of multiple skull base fractures was higher in children

Table 1. Demographic and Clinical Characteristics of Children with Skull Base Fracture

Number (%)	Characteristic
Sex	
153 (78.1)	Male
43 (21.9)	Female
Cause of trauma	
34 (17.3)	MVA
143 (73)	Fall
19 (9.7)	Other
Mechanism of injury	
193 (98)	Blunt
3 (2)	Penetrating
Skull base fracture location	
62 (31.6)	Anterior
112 (57.1)	Middle
13 (6.6)	Posterior
9 (4.6)	Multiple
GCS at admission	
18 (9.2)	3–8
8 (4.1)	9–13
170 (86.7)	14–15
Clinical presentation	
36 (18.4)	None
36 (18.4)	Vomiting
27 (13.8)	Loss of consciousness
3 (1.5)	Seizure
34 (17.3)	Otorrhagia
11 (5.6)	Rhinorrhagia
49 (25)	Mixed
Intracranial CT findings	
86 (43.9)	None
60 (30.6)	Bleeding (e.g., EDH, SDH)
37 (18.9)	Pneumocephalus
1 (0.5)	Edema
32 (16.3)	Mixed
CSF leak	
142 (72.4)	No
54 (27.6)	Yes
Type of CSF leak	
36 (67.9)	Otorrhea
12 (22.6)	Rhinorrhea
Continues	

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