Growing Skull Fracture of Temporal Bone in Adults: A Case Report and Literature Review

Xiao-hong Yan, MD1, Ke Qiu, MD1, Yan Gao, BS2, Jianjun Ren, PHD1, Danni Cheng, MD1, Wendu Pang, MD1, Yao Song, MD1, Wen Yang, MD1, Rong Yu, BS1, and Yu Zhao, MD, PhD1

Abstract
Growing skull fracture (GSF) is an uncommon post-traumatic complication, which accounts for approximately 0.05% to 1% of all skull fractures. Delayed diagnosis of GSF in adulthood is rare and often involved with a variety of neurological symptoms. Here, we reported an adult patient, with an interval of 17 years from initial head trauma to first diagnosis of GSF. The patient complained of short periods of fainting and bilateral visual hallucinations, with a hard palpable bulge around his right occipitomastoid suture region. Computed tomographic imaging demonstrated an arachnoid cyst extending into right mastoid cavity. Consequently, the delayed diagnosis of GSF was confirmed, and the patient was managed with duroplasty and cranioplasty. At the 8-month follow-up, the patient showed an uneventful postoperative recovery. A comprehensive literature review was also conducted, and a total of 70 GSF cases were identified and summarized. According to the literature review, patients with GSF generally have a history of head trauma in their childhood, and delayed diagnosis is a common situation. Diagnosis of GSF should include complete retrospective medical history, physical, and imaging examinations. Once the diagnosis is confirmed, cranioplasty accompanied with duroplasty might be the most effective way to relieve symptoms and prevent further damage.

Keywords
growing skull fracture, temporal bone, arachnoid cyst, middle cranial fossa, cranioplasty, duroplasty

Introduction
Growing skull fracture (GSF) is a rare post-traumatic complication, accounting for less than 1% of all skull fractures, which is commonly observed in children under 3 years of age.1-4 The osteodural defect resulting from head trauma gradually gets enlarged under the increasing pressure on fracture edges created by brain pulsation and herniation of intracranial tissue, which prevents them from apposition and healing.5-8 Since early-stage GSF usually presents with few clinical manifestations, delayed diagnosis until the development of obvious skull physical signs and neurological symptoms is a common situation.5,9,10 In past several decades, duroplasty and cranioplasty are 2 most widely applied therapies for GSF, which have been proven to be effective in most cases.11-13 Here, we reported an adult patient with GSF of the temporal bone who presented with rare neurological symptoms and summarized the clinical details of 70 GSF cases identified through the literature review, with the aim of providing some evidence for adulthood GSF’s pathology, diagnosis, and principles of management.

Case Report
A 19-year-old man presented with short periods of fainting which lasted for half an hour and 1-hour bilateral visual hallucinations, without migraine, vomiting, or loss of consciousness. Physical examination only revealed a hard palpable bulge around right occipitomastoid suture region, without other

1 Department of Oto-Rhino-Laryngology, West China Hospital, West China Medical School, Sichuan University, Chengdu, Sichuan, China
2 Department of Oto-Rhino-Laryngology, Chengdu Shangjin Nanfu Hospital, West China Hospital, West China Medical School, Sichuan University, Chengdu, Sichuan, China

Received: November 03, 2019; revised: February 20, 2020; accepted: March 02, 2020

Corresponding Authors:
Yu Zhao, MD, PhD, and Rong Yu, BS, Department of Oto-Rhino-Laryngology, West China Hospital, West China Medical School, Sichuan University, No. 37 Guo Xue Alley, Chengdu, Sichuan 610041, China.
Emails: yuzhao@163.com; entyurong@163.com
abnormal neurological findings. Computed tomographic scan indicated the right mastoid cavity was substantially enlarged, of which approximately two-thirds was occupied with a soft-tissue density and likely to be connected with intracranial cavity (Figure 1A). An additional magnetic resonance imaging was performed showing locally extensive encephalomalacia with T1 and T2 prolongations, involving the right temporal lobe, occipital lobe, and cerebellum (Figure 1B-C), of which the lesion was likely to be communicating with dilated temporal angle of the right lateral ventricle. However, neither hearing test nor otoscopy showed any abnormal findings.

On further questioning, the patient’s families recalled a head trauma caused by a falling brick 17 years ago. The patient lost consciousness immediately and the status lasted for 3 days without special medical intervention. After he regained his consciousness, no obvious sequelae was observed. Thereafter, he suffered from syncope twice, 1 year and 1 month before hospitalization, respectively. Both of the 2 episodes happened after playing basketball, with a short time of headache in advance (the patient couldn’t clarify the exact length of headache), accompanied with no vomiting or convulsions, and woke up with full consciousness in about half an hour without medical intervention.

The diagnosis of post-traumatic GSF and arachnoid cyst was made after complete evaluation. Subsequently, the patient underwent surgical repair of dural mater and cranium.

Under general anesthesia, a C-shaped retroauricular incision was made in the right temporal region, and the mastoid cortex was exposed. A pulsating cyst filled with clear, colorless fluid presented under the thin mastoid cortex was observed, with fluid squirting out after the cortex was opened (Figure 2A). We resected partial right skull base and obliterated the defect with abdominal fat (Figures 1D and 2B). The patient had an uneventful recovery. At the 8-month follow-up, he experienced no postoperative visual hallucinations, headache, dizziness, or syncopes, and no budging or pain were detected in his operative region.

**Literature Review**

**Methods**
To provide a review of previously published GSF cases, a PubMed search of the English language literature was
performed from the beginning of the database through October 30, 2019. The search strategy was (((growing skull fracture) OR growing cranium defect) OR leptomeningeal cyst) AND ((arachnoid cyst) OR ((head) OR skull) OR brain)). We also reviewed the reference sections of all GSF case reports or series to search for additional cases and included all adulthood GSF case reports with imaging diagnosis, with the exception of head trauma due to birth injuries.

Results

We conducted a comprehensive literature review for GSF. A total of 62 literatures containing 70 post-traumatic GSF cases were identified (Table 1), with their detailed characteristics summarized in Supplementary Table 1. Approximately two-thirds of patients reported a history of head trauma under the age of 3 (n = 51, 72.9%), of which the leading cause was fall (n = 44, 62.9%), followed by vehicle accidents (n = 13, 18.6%) and child abuses (n = 3, 4.3%). Meanwhile, according to our review, parietal region was the most frequently involved location (n = 21, 30.0%), followed by parieto-occipital region (n = 9, 12.9%), parietotemporal region (n = 8, 11.4%), and occipital region (n = 7, 10.0%). Diastasis of sutures without any other bone fractures was also observed in one case.14

The most common physical sign was progressive enlarging swelling of scalp, accounting for over one-third of all cases (n = 24, 34.3%), followed by nonpulsatile mass (n = 12, 17.1%) and palpable cranial defect (n = 9, 12.9%). Besides, loss of consciousness immediately after head trauma occurred in over one-third of patients (n = 22, 31.4%), with the duration ranging from several minutes to more than 10 weeks. In addition, the incidence of hemiparesis and seizures accounted for 18.6% and 17.1%, respectively. Mental retardation, such as had difficulty in learning and language or presented low intelligence quotient comparatively, was reported only in 3 cases.15-17

More than half of those reported GSF patients received delayed diagnosis or underwent surgical management over 1 year following head trauma (n = 37, 56.1%), ranging from 2 weeks to 54 years. Meanwhile, the most common characteristics in those delayed GSF images revealed cysts filled with cerebrospinal fluid (CSF) extending through skull defects (n = 25, 40.3%), herniation of brain tissue (n = 14, 22.6%), focal ventricular dilatation (n = 13, 21.0%), and porencephalic cysts (n = 10, 16.1%), respectively. About 83.3% (n = 50) GSF patients would receive cranioplasty and duroplasty.

Discussion

The incidence of GSF is less than 1% in all skull fractures.1 It mostly occurs in patients during their infancy and early childhood (1-3 year olds), as they are more likely to suffer from falling injuries and child abuse.14 The pathophysiological mechanisms of GSF remains elusive. It is widely believed that rapid brain growth and post-traumatic skull defects accompanied by dural tear are necessary for the formation of GSF. The increasing pressure on fracture edges created by brain pulsation and herniation of intracranial tissue would prevent them from apposition and healing.5,6,8,11,12,19 In consistent with previous studies,20 we don’t think the intracranial expansive force of CSF cyst can result in elevated intracranial pressure unless there was hydrocephalus (in our literatures review, such cases

| Table 1. Summary of Documented Clinical Details in 70 Patients With Growing Skull Fractures. |
|-----------------------------------------------|---------------|
| Clinical Characteristics                     | Number (Percent) |
|-----------------------------------------------|-----------------|
| Age                                           |                 |
| <18 years old                                 | 55 (78.6)       |
| ≥18 years old                                 | 15 (21.4)       |
| Gender                                        |                 |
| Male                                          | 46 (65.7)       |
| Female                                        | 24 (34.3)       |
| Age at head trauma                            |                 |
| <3 years old                                  | 51 (72.9)       |
| ≥3 years old                                  | 19 (27.1)       |
| Cause                                         |                 |
| Fall                                          | 44 (62.9)       |
| Vehicle accidents                              | 13 (18.6)       |
| Child abuses                                  | 3 (4.3)         |
| Other causes                                  | 10 (14.2)       |
| Interval from head trauma to diagnosis        |                 |
| <1 year                                       | 29 (43.9)       |
| ≥1 year                                       | 37 (56.1)       |
| Location                                      |                 |
| Parietal                                      | 21 (30.0)       |
| Parieto-occipital                             | 9 (12.9)        |
| Parietotemporal                               | 8 (11.4)        |
| Occipital                                     | 7 (10.0)        |
| Fronto-orbital                                | 6 (8.6)         |
| Frontal                                       | 5 (7.1)         |
| Frontoparietal                                | 5 (7.1)         |
| Other location                                | 9 (12.9)        |
| Symptoms                                      |                 |
| Hemiparesis                                   | 13 (18.6)       |
| Seizures                                      | 12 (17.1)       |
| Ocular presentations                          | 11 (15.7)       |
| Somnolence                                    | 8 (11.4)        |
| Headache                                      | 6 (8.6)         |
| Vomiting                                      | 5 (7.1)         |
| Convulsions                                   | 5 (7.1)         |
| Mental retardation                            | 3 (4.3)         |
| Skull physical examination                    |                 |
| Progressive enlarging swelling                | 24 (34.3)       |
| Nonpulsatile local mass                       | 12 (17.1)       |
| Palpable cranial defect                       | 9 (12.9)        |
| Fluctuating swelling                          | 6 (8.6)         |
| Pulsatile local mass                          | 4 (5.7)         |
| Pulsatile cranial defect                      | 4 (5.7)         |
| Treatment                                     |                 |
| Cranioplasty and duroplasty                   | 50 (83.3)       |
| Only cranioplasty                             | 3 (5.0)         |
| Only ventriculoperitoneal shunt               | 2 (3.3)         |
| Conservative treatment                        | 2 (3.3)         |
| Only duroplasty                               | 2 (3.3)         |
| No treatment                                  | 1 (1.7)         |
or speculation were not reported) because in the course of GSF, skull will accordingly enlarge. And surgical repairment of dura matter and cranium is the most widely applied treatment.

To the best of our knowledge, the present case is the first to report GSF patient presented with short periods of visual hallucinations and syncopes, with an arachnoid cyst herniation projecting into his right mastoid cavity, due to a head trauma happened as long as 17 years ago. Our case highlighted the importance of taking a thorough history and performing a complete examination when the patient manifested with rare neurological symptoms (such as visual hallucination and postexercise syncope).

**Authors’ Note**
Xiao-hong Yan and Ke Qiu contributed equally to this study and share first authorship.

**Declaration of Conflicting Interests**
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article

**Funding**
The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by 1·3·5 project for disciplines of excellence–Clinical Research Incubation Project, West China Hospital, Sichuan University [Grant No. 2019HXFH003]; Key Research and Development Support Programmes of Chengdu Science and Technology Bureau [Grant No. 2018-YFYF-00123-SN]; and the Fundamental Research Funds for the Central Universities [Grant No. 2012017yjsy118].

**ORCID iD**
Yu Zhao https://orcid.org/0000-0003-1874-908X

**Supplemental Material**
Supplemental material for this article is available online.

**References**
1. Gallo P, Mazza C, Sala F. Intrauterine head stab wound injury resulting in a growing skull fracture: a case report and literature review. _Childs Nerv Syst_. 2010;26(3):377-384.
2. Ciurea AV, Gorgan MR, Tascu A, Sandu AM, Rizea RE. Traumatic brain injury in infants and toddlers, 0-3 years old. _J Med Life_. 2011;4(3):234-243.
3. Lende RA, Erickson TC. Growing skull fractures of childhood. _J Neurosurg_. 1961;18:479-489.
4. Wang X, Li G, Li Q, You C. Early diagnosis and treatment of growing skull fracture. _Neuro India_. 2013;61(5):497-500.
5. De PDV, Njamnshi AK, Ongolo-Zogo P, et al. Growing skull fractures. _Child's Nerv Syst_. 2006;22(7):721-725.
6. Ersahin Y, Gülmen V, Palali I, Mutluer S. Growing skull fractures (craniocerebral erosion). _Neurosur Rev_. 2000;23(3):139-144.
7. Kingsley D, Till K, Hoare R. Growing fractures of the skull. _J Neurol Neurosurg Psychiatry_. 1978;41(4):312-318.
8. Muholen MG, Piper JG, Menezes AH. Pathogenesis and treatment of growing skull fractures. _Surg Neurol_. 1995;43(4):367-372; discussion 372-363.
9. Husson B, Pariente D, Tammam S, Zerah M. The value of MRI in the early diagnosis of growing skull fracture. _Pediat Radiol_. 1996;26(10):744-747.
10. Reddy DR. Growing skull fractures: guidelines for early diagnosis and effective operative management. _Neurol India_. 2013;61(5):455-456.
11. Ramamurthi B, Kalyanaraman S. Rationale for surgery in growing fractures of the skull. _J Neurosurg_. 1976;32(4):427-430.
12. Tamada I, Ihara S, Hasegawa Y, Aoki M. Surgical treatment of growing skull fracture: technical aspects of cranial bone reconstruction. _J Craniofac Surg_. 2019;30(1):61-65.
13. Singh I, Rohilla S, Siddiqui SA, Kumar P. Growing skull fractures: guidelines for early diagnosis and surgical management. _Childs Nerv Syst_. 2016;32(6):1117-1122.
14. Haar FL. Complication of linear skull fracture in young children. _Am J Dis Child_. 1975;129(1):1197-1200.
15. Scarfö GB, Mariottini A, Tomaccini D, Palma L. Growing skull fractures: progressive evolution of brain damage and effectiveness of surgical treatment. _Childs Nerv Syst_. 1989;5(3):163-167.
16. Sener RN. Growing skull fracture in a patient with cerebral hemiatrophy. _Pediatr Radiol_. 1995;25(1):64-65.
17. Sanford RA. Prevention of growing skull fractures: report of 2 cases. _J Neurosurg Pediatr_. 2010;5(2):213-218.
18. Liu XS, You C, Lu M, Liu JG. Growing skull fracture stages and treatment strategy. _J Neurosurg Pediatr_. 2012;9(6):670-675.
19. Taveras JM, Ranosohof J. Leptomeningeal cysts of the brain following trauma with erosion of the skull; a study of seven cases treated by surgery. _J Neurosurg_. 1953;10(3):233-241.
20. Drapkin AJ. Growing skull fracture: a posttraumatic neosuture. _Childs Nerv Syst_. 2006;22(4):394-397.