GROWING skull fracture (GSF) is a rare but significant late complication following head trauma. It accounts for 0.05%–1.6% of all childhood fractures\textsuperscript{6,13} and occurs almost exclusively in children under 3 years of age in whom the diastasis is greater than 3–4 mm.\textsuperscript{4,8,12,22,27,28} A GSF may remain undetected during the first few years of life. It has been described as a leptomeningeal cyst herniation through a dural tear without evidence of increased intracranial pressure, implicating physiological growth and brain cerebrospinal fluid pulsations as causative factors.\textsuperscript{17} Because a delay in diagnosis and/or improper management can exacerbate this condition,\textsuperscript{6,16} early identification of symptoms and prompt management are critical to achieving a good outcome. Although much is known about this uncommon condition, little is known about the British surgeon, Dr. John Howship, who described GSF for the first time.\textsuperscript{11} Here we review the life and accomplishments of Dr. Howship and his immense contributions to our understanding of GSF.

History

Biography of John Howship

John Howship (Fig. 1) was born in London, England, in 1781. Upon entering medical school in 1799, Howship worked as an assistant to Dr. John Heaviside (1748–1828), a distinguished surgeon and museum proprietor. “Museum medicine” of the 19th century focused students’ attention on particular anatomical sites of disease dissected out from the rest of the body. Under Heaviside’s tutelage, Howship became a skillful dissector, performed autopsies, and collected specimens from his dissections. These activities were considered gentlemanly pursuits in the late 18th century, and many of Howship’s specimens are pre-
served in the John Heaviside museum (Hanover Square, London) (Fig. 2).

In 1805, Dr. Howship was appointed as an assistant surgeon at the St. George’s Infirmary, London, and a lecturer at the school of the St. George’s Hospital. In 1834, Dr. Howship moved to the Charing Cross Hospital as an assistant surgeon and was subsequently promoted to chief surgeon in 1836, after his predecessor, Dr. Thomas Joseph Pettigrew (1791–1865), was ousted for demanding and obtaining £500 from Dr. Howship for the assistant surgeon position. In 1833, Dr. Howship gave the Hunterian Lecture at the College of Surgeons and was a member of the council of the Royal College of Surgeons from 1828 until his death on January 22, 1841, of hemorrhage from an abscess of the lower leg due to a chronic disease of the tibia. By the time of his death, he was one of the most distinguished surgeons in England.

Howship’s most noteworthy publication was his book, *Practical Observations in Surgery and Morbid Anatomy* (Fig. 3), published in 1816. This work contains the preliminary description of what is now known to us as “growing skull fracture.” In addition to his observations on GSF, Howship made significant contributions to the understanding of disorders of bone, the gastrointestinal system, and the genitourinary tract. Some of his other notable publications on gastrointestinal diseases are *Practical Remarks Upon Indigestion and Practical Observations on the Symptoms* (1823), and *Practical Observations on the Symptoms, Discrimination, and Treatment of Some of the Most Important Diseases of the Lower Intestines, and Anus* (1821). In urology he published *Practical Observations on the Diseases of the Urinary Organs* in 1816. He also described specific signs related to surgical disorders. The Howship-Romberg sign identifies obturator hernia and the Howship lacuna sign is a groove or pit containing osteoclasts indicative of bone resorption.

**Howship and the Idea of the Growing Skull Fracture**

The beginning of our current understanding of GSF dates back to 1816 when Dr. Howship reported in Section 1, Case 10 of *Practical Observations in Surgery and Morbid Anatomy*, partial absorption of the parietal bone in a 9-month-old female infant after she fell from stairs (Figs. 3 and 4). The child presented in an unconscious state with a 3 × 1-in depressed fracture of the parietal bone. The condition was managed conservatively with leeches for pain management and saturnine lotion, a saturated solution of subacetate of lead consisting of 25% acid and...
75% lead, to keep the injury site cool. Two weeks after the accident, the mother felt pulsations of the brain at the site of injury. Four months after the accident, the child regained consciousness but was weak. Until her 3rd year of life, she could not stand unsupported, and weakness in the left leg persisted. However, her strength and health gradually improved. By age 4, her left leg was still deficient in strength and the opening in the cranium remained undiminished. The pulsations of the brain could be felt over the site of injury and were distinct. Upon coughing or crying, the affected site became tense and swollen. On the basis of his observation, Dr. Howship implicated the pathophysiology of what is now known as the GSF to the disruption of blood supply to the fractured bone.

**Historical Evolution of Growing Skull Fracture**

Following the first description of GSF by Howship in 1816,11 Carl von Rokitansky (1804–1878) provided the first pathological description in Vienna in 1856.24 While performing an autopsy on an 8-month-old child, Rokitansky found a fluid-filled sac above and a dural opening and an underlying brain injury below the cranial aperture; this lesion measured 6 × 4 cm.24 In 1862, Theodor Billroth (1829–1894) first used the term “meningocele spuria” to describe an external sac of CSF in a child who suffered an injury to the cranium via forceps delivery. This “spurious meningocele” progressively enlarged to the size of the head itself. At autopsy, Dr. Billroth noticed an opening in the dura mater corresponding with the cranial defect.2 Until that time, the distinguishing feature of GSF was considered to be a collection of CSF exterior to the skull developing after a trauma, and meager, if any, attention was paid to the fractured cranial site.10,15,23 Later, Josef Weinlechner (1829–1906) broadened the clinical description by documenting an enlarging cephalhydrocele in a 5-month-old following a fall from height;31 however, the term “traumatic cephalhydrocele” appeared in the first American series reported in 1884 by Dr. P. S. Conner at the Medical College of Ohio.3 Subsequently, Dr. Thomas Smith reported another case of traumatic cephalhydrocele with a pulsatile cranial defect.26 In 1885, Rickman John Godlee (1849–1925) reported on 2 infants in whom pulsating subcutaneous tumors developed after a simple skull fracture.7 In the same year, Alexander von Winiwarter (1848–1917) documented a large hiatus in the skull subsequent to head trauma.30

The basis of a surgical approach to this condition was established following the 1907 operative report by Sir Charles Ballance (1856–1936), who described a 4-year-old male child who, after a fall from a height of 22 feet, developed a cephalhydrocele, widened fracture, dural defect, and underlying brain injury.1 A scalp flap was pulled downward at the site of injury and exposed the herniated brain mass through the fractured parietal bone. The flap was then replaced, and the patient eventually made a full recovery 2 years later.1 Soon after this, Sir Wilfred Trotter (1872–1939) operated on a patient in whom cystic dilation of the lateral ventricle extended out to the cranial defect. He designated the condition as “traumatic ventricular cyst.” The 3 characteristic features...
noted by Trotter were a gap in the skull, associated pulsations, and a history of childhood injury.29 With the advent of the roentgenogram as an aid to diagnosis, Cornelius Dyke (1900—1943) in 1937 first described the radiographic aspects of this condition and labeled it as a “leptomeningeal cyst.” The roentgenological diagnosis was based on 3 features: widening of an old fracture, edging of the inner table of the skull, and an accentuated vascularity of the affected bone. In 1940, on the basis of pathological findings of the biopsy materials, H. K. Pancoast et al.20 termed this condition “fibrosing osteitis.” In 1941, Wilder Penfield and T. C. Erickson used the term “cerebrocranial erosion” to refer to an erosion of the skull overlying dural defects.20 Likewise, in 1955 Dr. G. F. Rowbotham referred to traumatic meningocele and described the loss of bone as a traumatic malacia.25 However, it was H. W. Pia and W. Tonnis, describing their findings of traumatic cephalohydrocele with enlargement of fracture developing into a hiatus in the skull, who coined the term “growing skull fracture” to describe such conditions.21

Modern Concept and Treatment Options for Growing Skull Fracture

There are currently 2 widely accepted 3-stage classifications of GSF.14,18 The original classification was based on the clinical progression of the disease,18 while the more recent classification relies on the radiological features present in the GSF.14 In this modern classification, GSF is subdivided into the following 3 subtypes: skull fracture with the presence of a leptomeningeal cyst; skull fracture with underlying, damaged, gliotic brain; and porencephalic cyst extending through the skull defect into the subgaleal space.14 Treatment strategies vary depending on the subtype of the GSF. Simple cases with leptomeningeal cyst have been treated with duraplasty and acrylic cranioplasty.14,17,28 The possibility of increased intracranial pressure should be evaluated in patients with gliotic brain and/or a porencephalic cyst. If elevated intracranial pressure is present, this should be managed with the placement of a ventriculoperitoneal shunt. The GSF can then be treated with dural repair and cranioplast using autologous bone graft or methylmethacrylate.9,14,28 Children, especially those under 3 years of age, with linear skull fractures should be followed serially with clinical examination and palpation of the defect, and with radiographic imaging, if needed, to ensure healing of the fracture site.14

Conclusions

With the resources available in the 18th and 19th centuries, John Howship’s achievements are nothing short of astonishing. The first depiction of GSF by Howship heralds a significant contribution to the field of pediatric neurosurgery and has helped our current understanding of the disease. He should be recognized in the field of neurosurgery for his contributions to the discovery and management of GSF.

References

7. Godlee RJ: Two cases of simple fracture of the skull in infants followed by the development of a pulsating subcutaneous tumour. Trans Pathol Soc Lond 36:313–324, 1885
23. Reckitt JDT: Fracture of skull: effusion of cerebro-spinal fluid beneath the scalp; aspiration; recovery. Lancet 1:909, 1881

Author Contributions
Conception and design: Bir. Acquisition of data: Bir. Drafting the article: Bir. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Nanda.

Correspondence
Anil Nanda, Department of Neurosurgery, LSU Health Shreveport, 1501 Kings Hwy., Shreveport, LA 71130-3932. email: ananda@lsuhsc.edu.