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Characteristic MR Findings of Growing Skull Fracture in Children[1]

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Purpose: Leptomeningeal cyst or growing skull fracture can occur in young infants or children following head trauma. We present MR imaging findings in five children with growing skull fracture.

Materials and Methods: We reviewed the MR images of five children (M: F=2:3) with growing skull fracture. The mean age was 7.5 years. The time interval between the occurrence of head trauma and the presentation of growing skull fracture varied from three months to 12 years. We reviewed the precontrast CT scans and/or the plain skull radiographs in those patients for whom these studies were available.

Results: The most common location of the growing skull fracture was the parietal bone ($n=3$). On the MR images, there were bone defects with posttraumatic cystic encephalomalacia or porencephalic cysts. Marginal bony thickening and diploic space widening were noted in four patients. MR imaging was excellent for visualizing the parenchymal changes and pericranial lesions.

Conclusion: In children with growing skull fracture, MR imaging can clearly depict trauma-related parenchymal changes, pericerebral lesions as well as bony edge thickening with remodeling.

Index words : Skull, fracture
Magnetic resonance (MR)
Children, head trauma

Growing skull fracture or leptomeningeal cyst is a rare complication of skull fracture, occurring almost exclusively in infants and children under the age of three (1, 2). It follows head trauma with accompanying skull fracture. Dural tear associated with skull fracture is the basic mechanism by which this condition occurs. Growing skull fracture is most commonly observed in the frontal and parietal regions, but it can occur anywhere in the skull (3 - 5).

We reviewed the clinical data and MR images in five children with growing skull fracture, in order to determine the characteristic MR findings.

Subjects and Methods

Five patients (2 boys, 3 girls) aged 3 months to 13 years (mean age, 7.5 years) were retrospectively studied. All patients had a diagnosis of growing skull fracture, which was based either on surgery or imaging findings.

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The retrospective analysis included clinical data (cause of injury, interval between the injury and the detection of growing skull fracture) and imaging findings. We reviewed the brain MR images for all patients. We also reviewed the precontrast CT scans and/or plain skull radiographs in those patients for whom such studies were available and evaluated the characteristic findings.

MR imaging was performed with a 1.5 T scanner (Signa; General Electric Medical Systems, Milwaukee, WI), and spin-echo T1- and T2-weighted images were obtained with or without gadolinium injection. The MR findings were reviewed regarding the diploic space widening, bony thickening and parenchymal changes. Although one of our patients did not undergo surgery, growing skull fracture was the most likely diagnosis when considering the clinical history and MR imaging findings.

Results

Falling was the cause of injury in two of our study patients, while one patient's injury resulted from a motor vehicle accident. One patient (case 2) had no history of significant head trauma. The time interval between the history of head trauma and presentation of growing skull fracture varied from three months to 12 years (mean: 5.3 years) in four of these children.

On the available skull radiograph, for four of our patients (cases 1, 2, 3 and 4) two had an elliptical bony defect with scalloped margins and one had an osteolytic bony lesion with sclerotic margin and a bulging soft tissue mass. CT scans at the time of the initial injury were

Table 1. Summary of the Five Patients with Growing Skull Fracture

Case No	Age/Sex (years)	Mechanism of injury	Fracture site	Interval between trauma & MRI	MRI findings			Surgery
					Bone thickening	Diploic space widening	Parenchymal changes	
1	9.6/F	MVA	Rt. P	7 years	+	+	encephalomalacia porencephalic cyst	+
2	12/F	unknown	Lt. P	unknown	+	+	porencephalic cyst	-
3	0.3/M	unknown	Lt. P	3 months	+	+	porencephalic cyst	+
4	2.8/F	Fall	Rt. F orbital roof	1.9 years	+	-	encephalomalacia	+
5	13/M	Fall	Lt. O	12 years	+	+	encephalomalacia	+

* MVA: Motor vehicle accident, P: Parietal bone, F: Frontal bone, O: Occipital bone

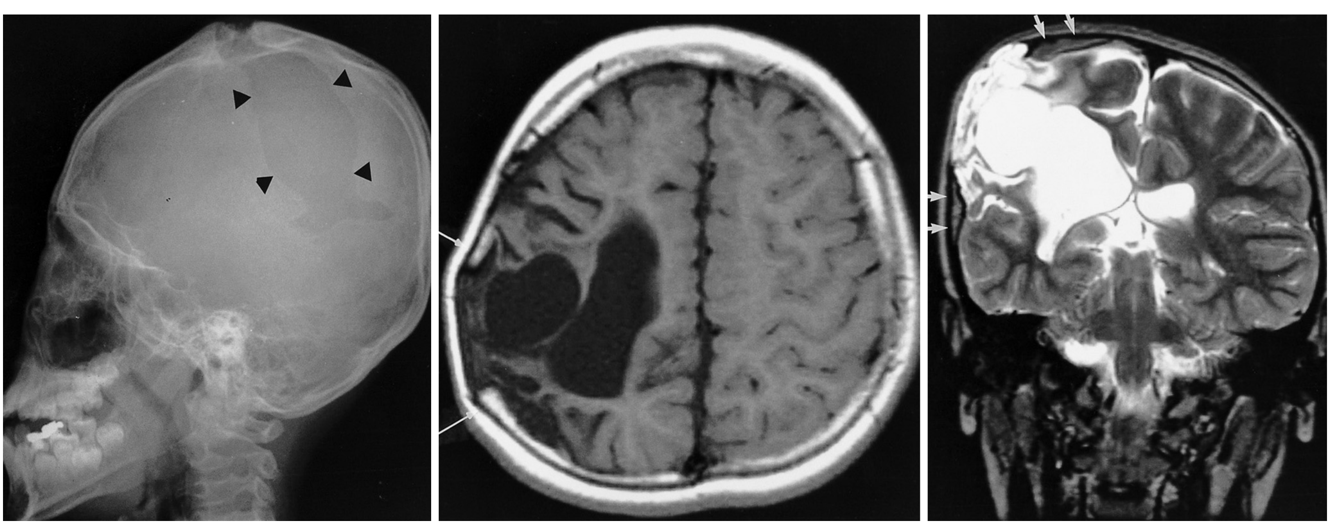

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Fig. 1. Nine-year-old girl with history of head injury seven years previously (Case 1).
A. Plain skull radiograph shows a large, elliptical bone defect (arrowheads) in the parietal bone.
B. Axial T1-weighted MR images reveal a right parietal bone defect through which herniation occurs. The herniated tissue includes a CSF-filled sac and damaged brain parenchyma with atrophy. There are also an encephalomalatic cyst and a passively dilated right lateral ventricle with a ragged border. Note the bony thickening (arrows) at the margins of the bone defect.
C. Coronal T2-weighted image shows a bulging right parietal mass. A porencephalic cyst and destroyed parenchyma, as well as a CSF-filled dural sac are herniated through the bony defect. Note the bony edge thickening with diploic space widening (arrows).

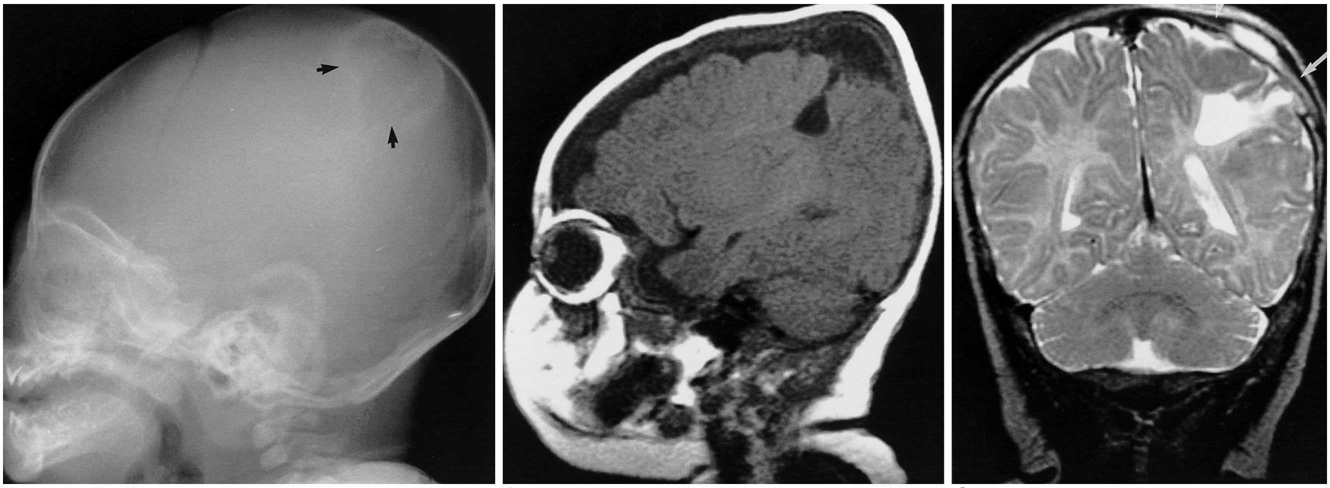

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Fig. 2. A three-month-old boy with a bulging scalp mass, which was present since his first week of life (Case 3).
A. Plain radiograph shows an osteolytic bony lesion with a sclerotic margin (arrows) in the left parietal bone.
B. Sagittal T1-weighted image shows a homogenous cystic mass, continuous with the damaged brain through the bone defect. A posttraumatic porencephalic cyst is suspected to be in communication with the leptomeningeal cyst.
C. Coronal T2-weighted image shows diploic space widening with extension of the intradiploic cyst into the left parietal region. Note the bony edge thickening (arrows).

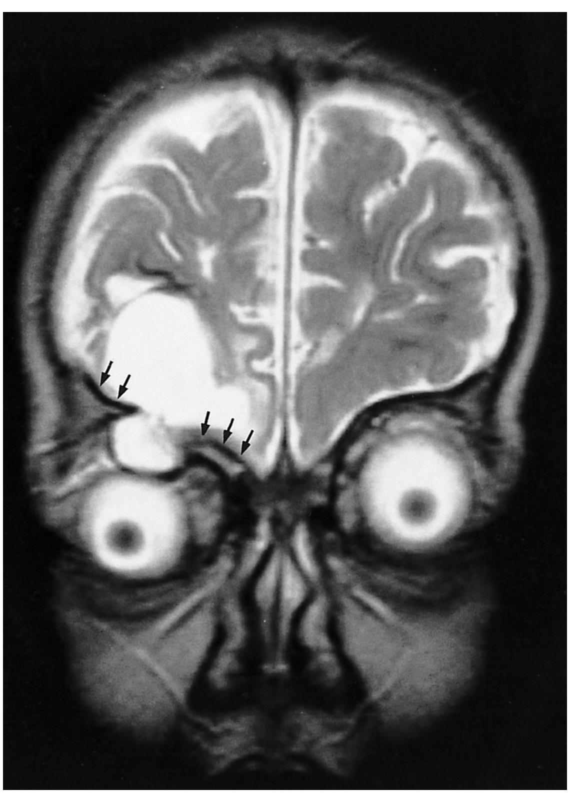

Fig. 3. A three-year-old boy with growing skull fracture in the right orbit (Case 4).
Coronal T2-weighted MR imaging shows a frontobasal porencephalic cyst extending into the right orbit. Note the bony edge thickening in the orbital roof (arrows).

only obtained in the case of one patient (case 4), who was not able to be diagnosed by means of the plain radiograph, but for whom there was evidence of skull fractures and underlying brain damage consisting of brain contusion with localized cerebromalacia.

On the MR images of all patients, there was evidence of posttraumatic cystic encephalomalacia or porencephalic cyst with herniation through the bony defect. Marginal bony thickening and diploic space widening were noted in four patients. One patient (case 4) showed marginal bony thickening without diploic space widening in the right orbital roof. Cranioplasty and duroplasty were performed in four patients (cases 1, 3, 4 and 5). The other patient (case 2) did not undergo follow-up evaluation.

Discussion

Growing skull fracture or leptomeningeal cyst is a relatively uncommon complication of skull fracture with an incidence of approximately 0.05 to 1.6% (3, 4). Lende and Erickson (1) reported that more than half of the cases of growing skull fracture occur in children under the age of 12 months, and 90% of these cases are in children aged three years or younger. These researchers suggested that the age at the time of injury is very important, because the more active skull growth in younger children may promote growing skull fracture. The reason why growing skull fractures occur most commonly during infancy and early childhood has been explained as follows: the dura adheres more tightly to the bone in this age group and is therefore more easily torn when the overlying bone is disrupted (2, 3). Rapid growth of the brain and skull within the first two years of life may contribute to the development of the growing skull fracture. Nevertheless, it can occur at any age, and several cases of growing skull fracture have even been reported in adults (3, 6, 7). Three of our five patients were more than three years old. Another of our patients (case 3) was a three-month-old boy without neurologic deficit, who had a bulging scalp mass, which had been found during the first week of life. Although there was no prior history of trauma, it was thought to be related to birth trauma. A few neonatal cases and one case of intrauterine growing skull fracture have previously been reported (8, 9).

Motor vehicle accidents, child abuse, birth injuries, and previous cranial surgery can also lead to growing skull fracture (2, 3, 10). The diagnosis is usually made weeks or months after the original injury, when a palpable skull defect or bulging mass is detected. Neurological deficits such as hemiparesis, squinting and visual field defects may accompany the scalp swelling. Seizure was common in some series (2, 3, 10). Growing skull fractures are mostly located in the frontal and parietal regions, but can occur anywhere in the skull, including the orbital roof, as in our case. Orbital growing fractures can cause a pulsating exophthalmus (3, 6, 11). Asymptomatic presentation is more common in cases involving the frontal, temporal, occipital and parieto-occipital regions (3).

The mechanism of growing skull fracture is known to involve the progressive growth of an arachnoid cyst herniating through a dural tear (8, 12). However, Tandon et al (10) reported that an arachnoid cyst is not always present and it is not the only mechanism of growing skull fracture. CSF pulse pressure is also an important factor and pulsation of the brain adjacent to the bone defect is thought to contribute to further bone erosion (8). Although most skull fractures and even diastatic fractures in children heal spontaneously, those associated with an underlying dural laceration may not heal and may develop into growing skull fracture (13). Widening of the bony gap at the fracture site occurs between four and eight weeks following trauma (10). Most cranial defects are typically irregular in contour and elliptical in shape, as in the case of our patients.

Plain skull radiography is a simple and useful imaging tool for the diagnosis of growing skull fracture. Diastatic skull fracture may be seen on the initial skull radiographs (3, 10). On CT, evidence of damage in the underlying brain can be found during the early period, as well as porencephalic cyst, focal dilatation of the lateral ventricle and herniation of the brain tissue into the bony defect, as seen on follow-up studies (3, 8).

MR images clearly showed brain herniation through the bone defect at the fracture site as well as parenchymal changes. Husson et al (8) reported that a CSF-filled sac or brain tissue protrusion through the bony defect on MR imaging was an indirect sign of dural tear, and that these MR findings suggested the possibility of head trauma, if it had not already been recorded. These researchers emphasized that MR imaging was superior to CT, because it better visualized the pericerebral and pericranial spaces with multiplanar capability, and also lacked a beam-hardening artifact.

The bony edges were markedly thickened (3, 10, 13). This was a characteristic MR finding of growing skull fracture in our cases. We thought that bony edge thickening might result from the tensile force on the wall of the progressively expanding arachnoid cyst. CSF pulsation may widen the bone defect at the fracture site, and longstanding pulsatile and tensile forces seem to cause bone remodeling with edge thickening.

There are several pediatric diseases associated with thickening of the skull , including osteopetrosis, neuroblastoma metastasis, and infantile cortical hyperostosis (14 - 16). Cranial Langerhans cell histiocytosis with spontaneous hemorrhage can be defined as a calvarial osteolytic defect with epidural hematoma, mimicking growing skull fracture (17).

The treatment of choice for growing skull fracture is surgical repair of the dural tear with cranioplasty. Some authors have recommended shunting without repairing the dural defect in the case of severe ventricular dilatation, in order to decrease the intracranial pressure (8).

One limitation of our study is its small number of patients. Another limitation is that cranioplasty was only performed in four of the five patients, and no correlation was made between the plain radiographies and the MR images.

In summary, MR imaging can clearly visualize cerebral and extracranial abnormalities including dural tear, CSF-filled cysts, bony changes and trauma-related parenchymal changes, and may be very helpful for diagnosing growing skull fracture, regardless of the trauma history. Bony edge thickening with remodeling is a unique MR finding in children with growing skull fracture.

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소아 성장성 두개골 골절(Growing Skull Fracture)의 특징적인 자기공명영상 소견[1]

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장윤우 · 윤혜경[2] · 신형진[3] · 조재민[2] · 정혜원[2]

목적: 성장성 두개골 골절은 영아나 소아에서 두경부 손상후에 발생한다. 저자들은 성장성 두개골 골절로 진단된 환아들의 MR 소견을 보고자 한다.

대상과 방법: 성장성 두개골 골절로 진단된 5명의 MR 영상을 후향적으로 분석하였고 남녀 비는 2:3 이었으며 평균연령은 7.5세 였다. 외상의 과거력과 성장성 두개골 골절로 내원 할 때까지 기간은 3달에서 12년까지 넓게 분포하였다. 단순 촬영과 CT가 있는 환아에서는 이들 영상 소견을 같이 분석하였다.

결과: 성장성 두개골 골절의 가장 흔한 위치는 두정엽 부위였으며 MR 에서 외상후 실질 변화로 낭성 뇌연화증과 공뇌증이 보였다. 골절 변연부 골 비후와 판사이 공간 확장이 4예에서 보였다. 이러한 모든 병변을 보여주는데 있어 MR 영상은 매우 우수하였다.

결론: 성장성 두개골 골절 환아에서 MR 영상은 외상 후의 뇌 실질 변화와 골절 변연부 골비후와 같은 골 변형 및 재형성 등을 분명하게 보여 주었다.