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Why Does the Fracture Not Heal? Vascular Channel Mimicking Skull Fracture

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Abstract Vascular channel of the frontal bone is a rare anatomical variant. This report describes a child who suffered from head injury with right parietal skull fracture and another suspicious fracture at the right frontal bone. Follow-up computed tomography showed persistent frontal "fracture" while the parietal fracture had resolved. Post-processing with 3D volume rendering showed that it was actually not a fracture. While there is no accessory frontal suture reported other than the metopic suture, the most likely cause for the radiolucency here is vascular channel of the frontal bone. Image post-processing is very helpful in doubtful situation, and should be considered in addition to axial images in our daily practice.

Key words Child; Computer-assisted; Image processing; Skull fractures; Tomography; X-Ray computed

Introduction

Head injury is one of the commonest indications for computed tomography (CT) scan of the brain, and skull fracture is usually diagnosed without difficulty by CT scan. However, it is well known that a number of anatomical variants can mimic skull fracture in the acute setting. These include various unfused or accessory sutures,[1] and different kinds of vascular impressions. This is particularly a problem in paediatric patients. Here we report a case in which a suspected skull fracture in a child who sustained a head injury turned out to be one of the anatomical variants in the skull.

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Case Report

A two-year-old boy presented to our A&E department after sustaining a head injury to the right parietal region during a road traffic accident, with a large parietal scalp swelling on presentation. A non-contrast CT scan of the brain was performed after clinical assessment (Figure 1a), which showed scalp swelling over the site of injury. A small epidural haematoma was also noted at the right parietal region. Bone window (Figure 1b) showed a subtle hair-line fracture at the right parietal bone, and another lucent line traversing the right frontal bone (Figure 1c), which was suspected to be a second fracture. He was referred to neurosurgical team, and put on conservative management.

Three months later, a reassessment CT scan of the brain was performed (Figure 1d). It was found that the right parietal scalp swelling, parietal bone fracture, and the epidural haematoma had all resolved (Figures 1d and 1e). However, persistent radiolucent line was seen traversing the entire right frontal bone (Figures 1e and 1f), raising the worry of non-healing fracture. On communication with the clinician, it was found that the patient has no symptom at the frontal region, and the site also did not correspond to that of the head injury. Three-dimensional (3D) volume rendering of the source images was therefore performed to have a better appreciation of the lesion concerned (Figure

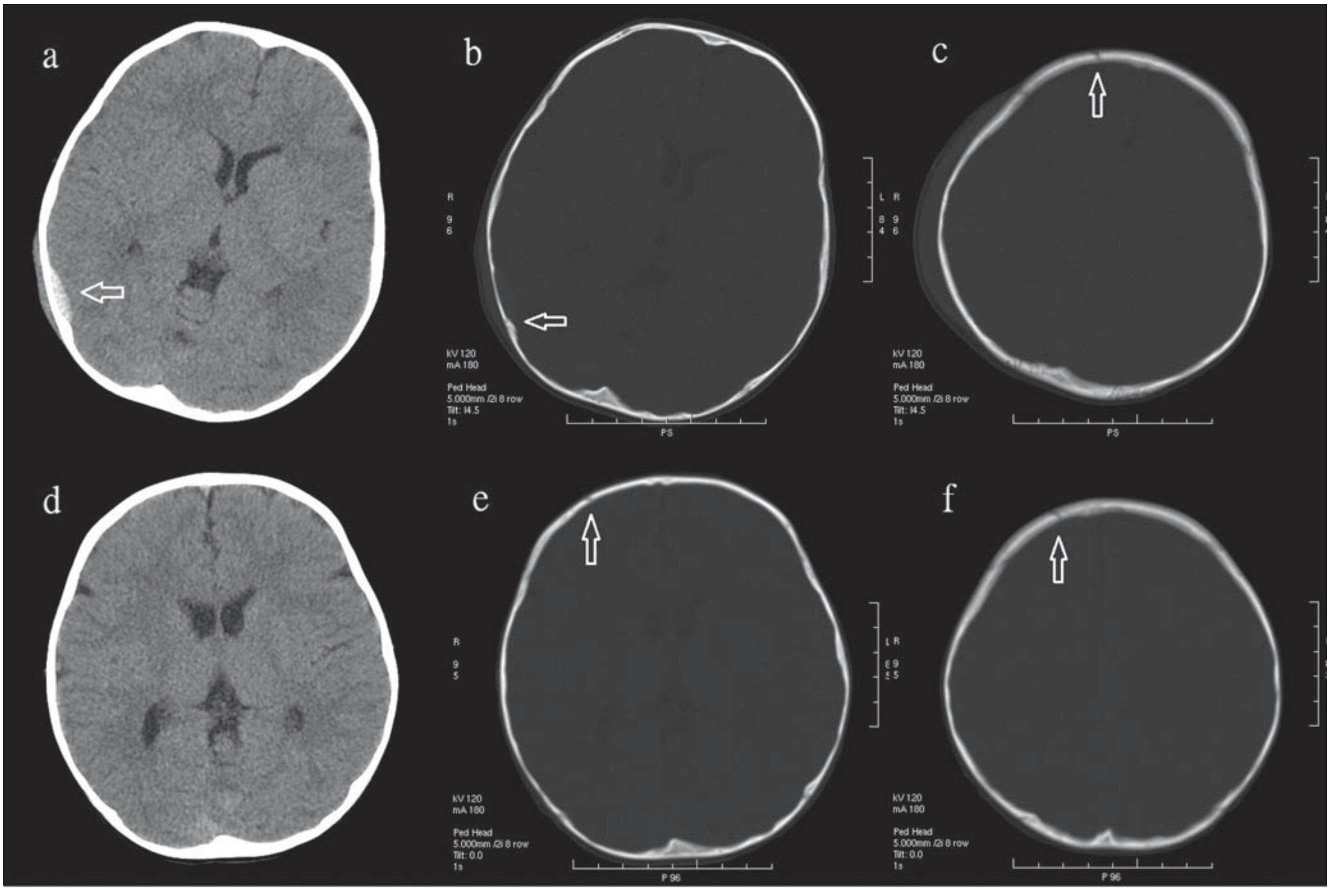

Figure 1 Non-contrast axial CT scan of a two-year-old boy in brain and bone windows, immediately after injury to the right parietal region of the head (a-c) and three months after injury (d-f). (a) A small epidural haematoma is noted (arrow), together with scalp swelling over the parietal region. (b) A subtle hair-line fracture at the parietal bone is noted at bone window (arrow). (c) Axial image at a higher level shows another more obvious lucent line at the right frontal bone (arrow), highly suspicious of a second fracture. (d) Three months later, the right parietal epidural haematoma and scalp swelling have completely resolved. Bone window (e) also showed healing of the right parietal bone fracture. However, a persistent lucent line is still seen tracking along the right frontal bone (arrows in e and f).

2). It showed that the lesion has a configuration not typical of a skull fracture. In conclusion, we think that it is a vascular channel in the right frontal bone, a rare anatomical variant that simulates skull fracture.

Discussion

Head injury is among the commonest reasons of consultation to the emergency department. In our hospital, it is also the commonest indication for CT scan of the brain. However, neuroimaging should be carefully considered especially in paediatric patients, to avoid unnecessary radiation to the developing body. It is clear that paediatric minor head injuries are common, and that most cases may be observed without neuroimaging.[2] On the other hand, the mechanism of injury in our patient was considered high risk, and the presence of large scalp haematoma precluded assessment of possible depressed skull fracture. These are some of the clinical risk factors, which if present in a child, requires immediate or early CT brain according to the NICE guideline for head injury.[3]

Assessment of skull fracture can be complicated, due to presence of multiple synchondroses and unusual accessory sutures particularly in children.[1] The problem is especially vivid in posterior cranial fossa and the skull base, where most of the anatomical variants are located. The use of CT scan has made such diagnosis much more accurate and easy

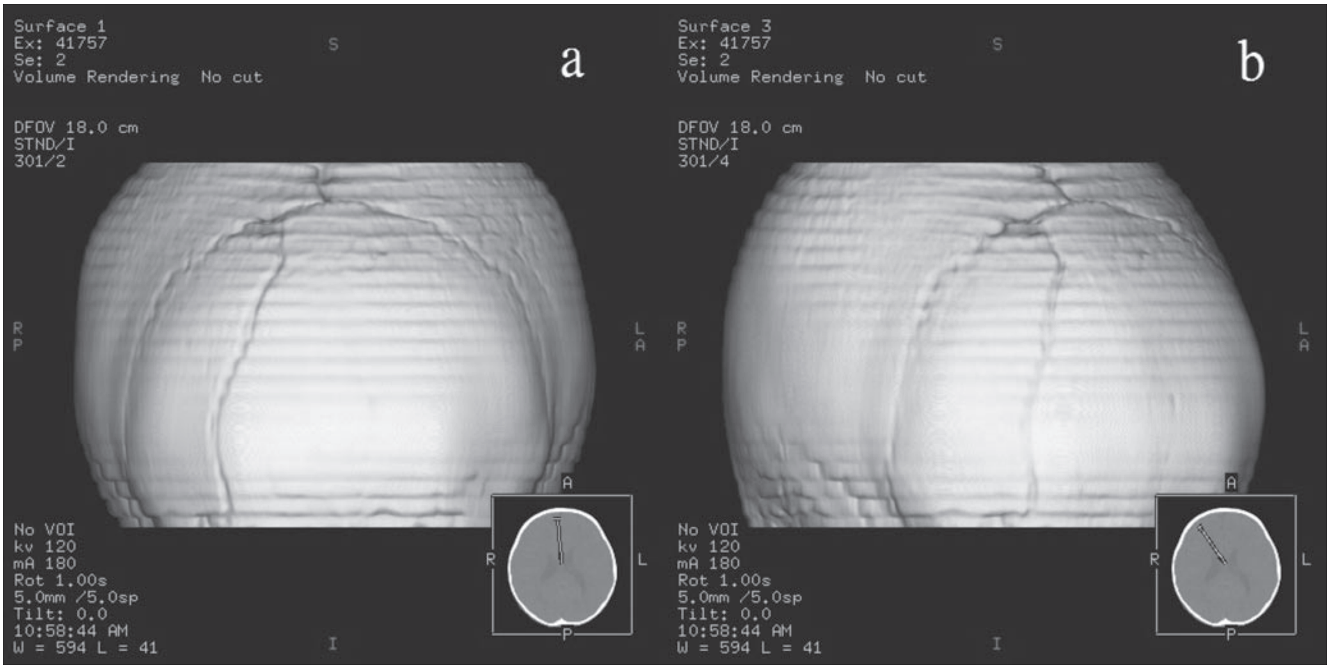

Figure 2 Post-processing of the source images using 3D volume rendering in frontal (a) and oblique (b) views. The lucent line in right frontal bone has a curved appearance that is atypical of fracture. Finding is compatible with vascular channel of the frontal bone.

in recent years. There are several useful differential points which help image interpreters to differentiate a fracture from other mimics.[1] Most importantly, fractures present as sharp linear lucencies with non-sclerotic edges, may cross sutures, and may have secondary signs like soft tissue swelling; while non-fractures like accessory sutures usually have a zigzag pattern with sclerotic borders, and are often bilateral or symmetrical. In the anterior part of the skull vault, these anatomical variants are less frequent, particularly in the frontal bone. The commonest pseudofracture in the frontal bone is probably the metopic suture. Metopic suture extends from the nasion to the bregma, which bisects the frontal bone into two halves. A persistent metopic suture is found in 5-8% of adults.[4] It has been reported that metopic suture can mimic a vertical fracture at the midline of the anterior skull.[5] However, in our case, the lucent line runs an oblique course along the right frontal bone, which is atypical for metopic suture. Given the rarity of variants in frontal bone, it is therefore not surprising that the lesion was mistaken as a fracture at first.

The reasons why the frontal lesion in our case is not a fracture are threefold. First, it did not correspond to the site of head injury, and the patient is asymptomatic at his forehead. Second, there was no secondary sign of skull fracture, such as scalp swelling and extraaxial collection beneath the fracture line, which were present in the genuine fracture site at parietal bone (Figure 1). Third, the configuration of the lucent line is atypical for skull fracture (Figure 2). With reference to Keat's atlas, the lesion is likely a vascular channel in the frontal bone.[6] Vascular channels can either be arterial (mainly due to meningeal arteries) or venous. In this case, it is probably due to a meningeal vein or a frontal diploic vein.

One point worth mentioned is the importance of using image post-processing techniques. There are multiple reports that emphasized the usefulness of techniques like multiplanar reformat, maximum intensity projection, or 3D volume rendering.[1,5,7] These are complimentary techniques which together give a much better appreciation of skull fractures in case of doubt. On the other hand, using these techniques can be time-consuming, and therefore usually not performed routinely. However, it should be remembered in our daily practice apart from just viewing the axial images, especially when dealing with difficult cases.

Finally, one must always bear in mind about the issue of radiation dose, especially in paediatric patient groups. The reported effective dose (in milliSievert, mSv) for CT brain examination in adults is 1-2 mSv for most reports, and that for children is up to 4 mSv.[8-9] It is worth noting that the effective dose for paediatric patients are substantially higher than for adults, mainly due to smaller organ sizes. In our patient, the first CT scan involved scanning in both standard and bone windows. The dose-length-product (DLP) for the first CT was 927 mGy. This converts to an effective dose of 2.13 mSv according to the Monte Carlo method.[10] The second CT scan of the patient involved only the standard window, with a DLP of 464 mGy and an effective dose of 1.07 mSv. Both CT scans had a radiation dose much lower than that reported in literature, and we found that scanning at a lower dose still give excellent diagnostic details without compromising image quality. It had been reported long ago by a local study that dose reduction of up to 40% is possible in paediatric brain CT without affecting the diagnostic quality of the images.[11] We recommend scanning of paediatric brain in a single standard window, which is already enough for post-processing techniques like volume rendering. Even if the radiologist wants to add another scan in bone window, the dosage shown here is still almost 50% lower than that reported. In our case, the use of 3D volume rendering did not just help us to differentiate a fracture from a vascular channel, it also helped the patient by avoiding further unnecessary follow up scan, and thus reducing the total amount of irradiation to the patient.

In summary, we report a case of vascular channel in the frontal bone, which is a rare anatomical variant that can mimic skull fracture. The use of clinical correlation, follow-up study and image post-processing techniques can increase our accuracy in the diagnosis or exclusion of genuine skull fracture, as well as reducing further unnecessary irradiation to the patient. We recommend the use of low dose CT protocol in pediatric patients with head injury. Image post-processing techniques should be considered in addition to axial images in our daily practice.

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