Added value of 3D CT images in pediatric linear skull fracture diagnosis

TO THE EDITOR: We read with great interest the paper by Orman et al.¹ (Orman G, Wagner MW, Seeburg D, et al: Pediatric skull fracture diagnosis: should 3D CT reconstructions be added as routine imaging? J Neurosurg Pediatr 16:426–431, October 2015). The authors investigated the efficacy of combining 3D CT images with 2D CT images and found it useful in the diagnosis of linear skull fractures in all children. They also showed increased specificity with 3D CT images in the interpretation of linear fractures in children younger than 2 years of age. We also believe that 3D CT images should be added as part of routine imaging because in a daily pediatric emergency care unit practice most of the head CT images are interpreted by residents and clinicians on admission and missing skull fractures can lead them to overlook associated intracranial injuries not evident on the first head CT scan. Missing fractures can also preclude the performance of MRI as an alternative method to show subtle associated traumatic brain injuries.²

One point we would like to make is that although the authors emphasized that linear fractures can be missed on 2D CT when they are within the plane of the image reconstruction, they did not evaluate the role of the orientation of the fracture between readers. Linear skull fractures that are parallel or nearly parallel to the section orientation can be missed on the interpretation of CTs even in older children and sometimes even by experienced readers.³ The use of 3D CT images is helpful not only in the diagnosis of parallel-oriented linear skull fractures but also in differentiating them from vascular canals (Fig. 1 left).

The other point we would like to make is that children younger than 2 years old may show abnormalities in head shape. Neonatal calvaria may be abnormal in shape due to pressure on the head during childbirth. Plagiocephaly without craniosynostosis (posterior deformational positional plagiocephaly) associated with sleeping position (sleeping on back), congenital torticollis, abnormal vertebra, and neurological deficits is common in infants.³,⁵ Premature fusion of one or more sutures, craniosynostosis, isolated or rarely associated with syndromes, may exist in patients with head trauma. In patients with an abnormal head shape, the symmetrical nature of sutures may not be appreciated on 2D CT images. As radiological differ-

FIG. 1. Left: Three-dimensional CT image obtained in a 6-year-old girl who fell off her bicycle, showing a parallel-oriented linear skull fracture (arrows) of parietal bone. Arrowhead indicates a vascular canal that is more clearly defined on the 3D CT image. Right: Three-dimensional CT image obtained in a 1-month-old boy who fell from a couch. The patient has an abnormal head shape without craniosynostosis (positional plagiocephaly). There is a linear skull fracture of the left parietal bone on the vertex that is parallel to the imaging plane (arrows). Figure is available in color online only.
entiation between suture lines and linear skull fractures is mainly based on the bilateral and fairly symmetrical nature of the major sutures, adding 3D CT images really helps us to improve diagnostic confidence (Fig. 1 right). Furthermore, there are some associated vascular canals and enlarged emissary veins associated with syndromic craniosynostosis that can be misdiagnosed as fracture. In brief, combining 2D and 3D CT images would be very helpful to decrease false-negative and false-positive diagnoses in infants with an abnormal head shape.

Yeliz Pekcevik, MD
Hilal Sahin, MD
Tepecik Training and Research Hospital, Izmir, Turkey

References

Disclosures
The authors report no conflict of interest.

Response
We appreciate the interest in our article by Drs. Pekcevik and Sahin, who raised some interesting points.

The first point is that the role of the orientation of the fracture was not evaluated in our study. Drs. Pekcevik and Sahin are correct. In our study all linear fractures regardless of their orientation were evaluated by all readers. The study was not designed specifically to evaluate the differences in the orientation of linear skull fractures between the readers, although this could be pursued as a future study. Linear fractures on 2D CT can be missed when they are within the plane of image reconstruction, and the addition of 3D images should alleviate this problem.

As a second point, Drs. Pekcevik and Sahin mention that linear fractures parallel to the section orientation can also be missed in children older than 2 years of age and by experienced readers. In keeping with our study, we agree with Drs. Pekcevik and Sahin that linear skull fractures, regardless of the age of the patient or the experience of the reader, can be missed if they are in an orientation parallel to the section. The addition of 3D data to the 2D CT data set gives the reader increased confidence, as sutures and other nonfracture-related linear lucencies such as vascular channels can be easily followed and distinguished from linear fractures. However, our data showed 1) that the addition of 3D data to the 2D CT data set significantly increased specificity in the diagnosis of linear skull fractures only in children younger than 2 years of age, and 2) that the greatest increase in the specificity of the diagnosis of linear skull fractures was for the less experienced reader.

Finally, as their third point, Drs. Pekcevik and Sahin suggest that the evaluation of sutures can be challenging in children with an abnormal head shape. We agree that an abnormal head shape in children with conditions such as craniosynostosis would certainly affect the evaluation of the symmetry of sutures. In our study, we did not specifically evaluate children with craniosynostosis or conditions such as achondroplasia where prominent emissary veins or vascular channels can mimic linear fractures. Our study has shown that the use of 2D+3D CT combined demonstrates increased sensitivity in the diagnosis of linear skull fractures in all children and increased specificity in children younger than 2 years of age, regardless of head shape, age, or underlying syndromal abnormality.

Thangamadhan Bosemani, MD
Andrea Poretti, MD
The Johns Hopkins University School of Medicine, Baltimore, MD

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Pediatric sports-related concussions

TO THE EDITOR: The paper by Ellis et al.1 in the September issue (Ellis MJ, Leiter J, Hall T, et al: Neuroimaging findings in pediatric sports-related concussion. J Neurosurg Pediatr 16:241–247, September 2015) serves to illustrate the need for “updating” our physician and athletic management community, including the families and individuals with concussion/mild traumatic brain injury (mTBI), on the newer objective radiological brain injury evaluations available today. The retrospective chart review, diagnostic conclusions, and follow-up by a single neurosurgeon appear to have reflected out-of-date evaluative procedures. Ellis et al. reviewed data acquired in 36 patients (2% of 151 patients diagnosed with sports-related concussions [SRCs]) who underwent neuroimaging before referral to a specialty clinic. MR images were obtained in patients with focal neurological findings or symptoms or symptoms lasting more than 1 or 2 months, and those with abnormal CT findings. The abnormal CT findings