MDCT Diagnosis of the Child with Posterior Plagiocephaly

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OBJECTIVE. In this article, we review the normal anatomy and development of the posterior skull base and describe distinguishing imaging features of the two most common causes of posterior plagiocephaly: posterior deformational plagiocephaly and unilateral lambdoid synostosis. We also describe three unusual cases of posterior plagiocephaly, including asymmetric premature fusion of the anterior and posterior intraoccipital synchondroses, with diagnoses enabled by volume-reformatted MDCT.

CONCLUSION. Three-dimensional reformatted MDCT enables accurate diagnosis of common and rare causes of posterior plagiocephaly in children.

Posterior Plagiocephaly Controversies

Although diagnostic considerations in the infant with posterior plagiocephaly have long centered on posterior deformational plagiocephaly versus unilateral lambdoid synostosis, the incidence, clinical findings, and imaging criteria have been extremely controversial until recently [1, 2]. It is now accepted that lambdoid synostosis requires true osseous fusion and cannot be functionally fused. True lambdoid fusion occurs in only 2–3% of patients with posterior plagiocephaly, not 15–20% as incorrectly stated in previous literature [1]. The skull morphology of children with posterior deformational plagiocephaly versus unilateral lambdoid synostosis imaged with 3D CT is different, not similar [1]. Imaging signs misinterpreted as representing unilateral lambdoid synostosis include perisutural sclerosis, thickening of the adjacent inner table, and an end-to-end morphology of the suture [3]. Contributing to the sixfold increase in craniofacial center referrals for posterior plagiocephaly was the 1992 American Academy of Pediatrics recommendation that sleeping infants be placed on their back to reduce the risk of sudden infant death syndrome [4].

Occipital Bone Anatomy and Development

The occipital bone comprises the Kerckring ossicle and basioccipital, supraoccipital, interparietal, and paired exoccipital portions (Fig. 1). Six sutures or synchondroses join the occipital bone portions or form margins with the neighboring petrous and mastoid portions of the temporal bone and sphenoid body. These include the Kerckring ossicle-supraoccipital synchondrosis, anterior intraoccipital synchondrosis, posterior

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Fig. 1—Endocranial skull base views show basioccipital (B), paired exoccipital (E), supraoccipital (S), and interparietal (I) portions of occipital bone. Surrounding synchondroses include sphenoc-occipital (small solid arrows), anterior intraoccipital (large solid arrow), posterior intraoccipital (solid arrowhead), petrooccipital (open arrowheads), and occipitomastoid (open arrows). Mendosal sutures (small solid arrowheads) mark junction between membranous and endocranial portions of occipital bone. 

A, Image shows portions of occipital bone and surrounding synchondroses in 3-week-old boy. 

k = Kerckring ossicle.

B, Image shows portions of occipital bone, fusion of mendosal sutures, and narrowing but preserved patency of multiple skull base synchondroses in 10-month-old girl.

Fig. 2—10-month-old boy with posterior deformational plagiocephaly. 

A, Posterior view of volume reformations shows normal, flat posterior skull base and normal-appearing skull shape. 

B, Vertex view of volume reformation shows parallelogram shape of skull with parallel relationship between frontal and posterior convexities. 

C, Endocranial skull base view shows no deviation in anterior skull base axis line (bisecting cribiform plate) and posterior skull base axis (connecting basion and opisthion). 

D, Axial CT scan shows asymmetric flattening of right posterior skull but patency of bilateral lambdoid sutures. Note that perisutural thickening (arrowhead) is not sign of suture fusion.
intraoccipital synchondrosis, mendosal sutures, spheno-occipital synchondrosis, petrooccipital synchondrosis, and occipitomastoid synchondrosis (Fig. 1). The mendosal sutures represent the junctions between membranous and endochondral origins of the occipital bone (Fig. 1). The pattern and timing of skull base synchondroses fusion were established with CT [5]. The Kerckring ossicle fuses with the supraoccipital portion within the first month of life. Both the anterior intraoccipital synchondrosis and posterior intraoccipital synchondrosis, petrooccipital synchondrosis, and occipitomastoid synchondrosis begin fusing when infants are approximately 1–2 years old. The posterior intraoccipital synchondrosis fusion process is central-lateral and is usually complete in children 4–7 years old. The anterior intraoccipital synchondrosis fusion pattern is more complex but is usually complete in children 7–10 years old. Both the occipitomastoid and petrooccipital synchondroses complete fusion by the late teens.

**MDCT Craniofacial Scanning Technique**

Our 16-MDCT craniofacial scanning protocol is 0.5-mm collimation, 16 slices every half second, and 90 or 150 mAs for children below or above 1 year old, respectively. We include the upper cervical spine through the vertex; acquisition time is 15–20 sec. This protocol results in 0.5-mm isotropic voxels subsequently postprocessed on a workstation (Vitrea, Vital Images). In addition to a standard filming protocol of the skull without and with the calvarium removed, the workstation enables interactive segmentation and magnification of the data.

**Unilateral Lambdoid Synostosis Versus Posterior Deformational Plagiocephaly**

On axial images and volume reformations, detection of an area of osseous fusion of the lambdoid suture is diagnostic of lambdoid synostosis. A short segment fusion, however, can be missed on axial views. Importantly, perisutural ridging and an end-to-end morphology are not signs of suture fusion (Figs. 2 and 3). On volume reformations, several discriminators become evident [1]. On the posterior view, the posterior deformational plagiocephaly skull has a flat skull base and normally appearing head shape, and the unilateral lambdoid synostosis skull has an ipsilateral downward cant of the skull base and a parallelogram head shape (Figs. 2 and 3). On the vertex view, the posterior deformational plagiocephaly skull has a parallelogram shape, and the...
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Fig. 4—3-month-old boy with right lambdoid fusion modified by prominent communicating mendosal sutures.
A, Posterior volume reformation shows fusion of lateral half of right lambdoid suture (open arrow) and prominent mendosal sutures (solid arrows) meeting in midline, giving impression of duplicated lambdoid suture. Skull base cant expected from unilateral lambdoid synostosis has been minimized by patent mendosal sutures.
B, Right posterior oblique view of volume reformation shows fusion of lateral right lambdoid and prominent bulge over right mendosal suture.
C, Endocranial skull base view shows bulge over patent right mendosal suture and only minimal deviation of relationship between anterior and posterior skull base axis lines.

Fig. 5—6-month-old girl with premature fusion of posterior intraoccipital synchondrosis.
A, Posterior view of volume reformation shows prominent left inferior skull base cant not associated with lambdoid suture fusion.
B, Endocranial skull base view shows leftward deviation of posterior skull base axis lines. Right posterior intraoccipital synchondrosis is prematurely fused and not visible. Normal, patent left posterior intraoccipital synchondrosis (arrowhead) is well seen.
C, Axial CT image shows how difficult this diagnosis would be to make without volumetric endocranial skull base views. Patent left intraoccipital synchondrosis (arrowheads) is seen for only very short segments because it is in plane with axial slices.
D, Axial CT image does show right posterior intraoccipital synchondrosis is fused; however, this can be determined only by directed interrogation of its expected course in posterior skull base (arrowhead).
unilateral lambdoid synostosis has a trapezoid shape (Figs. 2 and 3). Finally, on the endocran- nial skull base view, the posterior deforma- tional plagiocephaly skull base shows a distinct ipsilat- eral deviation of the posterior fossa (Figs. 2 and 3). This is best assessed by drawing an an- terior skull base axis (bisecting the cribriform plate) and a posterior skull base axis (from the basion to opisthion); the posterior deforma- tional plagiocephaly skull will have minimal if any deviation of these intersecting lines (mean ± SD, 2.3° ± 1.3°), whereas the unilateral lambdoid synostosis skull will show sub- stantial deviation (mean ± SD, 13.7° ± 5.6°) [6]. A mental trick for anticipating the skull changes of lambdoid fusion is to think of the abnormal suture as a “black hole” drawing the surrounding structures toward it, thus leading to the ipsilateral skull base cant, “twisting” of the posterior fossa, and trapezoidal distortion of the calvarium.

Unusual Causes of Posterior Plagiocephaly

Since the installation of an 16-MDCT scanner at our institution and modification of our protocols 1 year ago, we have encountered three unusual cases of posterior plagiocephaly. The first child had partial fusion of the right lambdoid suture with modification of the character- istic skull and skull base changes due to unusual prominence and midline continuation of the mendosal sutures (Fig. 4). The ipsilat- eral skull base cant and posterior fossa distor- tion were attenuated, and the most prominent feature of the skull was a marked ipsilateral bulge centered on the mendosal suture.

We also have encountered two patients each with premature fusion of the posterior intraoc- cipital synchondrosis or anterior intraoccipital synchondrosis. The patients had patent lamb- doid sutures, but they had skull base and calva- rial changes typical for unilateral lambdoid synostosis (Figs. 5 and 6). The ability to interro- gate the skull base in three dimensions was critical to making the final diagnosis.

We are not aware of previous descriptions of these abnormalities, and it seems unlikely they would make their first appearance after we ob- tained access to improved imaging technology. We therefore suggest that MDCT and volumet- ric postprocessing technology finally have reached a point at which previously occult causes of posterior plagiocephaly are now detectable, necessitating a broadening of the differential di- agnosis considerations in the infant or child pre- senting with abnormal posterior head shape.

References