Pediatric Neurology 53 (2015) 394–401

Contents lists available at ScienceDirect

Pediatric Neurology

journal homepage: www.elsevier.com/locate/pnu

Topical Review

Craniosynostosis

Lance S. Governale MD [a,b,*]

[a] *Division of Pediatric Neurosurgery, Nationwide Children's Hospital, Columbus, Ohio*
[b] *Department of Neurosurgery, Ohio State University, Columbus, Ohio*

ABSTRACT

Craniosynostosis is the premature fusion of one or more of the cranial sutures. About 8% of the patients have familial or syndromic forms of synostosis, and in the remainder it occurs as a spontaneous isolated defect. Familial craniosynostosis syndromes are typically transmitted as an autosomal dominant trait resulting in disruption of the fibroblast growth factor receptor pathway. Familiarity with the characteristic head shapes resulting from craniosynostosis allows bedside diagnosis and differentiation from positional plagiocephaly. Because of the risks associated with untreated craniosynostosis, surgical treatment is usually undertaken soon after diagnosis. Current surgical methods include open calvarial reconstruction, minimally invasive strip craniectomy with use of postoperative molding helmet, minimally invasive strip craniectomy with spring implantation, and cranial distraction. Early referral to a pediatric craniofacial center allows all treatment options to be explored.

Keywords: craniosynostosis, minimally invasive, neurosurgery, pediatric, craniofacial, plagiocephaly

Pediatr Neurol 2015; 53: 394-401

Craniosynostosis is the premature fusion of one or more of the cranial sutures. Its incidence is estimated to be 1 in 2000-2500 live births.[1] It may be spontaneous, syndromic, or familial and can involve one or multiple cranial sutures. Familiarity with associated head shapes can allow bedside diagnosis and differentiation from positional plagiocephaly. Multiple surgical options for craniosynostosis currently exist, but early referral to a pediatric craniofacial center is needed to allow all options to be explored. This review seeks to familiarize pediatric neurologists with the nuances of craniosynostosis.

Only about 8% of patients are syndromic or familial.[2] Multiple syndromes have been described, each with their own associated facial features, systemic features, and relationship to hydrocephalus. The Table provides a review of some of the more common syndromes. The fibroblast growth factor receptor pathway is most frequently involved. This tyrosine kinase receptor pathway is active in osteoblast differentiation and maturation with mutations usually gain of function.[3] Craniosynostosis syndromes usually have an autosomal dominant inheritance pattern; however, penetrance is incomplete and expressivity is variable.[2] Bilateral coronal sutures are most affected, and there is often associated syndactyly and/or midface hypoplasia.

Most craniosynostosis cases are not syndromic or familial. Most frequently affected is the sagittal suture, and the cause is usually not known. Spontaneous mutation of a syndromic gene is possible.[2] Other risk factors may include: fetal constraint (nulliparity, plurality, macrosomia), low birth weight, preterm delivery, maternal valproate use, and shunted hydrocephalus.[4-6]

Classification

The cranial sutures are characterized as "major" or "minor." Major sutures are the sagittal, metopic, coronals, and lambdoids (Fig 1). Minor sutures include the squamosals, mendosals, intraoccipitals, and others. Premature closure of a major suture can result in cranial deformity and, potentially, overall cranial growth restriction with resultant increased intracranial pressure. When a suture closes early, the skull cannot grow perpendicular to the suture and

Article History:
Received March 19, 2015; Accepted in final form July 17, 2015

* Communications should be addressed to: Dr. Governale; Pediatric Neurosurgery; Nationwide Children's Hospital; 555 South 18th Street, Columbus, OH 43205, USA.
E-mail address: lance.governale@nationwidechildrens.org

0887-8994/$ – see front matter © 2015 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.pediatrneurol.2015.07.006

TABLE.
Summary of Craniosynostosis Syndromes

Syndrome	Gene	Inheritance	Sutures Affected	Craniofacial Features	Systemic Features	Hydrocephalus Reported?
Apert	*FGFR2*	Autosomal dominant	Coronal	Midface hypoplasia, hypertelorism	Syndactyly of hands/feet, cervical vertebral fusion, hearing loss	Yes
Crouzon	*FGFR2*, *FGFR3*	Autosomal dominant	Coronal, sagittal, and/or lambdoid	Midface hypoplasia, exophthalmos, hypertelorism	Cervical vertebral fusion, hearing loss	Yes
Pfeiffer	*FGFR1*, F*GFR2*	Autosomal dominant	Coronal and/or sagittal, possible cloverleaf	Midface hypoplasia, hypertelorism	Broad thumbs/great toes, brachydactyly, syndactyly, cervical vertebral fusion, hearing loss	Yes
Muenke	*FGFR3*	Autosomal dominant	Coronal (unilateral or bilateral)	Midface hypoplasia, Hypertelorism, macrocephaly	Hearing loss	Yes
Saethre-Chotzen	*TWIST1*, *FGFR2*	Autosomal dominant	Coronal, lambdoid, and/or metopic	Parietal foramina	Syndactyly, heart defects	Yes
Antley-Bixler	*FGFR2*	Autosomal recessive	Coronal and/or lambdoid	Midface hypoplasia, choanal atresia	Joint contractures, radiohumeral synostosis	Yes

Sources: Jezela-Stanek A, Krajewska-Walasek M. Genetic causes of syndromic craniosynostoses. *Eur J Paediatr Neurol.* 2013; 17:221-224; and Online Mendelian Inheritance in Man. Available at: http://omim.org. Accessed May 29, 2015.

instead grows parallel to it. This is known as Virchow's law and predicts the shape of the cranial deformity. Although specific terminology for different head shapes exist (and can be confusing), it is more important to recognize the shape on examination than to know the term for it.

Sagittal craniosynostosis causes a long (anteroposterior) and narrow (transverse) head (Fig 2). There is frequently "bossing" or prominence of the forehead and occiput. The occipital prominence is sometimes termed a "bullet" because of associated narrowing. The anterior fontanel may be open or closed. This head shape is called scaphocephaly or dolichocephaly.

Bilateral coronal craniosynostosis causes a short (anteroposterior) and wide (transverse) head (Fig 3). The anterior fontanel may be open or closed. The discovery of this type of craniosynostosis should prompt a search for a syndromic diagnosis. This head shape is called brachycephaly.

Unilateral coronal craniosynostosis causes ipsilateral forehead flattening and elevation of the ipsilateral sphenoid wing and orbital roof (Fig 4). This elevation is termed a Harlequin eye deformity because, when viewed on a frontal x-ray, it resembles the shape of the similarly named masquerade mask. The nasal root is deviated toward the side of the closed suture. The anterior fontanel, which can

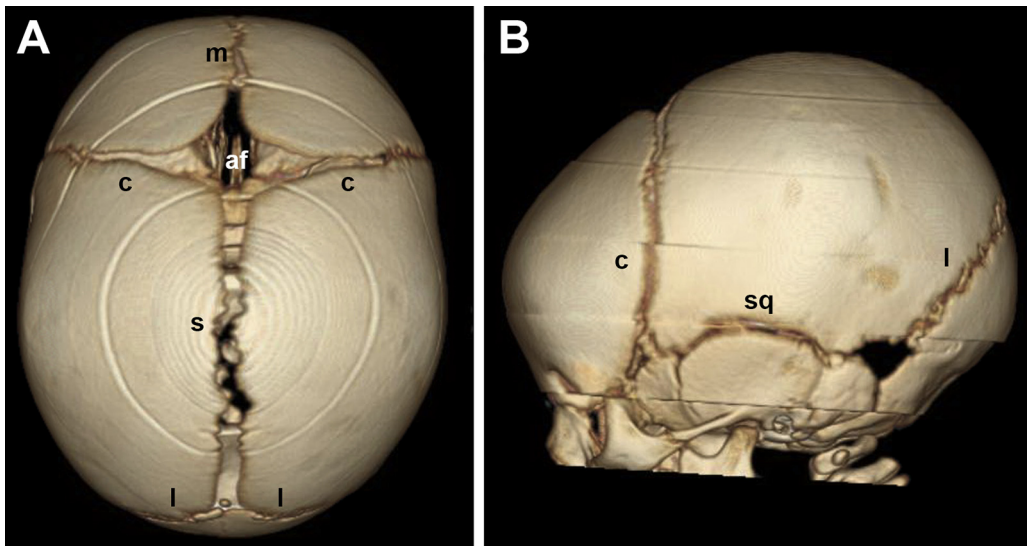

FIGURE 1.
Normal cranial sutures and skull shape. Top (A) and side (B) views of a three-dimensional computed tomography scan shows metopic (m), coronal (c), sagittal (s), lambdoid (l), and squamosal (sq) sutures as well as the anterior fontanel (af). (The color version of this figure is available in the online edition.)