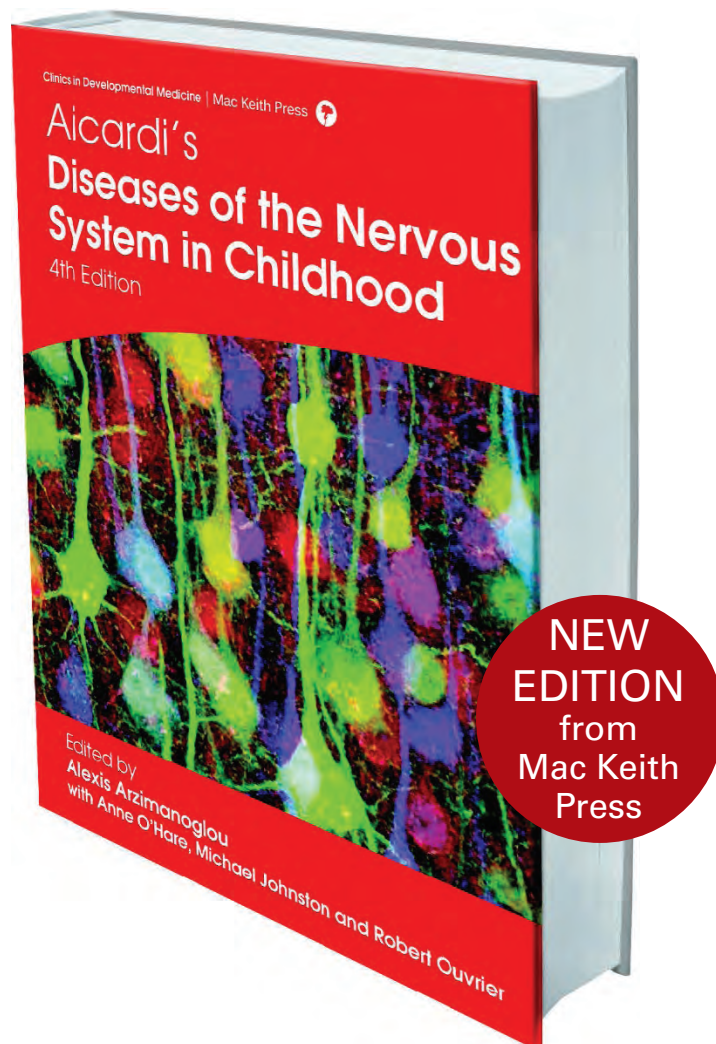


Aicardi's Diseases of the Nervous System in Childhood

4th Edition

Edited by Alexis Arzimanoglou with Anne O'Hare,
Michael Johnston and Robert Ouvrier



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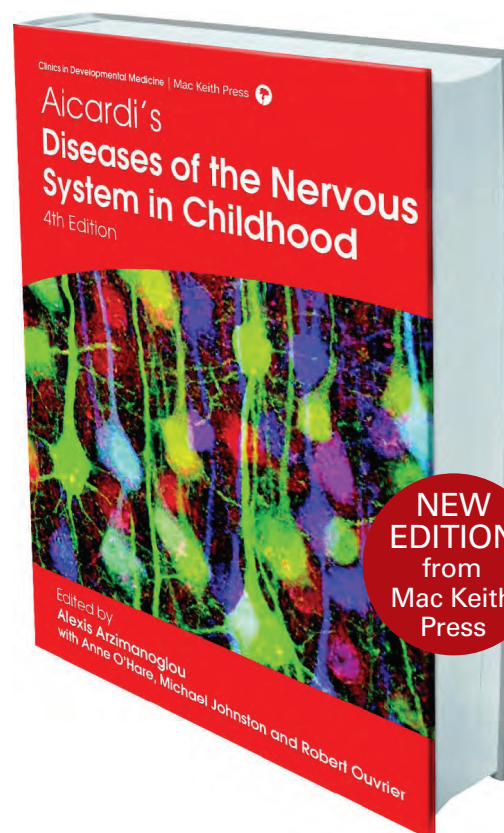
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Meet the Editors behind this updated and revised new edition



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SAMPLE MATERIAL FROM CHAPTER 6

Craniosynostosis/ Paediatric Craniovertebral Anomalies

Richard Hayward FRCS

INTRODUCTION

Craniosynostosis is defined here as the premature closure of one or more of the skull vault sutures. While advances in molecular genetics have revolutionised our understanding of the various syndromes that may include craniosynostosis, and improved imaging techniques have provided new information about not only the calvarial sutures but also changes affecting the skull base and facial skeletons, the initial diagnosis (or more accurately the initial suspicion) of craniosynostosis still depends primarily on the patient's – usually a child's – appearance.

The aim of this chapter is to provide for the paediatric neurologist a broad overview of this complex subject. For convenience craniosynostosis affecting a single vault suture (sometimes referred to as 'simple' synostosis) will be dealt with separately from the various complex/syndromic forms in which premature closure of several – sometimes all – of the skull sutures is usual although overlap between the two groups is not uncommon. Johnson and Wilkie have provided a useful overview from a craniofacial surgeon and geneticist's perspective (Johnson and Wilkie 2011).

AETIOLOGY OF CRANIOSYNOSTOSIS

The various causes of craniosynostosis (or conditions with which it may be associated) can be broadly classified as shown in Table 6.1.

Single Suture Synostosis

The direct consequences of premature fusion of a single skull vault suture are for the most part cosmetic – the result of a usually characteristic alteration in head shape. Effects on the facial skeleton, if any, are modest and severe functional consequences affecting vision, breathing and feeding, for example, are rare. This is in marked contrast to the complex/syndromic forms of craniosynostosis in which such issues are common.

Table 6.1

Primary	Idiopathic	No genetic cause either known or suspected ^a
	Genetic cause known or suspected	Gene mutation ^b
Secondary	Metabolic:	Chromosomal abnormality ^c
		Vitamin D deficient rickets
		Hyperthyroidism
	Disorders of bone metabolism	Cranio-meta/diaphyseal dysplasia
	Storage disorders	Osteopetrosis Hurler syndrome Morquio syndrome
Drug induced:	Metopic synostosis, as part of the fetal valproate syndrome	
Physical distortion:	Post-CSF shunting positional scaphocephaly	

^aThe majority of single suture synostosis fall into this category – in particular those affecting the sagittal and metopic sutures.

^bThis includes not only the syndromes once described eponymously (Crouzon, Apert etc.) but also many previously labelled as non-syndromic that have now had their underlying gene mutation mapped.

^cThe metopic suture appears to be the most vulnerable when craniosynostosis forms part of a chromosomal abnormality – a deletion of part of the short arm of 7, for example.

CSF, cerebrospinal fluid

Aetiology

While the majority of cases of single suture synostosis arise as isolated events the possible genetic implications of the diagnosis should not be overlooked particularly for unicoronal synostosis (Moloney et al. 1997) (see Unicoronal [and Frontal-Sphenoidal] Synostosis). Whereas no common candidate genes are presently known for isolated sagittal and metopic synostosis, it is essential that all children with unicoronal synostosis are referred for evaluation by a geneticist (Johnson and Wilkie 2011).

infection, for example) never absent from what is never a minor cranial operation.

The various surgical interventions (and their timing) currently employed in the management of each single suture synostosis are here briefly described. For a more detailed summary, see the review by Garza and Khosla (2012).

Sagittal Synostosis

Premature closure of the sagittal suture is the most frequent form of craniosynostosis and leads to a characteristic scaphocephalic (boat-shaped) deformity of the skull. A prevalence of approximately 1 in 5 000 children has been estimated and the condition is more frequently seen in boys. Six per cent of cases are familial with transmission following an autosomal dominant pattern with a penetrance of 38% (Lajeunie et al. 1996).

The affected skull has an increased antero-posterior diameter, its bi-parietal diameter is reduced (Fig. 6.1) and a bony ridge can often be both seen and felt along the line of the fused suture. Victims of teasing may be called 'peanut head'. The synostotic process does not always involve the entire suture and even when it does the severity with which the child's head shape is affected is very variable, with a mild prominence of the forehead at one end of the spectrum to gross elongation (frontal and occipital bossing) plus narrowing (particularly in the pterional regions) at the other.

The variety of surgical treatments presently employed for the correction of sagittal synostosis (for those children whose parents have opted for intervention) suggests either that all are equally effective – or equally non-effective! The operations vary in scale from removal of the fused suture (suturoctomy) combined with internal springs (de Jong et al. 2013) or external (helmet/orthosis) manoeuvres (Proctor 2012) designed to induce a more round shape (all of which need to be performed

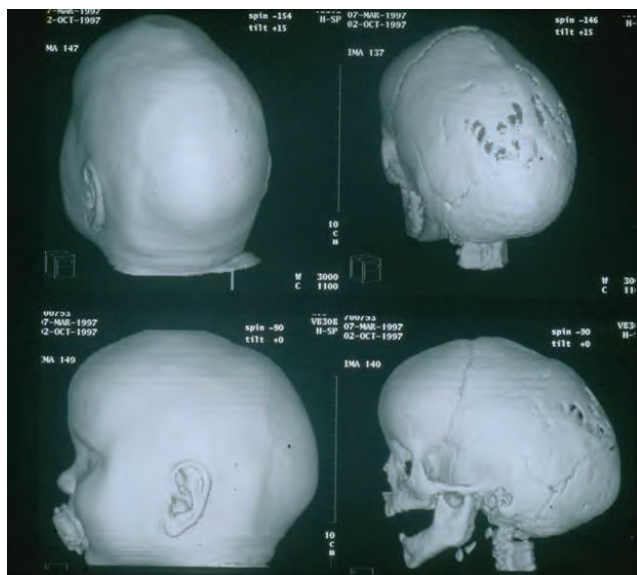


Figure 6.1 Three-dimensional CT scans showing the typical scaphocephalic head shape caused by sagittal synostosis.

before six months of age to be most effective) to increasingly major forms of skull reconstruction for which there are no age limits.

Unicoronal (and Fronto-Sphenoidal) Synostosis

Craniosynostosis of a single coronal suture produces a characteristic asymmetry of the forehead: frontal plagiocephaly. The supra-orbital ridge on the affected side is recessed as is the forehead above while the temporal region is unusually prominent. On the contralateral side the frontal region is often bossed, accentuating the asymmetry and the nose is set an angle, its root 'pointing' towards the side of the affected suture. The net result is to give the face a characteristic 'scoliosis' or curve convex to the affected side. The anterior skull base is also curved – but concave to the affected side (Fig. 6.2).

The elevation of the lateral wing of the sphenoid bone on the affected side is responsible for the characteristic 'harlequin eye' appearance on an antero-posterior skull X-ray. The deformation of the orbit results in a subtle malposition of the extra-ocular muscle attachments that may in turn cause a complex abnormality of eye movement and a secondary compensatory head tilt (Gosain et al. 1996). All children with unicoronal synostosis should therefore be referred to a paediatric ophthalmologist.

Although the cause of unicoronal synostosis is in many cases unknown it can result from a variety of genetically mediated disorders. Most prominent amongst these is the Muenke (or FGFR3-associated synostosis) (Muenke et al. 1997). Saethre–Chotzen syndrome (Reardon and Winter 1994) and craniofrontonasal dysplasia (Cohen, Jr 1979) may also involve premature closure of a single coronal suture but their other features are usually sufficiently characteristic to suggest the diagnosis.

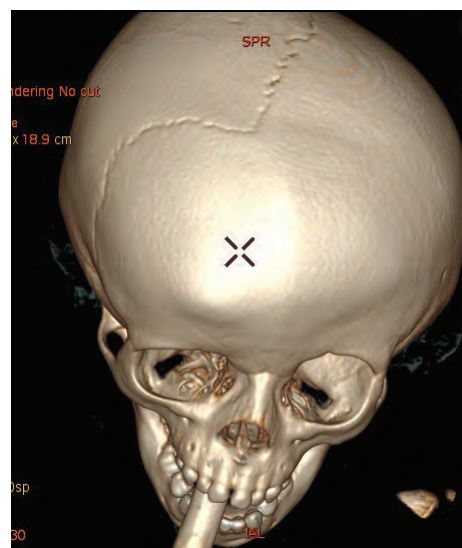


Figure 6.2 Three-dimensional CT scan showing the typical deformity caused by unicoronal synostosis.

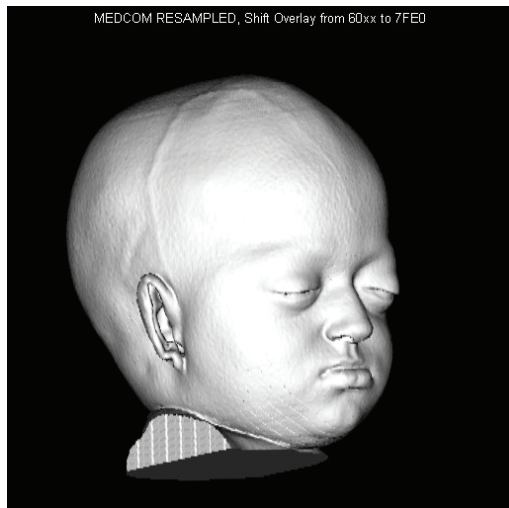


Figure 6.5 Three-dimensional CT of a child with Crouzon syndrome showing the typical facial appearance. Note also the enlarged scalp veins suggesting raised intracranial pressure secondary to intracranial venous hypertension.

developmental and learning difficulties. Marked intellectual compromise was present in 3% of Kreiborg's series (Kreiborg 1981).

Apert Syndrome

The child with Apert syndrome has a head that is tall and shortened from front to back (turri-brachycephaly), midfacial (maxillary) retrusion, proptosis, a downward cant to the palpebral fissures and hypertelorism (Lajeunie et al. 1999) (Fig. 6.6a). The essential clinical feature however is a complex fusion (syndactyly) of the fingers and toes (Anderson et al. 1997d, Anderson et al. 1999, Cohen and Kreiborg 1995b) that may require multiple surgical procedures before functional effectiveness is achieved (Guero et al. 2004) (Fig. 6.6b). Visceral (Cohen and Kreiborg 1993) and cutaneous (Cohen

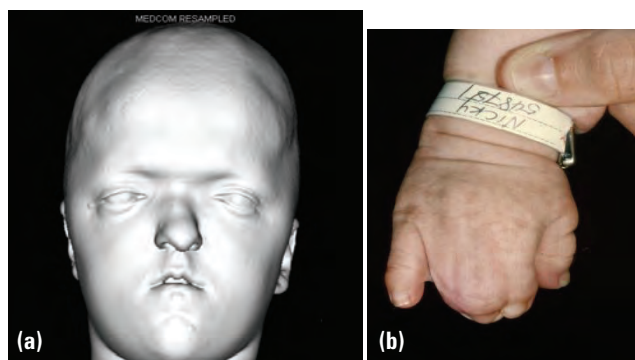


Figure 6.6 (a) Apert syndrome. Syndactyly. (b) Three-dimensional CT showing the typical facial features.

and Kreiborg 1995a) abnormalities can also occur. Palatal abnormalities (Kreiborg and Cohen 1992) ranging in severity from frank clefts to a bifid uvula are common and occur with a frequency of up to 75% (Peterson and Pruzansky 1974, Slaney et al. 1996). Cervical vertebral fusions that may be progressive occur in over half of affected children although it is unusual for them to become clinically significant (Thompson et al. 1996).

Developmental and learning difficulties are the norm in Apert syndrome although a combination of developmental assessment tools designed for non-Apert children and low societal expectations may overestimate their severity (Shipster et al. 2002). While a small percentage of children may complete secondary education (and usually only with assistance in the classroom), many drop out of mainstream education during their primary school years while a small percentage are too affected for the mainstream education system at anything above kindergarten level (Patton et al. 1988, Renier et al. 1996).

Pfeiffer Syndrome

Although described separately for historical reasons, the genetic overlap between Pfeiffer and Crouzon syndromes is such that they are now often considered together as 'Crouzon-Pfeiffer syndrome'.

The 'traditional' Pfeiffer syndrome is an autosomal dominant condition characterised by suture fusions that range from bicoronal synostosis alone to pan-synostosis (with or without the cloverleaf skull deformity – see next section) (Winter 1994). Affected patients also have digital abnormalities (Panthaki and Armstrong 2003) that include curved and shortened thumbs and great toes (Anderson et al. 1998b) and, less commonly, digital fusions (although to a lesser degree than in Apert syndrome [Panthaki and Armstrong 2003]).

Cohen (1993) divided children with Pfeiffer syndrome into three types based on their clinical severity. Type 1, those least affected, may display little more than bicoronal synostosis and midface retrusion (in addition to their digital



Figure 6.7 The typical hallux deformity of Pfeiffer syndrome.

ed chromosomal abnormalities. It may also occur as a post-operative complication, a consequence of the frontal lobe retraction required during fronto-facial monobloc and bipartition procedures in children with severe frontal bone recession (Cobb et al. 2013).

Cosmesis

The cosmetic disabilities that most trouble patients with syndromic synostosis and their families include a misshapen forehead, eyes that protrude, eyes set too far apart (hypertelorism) and an upper jaw set back while the lower jaw protrudes.

When correcting for cosmesis alone it is important to remember that surgery carried out on a part of the craniofacial skeleton that is still growing may need to be repeated either wholly or in part in order to achieve a result that will prove stable over time. Our own policy, based more on clinical observation than measurement, is to assume that a forehead and supra-orbital region in a satisfactory configuration at around 10 years of age is unlikely to need further correction and essentially cosmetic reconstructions after that age can focus more on the maxilla and mandible where growth will continue until secondary dentition is complete – the mid to late teens.

CONCLUSION

Primary craniosynostosis whether it affects one or multiple sutures and is associated or not with a particular syndrome is rare and its management should only be undertaken by a unit with sufficient experience to ensure affected children achieve their developmental potential.

Early assessment by such a unit will enable the correct diagnosis (both genetic and clinical) to be made, the risk of complications assessed and a management plan made that is tailored to each individual child's needs.

While in non-syndromic unisutural synostosis treatment may require no more than a single reconstructive operation, more complex cases require input from a wide range of specialists including the paediatric neurologist often until the completion of skeletal maturity.

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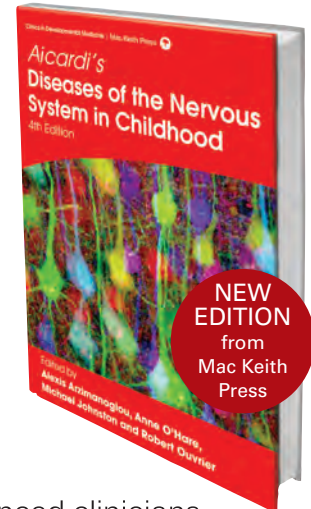
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