

**Analysis of Posterior Plagiocephaly:
Deformational versus Synostotic**
[Articles]

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Abstract

Appropriate management of posterior plagiocephaly requires differentiation of occipitoparietal flattening caused by lambdoid synostosis from that caused by deformational forces. In a 2 1/2-year prospective study of 115 infants presenting with unilateral posterior cranial flattening, only one child had synostotic posterior plagiocephaly (lambdoid synostosis), whereas 114 infants had deformational posterior plagiocephaly.

Deformational occipitoparietal flattening was more common on the right (61 percent) than on the left (30 percent), and minor contralateral frontal flattening was not unusual (52 percent). The ipsilateral ear was anteriorly displaced in virtually all infants (97 percent). Some infants had ipsilateral torticollis (19 percent); a few had contralateral torticollis (8 percent). Gender ratio was 3:1, male:female. A total of 114 infants with deformational posterior plagiocephaly were treated conservatively either by head positioning in the crib ($n = 63$) or with a molding helmet ($n = 51$). Outcome was assessed by pretreatment and posttreatment anthropometry on 53 of these infants, who were either positioned ($n = 17$) or helmeted ($n = 36$). Improvement occurred in 52 of 53 patients (mean follow-up 4.6 months), i.e., the difference in length between the long and short transcranial axis diminished in 52 infants (mean 1.2 to 0.7 cm), did not progress in any child, and was unchanged in one infant. At an average age of 10 months, posterior cranial symmetry was better in infants treated with a helmet (mean difference 0.6 cm) than in those managed by positioning (mean difference 1.0 cm) ($p < 0.001$). Age at initiation of helmet therapy (from 2 to 9 months) was unrelated to rate of improvement.

In a 10-year retrospective study, the authors identified 12 infants who had an operation for posterior plagiocephaly. All but one had confirmed premature lambdoid fusion; thus, this condition accounted for 3.4 percent of all primary operations performed for craniosynostosis during this decade ($n = 323$).

In retrospect, the physical findings of synostotic posterior plagiocephaly were not clearly different from those of deformational posterior plagiocephaly. Plain radiography was sometimes used to confirm the clinical diagnosis. Neither sutural narrowing, deep interdigitations, nor perisutural sclerosis indicated lambdoid synostosis. Computed tomography (CT) was necessary if

the physical findings were suspicious for lambdoid synostosis or if plain films did not give a definitive diagnosis. Axial CT scans ($n = 7$) showed a symmetric forehead in all but one patient with lambdoid synostosis. CT studies also demonstrated that auricular position was indeterminate in synostotic posterior plagiocephaly, being anterior, posterior, or symmetric, whereas the ipsilateral ear was virtually always anterior in deformational posterior plagiocephaly.

Plagiocephaly or cranial asymmetry is pathogenetically heterogeneous. The mechanisms can be categorized as either primary-to-abnormal sutural development (synostotic plagiocephaly) or secondary-to-abnormal forces acting on an intrinsically normal, developing cranium (deformational plagiocephaly). The locus of the pathologic process can be further characterized as either primarily anterior or posterior.¹ The term "synostotic anterior (frontal) plagiocephaly" is synonymous with "unilateral coronal synostosis," whereas the term "synostotic posterior (occipital) plagiocephaly" denotes "lambdoid synostosis." We introduced the adjective "compensational" to describe secondary cranial expansion or bossing that can occur in association with either synostotic or deformational plagiocephaly.² Some investigators differentiate plagiocephaly as with or without synostosis, calling the latter "positional plagiocephaly."³ We believe the adjective "deformational" more accurately designates the pathogenesis of nonsynostotic cranial flattening, since the process usually occurs in utero and is accentuated by postnatal posture.

Several craniofacial centers have documented the exponential increase in the number of children referred for evaluation of posterior plagiocephaly.⁴⁻⁶ This is attributed to the 1992 recommendation by the American Academy of Pediatrics that an infant should sleep on the back to reduce the risk of sudden infant death syndrome.⁷ Proper diagnosis of plagiocephaly is critical because surgical correction is indicated for unilateral coronal synostosis and often is necessary for unilateral lambdoid synostosis. In contrast, both anterior and posterior deformational plagiocephaly improve with conservative management. Anterior (frontal) plagiocephaly can be accurately classified as synostotic or deformational by characteristic facial features.² Such a precise clinical diagnosis is often difficult in infants with posterior (occipital) plagiocephaly.¹ However, Huang et al. reported that physical findings are distinct so as to allow differentiation of posterior plagiocephaly as synostotic or deformational.⁸ Lo et al. used axial CT to quantitate the differences between posterior synostotic and deformational plagiocephaly.³

We undertook a two-part study of infants with posterior plagiocephaly seen in our craniofacial unit. First, we retrospectively evaluated synostotic posterior plagiocephaly to assess the relative incidence and to document physical findings. Second, we prospectively recorded the physical and radiographic findings of infants with deformational posterior plagiocephaly and used cranial anthropometry to compare the outcome of crib positioning with helmeting therapy.

Methods

Retrospective Study

This section focused on the relative incidence of posterior versus anterior plagiocephaly. We reviewed the records of all patients presenting to the craniofacial program with plagiocephaly over

a 5-year period, 1992 through 1996. Furthermore, all case records of children operated on for a diagnosis of "posterior plagiocephaly" in the previous 10 years were analyzed. Available radiologic, operative, and histologic findings, as well as preoperative photographs, were recorded.

Prospective Study

This section consisted of qualitative and quantitative assessment of all children with posterior plagiocephaly managed by the neurosurgical and plastic surgical services from June of 1994 to December of 1996. Radiologic findings were noted, with particular emphasis on those infants whose lambdoid suture appeared to be open but who had abnormal findings on plain films. Antenatal histories were obtained, looking for evidence of intrauterine constraint, such as multiple pregnancy, abnormal fetal lie, early pelvic descent, and uterine pathology.

Anthropometric assessment of cranial shape in the horizontal plane was performed using a spreading caliper (Trystom Company, Olomouc, Czech Republic). The child's head was held in neutral position by an assistant. Two transverse cranial diameters were measured obliquely, from supraorbital point, *orbitale superius*, to the parietooccipital scalp at the midpoint of the flattened area (short axis) and at the point of maximal convexity (long axis) (Fig. 1). Each measurement was made three times, the average (in centimeters) was noted, and the difference between the transcranial axial length on the flat side and the contralateral side was recorded. Infants with a clinical and, if necessary, radiologically confirmed, diagnosis of deformational posterior plagiocephaly were treated with physical therapy (if there was torticollis). After thorough discussion, the parents decided whether to use crib positioning or a custom-made molding helmet. The oblique transcranial measurements were repeated at approximately three monthly intervals, during follow-up evaluation for both the crib positioned (control) and helmeted infants. Positioning therapy included posturing the infant with foam wedges, keeping objects of interest to the side opposite the posterior cranial flattening, and proper placement of the crib.

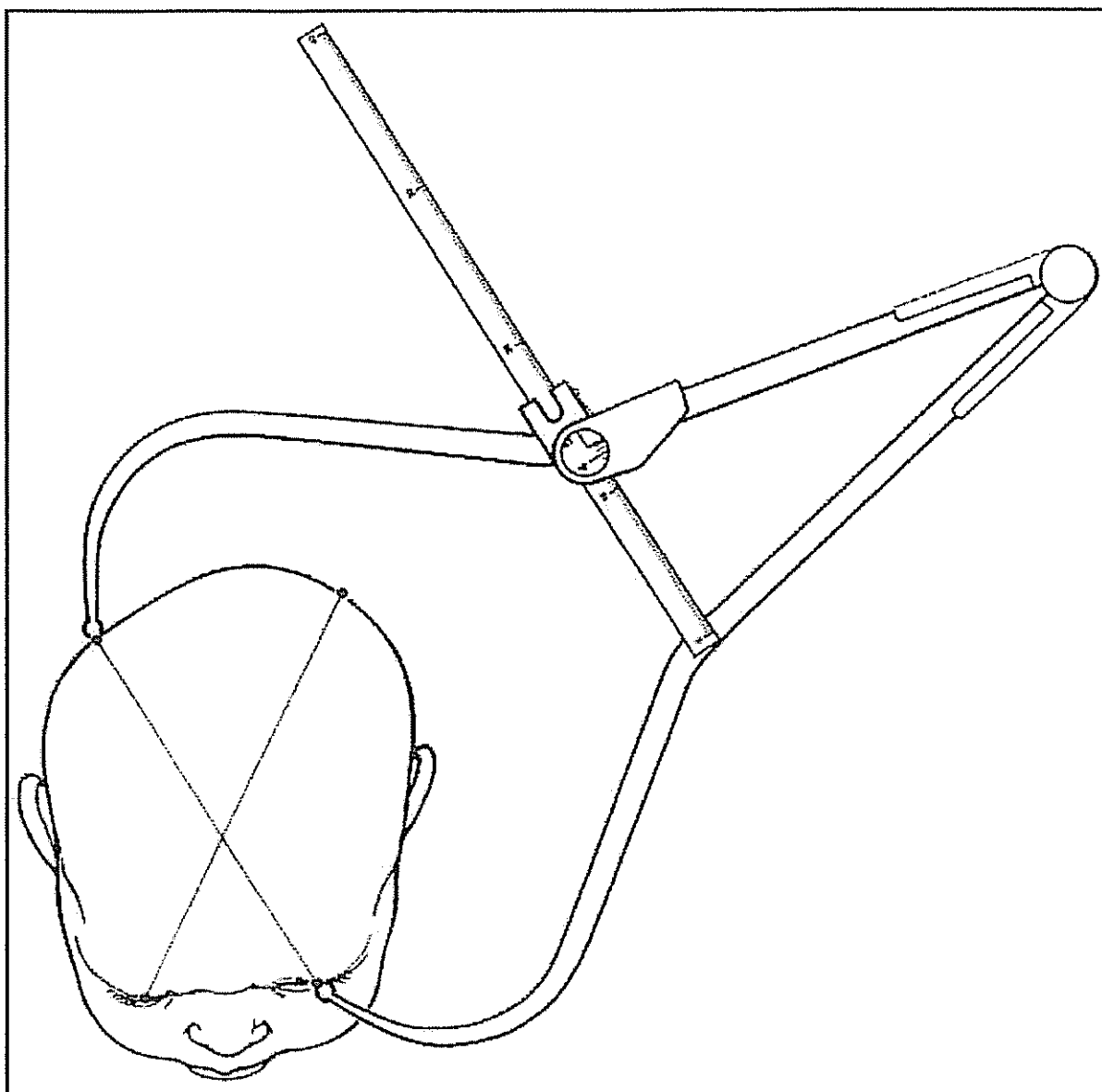


Fig. 1. Transcranial anthropometry. Sliding caliper used to measure diagonal distance from the midpoint of the supraorbital rim, *orbitale superius* (*os*), to the midpoint of the opposite parieto-occipital scalp in the same transverse plane.

Helmeting Therapy

A plaster of Paris bandage negative mold is taken of the child's head and filled with liquid plaster of Paris to form the positive mold. The "low points" of the positive mold are built up to make it more symmetric, and multiple layers of thermoformed polyethylene foam are vacuum formed on the positive mold. Thermoformed polyethylene is vacuum formed over the foam and positive mold to complete construction of the helmet (Fig. 2). For some infants, particularly those wearing a helmet in the warm months, small ventilation holes are bored in the helmet.



Fig. 2. Infant with custom-made molding helmet instituted at age 9 months when transcranial diameter difference was 1.3 cm (15.6 versus 14.3 cm). By age 12 months, the difference was only 6 mm (15.9 versus 15.3 cm), and the helmet was discontinued.

This is a "passive" helmet, i.e., no effort is made to compress the cranium. The helmet is adjusted every 2 to 3 weeks by removing or adding material to the foam liner. Removing foam allows for growth and expansion in the flat areas, while strategically adding foam improves helmet suspension. Initially, the helmet is worn 15 to 22 hours per day and, after improvement following 3 to 4 months of therapy, it is worn only at night. One helmet usually suffices because helmeting is typically discontinued by 10 to 12 months of age.

Results

Retrospective Study

A total of 323 primary procedures for various craniosynostoses (syndromic and nonsyndromic) were performed during the period 1984 through 1994 (Table I). Of the total, only 12 infants underwent cranial release for posterior plagiocephaly: eight had isolated lambdoid synostosis,

three had lambdoid synostosis with at least one other suture involved (usually sagittal), and one had a radiographically open lambdoid suture but marked posterior cranial deformity. Ten of the 11 children had CT studies in addition to plain radiographs that corroborated the diagnosis of lambdoid synostosis. Eight of the 11 patients had operative findings of lambdoid fusion, but in only four instances was there histologic confirmation. Thus, a diagnosis of posterior plagiocephaly accounted for 3.4 percent (11 of 323), and verified, isolated unilateral lambdoid synostosis comprised only 2.5 percent (8 of 323) of surgically treated craniosynostoses.

	No.	%
Sagittal	166	51
Unilateral coronal	69	21
Bilateral coronal with/without other sutures	53	16
Metopic	23	7
Lambdoid	12	4
Total	323	

TABLE I Craniosynostosis: Operative Cases, 1984-1994

Available axial CT scans of seven infants that documented synostotic posterior plagiocephaly (lambdoid synostosis) were reviewed; 4 of 7 were three-dimensional CT reconstructions (Fig. 3). The shape of the cranial vault was evaluated and compared to CT studies of eight infants with deformational posterior plagiocephaly. The deformity of the posterior cranial vault was similar in deformational and synostotic patients, i.e., the affected side is flattened and the contralateral side is bossed ($n = 5$). That is, there is compensational plagiocephaly in both conditions as the posterior midline is shifted away from the flattened occiput. The contour of the forehead was symmetric in six of seven axial scans of infants with lambdoid synostosis; however, in one instance the ipsilateral frontal region was slightly forward (Fig. 3). CT studies showed that the ipsilateral external ear canal is anteriorly displaced in all infants with deformational posterior plagiocephaly, whereas in synostotic posterior plagiocephaly the ipsilateral external ear and auditory canal was anteriorly displaced ($n = 3$), symmetric ($n = 3$), or slightly posteriorly displaced ($n = 1$).

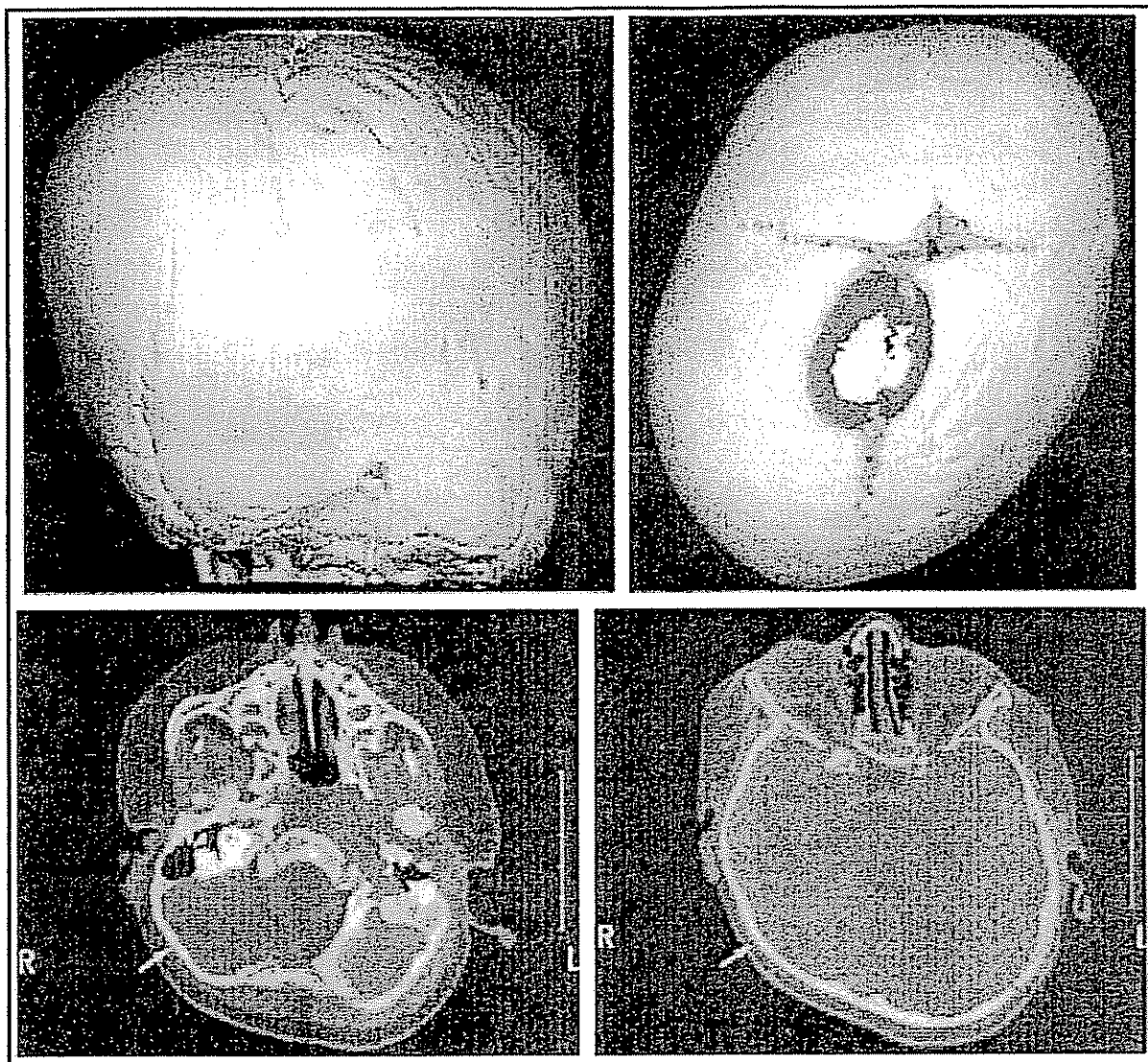


Fig. 3. Three-dimensional CT study of child with right synostotic posterior plagiocephaly. (*Above, left*) Note obliteration of right lambdoid suture, occipitoparietal flattening, ipsilateral occipitomastoid bossing and (*above, right*) minor, ipsilateral frontal ("compensational") bossing on vertex view. Lambdoid fusion can be "spotty" on CT examination. (*Below, left*) Axial cut shows open right lambdoid suture (*arrow*), but (*below, right*) higher axial cut reveals fusion (*arrow*). Note anterior displacement of the ipsilateral ear canal on both axial views and wormerian bone in left (open) lambdoid suture.

Prospective Study

Of 115 infants presenting with posterior plagiocephaly over the 30-month study period, all but one were deformational in type. The male: female ratio was 3:1. Antenatal history suggestive of intrauterine compression was elicited in only 14 patients. Physical findings in the 114 patients with deformational posterior plagiocephaly are shown in Table II. Despite marked posterior flattening, there was little distortion of facial features in the frontal plane. The ipsilateral ear was displaced anteriorly in virtually all infants. There was minor contralateral forehead flattening (deformational anterior plagiocephaly) observed in just over one-half of the children (average 52 percent). Twenty percent of infants ($n = 20$) had torticollis ipsilateral to the flattened posterior cranium, and some ($n = 8$) had contralateral torticollis.

	No.	%
Right DPP [<i>n</i> = 70 (61%)]		
Left DFP	39/70	56
Ipsilateral ear anterior	68/70	97
Ipsilateral torticollis	13/70	19
Contralateral torticollis	5/70	7
Left malar flatness	5/70	7
Left DPP [<i>n</i> = 35 (30%)]		
Right DFP	15/35	43
Ipsilateral ear anterior	34/35	97
Ipsilateral torticollis	7/35	20
Contralateral torticollis	3/35	9
Right malar flatness	5/35	14
Bilateral [<i>n</i> = 10 (9%)]		
DFP, deformational frontal plagiocephaly.		

TABLE II Physical Findings in Deformational Posterior Plagiocephaly (DPP)

Plain radiographs were available for review in 54 of 115 infants. Only one infant in this prospective group had plain film evidence of a fused lambdoid suture, and this finding was confirmed by CT scan. There were no sutural abnormalities in 35 of 53 infants. However, 19 of 53 had open, but abnormal, sutures, namely, marginal sclerosis along the lambdoid suture (*n* = 13), indentation or ridging along the line of the lambdoid suture and narrowing of the sutural space (*n* = 2), and contralateral occipital cortical thinning (*n* = 4) (Fig. 4). In 11 infants, the plain films alone were equivocal or inadequate to evaluate the lambdoid sutures, and in all 11 cases, CT scan demonstrated lambdoidal patency.

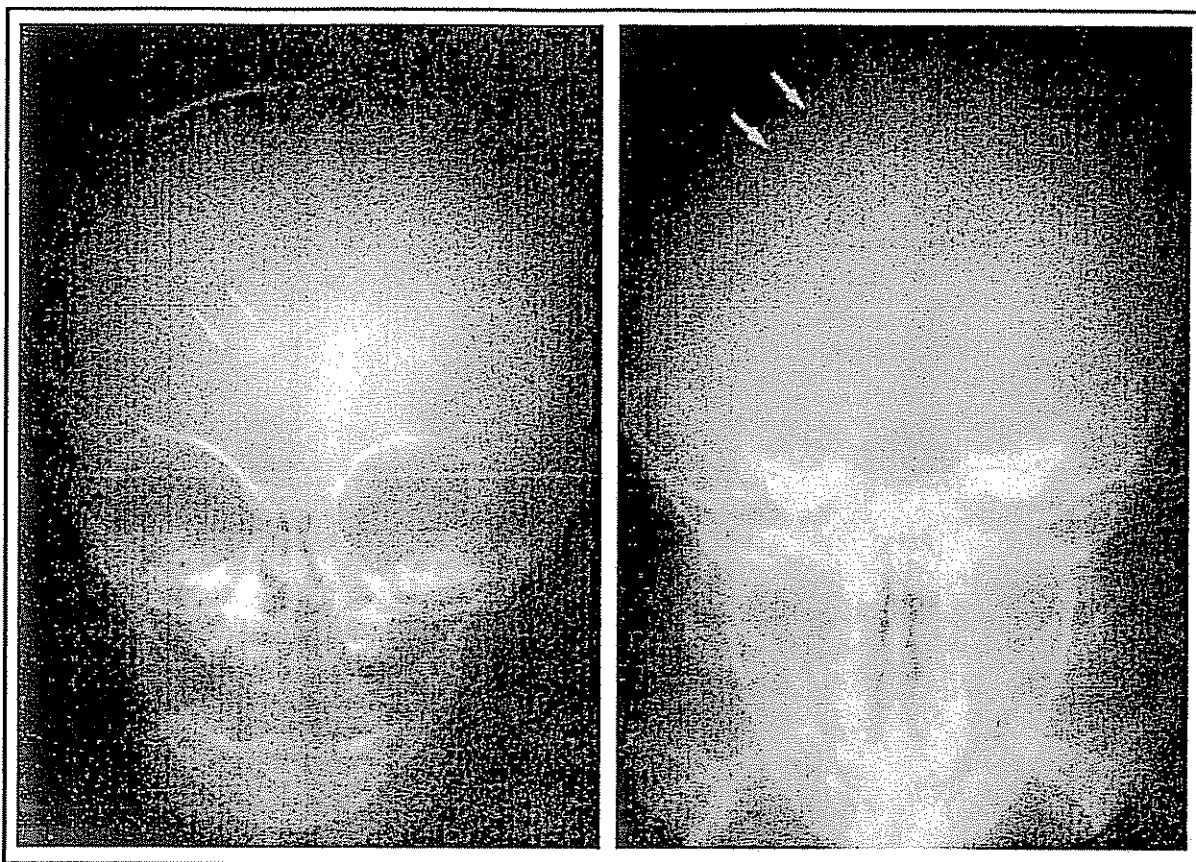


Fig. 4. Plain radiographs of an infant with right deformational posterior plagiocephaly: Perisutural sclerosis and narrowing of right lambdoid suture (*arrows*) seen on frontal (AP) film (*left*) and Towne view (*right*).

Anthropometry was performed on 76 infants during their initial office visit. Follow-up measurements were obtained in 53 treated infants. All measurements were performed by the first author (J.B.M.). The average mean measurement error was ± 1 mm. The average long axis was 14.7 cm, the average short axis was 13.5 cm, and the mean difference was 1.2 cm. In this entire cohort of measured infants (those managed by either crib positioning or helmet therapy), the mean difference between the long and short axial diameter decreased from an average of 1.2 cm (8 percent shorter than the unaffected side) to 0.7 cm (or 5 percent shorter than the unaffected side) (Table III). The 36 infants treated with a helmet demonstrated a more impressive anthropometric improvement (i.e., from 1.2 cm transcranial difference at presentation to 0.6 cm), compared with the nonhelmeted (control) group ($n = 17$) treated by positioning alone, who improved from 1.2 to 1.0 cm (Table IV).

	First Visit	Last Visit
Long axis (average cm)	14.7	15.4
Short axis (average cm)	13.5	14.7
Mean difference (cm)	1.2	0.7
Mean age (months)	5.5	10.4

* Mean follow-up, 4.7 months. Difference in transverse cranial diameters significantly reduced from pretreatment to follow-up evaluation (paired *t* test) = $p < 0.001$.

TABLE III Cranial Anthropometry-Two or More Measurements ($n = 53$)*

	Molding Helmet ($n = 36$)	No Helmet ($n = 17$)
Difference, first visit (mean age)	1.2 cm (5.4 mos)	1.2 cm (5.6 mos)
Difference, last visit (mean age)	0.6 cm (10.0 mos)	1.0 cm (10.4 mos)
Mean follow-up	4.6 months	4.8 months

* Difference in transverse cranial diameters from pretreatment to follow-up evaluation significantly more reduced for infants treated with molding helmet (independent groups *t* test) = $p < 0.001$.

TABLE IV Change in Oblique Transverse Cranial Diameter with and without Molding Helmet*

None of the parents considered surgical correction of their child's minor residual posterior cranial asymmetry. Torticollis in 28 infants resolved completely, and 16 of these infants had been referred for physical therapy ($n = 13$ crib positioned and $n = 3$ helmeted).

Statistical Analysis

Infants treated with a molding helmet had a significantly greater decrease ($p < 0.001$) in posterior cranial asymmetry than did infants treated by positioning alone. The difference in transverse cranial diameter from 1.2 to 0.6 cm with helmet therapy was significantly different from zero, whereas in infants treated by positioning without the use of a helmet, a reduction in transverse cranial diameter from 1.2 to 1.0 cm was not significantly different from zero. The same results were found using percent change.

We could not control for the time between the first and final measurements. Furthermore, helmet therapy was instituted at different ages during the study. Thus, given the age range at initiation of therapy and the variation in follow-up times, we considered the percent change to be

the best way to standardize outcomes across subjects. There was no significant relationship between percent change and age at beginning of molding therapy ($R^2 = 0.08$, $p =$ nonsignificant) or between percent change and length of time to follow-up evaluation ($R^2 = 0.07$, $p =$ nonsignificant).

Discussion

Plagiocephaly is a generic term denoting unilateral flattening (asymmetry) of the cranium. For the vast majority of affected infants, this is prenatal deformational plagiocephaly caused by compressional forces in utero that alter the shape of the rapidly growing fetal head. The process likely involves the normal compression of the anterior cranium, engaged against the maternal pubic bone, and compression of the posterior cranium by the lumbosacral spine.^{1,2} Anterior-posterior cranial deformation can also result from various abnormal forms of uterine constraint, e.g., oligohydramnios, uterine malformation, fetal malposition, multiple fetuses, cephalohematoma (two in this series), and other factors. A neonate has limited strength of the cervical muscles. If an infant with unilateral frontal flattening lies preferentially prone, deformational anterior plagiocephaly will evolve.^{2,4,9} Similarly, if an infant is placed supine, the head will roll to rest on the flattened side of the occiput, and deformational posterior plagiocephaly will become more pronounced. Often, occipital flattening is subtle and goes unnoticed in the neonatal period. Only after 2 to 3 months do the parents and the pediatrician first notice cranial asymmetry. In some instances, posterior deformational plagiocephaly is primarily "positional," i.e., evolving postnatally as the infant lies in a favored posture ("the position of comfort").

Deformational anterior plagiocephaly was commonly seen in our unit before 1992; this was a time when newborns were sleeping prone.² However, only four infants with unilateral frontal flattening presented during the last 2 years of the prospective study period. From 1992 through 1995, there was a reciprocal and exponential increase in the number of infants seen with deformational posterior plagiocephaly (Fig. 5). We agree with other investigators that the most likely explanations are the 1992 recommendation that infants sleep in the supine position and the increased awareness of plagiocephaly among pediatricians.^{4-6,10} Now most infants spend the first months of life lying on their backs, perpetuating and probably accentuating congenital occipitoparietal deformation. In the past, the common congenital posterior cranial flattening usually improved spontaneously as infants were allowed to sleep prone. This explanation is corroborated by our finding that the incidence of deformational anterior plagiocephaly rapidly declined over the past 3 years, despite an increased awareness in the medical community.

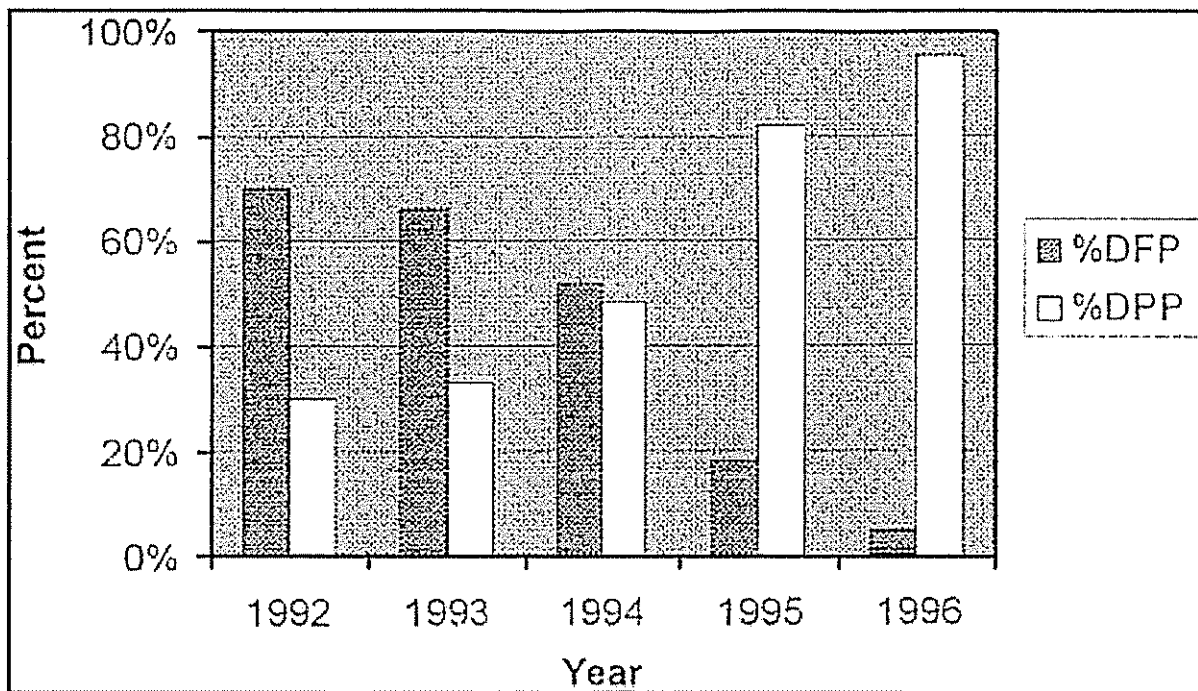


Fig. 5. Relative percent of deformational frontal plagiocephaly (DFP) versus deformational posterior plagiocephaly (DPP), 1992 to 1996.

We believe that the mechanism for deformational posterior plagiocephaly is the same as for congenital flattening of the forehead. In utero, the cranium is distorted in the shape of a parallelogram. Indeed, we found minor contralateral deformation of the forehead in 52 percent of children with deformational posterior plagiocephaly. Analogously, it would be predicted that the changes in ear position would be similar as well, and this was so in 97 percent of infants. Deformational anterior plagiocephaly occurs more commonly on the left forehead, and as predicted, for the majority (61 percent) of infants with posterior plagiocephaly there was flattening on the right (contralateral) side. Likewise, in patients with deformational anterior plagiocephaly, there is often minor contralateral occipital deformation.²

We found a 3:1 preponderance of males with deformational posterior plagiocephaly, as have other authors.⁶ Possible explanations include: (1) the head of a male is larger and grows more rapidly than that of a female, and (2) male fetuses are less flexible than female fetuses and thus have more deformational anomalies.¹¹

Ipsilateral torticollis was present in 20 percent and contralateral torticollis in 8 percent of infants with deformational posterior plagiocephaly. This finding is obverse and analogous to deformational anterior plagiocephaly wherein ipsilateral torticollis is present in 64 percent of affected infants.² There is an unresolved controversy over whether torticollis is secondary to the abnormal head shape in deformational plagiocephaly or is the primary abnormality causing the deformational abnormality.² The finding that an infant with deformational posterior plagiocephaly who lies supine on the flattened occiput can have either ipsilateral or contralateral shortening of the sternocleidomastoid muscle suggests that intrauterine deformation (and cranial posture) is determinant.

Some observers believe that there is a continuum from pure deformational posterior plagiocephaly (without synostosis) to definite lambdoid synostosis, and, in between, there is a group of infants with an open, but a radiographically abnormal, lambdoid suture. McComb considered that the extent of bony fusion across the lambdoid suture, as judged by radiography and computed tomography, has little relation to the degree of deformity. He coined the term "functional synostosis" to denote a condition wherein the lambdoid suture is radiographically abnormal and requires operative release.¹² He reported, "15 to 20 percent of our operative procedures for craniosynostosis involve the lambdoid suture." However, McComb has lately modified his view, stating that the majority of these infants can be corrected with a "dynamic cranial orthotic, or headband" with results that are "comparable to surgical intervention."¹³

Graham goes even further than McComb's conception, for he thinks that compressive or restrictive forces across a suture can produce actual fusion.¹⁴⁻¹⁶ Koskinen-Moffett and Moffett tested this theory using an animal model of intrauterine constraint and found that histologic "synostosis" did occur in the coronal, squamosal, and/or squamoso-frontal sutures.¹⁷ However, in many of the affected mice, there was overlapping fusion of the sutural margins, in contrast to the end-to-end fusion characteristic of human craniosynostosis.

Our prospective study did not support Graham's hypothesis as applied to the parieto-occipital suture. None of the 114 infants with deformational posterior plagiocephaly developed lambdoid fusion. Plain radiography, used for diagnosis early in the series, showed lambdoidal radiographic changes in 19 of 53 patients; however, posterior cranial flattening improved with conservative measures in all these infants. For this reason, we did not obtain follow-up radiographs. We underscore that radiologic findings (i.e., perisutural sclerosis, sutural narrowing, or increased interdigitations) indicate sutural compression or restriction; they are not signs of impending synostosis, functional or otherwise.¹⁸⁻²¹ A CT scan was obtained for any infant with major posterior flattening and contralateral occipitoparietal bossing or if plain radiographs did not clearly demonstrate patent lambdoid sutures. CT demonstrated open lambdoid sutures in all these children.

Three-dimensional reformatted images of patients with posterior plagiocephaly were evaluated retrospectively for cranial basilar changes, as described by Lo et al.³ We found this analysis to be useful for the rare infant with an equivocal diagnosis.^{22,23} Jimenez et al. reported that 21 percent of children evaluated for posterior plagiocephaly had a "stenosed region of the asterion," as seen on three-dimensional computed tomography and by histologic examination of sutural bone from the region of the asterion.²⁴ There were no children in our series who fit their description. Specifically, asterion was patent in those children with radiographic evidence of sclerosis along the margins of the lambdoid suture. It is possible that fusion might have begun at the asterion in the few children with "true" lambdoid synostosis, analyzed in our retrospective series. Three-dimensional CT is the best method for determining the presence or absence of lambdoid synostosis. However, we caution that these reformatted images can be deceptive. With thick slice intervals, the program can "smooth" the open suture, giving a false diagnosis of synostosis. In addition, the deep interdigitation of the lambdoid suture compounds radiographic interpretation. Even the asterion can appear "fused," although it is histologically open. Furthermore, an axial CT slice can miss an open suture if it is in the same plane as the scan. Thus, a three-dimensional

scan more reliably shows a vertically oriented (crossing multiple axial images) suture than a horizontal suture. We have observed three-dimensional images with apparent absence of the asterion, but with an open asterion seen on plain radiography and subsequent improvement of the posterior cranial flattening.

Can physical examination accurately distinguish between deformational and synostotic posterior plagiocephaly? Huang et al. presented their description of the physical findings in synostotic posterior plagiocephaly.⁸ They characterized the head shape as "trapezoidal" on vertex view with ipsilateral occipital flattening, contralateral parietal and frontal bossing, ipsilateral occipitomastoid bulging, and inferioposterior positioned ipsilateral ear. We found more subtle dysmorphic features and CT findings that might distinguish synostotic from deformational posterior plagiocephaly: (1) Ipsilateral posterior flattening and contralateral parieto-occipital bossing are more severe in lambdoid synostosis. (2) Contralateral frontal deformation is common in deformational posterior plagiocephaly, whereas the forehead is usually symmetric in synostotic posterior plagiocephaly, and in one patient, it was slightly forward on the affected side. (3) The ipsilateral external ear canal is anteriorly displaced in deformational posterior plagiocephaly. However, in synostotic posterior plagiocephaly, the auricle is anteriorly positioned, symmetric (in the horizontal plane), or posteriorly displaced. Based on our small numbers of CT studies, perhaps it is best to state that cranial deformity in lambdoid synostosis is variable. The head shape in vertex view can be trapezoidal if the ipsilateral forehead is posteriorly positioned. However, more often, the two sides of the forehead are symmetric, and we noted one instance of anterior prominence of the ipsilateral forehead. Thus, frontal plagiocephaly can occur in both deformational and synostotic posterior plagiocephaly. In the former, the contralateral forehead is flattened secondary to deformation; whereas, in the latter, ipsilateral frontal bossing is secondary or "compensational" plagiocephaly.²

Photometry,²⁵ anthropometry,²⁶ and subjective evaluation by physician and parents²⁷ have been used to document efficacy of helmet molding in the treatment of deformational plagiocephaly. Our prospective study was analyzed retrospectively in two groups: those infants treated with crib positioning (controls) and those treated with a passive type of molding helmet. All infants with deformational posterior plagiocephaly, even those with radiologically abnormal sutures, improved, as measured by the change in difference between the length of the two oblique cranial axes. We found that infants treated with crib positioning alone had an average residual posterior flattening of 1.0 cm transcranial axial difference, whereas infants treated with a helmet seemed to improve more rapidly and had, on average, a residual 0.6 cm transcranial axial difference at a mean age of 10 months. Neither we nor the parents considered that the minor degree of residual posterior plagiocephalic cranial asymmetry warranted operative correction.

This was a prospective, not a randomized, study. Physician bias is evident in that twice as many parents elected helmet therapy rather than the control treatment of crib positioning. However, the two groups were very similar for the important variables of age at first measurement and beginning therapy, initial transcranial asymmetry (plagiocephalic deformity), and age at follow-up assessment. Tests of the differences between groups did not rule out that the two groups were random samples from the same population. Another criticism of this study is that there are no long-term measurements. Is possible that the molded and non-molded heads

could become more symmetric in time? Cranial asymmetry will appear less obvious because, as the head enlarges, there will be a relative change in the proportion of the difference in transcranial dimensions to cranial diameter. However, we do not think there is significant "self-correction" of deformational posterior plagiocephaly in childhood. The basis for this statement is the relatively minor slope of the cranial growth curve after infancy. In addition, we found helmet therapy to be minimally effective after age 1 year (unless the infant is premature), and not effective after 16 to 18 months. Furthermore, we have measured several children who first presented at 14 to 18 months with major cranial asymmetry (12 to 18 mm difference), despite the fact that their parents had conscientiously used crib positioning.

The retrospective arm of this study confirmed that lambdoid fusion is a rare cause of occipitoparietal flattening (either alone or in association with the sagittal synostosis). Lambdoid synostosis can cause progressive distortion to such a degree as to justify resection of the fused suture and/or remodeling the posterior cranial vault.²⁸⁻³² The incidence of isolated "unilateral lambdoid synostosis" is reported to be from 1.3 to 20 percent of all cases of synostosis.^{33,34} This wide range is likely due to differences in diagnostic criteria and to past confusion about the pathogenesis of posterior plagiocephaly. Shillito and Matson reported a 1.3 percent incidence of lambdoid synostosis using strict criteria of complete fusion, seen radiographically and at operation.³⁴ In contrast, Muakkassa et al. noted an incidence of 16 percent of lambdoid synostosis based on clinical, radiologic, radionuclear, and intraoperative evaluation.³⁵ However, their diagnostic radiographic abnormalities included marginal sclerosis, flattening, and thinning of the occipital bone, the very findings we associate with deformational posterior plagiocephaly. Indeed, histologic examination of the resected sutures indicated that 34 of 37 of the patients of Muakkassa et al. had open sutures without evidence of bony union. Cohen reviewed this report and suggests only 3 of the 37 patients had lambdoid craniosynostosis; the remainder had deformational posterior plagiocephaly.¹⁹

The recommendation that neonates be placed exclusively on the back to prevent sudden infant death syndrome should be amended. An infant born with deformational posterior plagiocephaly should be turned to the contralateral side and positioned in the crib using foam wedges. After age 6 months, the infant can safely be placed prone. If flattening persists after a trial of crib positioning for 2 months, we recommend helmet therapy, particularly if the difference between the transverse cranial diameters remains greater than 1.0 cm. There was no difference in results at 1 year if helmet therapy was started before or after 6 months of age. However, based on the slope of the cranial growth curve, helmet therapy is diminishingly effective if instituted after age 1 year. Posterior craniotomy and surgical modeling is indicated for the rare infant with documented lambdoid synostosis and, in very rare instances, for the child with gross posterior cranial deformation who never had the benefit of conservative therapy during infancy.

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