Incidence of Cranial Asymmetry in Healthy Newborns

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ABSTRACT. *Objective.* **During recent years, coincident with the recommendation to position infants supine, the incidence of posterior deformational plagiocephaly has increased dramatically. The purpose of our study was to determine whether early signs of cranial flattening could be detected in healthy neonates and to document incidence and potential risk factors.**

Design. **A cross-sectional study was performed in healthy newborns. Physical findings, anthropometric cranial measurements, and data on pregnancy and birth were recorded.**

Results. **The incidence of localized cranial flattening in singletons was 13%; other anomalous head shapes were found in 11% of single-born neonates. In twins, localized flat areas were much more frequent with an incidence of 56%. The following risk factors for cranial deformation were identified: assisted vaginal delivery, prolonged labor, unusual birth position, primiparity, and male gender.**

Conclusion. **We propose that localized lateral or occipital cranial flattening at birth is a precursor to posterior deformational plagiocephaly. The infant lies supine, with the head turned to the flattened area, and is unable to roll. Intrauterine risk factors for localized cranial flattening are the same as for deformational plagiocephaly. To avoid postnatal progression from a localized cranial flattening to posterior-lateral deformational plagiocephaly, we suggest amending the recommendation of the American Academy of Pediatrics on sleep position: Alternate the head position and allow sleeping on the side and, when awake, supervise prone time.** *Pediatrics* 2002; 110(6). URL: http://www.pediatrics.org/cgi/content/full/110/6/e72; *cranial asymmetry, deformational plagiocephaly, newborn infant, sleep position.*

ABBREVIATIONS. SIDS, sudden infant death syndrome; TCD, transcranial difference.

Plagiocephaly is a general term for cranial asymmetry, derived from the Greek word roots, plagios, meaning "oblique, aslant" and kephalê, meaning "head." Pathogenically, plagiocephaly can be classified as synostotic, caused by abnormal sutural development, or deformational, caused by external forces acting on the cranium. Synostotic plagiocephaly usually requires surgical correction,

whereas deformational plagiocephaly improves with crib positioning and, more predictably, with a molding helmet.[1–5] Earlier intervention results in improved outcome.[6]

Plagiocephaly is either preponderantly anterior or posterior, or both. Before 1992, most American infants were placed prone, and anterior deformational plagiocephaly was commonly seen in our craniofacial unit. Physical findings easily differentiate this type of flattened forehead from synostotic frontal plagiocephaly, caused by unilateral coronal synostosis.[7]

In 1992, the American Academy of Pediatrics recommended that infants be placed supine to sleep to reduce the risk of sudden infant death syndrome (SIDS).[8] This campaign has been successful with a decline in the prevalence of prone sleep position from 70% in 1992 to 24% in 1996[9] and coincident with lowered incidence of SIDS.[9] Since this change in the sleeping position, our craniofacial unit and many other centers have documented a remarkable decrease in anterior deformational plagiocephaly; however, posterior deformational plagiocephaly has assumed almost "epidemic" proportions. Thus, it is generally accepted that this increase in posterior deformational plagiocephaly is related to supine sleeping.[5,10–13] This phenomenon is also supported by the common observation of "flat heads" in Asian infants who are traditionally positioned supine. In countries in which infants lie traditionally on their back, the incidence of SIDS is low.[14–19]

There are subtle differences that discriminate between posterior (occipital) plagiocephaly caused by rare lambdoidal synostosis versus common deformational or positional molding. Plain radiographs of an infant with posterior cranial flattening were often interpreted as "functional synostosis" or "sticky lambdoid," although the suture was open. Many of these children with deformational posterior plagiocephaly underwent surgical correction.[20–23] More recently, the physical findings that differentiate deformational and synostotic posterior plagiocephaly have been determined.[5,24] At the same time, radiologists began reinterpreting plain films and using computed tomography to determine the correct diagnosis.[25–27] Furthermore, clinical studies showed that deformational plagiocephaly could be corrected by positioning in the crib and use of a molding helmet.[3–5] In fact, the incidence of true lambdoid synostosis is very rare (<4% of craniosynostosis).[5,28]

Usually, the parents and the pediatricians first notice deformational posterior plagiocephaly around 2 to 3 months. Mothers typically say that the infant's

head was round at birth. Thus, some investigators use the term "positional" plagiocephaly to underscore that the cranial flattening is postnatal, caused by sleeping in the "position of comfort."[2]

Other observers think that deformational plagiocephaly begins prenatally. They note the association with intrauterine constraint, resulting from a large fetus, a small or malformed uterus, increased abdominal muscular tone, or decreased amniotic fluid.[29] Deformational plagiocephaly is also known to occur more frequently in multiple-birth infants.[30] Bruneteau and Mulliken[7] proposed that the fetal head becomes distorted in a parallelogrammic shape as the anterior cranium is compressed by the maternal pubic bone and the posterior cranium by the lumbosacral spine. This would account for the high incidence of right posterior and left anterior deformational plagiocephaly, as would be expected with the common left occipital anterior passage through the birth canal.

Nevertheless, the question of whether deformational plagiocephaly begins in utero is unanswered. The aim of our study was to determine whether early signs of cranial flattening could be detected in the newborn nursery. We documented the following: 1) the incidence of cranial flattening in healthy neonates, and 2) potential risk factors. Our working hypothesis was that if subtle posterior cranial asymmetry is present at birth, it may go unnoticed in the neonatal period. Then, as the infant lies on the flattened area, in the "position of comfort," the cranium progressively distorts. If this scenario occurs and infants with localized areas of cranial flattening could be identified at birth, then progression to deformational plagiocephaly could be prevented by early crib positioning.

MATERIALS AND METHODS

The study was composed of 201 essentially healthy neonates at Brigham and Women's Hospital who were examined 24 to 72 hours after delivery. We excluded infants with a gestational age <36 weeks and infants who required prolonged treatment in the intensive care unit. After obtaining consent for participation, parents were questioned about the pregnancy and birth history. Data were collected on gender, height, birth weight, gestational age, Apgar score, and possible medical problems and anomalies. Also documented were number of pregnancies and deliveries; possible uterine or pelvic anomalies; and events during the pregnancy (oligo- or polyhydramnios, early pelvic descent, and other complications). Information was also noted about mode of delivery, use of forceps or vacuum assistance, length of first- and second-stage labor, position at birth, and birth complications. Medical records of the neonate and the mother were reviewed for all of these items.

Physical examination of the neonate noted cranial or facial asymmetry, head shape, cephalohematoma, torticollis, and anomalies of the ears, the hands, the feet, and the hips. Height was measured in the crib, using a measuring board, for most infants; however, in some infants, such as those recently circumcised, height and hip stability were recorded from the charts.

Anthropometric cranial measurements were made, using a spreading caliper (Tyrostom Company, Olomouc, Czech Republic), with the head held in a neutral position by an assistant or the mother. Two oblique cranial diameters were determined, measuring from the supraorbital point (os, orbitale superius) to the parietooccipital scalp at the point of maximal convexity, as described previously.[5] These diameters were measured 3 times, the average was recorded in centimeters and used to calculate the transcranial difference (TCD). Measurements of the head circumference were performed 3 times using a measuring tape; the average was noted in centimeters. All measurements were made by the same person with the same measuring device.

If an infant had either localized head flattening or cranial asymmetry, defined as a TCD of >4 mm, the parents were encouraged to change the infant's position in the crib frequently and to position the infant away from the flattened area. Parents were also offered the opportunity to have their infant's head shape reevaluated after 2 or 3 months in our craniofacial unit. The parents were given the transverse cranial diameters to allow comparison of the initial and the 2-month follow-up measurements without identifying the child in the primary study.

Data were tested for statistical significance with Pearson χ^2 tests or with 1-way analysis of variance.

RESULTS

Of the total of 201 neonates, 183 were singletons and 18 were twins from 9 pairs. Singletons and twins were analyzed separately.

Single-Born Infants

Of the 183 single-born infants, 24 (13.1%) were found to have lateral or posterior cranial flattening, and 21 (11.5%) had otherwise unusual head shapes on physical examination. Based on these findings, we divided the single-born neonates into 3 groups: 1) infants with a flat cranial area; 2) infants with otherwise unusual head shapes; and 3) neonates with normal head shapes.

Head Shapes

Of the 24 infants with flat areas, 9 were right posterior, 4 right lateral, 9 left posterior, 1 left lateral, and 1 bilateral posterior flattening. Thus, right-sided head flattening accounted for 54.2% of the total of the flattened areas. In most infants, the flat area was well localized, between 5- and 7-cm diameter. Six neonates with head flattening had anterior displacement of the ipsilateral ear (Fig 1).

In the group of 21 infants with otherwise unusual head shapes, 11 were found to have cephalohematoma; 7 presented with dolicocephalus or a protruding occiput; and 2 had molding in the region of the vertex. Two neonates had bilateral frontal flattening, 1 of these also had a cephalohematoma.

Anthropometric Measurements

The mean TCD was calculated and compared among the 3 groups. In the group of infants whose head shapes were unusual, but not flat, a cephalohematoma interfered with the posterior measuring point in 4 out of 11 cases, with TCDs ranging from 5 to 10 mm (attributable to the cephalohematoma). These 4 infants were excluded from the calculation of the mean TCD. Infants with head flattening had a mean TCD of 3.96 mm. When infants with posterior flattening were evaluated separately from those with lateral flattening, the mean TCD of infants with occipital flat areas was 4.74 mm, with a minimum of 0 mm, because of the case of bilateral posterior flattening, and a maximum of 8 mm. In neonates with lateral flattening, the mean TCD was 1 .0 mm, with a range from 0 mm to 2 mm. In contrast, neonates with otherwise unusual head shapes had a mean TCD of 1.29 mm, with a minimal value of 0 mm and a maximal value of 2 mm. Infants whose head shape
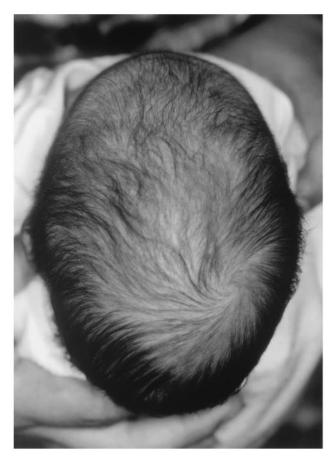
Fig 1. Photograph of head of patient 90, a female born by cesarean section for breech position to a primipara. Head evidenced right posterior-lateral flattening, with measurements R os L scalp: 11.4 cm and L os–R scalp: 10.6 cm, for TCD: 8 mm. Infant had R ear prominent and minor R torticollis.

was classified as normal had a mean TCD of 0.88 mm, ranging from 0 mm to 4 mm. Comparing the 3 groups with 1-way analysis of variance, the differences in the TCDs were significant ($P < .001$; Table 1).

Male Versus Female Ratio

In infants with a flat cranial region, the prevalence of males was 66.7%. In the group of infants with otherwise unusual head shapes, the male prevalence was 71.4%, whereas only 53.6% of neonates with normal head shapes were male. However, differences between the 3 groups were not statistically significant.

TABLE 1. TCD in Infants Either With Cranial Flat Area, Otherwise Unusual Head Shape, or Normal Head Shape

| | TCD (mm) | | | |
	n	Mean	SD	P Value
Localized cranial flattening	24	3.96	2.01	.001
Posterior	19	4.74	1.40	.001
Lateral	5	1.00	0.71	<.001
Unusual head shape	17	1.29	0.69	.001
Normal head shape	138	0.88	0.88	.001

SD indicates standard deviation.
Level of significance determined by Pearson χ^2 tests.

Primipara Versus Multipara

The primipara percentage was 62.5% in mothers of children with a flat area and 57.1% in mothers of infants with otherwise unusual head shapes, but only 37.0% mothers of children with normal heads. The differences in parity between these 3 groups were statistically significant ($P = .02$; Table 2).

Mode of Delivery

Forceps or vacuum-assisted deliveries were more frequent in infants with a flat area and other unusual head shapes than in those with normal heads. Out of the 24 infants with head flattening, 9 (37.5%) were born by normal vaginal delivery, 10 (41.7%) by assisted delivery (4 vacuum-assisted and 6 forceps-assisted), and 5 (20.8%) by cesarean section. In the group of neonates with otherwise abnormal head shapes, 8 mothers (38.1%) had a normal vaginal delivery, 8 (38.1%) an assisted vaginal delivery (all vacuum-assisted), and 5 (23.8%) had cesarean section. However, in infants with normal head shape, the percentage of normal delivery was 76.8% and the percentage of cesarean section was 22.5%. Only 1 infant (0.7%) had a forceps-assisted delivery in this group. Using the Pearson χ^2 test, the differences in the modes of delivery were statistically significant ($P < .001$; Table 2).

Length of Labor

Information about the length of first-stage labor, corresponding to the period of regular contractions, and second stage labor, corresponding to active pushing, was obtained from the mothers. Average time for both stages was calculated for the 3 groups. Mothers with scheduled cesarean sections were excluded from both calculations, and mothers who underwent secondary cesarean section were excluded from calculation of the second-stage labor. A longer period of contraction and of pushing was noted for either infants with head flattening or other unusual head shapes, as compared with infants with a normal head shape. The mean time for first stage labor were 17.6 hours in the group of infants with a flat area and 16.1 hours in children with otherwise unusual head shape, as compared with only 10.8 hours in infants with normal head shape. Similarly, the times for second stage labor were as follows: 85 minutes for infants with a flat area and 76 minutes for those with other unusual head shapes, but only 45 minutes for neonates with normal head shape. Both were significant, with $P = .002$ for first-stage and $P = .02$ for second-stage labor (Table 3).

Length, Birth Weight, and Head Circumference

Surprisingly, the infants' length, birth weight, and head circumference did not correlate with presence of a flat area or other unusual head shapes. Infants with a flat area and with other unusual head shapes had slightly lower mean birth weights (3460 g and 3437 g) compared with the mean birth weight of neonates with normal head shape (3535 g), but this was not statistically significant. Heights were very similar in the 3 groups, with at total mean of 50.8 cm,

TABLE 2. Parity and Mode of Delivery in Neonates With Localized Cranial Flattening, Other Unusual Head Shape, or Normal Head Shape

		Parityl			Mode of Delivery		
	n	Primipara	P Value	Vaginal	Assisted	Cesarean Section	P Value
Localized cranial flattening	24	15 62.5%	.02	9 37.5%	10 41.7%	5 20.8%	.001
Unusual head shape	21	12 57.1%	.02	8 38.1%	8 38.1%	5 23.8%	<.001
Normal head shape	138	51 37.0%	.02	106 76.8%	1 0.7%	31 22.5%	.001

Level of significance determined by Pearson χ^2 tests.

TABLE 3. Length of First- and Second-Stage Labor in Infants With Localized Cranial Flattening, Otherwise Unusual Head Shape, or Normal Head Shape

	First-Stage Labor (Hours)			Second-Stage Labor (Minutes)		
	n	Mean	P Value	n	Mean	P Value
Localized cranial flattening	20	17.60	.002	19	85.2	.018
Other unusual head shape	20	16.15	.002	15	76.5	.018
Normal head shape	126	10.85	.002	110	45.4	.018

Level of significance determined by 1-way analysis of variance.

TABLE 4. Unusual Birth Positions and Auricular Anomalies in Infants With Localized Cranial Flattening, Compared With All Other Infants

		Unusual Birth Position	
	n	n	P Value
Infants with localized cranial flattening	24	7 29.2%	NS (.07)
All other infants	159	23 14.5%	

NS indicates not significant.
Level of significance determined by Pearson χ^2 tests.

Unusual Birth Positions

We noted positions other than the most common occipital anterior. Unusual birth positions were found in the 183 single-born infants: occipital posterior ($n = 15$); occipital transverse ($n = 6$); complete and incomplete breech ($n = 4$); compound head and hand presentation ($n = 3$); hand/arm/shoulder presentation ($n = 1$); and mentum anterior ($n = 1$). Among the 3 groups, unusual birth positions were distributed as follows: The percentage of birth positions other than occipital anterior was 29.2% in infants with a flat area, 19.0% in neonates with other unusual head shapes, and 13.8% in those with normal head shape. Thus, an unusual birth position occurred more frequently in infants with head flattening, as compared with the other groups. Analysis with the Pearson χ^2 test showed that when the infants with head flattening were compared with all other neonates, the difference was close to significance ($P = .07$; Table 4).

Auricular Anomalies

Minor auricular deformations were very common (42 of 183 infants), whereas only 5 infants were found to have auricular malformations. Auricular anomalies were found in 10 (41.7%) of 24 infants with a flat area, all of them deformational. The auricular deformations were always on the same side as the flat spot or more accentuated at this side. Among all other infants, only 23.5% had auricular anomalies. The higher prevalence of auricular anomalies in infants with localized cranial flattening, compared with all other infants, was statistically significant ($P = .05$; Table 4).

Other Potential Risk Factors: Torticollis, Cephalohematoma, Oligohydramnios, and Anomalies of Uterus or Birth Canal

Because torticollis is known to be associated with deformational plagiocephaly, we expected to observe torticollis in the neonates with unilateral head flattening. However, torticollis was noted in only 2 infants with a flat area. One infant had right lateral head flattening and obvious ipsilateral torticollis, in combination with multiple other anomalies, including a flexion deformity of the left wrist, a left facial nerve palsy, and a left clavicular fracture. The other infant had right posterior head flattening and minor ipsilateral torticollis.

Of the 24 infants with flat areas, 6 (25%) presented with cephalohematoma. In all of these, the cephalohematoma did not extend over the whole occiput, but was limited to the vertex or the upper occiput, presumably the leading part during birth. Thus, it did not interfere with our transcranial measurements. The prevalence of cephalohematoma in all other neonates, however, was only 6.9% ($n = 11$), suggesting that cranial flattening is associated with cephalohematoma.

A priori reasoning suggests that deformational plagiocephaly might correlate with oligohydramnios. Among the 183 single-born infants, decreased or increased levels of amniotic fluid were recorded in 8 cases; 5 of these (3 oligohydramnios, 2 polyhydramnios) in the category of infants with normal head shape. Unexpectedly, we found 2 cases of polyhydramnios, but only 1 case of oligohydramnios in infants with cranial flattening. Our numbers are too small to draw conclusions from this observation.

The percentage of uterine or birth canal anomalies was 16.7% in mothers whose infants had head flattening, 14.3% in mothers of infants with otherwise unusual head shapes, and 8.0% in those whose infant had a normal head shape, suggesting an association of intrauterine constraint with cranial deformation. However, definitive correlation would require a larger number of cases.

Other types of anomalies ($n = 28$) were found: 22 in neonates with a normal head and 3 each in infants with head flattening and otherwise unusual head shapes. The most frequently noted were shoulder dystocia ($n = 5$), heart murmurs($n = 4$), hydronephrosis ($n = 4$), hip dysplasia ($n = 2$), and club feet ($n = 2$). We did not find a correlation with head flattening and other unusual head shapes.

Twins

We examined 9 pairs of twins, all were dizygotic and diamniotic, with a male versus female ratio of 8:10. Three pairs were delivered vaginally, 6 by cesarean section. Six mothers were primipara.

The prevalence of head flattening in twins was 55.6% ($n = 10$), more than 4 times as frequent as in singletons. Of these 10 infants, 5 presented with a right posterior, 2 with a right lateral and 3 with a left posterior flat area. Thus, preponderant right-sided flattening was noted. These flat areas were well-localized, and in 2 infants the ipsilateral ear was forward. In twins, the TCD of 3 mm was more easily perceived, compared with single-born infants with a flat area. Although most single-born infants with a TCD of 3 mm had normal head shapes, on physical examination, the same TCD of 3 mm was often perceived as a flat area in twins. A possible explanation for this observation could be that multiple-birth infants generally have smaller heads; thus, a smaller degree of asymmetry is more noticeable. The mean TCD in multiple-birth infants with head flattening was 3.40 mm, compared with a mean TCD of 3.96 mm in the group of single-born neonates with a flat area.

In the 10 twins with a flat area, the gender ratio was 1:1. Three were born by normal vaginal delivery, 7 by cesarean section; 6 were delivered as firstborn. Thus, gender, mode of delivery, and parity were similarly distributed as in the population of examined twins. A flat area was found in first-born twins ($n = 6$) and in the second-borns ($n = 4$), and in twins with vertex presentation ($n = 7$) and breech presentation ($n = 3$). Associated deformational anomalies were observed in 4 twins with a flat area: Two of these presented with clubfeet—1 with a small jaw and 1 with an auricular deformation.

Otherwise unusual head shapes were noticed in 3 multiple-birth infants, including cephalohematoma, dolicocephaly, and frontal bossing ($n = 1$).

When all 18 twins were compared with all singletons, twins were found to have a higher TCD: 2.33 mm in twins versus 1.33 mm in singletons. This difference was statistically significant ($P < .01$; Table 5).

TABLE 5. TCD in All Twins, Compared With All Singletons

		TCD (mm)		
	n	Mean	SD	P Value
Twins	18	2.33	1.88	.009
Singletons	179	1.34	1.50	

SD indicates standard deviation.
Level of significance determined by 1-way analysis of variance.

DISCUSSION

This study suggests that congenital, localized flattening of the occiput or the posterior parietal cranium is a precursor of posterior deformational plagiocephaly. Many of the findings in neonates with localized flat areas are the same as in infants with fully expressed posterior deformational plagiocephaly diagnosed at a later age:

1. Boys are more commonly affected. In our study, we found a male versus female ratio of 2:1. In infants with posterior deformational plagiocephaly, predominance of males is uniformly reported, with gender ratios between 3:1[5] and 3:2.[31] Possible explanations include that males have larger heads than females and that male fetuses are less flexible than females, which makes them more susceptible to deformational anomalies.[29] We did not find that head circumference differed between infants with normal and flat heads. This discrepancy is probably explained by our small numbers.

2. Cranial flattening is more frequently observed on the right side. In our study, right-sided flattening was present in 54%, left sided flattening only in 41%, corresponding to observations in infants with deformational plagiocephaly.[5,11] One possible reason for the higher incidence of right-sided flattening might be the preponderance of the left occipital anterior presentation at birth. In this position, the infant's right occiput is compressed against the maternal pelvic bone and the left forehead against the lumbosacral spine. Also postnatally, the infant's head is rarely straight in the midline, and infants turn their head to the right side in nearly 80%, according to Volpe.[32] Thus, preponderance of right-sided flattening is not surprising.[33]

3. We assumed that, similar to infants with fully expressed deformational plagiocephaly, neonates with localized head flattening have an increased risk of having other deformational anomalies. Our study showed a significant association between cranial flattening and auricular deformations, both commonly observed in neonates. We found other deformational anomalies as well, such as hip dysplasia, club feet, and mandibular hypoplasia, but our population was too small to make a definite statement about a statistically significant correlation. With regard to torticollis, there is an unresolved controversy over which is the primary disorder: cranial asymmetry or torticollis, or are both congenital anomalies.[1,2,33–35] In our craniofacial unit, we observed torticollis in 64% of infants with frontal deformational plagiocephaly[7] and in 26% of children with posterior deformational pos-

terior plagiocephaly.[5] In this study, however, torticollis was only noted in 2 infants (<10%), both of whom had ipsilateral flat areas. Thus, the prevalence of torticollis was much lower in neonates with precursor deformation than in infants with fully developed deformational plagiocephaly. Our study supports the belief that, frequently, torticollis associated with head deformation develops postnatally. Thus, in most cases, torticollis is not the primary anomaly causing cranial asymmetry; rather stiffness of the neck muscles develops secondary to deformational plagiocephaly if the head is permanently tilted toward the "position of comfort." It could equally be argued that neonatal torticollis is a causative factor and often missed in routine examination. We relied not only on the pediatricians, but also our study examiner was alert to the potential finding.

4. Cephalohematoma is a well-known risk factor for posterior deformational plagiocephaly.[29] In infants with localized cranial flattening at birth, we found a much higher incidence of cephalohematoma, compared with all other newborns. If infants with a localized flat area also have a contralateral cephalohematoma, they are even more likely to lie preferentially on the flat area. Thus, they are at very high risk of progression to full deformational plagiocephaly.

5. Both multiple birth and intrauterine constraint have been reported as risk factors for fully expressed deformational plagiocephaly.[30,36] We observed a prevalence of 56% of head flattening in twin births, which is presumably a reflection of intrauterine constraint. The effects of this constraint are discussed controversially. Some authors suggest that compressive and restrictive intrauterine forces cause secondary conformational changes[30] or even fusion of cranial sutures.[36–39] We think that intrauterine constraint acts as a molding force and does not cause true sutural synostosis.[5] This is consistent with the observation that crib positioning or a molding helmet can easily correct cranial flattening.

6. Localized flat areas are more likely to occur with primiparity, assisted delivery, and long labor. All of these conditions have also been identified as risk factors for deformational plagiocephaly[36] and for other deformational anomalies. It is obvious that they cause increased molding, acting on the fetal head during delivery.

We emphasize that a well-localized flat area we observed in our study does not constitute fully developed "neonatal plagiocephaly." However, we suggest that many of these infants with posterior or lateral flattening will likely develop posterior deformational plagiocephaly. In the past, when infants were positioned prone, this common posterior flattening improved spontaneously. The infant with congenital posterior flattening lying supine will prefer to turn the head to the flat side because this position is most comfortable. Thus, congenital occipitoparietal deformation is perpetuated and accentuated by pressure from the mattress. Assuming this

pathogenesis, the term "positional" rather than "deformational" plagiocephaly has some merit, although the precursor to deformation is present at birth. As this flattening is quite subtle, it is frequently overlooked in the neonatal period. This explains why most mothers of infants with deformational plagiocephaly recall that their infant had a normal head shape after birth,[36] and why parents and pediatricians often do not notice deformational plagiocephaly until 2 to 3 months of age.[5]

This study showed a prevalence of 13% of localized cranial flattening in essentially healthy newborn singletons. The incidence of fully developed posterior deformational plagiocephaly in infancy is not known, as there have been no good prospective studies.[40] Data from the 1970s suggest an incidence of 1:300 for occipital plagiocephaly.[41] Given the almost epidemic increase in the problem reported by many craniofacial centers since the 1992 recommendation of the American Academy of Pediatrics, the present incidence is likely much higher. Furthermore, without a prospective study, we cannot predict how many neonates with localized flat areas will develop full deformational plagiocephaly. Nor can we know whether the 13% of newborns with congenital flat areas account for all of the increased incidence. The reasons that we did not do this study are: 1) this would require funding to follow 200 healthy infants; 2) and, more importantly, we had alerted the parents to the cranial flattening and had given instruction to keep the infant's head off the flat area. Therefore, such a study would be scientifically flawed.

Neonates with a gestational age of <36 weeks and neonates who required prolonged intensive care treatment during their first days of life where excluded from our study. Preterm infants, low birth weight infants and seriously compromised neonates, are, however, more likely to have anomalous head shapes than essentially healthy newborns.[42] All pediatricians and neonatologists are familiar with the dolicocephalic head so commonly observed in preterm infants; often called "preemie head." Preterm infants have malleable calvarial bones,[43–46] making them more susceptible to molding forces during birth. In addition, newborns who receive prolonged treatment in the intensive care unit have a higher incidence of neurologic impairment, which is another risk factor for deformational cranial anomalies.[47] Thus, we assume that the true incidence of cranial flattening in all newborn singletons is slightly higher than in the population assessed in this study.

All examined newborns were classified as having either cranial flattening, infants with an unusual head shape, or normal head shape, according to our physical examination. Because the measurements were recorded within 24 to 72 hours of life, it could be argued that the localized flattening we found is a transient phenomenon. However, in our experience, cranial molding improves within hours of birth and resolves within days. Hence, our finding of localized flattening on the second and third days of life is unlikely to be evanescent.

When the anthropometric measurements for these 3 groups were compared, there was, all in all, a very

good correlation between transcranial measurements and physical findings. The mean TCD in infants with a normal head shape was <1 mm and a TCD of 4 mm was, in general, perceived as a posterior flat area. However, a few infants with TCDs of 4 mm had a perfectly normal head shape on physical examination. This is a general problem of anthropometry: the measured difference does not always correlate with the perceived degree of asymmetry.

The few infants whose heads looked completely symmetrical but with a measured TCD of 4 mm should be carefully monitored. However, decisions about treatment should be made according to the perceivable degree of asymmetry, and not based solely on anthropometry.

CONCLUSION

Our study showed that localized areas of cranial flattening can be identified in a significant percentage of grossly healthy neonates. We consider these flat areas to be precursors to posterior deformational ("positional") plagiocephaly. Progression to full deformational plagiocephaly is likely to occur if such an infant continuously lies on the flat side of the head. Thus, we recommend the following:

1. Neonates with occipital flat areas can be easily identified. Parents should be on alert for cranial flattening. If it occurs, the parents should change position in the crib regularly and be certain the infant does not always lie on the flat side of the head.
2. Amendation be made to the recommendations of the American Academy of Pediatrics, acknowledging that the incidence of SIDS has dropped significantly with the supine sleep position. When lying on the back, the infant's head should be turned regularly. As an alternative, the infant could be positioned on either side, with a blanket behind the back. The parents should be instructed to allow supervised "tummy time" while their infant is awake. They should also be told to be cautious about the amount of time their infant spends in a car seat.

These are simple instructions that we consider effective to avoid progression from a localized flattened cranial area to posterior-lateral deformational plagiocephaly. We believe that if both parents and pediatricians paid more attention to the infant's head shape and crib positioning, the high incidence in posterior deformational plagiocephaly would decrease significantly.

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