Palpatory diagnosis of plagiocephaly

Article *in* Complementary Therapies in Clinical Practice · June 2006

DOI: 10.1016/j.ctcp.2005.11.001 · Source: PubMed

3 authors:

Nicette Sergueef
Midwestern University, Chicago, United States

Kenneth E Nelson
Midwestern University, Chicago College of Os…

Thomas Glonek
University of Illinois at Chicago

Complementary Therapies in Clinical Practice (2006) 12, 101–110

ELSEVIER

Complementary Therapies in
Clinical Practice

www.elsevierhealth.com/journals/ctnm

Palpatory diagnosis of plagiocephaly

Nicette Sergueef, Kenneth E. Nelson, Thomas Glonek*

Department of Osteopathic Manipulative Medicine, Midwestern University, 555 31st Street, Downers Grove, IL, USA

KEYWORDS
Osteopathy;
Cranial manipulation;
Plagiocephaly;
Diagnosis;
Somatic dysfunction;
Cranial osteopathy

Summary

Introduction: The term *plagiocephaly*, from the Greek *plagios* (oblique) and *kephalê* (head), means distortion of the head, and refers clinically to cranial asymmetry. Cranial Osteopathy, since it was first proposed, has focussed upon the diagnosis and treatment of birth trauma and cranial asymmetries, and consequently specific therapy for plagiocephalic deformities has been described. Osteopathic manipulation also has been proposed as a treatment for torticollis, a condition associated with plagiocephaly. For these reasons, we decided to look at the mechanics of the occipital bone and the adjacent atlas and bones of the cranial base, in relation to functional plagiocephaly.

Methods: The records of 649 children seen in an osteopathic practice in Lyon, France, were reviewed retrospectively, in compliance with the legal requirements of the Commission Nationale de l'Informatique et des Libertés (CRIL) and the Helsinki accord, for gender, age at presentation, birth history, obstetrical data (breech presentation, vacuum extraction, forceps delivery or Caesarean section), presenting complaint, side of posterior plagiocephaly, side of frontal plagiocephaly, torticollis, motion pattern of the occipital bone upon the atlas, and motion pattern of the spheno-occipital synchondrosis.

Results: We found significant correlations between plagiocephaly (right/left) and primipara ($P = 0.024$), use of forceps ($P = 0.055$) and extractor suction ($P = 0.055$). Correlations were also found between flattening of the occiput (right/left) and lateral strain of the spheno-occipital synchondrosis ($P = 0.002$) and between plagiocephaly (right/left) and occipito-atlantal motion ($P = 0.000$).

Conclusion: We found a significant correlation between the lateral strain pattern of the spheno-occipital synchondrosis and plagiocephaly and between rotational dysfunction of the occiput upon the atlas and the side of posterior plagiocephaly. We suggest that thorough neonatal osteopathic examination can identify individuals predisposed to develop posterior plagiocephaly.

*Corresponding author. Tel.: +1 312 791 4043; fax: +1 708 386 1980.
E-mail address: tglonek@rcn.com (T. Glonek).

1744-3881/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ctcp.2005.11.001

Introduction

The term plagiocephaly, from the Greek 'plagios' (oblique) and 'kephalê' (head), means distortion of the head, and refers clinically to cranial asymmetry. The oldest known example is from Iraq, ca. 45,000 BC, and appears to have been intentionally induced.[1] Clinical interest in cranial asymmetries has increased in the last decade. Prior to 1992, children commonly slept in the prone position, and frontal plagiocephaly was prevalent. Following the 1992 recommendation from the American Academy of Pediatrics, that infants sleep supine to reduce the risk of sudden infant death syndrome, an increased incidence of posterior plagiocephaly has been described.[2] Currently, one of every 60 live births demonstrate some degree of posterior plagiocephaly.[3]

Human beings are bilaterally symmetrical. The more balanced the symmetry, the more beautiful the subject is perceived to be.[4,5] 'The existence of sensory biases for symmetry may have been exploited independently by natural selection acting on biological signals and by human artistic innovation. This may account for the observed convergence on symmetrical forms in nature and decorative art'.[6] The bilateral symmetry of human anatomy has functional as well as aesthetic significance, function follows structure. The cranial asymmetry of plagiocephaly has aesthetic impact and, if left untreated, can lead to: musculoskeletal dysfunction,[3] psychomotor retardation,[7] dysfunction of the nervous system,[8,9] oro-facial developmental problems,[10] ophthalmic dysfunction,[11] ear–nose–throat (ENT) dysfunction,[12] and gastro-intestinal dysfunction.[13]

Severe plagiocephaly is an easily identified clinical deformity, while milder forms of plagiocephaly may go unrecognised, often progressing in severity as time passes. A common misconception that occurs when the plagiocephaly is first recognised is that the problem will resolve naturally. When this does not happen, typically around 6 months,[14,15] treatment is initiated. By this time, however, the skull has grown in the asymmetrical pattern, resulting in a head that is much more recalcitrant to remedy and, therefore, to a favourable outcome.

In either case, the anatomic asymmetry has functional consequences. It is an established clinical deformity that, in severe cases, may have marked social—'10% of affected plagiocephalies may persist as a permanent mild-to-severe cosmetic deformity'[16]—as well as functional consequences. Thus, in all instances treatment is indicated. Moreover, treatment is most efficacious when conducted very early in life (3–4 months, best), preferably before ossification of the synchondroses in the base of the skull. 'The occipital–frontal circumference enlarges 8.3 cm in the first 6 months of life. Between 6 and 18 months, slow brain growth accounts for approximately 0.6 cm of increased head circumference each month'.[16] Thus, the longer one waits, the more the skull becomes organised and the potential for plasticity diminished.

Although originally thought to result from premature sutural closure, plagiocephalies may, or may not, be associated with cranial articular synostoses. It is classified as synostotic when an articular fusion occurs earlier than normal.[17–19] Premature synostosis of one or several cranial sutures is thought to have a genetic or metabolic origin.[20,21] Synostosis of the lambdoid suture, that will result in posterior plagiocephaly (ipsilateral posterior cranial flattening), is rare and represents only 3.1% of all synostoses.[22] The clinical diagnosis of synostotic plagiocephaly is most specifically accomplished by radiological means.

Plagiocephaly without synostosis is classified as functional and must be differentiated from craniosynostosis.[2,23,24] Many categories of functional plagiocephaly have been proposed based upon their theorised aetiologies. Positional and gestational plagiocephalies result from chronic asymmetry of intra-uterine position.[16] Deformational plagiocephaly refers to the forces, pre-partum, perinatal or post-partum, that produce cranial asymmetry.[14,19,22,23,25–28] Postural plagiocephaly results from chronic asymmetry of the infant's post-partum resting posture.[25] Compensational plagiocephaly occurs as the result of another area of cranial deformation.[27] Ocular plagiocephaly is associated with strabismus.[29]

Although the causative factors resulting in functional plagiocephaly remain open for discussion, certain relationships have been clearly documented. The development of plagiocephaly is statistically associated with primipara, premature birth, intrauterine environment[19,25,30]; torticollis[28,31,32]; and supine sleeping position.[2,19,33]

Frontal, or anterior, and occipital, or posterior, plagiocephaly refer to the location of the deformity.[31,32] Although posterior synostotic plagiocephaly is rarely observed, posterior functional plagiocephaly is much more frequently encountered. Presently, the most common type of posterior functional plagiocephaly is associated with occipital flattening on one side and prominence on the other side. This is often encountered with frontal prominence, or bossing, on the same side as the occipital flattening and frontal flattening on the other side. This configuration, when viewed from above, results in a parallelogram deformity of the head.[15,22,28,32,34,35] The ear on the side of the occipital flattening will be displaced slightly anteriorly. Additionally, restriction of neck motion has been reported in 19.5% of cases of plagiocephaly.[2]

The parallelogram cranial shape described in contemporary medical literature[3,23,28,31,32,34] also has been described in the osteopathic literature.[36–38] Osteopathic practitioners diagnose and treat positional asymmetries, such as plagiocephaly, in part by identifying and treating articular motion restrictions. The occipital bone relative to the atlas demonstrates the motions of flexion, extension, rotation, and sidebending. Occipito-atlantal sidebending and rotation occur as coupled motions in opposite directions (sidebending left with rotation right and sidebending right with rotation left).[39]

The cranial base of the child's skull consists of multiple synchondroses.[40] In the osteopathic literature, the spheno-occipital synchondrosis is given great significance and has been described as permitting motion. The identified motion patterns of the spheno-occipital synchondrosis include: flexion, extension, torsion, sidebending-rotation, lateral strain, and vertical strain.[37]

Cranial Osteopathy, since it was first proposed, has focussed upon the diagnosis and treatment of birth trauma and cranial asymmetries, and consequently specific therapies for plagiocephalic deformities have been described.[36,41] Osteopathic manipulation also has been proposed as a treatment for torticollis, a condition associated with plagiocephaly.[42] Because we had access to a large osteopathic paediatric database, based upon the above information, we decided to look at the mechanics of the occipital bone and the adjacent atlas and the bones of the cranial base, in relation to functional plagiocephaly.

We began with a review of rigorously documented clinical records from an established osteopathic practice, originally gathered to study otitis media. A set of variables, including patient demographics, patient history, presenting complaints and findings of specific somatic dysfunctions were entered into a database. When these data were analysed for statistical correlations, strong relationships among patterns of somatic dysfunction and functional plagiocephaly were found. From these a hypothesis emerged proposing that cervical and cranial somatic dysfunction contribute to the development and maintenance of posterior plagiocephaly of nonsynostotic origin.

Methods

Population

A retrospective, serial, diagnostic, clinical, single-centre study of 649 children presenting consecutively at an osteopathic practice in Lyon, France, was performed. Records were reviewed for patient demographics, prenatal and delivery history, general medical history and physical findings, osteopathic structural findings, and osteopathic manipulation performed. This study was performed in adherence to the tenets of the declaration of Helsinki and in compliance with the legal requirements of the Commission Nationale de l'Informatique et des Libertés (CRIL).

Palpatory diagnostic methods

Palpatory diagnosis was performed on the first patient visit, with the child, preferably lying on the examination table, or in the mother's arms. Palpation for somatic dysfunction was done employing very light touch, assessing first the shape of the skull and secondly the patterns of cranial and cervical motion.[43,44]

The motion pattern of the occiput upon the atlas was assessed for somatic dysfunction with the infant supine and the examiner's hands placed under the occiput with the tips of the index fingers laterally at the level of the first cervical vertebra. Occipito-atlantal motions, flexion and extension, rotation right and left, and sidebending right and left were evaluated. Sidebending and rotation of the occiput upon the atlas tends to occur coupled in opposite directions. In this paper, this relationship is identified as sidebending rotation (SR) and is named according to the direction of unrestricted occipital rotation. Therefore, if the occiput is sidebent left and rotated right relative to the atlas, it will be described as SR right, and occipital sidebending right, rotation left is SR left.

The spheno-occipital synchondrosis was examined utilising a vault hold (Fig. 1) in which the examiner's index fingers contact the greater wings of the sphenoid and the little fingers contact the lateral angles of the occiput. Spheno-occipital synchondrosis motions of: flexion and extension, torsion right and left, SR right and left, lateral strain (lateral translation) right and left, and vertical strain (vertical translation) superior and inferior were assessed as described in the osteopathic literature.[37] All of these motions were evaluated in a very gentle manner, such that the application of digital pressure was never greater

Figure 1 The spheno-occipital synchondrosis was examined utilising a vault hold in which the examiner's index fingers contact the greater wings of the sphenoid and the little fingers contact the lateral angles of the occiput. Reproduced with permission from: Nicette Sergueef. *La thérapie cranio-sacrée chez l'enfant*. Paris: Spek éd, 1988.

than the force of the inherent motion of the cranial system being diagnosed.[38] The perception of compliance in one direction indicated the cranial pattern. When the opposite coupled motion was introduced, it resulted in resistance, or a feeling of noncompliance, often with the child manifesting discomfort. The palpated spheno-occipital motion patterns were named, as was occipito-atlantal motion, according to the direction of ease of the induced motions.

Database and statistical analysis

The statistical database consisted of 649 cases, each case being one patient encounter, and 85 clinical variables: (patient demographics) visit date, visit number, previous visit date, surname, given name, address, (birth) month, (birth) year, number of children in family, twins, rank of study child, gender, height, weight; (prenatal and delivery history) multiple birth, difficult conception, pregnancy quality, delivery quality, breech, programmed, epidural anaesthesia, forceps, vacuum, Caesarean; (general medical history and physical findings) chief complaint, fragile health, concomitant pathologies-1, -2, -3, sleep, occurrence, and manifestation of sleep disorders, feeding mode, suckling, bottle, pacifier, pacifier (brand), eyes, otitis present, otitis side, otitis how-many, medical treatment, respiration, crawling; (osteopathic structural findings) cranial rhythmic impulse, occiput movement and quality, sphenobasilar synchondrosis movement and quality, including flexion and extension, lateral and vertical strains, and other sphenobasilar information-1, -2, -3, temporal right and left movement, and quality (with subsets of squamous portion right and left movement and quality, mastoid portion right and left movement and quality, and tympanal portion right and left movement and quality), mandible movement and quality, other spinal findings-1, -2, sacrum movement and quality, ilium right and left movement and quality; (osteopathic manipulation) treatment, when, how many times, for what reason, result.

Statistical analyses were carried out using the SPSS for Windows statistical package (version 10.1, SPSS, Inc., Chicago, IL, USA).[45] Computed statistical determinants consisted of frequencies with descriptive statistics for scalar variables and cross-tabulations for nominal and ordinal data.

Results

Study population

The study group database consists of the clinical visits of children presenting between 24/1/99 and 30/5/00: *N*, 649; age (mo), min 0.30, max 176.42, range 176.12, mean = 24.31; 392 males, 60.7%; 254 females, 39.1%; 3 cases gender not recorded. Of these, 314 (49.1%) were first-born. Table 1 summarises the obstetrical histories. Of the 649 subjects in the database, 442 were delivered with epidural anaesthesia, and 129 had a history of induced obstetrical delivery. There were 112 Caesarean section (17.5% total, 10.9% male, 6.6% female), 78 forceps-assisted deliveries (12.3% total, 7.7% male, 4.6% female), 54 deliveries via vacuum extractor (8.5% total, 4.7% male, 3.8% female), and 29 breech deliveries (4.6% total, 2.9% male, 1.8% female).

Table 1 Obstetrical history ($N = 649$ cases).

Gender	Epidural	Induced	C-section	Forceps	Extractor	Breech
Boys (%)	42.7	12.8	10.9	7.7	4.7	2.9
Girls (%)	26.7	10.8	6.6	4.6	3.8	1.8
Total number	442	129	112	78	54	291
% of total	69.4	23.6	17.5	12.3	8.5	4.7

Table 2 Most common presenting complaints in the 649-case database.

Presenting complaint	Number of cases	Percentages*
ENT	137	21.1
Cranial asymmetry (plagiocephaly)	106	16.3
Torticollis	79	12.1
Colic	54	8.3
Sleep disorders	42	6.4
Nervousness	41	6.3
Constipation	38	5.8
Regurgitation	38	5.8

*% = number of cases/649 × 100.

Presenting complaints

There were 94 separate categories of presenting complaint. The eight most frequently encountered complaints are listed in Table 2. Of these, cranial asymmetry ($N = 106$, 16.3%) and torticollis ($N = 79$, 12.1%) were, respectively, the second and third most common complaints encountered. Consideration of the commonest presenting complaint, 'ENT', a conglomerate of various upper respiratory maladies, was not germane to this study.

Head shape patterns

Occipital bone flattening was observed in 98 cases, or 15.1% of the 649 total cases. (The vast majority of these children (91.7%) were less than 12 months of age). In this occipital-bone-flattening subset, flattening of the occiput was present on the right 51% of the time and on the left 49% of the time. Flattening of the frontal bone was found in 77 cases, or 11.9% of the 649 total cases. In this frontal group, flattening of the frontal was present on the right in 52.0% of the time and on the left in 48.1% of the time.

Palpable motion patterns

A palpably discernible, asymmetric, SR motion pattern of the occipital bone upon the atlas was identified in 591 of 649 cases. SR on the right was found for 331 cases (56.0%), while SR on the left was found for 258 cases 43.7%. Two individuals demonstrated an atypical occipito-atlantal motion pattern (sidebending right coupled with rotation right).

The pattern of the spheno-occipital synchondrosis observed in the 649 study cases is summarised in Table 3. There are five commonly described dysfunctional palpatory patterns involving the spheno-occipital synchondrosis: torsion, SR, lateral strain, vertical strain, and compression.[37] Of these, torsion, SR, and lateral strain are designated left or right sided, while vertical strain occurs in the saggital plane and is subdivided as being either superior or inferior. These patterns may present individually or, as in the case of compression, may be found in combination with one another. Because of these potential combinations, the total percentage reported in Table 3 is greater than 100%.

Under ideal circumstances, the palpable cranial motion pattern should be symmetrical and unencumbered. The sensation of torsion to the left should be equal to the degree of compliance palpable when torsion to the right is induced. Compression of the spheno-occipital synchondrosis results in diminished compliance in all directions and is thought to result in untoward effect by damping the global cranial motion pattern.

Comparisons

The following statistical findings, including valid N's, percentages, and significances are summarised in Table 4. We found a correlation between plagiocephaly (right or left) and primipara ($P = 0.024$). Correlation also was identified between plagiocephaly (right or left) and the use of forceps ($P = 0.055$) and vacuum extractor suction ($P = 0.055$), with a greater incidence of left-sided plagiocephaly in both cases. There was no

Table 3 Frequency of palpable spheno-occipital synchondrosis patterns encountered.

Spheno-occipital synchondrosis patterns	Total (counts)	Left (counts)	Right (counts)	Total (%)	Left (%)	Right (%)
Torsion	272	218	54	41.9	33.6	8.3
Sidebending rotation (SBR)	160	94	66	24.7	14.5	10.2
Compression	50			7.7		
Compression and torsion	87	68	19	13.4	10.5	2.9
Compression and SBR	40	23	17	6.2	3.5	2.6
Lateral strain	212	94	118	32.7	14.5	18.2
Inferior vertical strain	99			15.3		
Superior vertical strain	8			1.2		

Note: Because of the occurrence of more than one pattern in any given individual, the total incidence sums to >100%.

Table 4 Cross-tabulation comparisons; counts presented as percentages of the total valid counts.

Variables compared	Valid *N*	Percent			Significance (two-sided)
Plagiocephaly (R) with primipara	69	% within primipera	#1, 35.9	#2, 63.3	0.024
Plagiocephaly (L) with primipara		% within primipera	#1, 64.1	#2, 36.7	
Plagiocephaly with forceps	69	% within plagiocephaly	L, 10.8	R, 0.0	0.055
Plagiocephaly with vacuum extraction	69	% within right-lateral strain	L, 10.8	R, 0.0	0.055
Plagiocephaly with gender	69	% within right-lateral strain	L, 53.6	R, 46.4	0.227
Plagiocephaly with induced delivery	64	% within plagiocephaly	L, 26.5	R, 20.0	0.542
Plagiocephaly with epidural anaesthesia	69	% within plagiocephaly	L, 64.9	R, 62.5	0.839
Plagiocephaly with Caesarean section	69	% within plagiocephaly	L, 13.5	R, 25.0	0.224
Plagiocephaly with breech delivery	64	% within plagiocephaly	L, 3.1	R, 6.3	0.554
Occipital flattening with lateral strain patterns	39	% within right-lateral strain	R, 72.2	L, 27.8	0.002
		% within left-lateral strain	R, 23.8	L, 76.2	
Plagiocephaly with occipito-atlantal motion	73	% within right plagiocephaly	R, 88.6	L, 23.7	0.000
		% within left plagiocephaly	R, 11.4	L, 76.3	
Occipital rotation with primipara	502	% within occipital rotation	R, 53.8	L, 46.2	0.416
Occipital rotation with gender	586	% within right occipital rotation	M, 61.0	M, 59.6	0.728
		% within left occipital rotation	F, 39.0	F, 40.4	
Occipital rotation with forceps	576	% within occipital rotation	R, 63.5	L, 36.5	0.177
Occipital rotation with vacuum extraction	577	% within occipital rotation	R, 52.1	L, 47.9	0.536
Occipital rotation with induced delivery	492	% within occipital rotation	R, 50.8	L, 49.2	0.135
Occipital rotation with epidural anaesthesia	578	% within occipital rotation	R, 57.2	L, 42.8	0.577
Occipital rotation with Caesarean section	580	% within occipital rotation	R, 56.1	L, 43.9	0.955
Occipital rotation with breech delivery	570	% within occipital rotation	R, 65.2	L, 34.8	0.408
Lateral strain with sleep disorders	199	% within sleep disorders	Y, 49.2	N, 32.9	0.025

correlation between plagiocephaly and gender ($P = 0.227$), induced delivery ($P = 0.542$), epidural anaesthesia ($P = 0.839$), Caesarean section ($P = 0.224$), or breech delivery ($P = 0.554$).

We found correlation between occipital flattening (right or left) and lateral strain pattern of the spheno-occipital synchondrosis ($P = 0.002$). Considering only right-lateral strain, we found 72.2% right flattening, and 27.8% left flattening. Considering only left-lateral strain, we found 23.8% right flattening, and 76.2% left flattening. No significant correlations could be found, however, with the other patterns of spheno-occipital synchondrosis examined.

We found a significant correlation between plagiocephaly (right or left) and the pattern of occipito-atlantal motion ($P = 0.000$). Further, there was a greater statistical count involving SR right with right posterior plagiocephaly (31 cases right, 9 left) and a greater count involving SR left with left posterior plagiocephaly (4 right, 29 left).

There was, however, no correlation between occipital rotation (right or left) and primipara ($P = 0.416$), gender ($P = 0.728$), delivery with forceps ($P = 0.177$), delivery with vacuum extractor ($P = 0.536$), induced delivery ($P = 0.135$), epidural anaesthesia ($P = 0.577$), Caesarean section ($P = 0.955$), or breech delivery ($P = 0.408$).

As an interesting additional observation, the incidence of sleep disorders was found to correlate with the presence of a lateral strain pattern ($P = 0.025$).

Discussion

Plagiocephaly, although associated with a multitude of physical conditions,[3,7–13] commonly presents initially because of parental concern about the aesthetic impact of cranial asymmetry. The importance of early recognition and treatment is established.[14] Moreover, the development of significant clinical sequellae occurs typically after the establishment of functional plagiocephaly, and, therefore, should be prevented by early diagnosis and treatment.

Sleeping supine has been suggested as a cause of posterior plagiocephaly.[2,19,33] This is a logical assumption, because the incidence of posterior plagiocephaly has increased since it was recommended that infants sleep in a supine position. Mothers of children with plagiocephaly frequently state that the deformity was not present at birth. The deformity is often unnoticed until 2–3 months of age, or later. In a separate study of 69 children with plagiocephaly, occipital flattening was initially observed in 35 during the first 2 months of life.[31] These observations from the literature are used to support the hypothesis that cranial shape results from sleeping habits.

Sleeping position alone, however, cannot account for the development of plagiocephaly, otherwise every child who sleeps supine would develop posterior plagiocephaly. This does not occur. There must, therefore, be predisposing or contributory factors involved.

Asymmetry of foetal position has been another proposed explanation for plagiocephaly.[3,23,25,27,28,46] Additionally, forceps and vacuum extractor deliveries are statistically associated with plagiocephaly.[19] Thus, intrauterine posture and birth trauma may explain why examination of infants 24–72 h after delivery ($N = 201$) showed that 13.1% had lateral or posterior flattening.[19]

Cervical motion restriction and torticollis are commonly correlated with plagiocephaly.[2,19,28,31,32] Cervical rotation and preferential head orientation is commonly found to the right in the newborn. It has, however, been proposed that head position preference towards one side beyond the first day can be considered an indication of abnormality. Additionally, it must be noted that post-partum head orientation preference has been shown to have no relationship to intra-uterine position.[47]

Males appear to be at increased risk during labour and pregnancy.[48] In one exception to this general finding, a study on frontal plagiocephaly identified a preponderance of females (76%).[27] Consistent with the majority of reports, we saw more boys than girls with plagiocephaly (61.6%) in this practice.

The majority of authors have reported a greater incidence of right-sided occipital flattening[14,19,23,28,49]; however, in at least one instance, a preponderance of left-sided flattening has been reported.[50] In this study, of the group of subjects exhibiting occipital bone flattening, we found 51% with right flattening and 49% with left flattening. Consistent with earlier studies, we observed correlations between posterior plagiocephaly and both forceps ($P = 0.055$) and vacuum-assisted delivery ($P = 0.055$).[19]

Considering the palpatory diagnosis of somatic dysfunction, we found a significant correlation between the lateral strain pattern effecting the spheno-occipital synchondrosis and plagiocephaly. This can explain the parallelogram shape of the head. It has been proposed that external force applied to one side of the occiput will cause a shearing deformation with contralateral skull changes, including forehead flattening and postero-inferior displacement of the ear.[51] Spheno-occipital synchondrosis ossification does not occur until between the ages of 8 and 20 years.[52–57] It is quite possible, therefore, for the newborn to have strain-pattern mechanics effecting this articulation (Fig. 2).

The bilateral symmetry of human anatomy is ideally associated with bilateral functional

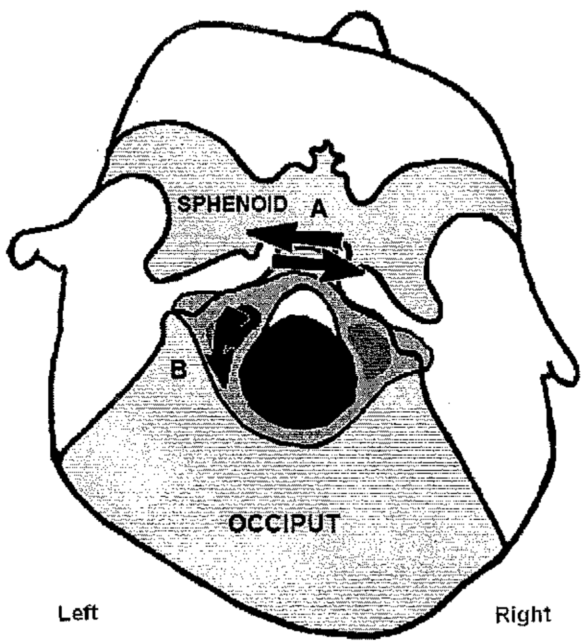

Figure 2 Left posterior plagiocephaly demonstrating the relationship between occipital flattening (left), lateral strain pattern (A) of the spheno-occipital synchondrosis and occipito-atlantal rotation (B) to the left.

symmetry. Cervico-occipital somatic dysfunction prevents the child from turning the head with equal facility in both directions, as should occur by 12 weeks of age.[58] Neural mechanisms responsible for maintaining a midline position of the head, though present at birth, are not functional until later, because of a lack of muscular strength of the neck.[59] Somatic dysfunction results in asymmetry of cervical motion. An occipital dysfunction associated with intrauterine posture or the stresses of the birth process will predispose the infant to a more-preferred position of the head for sleeping and, thus, foster the development of posterior plagiocephaly. It is of interest to note that we also identified a statistical correlation between lateral strain pattern effecting the spheno-occipital synchondrosis and sleep disorders ($P = 0.025$).

The child who remains chronically in the same cervical rotational pattern after 12 weeks of age has a greater chance to incur a plagiocephaly. It has been stated that most of the time parents and paediatricians do not notice plagiocephaly before the age of 2–3 months.[19] The average age to consult has been estimated to be 6.5 months, although parents may have noticed the problem as early as 2 months.[14]

This study provides insight into the contribution of cranial and cervical somatic dysfunction to the development of functional plagiocephaly. The study is limited, however, in that it is a retrospective analysis of serially gathered clinical data.

Conclusion

Thus, it can be concluded that atlanto-occipital somatic dysfunction and/or horizontal strain of the spheno-occipital synchondrosis, the residuum of chronic intrauterine posture or the result of the mechanical stresses of the birth process (particularly as induced by the use of forceps or vacuum extraction) can predispose the infant to assume a preferential head position. The resultant asymmetrical supine sleeping posture will induce or aggravate unilateral occipital flattening, functional plagiocephaly.

From the data presented in this paper, it seems appropriate to add cranial and cervical somatic dysfunction to the list of proposed aetiologies of functional plagiocephaly. The diagnosis of cranial and cervical somatic dysfunction is applicable to the newborn as early as the first hours of life.[38] Early recognition of plagiocephaly is a key factor in treatment. Left untreated, it has been estimated that 2.4% of all children will suffer from restricted range-of-motion and/or flattening of the skull at the age of 2 or 3 years.[60] Early treatment of plagiocephaly may help to prevent secondary dysfunction, such as scoliosis, which has been associated with plagiocephaly and where sleeping supine has been identified as a causative factor.[50,61] We, therefore, suggest that thorough neonatal osteopathic examination may identify individuals predisposed to develop posterior plagiocephaly, thereby providing for the earliest possible intervention.

References

1. Gerszten PC, Gerszten E. Intentional cranial deformation: a disappearing form of self mutilation. *Neurosurgery* 1995;**37**:374–81.
2. Kane AA, Mitchell LE, Craven KP, Marsh JL. Observations on a recent increase in plagiocephaly without synostosis. *Pediatrics* 1996;97(6, Part 1):877–85.
3. Biggs WS. Diagnosis and management of positional head deformity. *Am Fam Physician* 2003;**67**:1953–6.
4. Baudouin JY, Tiberghien G. Symmetry, averageness, and feature size in the facial attractiveness of women. *Acta Psychol (Amst)* 2004;**117**:313–32.
5. Muller A. Chemistry. The beauty of symmetry. *Science* 2003;**300**:749–50.
6. Enquist M, Arak A. Symmetry, beauty and evolution. *Nature* 1994;**372**:169–72.
7. Davis BE, Moon RY, Sachs HC, Ottolini MC. Effects of sleep position on infant motor development. *Pediatrics* 1998;**102**: 1135–40.

8. Miller RI, Clarren SK. Long-term developmental outcomes in patients with deformational plagiocephaly. *Pediatrics* 2000;**105**:E26.
9. Balan P, Kushnerenko E, Sahlin P, Huotilainen M, Naatanen R, Hukki J. Auditory ERPs reveal brain dysfunction in infants with plagiocephaly. *J Craniofac Surg* 2002;**13**:520–5 [discussion 526].
10. Kreiborg S, Moller E, Bjork A. Skeletal and functional craniofacial adaptations in plagiocephaly. *J Craniofac Genet Dev Biol Suppl* 1985;**1**:199–210.
11. Gupta PC, Foster J, Crowe S, Papay FA, Luciano M, Traboulsi EI. Ophthalmologic findings in patients with nonsyndromic plagiocephaly. *J Craniofac Surg* 2003;**14**:529–32.
12. Kemaloglu YK, Goksu N, Ozbilen S, Akyildiz N. Otitis media with effusion and craniofacial analysis-II: 'mastoid-middle ear-eustachian tube system' in children with secretory otitis media. *Int J Pediatr Otorhinolaryngol* 1995; **32**:69–76.
13. Magoun HI. *Osteopathy in the cranial field*, 2nd ed. Kirksville, MO: The Journal Printing Company; 1966. p. 234.
14. Kelly KM, Littlefield TR, Pomatto JK, Ripley CE, Beals SP, Joganic EF. Importance of early recognition and treatment of deformational plagiocephaly with orthotic cranioplasty. *Cleft Palate Craniofac J* 1999;**36**:127–30.
15. Pattisapu JV, Walker NL, Myers GG, Cheever J. Use of helmets for positional molding. *Concept Pediatr Neurosurg* 1980;**9**:178–84.
16. Clarren SK. Plagiocephaly and torticollis: etiology, natural history, and helmet treatment. *J Pediatr* 1981;**98**:92–5.
17. Delaire J. *Les mécanismes de la croissance du squelette facial, dans Orthopédie dento-faciale. Bases fondamentales*. Paris: Julien Prélat; 1975. p. 100.
18. Bridges SJ, Chambers TL, Pople IK. Plagiocephaly and head binding. *Arch Dis Child* 2002;**86**:144–5.
19. Peitsch WK, Keefer CH, LaBrie RA, Mulliken JB. Incidence of cranial asymmetry in healthy newborns. *Pediatrics* 2002; **110**:e72.
20. Cohen Jr MM. Sutural biology and the correlates of craniosynostosis. *Am J Med Genet* 1993;**47**:581–616.
21. Hehr U, Muenke M. Craniosynostosis syndromes: from genes to premature fusion of skull bones. *Mol Genet Metab* 1999;**68**:139–51.
22. Huang MH, Gruss JS, Clarren SK. The differential diagnosis of posterior plagiocephaly: true lambdoid synostosis versus positional molding. *Plast Reconstr Surg* 1996;**98**:765–74.
23. O'Broin ES, Allcutt D, Earley MJ. Posterior plagiocephaly: proactive conservative management. *Br J Plast Surg* 1999; **52**:18–23.
24. Bridges SJ, Chambers TL, Pople IK. Plagiocephaly and head binding. *Arch Dis Child* 2002;**86**:144–5.
25. Dunn PM. Congenital postural deformities. *Br Med Bull* 1976;**32**:71–6.
26. Clarren SK, Smith DW, Hanson JW. Helmet treatment for plagiocephaly and congenital muscular torticollis. *J Pediatr* 1979;**94**:43–6.
27. Bruneteau RJ, Mulliken JB. Frontal plagiocephaly: synostotic, compensational, or deformational. *Plast Reconstr Surg* 1992;**89**:21–31.
28. David DJ, Menard RM. Occipital plagiocephaly. *Br J Plast Surg* 2000;**53**:367–77.
29. Greenberg MF, Pollard ZF. Ocular plagiocephaly: ocular torticollis with skull and facial asymmetry. *Ophthalmology* 2000;**107**:173–8 [discussion 178–9].
30. Shahinian HK, Jaekle R, Suh RH, Jarrahy R, Aguilar VC, Soojian M. Obstetrical factors governing the etiopathogenesis of lambdoid synostosis. *Am J Perinatol* 1998;**15**: 281–6.
31. Pollack IF, Losken HW, Fasick P. Diagnosis and management of posterior plagiocephaly. *Pediatrics* 1997;**99**:180–5.
32. Persing J, James H, Swanson J, Kattwinkel J. Prevention and management of positional skull deformities in infants. *Pediatrics* 2003;**112**(1, Part 1):199–202.
33. Moss ML. The pathogenesis of artificial cranial deformation. *Am J Phys Anthropol* 1958;**16**:269–86.
34. Captier G, Leboucq N, Bigorre M, Canovas F, Bonnel F, Bonnafe A, et al. Etude clinico-radiologique des déformations du crâne dans les plagiocéphalies sans synostose. *Arch Pediatr* 2003;**10**:208–14.
35. Ehret FW, Whelan MF, Ellenbogen RG, Cunningham ML, Gruss JS. Differential diagnosis of the trapezoid-shaped head. *Cleft Palate Craniofac J* 2004;**41**:13–9.
36. Magoun HI. *Osteopathy in the cranial field*. Kirksville, MO: The Journal Printing Company; 1951. p. 203.
37. Magoun HI. *Osteopathy in the cranial field*, 2nd ed. Kirksville, MO: The Journal Printing Company; 1966. p. 133.
38. King HH, Lay EM. Osteopathy in the cranial field. In: Ward RC, editor. *Foundations for osteopathic medicine*. 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2003. p. 993–6.
39. Fryette HH. *Principles of osteopathic technique*. Indianapolis, IN: American Academy of Osteopathy; 1954. p. 147.
40. Williams PL, editor. *Gray's anatomy*. 38th ed. Edinburgh: Churchill Livingstone; 1995.
41. Arbuckle BE. *The selected writings of Beryl E. Arbuckle, D.O., F.A.C.O.P.* Newark OH: American Academy of Osteopathy; 1971. p. 188.
42. Jacquemart M, Piedallu P. Le torticolis 'congénital' est-il simplement un torticolis obstétrical ? *Le concours médical* 1964;**36**:4867–70.
43. Ward RC, editor. In: *Glossary of osteopathic terminology. Foundations for osteopathic medicine*, 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2003. p. 1249–50.
44. 1999 physician ICD 9 CM, International Classification of Disease, 9th revision. *Clinical modification*, vol. 1, 5th ed. Salt Lake City, UT: Medicode; 1998. p. 169.
45. SPSS® Base 10.1 for windows®. *User's guide*. Chicago, Il: SPSS Inc.; 2000.
46. Clarren SK, Smith DW. Congenital deformities. *Pediatr Clin North Am* 1977;**24**:665–77.
47. Vles J, van Zutphen S, Hasaar T T, Dassen W, Lodder J. Supine and prone head orientation preference in term infants. *Brain Dev* 1991;**13**:87–90.
48. Bekedam DJ, Engelsbel S, Mol BW, Buitendijk SE, van der Pal-de Bruin KM. Male predominance in fetal distress during labor. *Am J Obstet Gynecol* 2002;**187**:1605–7.
49. Pople IK, Sanford RA, Muhlbauer MS. Clinical presentation and management of 100 infants with Occipital Plagiocephaly. *Pediatr Neurosurg* 1996;**25**:1–6.
50. Wynne-Davies R. Infantile idiopathic scoliosis, causative factors, particularly in the first six months of life. *J Bone J Surg* 1975;**57-B**:138–41.
51. Bradley JP, Shahinian H, Levine JP, Rowe N, Longaker MT. Growth restriction of cranial sutures in the fetal lamb causes deformational changes, not craniosynostosis. *Plast Reconstr Surg* 2000;**105**:2416–23.
52. Irwin GL. Roentgen determination of the time of closure of the spheno-occipital synchondrosis. *Radiology* 1960;**75**:450–3.
53. Madeline LA, Elster AD. Suture closure in the human chondrocranium: CT assessment. *Radiology* 1995;**196**:747–56.

54. Mann SS, Naidich TP, Towbin RB, Doundoulakis SH. Imaging of postnatal maturation of the skull base. *Neuroimaging Clin N Am* 2000;**10** 1–21, vii.
55. Melsen B. Time of closure of the spheno-occipital synchondrosis determined on dry skulls. A radiographic craniometric study. *Acta Odontol Scand* 1969;**27**:73–90.
56. Melsen B. Time and mode of closure of the spheno-occipital synchondrosis determined on human autopsy material. *Acta Anat* 1972;**83**:112–8.
57. Okamoto K, Ito J, Tokiguchi S, Furusawa T. High-resolution CT findings in the development of spheno-occipital synchondrosis. *Am J Neuroradiol* 1996;**17**:117–20.
58. Hopkins B, Lems YL, van Wulfften Palthe T, Hoeksma J, Kardaun O, Butterworth G. Development of head position preference during early infancy: a longitudinal study in the daily life situation. *Dev Psychobiol* 1990;**23**:39–53.
59. Ronnqvist L, Hopkins B. Head position preference in the human newborn: a new look. *Child Dev* 1998;**69**: 13–23.
60. Boere-Boonekamp MM, van der Linden-Kuiper LT. Positional preference: prevalence in infants and follow-up after two years. *Pediatrics* 2001;**107**:339–43.
61. Magoun Sr HI. Idiopathic adolescent spinal scoliosis: a reasonable etiology (1975). In: Peterson B, editor. *Postural balance and imbalance*. Indianapolis, IN: American Academy of Osteopathy; 1983. p. 94–100 (now available through the American Academy of Osteopathy, Indianapolis, IN).