Deformational Posterior Plagiocephaly: Diagnosis and Treatment

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Objective: **This study was designed to evaluate the effectiveness of helmet therapy (DOC band) in the correction of patients with moderate to severe posterior deformational plagiocephaly.**

Design: **In this prospective study, the infants were evaluated using 18 anthropometric measurements.**

Patients: **The charts of 248 patients seen between August 1, 1995, and July 31, 1999, were reviewed, and 125 met the criteria for inclusion in the study. All the patients had posterior deformational plagiocephaly with no other craniofacial deformities or medical conditions. Treatment was instituted prior to 1 year of age, and all patients were compliant with DOC band usage and had complete anthropometric measurements.**

Results: **The study recorded a 41.56% ($p < .001$) reduction in cranial vault asymmetry and a 40.23% ($p < .001$) reduction in cranial base asymmetry. Orbitotragial asymmetry was improved 18.72% ($p = .0738$). The age at which treatment was begun was not a significant factor in predicting treatment outcomes.**

KEY WORDS: *helmet molding, plagiocephaly, posterior deformation*

Plagiocephaly (Greek plagios = oblique; kephale = head) is a general term used for patients with cranial asymmetry. Deformational plagiocephaly occurs in infants subject to intrauterine constraint and is perpetuated by postnatal positioning (Kane et al., 1996). The rapid increase in the incidence of posterior deformational plagiocephaly has been linked to the American Academy of Pediatrics' (1992) recommendation that sleeping infants be placed in the supine position to avoid the risk of sudden infant death syndrome (Argenta et al., 1996; Turk et al., 1996; Littlefield et al., 1998). The craniofacial skeleton in these infants is characterized by an ipsilateral occipital flattening and frontal bossing. The ipsilateral ear is anteriorly displaced, and there is concomitant contralateral occipital bossing. In patients with moderate to severe posterior deformational plagiocephaly, the ipsilateral cheek is often anteriorly displaced and there is mandibular asymmetry. Uncorrected posterior deformational plagiocephaly may result in permanent craniofacial asymmetries (Mulliken et al., 1999). Prior to 1992, the incidence of the deformity was conservatively estimated at 1 in 300 infants (O'Broin et al., 1999). Current estimates are as high as 8.2% of all live births (Boere-Boonekamp and Linden-Kuiper, 2001). The treatment modalities for deformational plagiocephaly include: nonintervention, head positioning, helmet therapy, surgery, or any combination of these. Helmet therapy is currently the treatment of choice in infants with moderate to severe deformational plagiocephaly. The purpose of this article is to present the authors' experience with the treatment of infants with posterior deformational plagiocephaly.

Materials and Methods

The purpose of this prospective study was to evaluate the effectiveness of helmet therapy using the DOC band (Cranial Technologies, Inc., Phoenix, Arizona) in 248 patients diagnosed with moderate to severe posterior deformational plagiocephaly. The patients were treated at the University of Texas

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TABLE 1 Anthropometric Landmarks*

CIRCUM	A horizontal plane around the head, through the glabella and opisthocranion
EU-L, EU-R	Left or right eurion, the most prominent lateral point on each side of the skull in the area of the parietal and temporal bones
EX-L, EX-R	Left or right exocanthion, the point at the outer commissure of the eye fissure
FT-L, FT-R	Left or right frontotemporale, the point on each side of the forehead, on the slight elevation of the linea temporalis, immediately anterior to the planum temporale that grossly corresponds with the level of the terminal points of the tail of the eyebrow
FZ-L, FZ-R	Left or right frontozygomaticus, the most lateral point on the frontozygomatic suture
G	Glabella, the most prominent midline point between the eyebrows and identical to the bony glabella on the frontal bone
I	A point on the external occipital protuberance at the intersection of the cranial midline with the right and left superior nuchal lines
OP	Opisthocranion, the point situated in the occipital region of the head and most distant from the glabella. It is the most posterior point of the line of greatest head length and is close to the midline on the posterior rim of the foramen magnum.
T-L, T-R	Left or right tragion, the notch on the upper margin of the tragus
V-PO-L, V-PO-R	Vertex (the highest point of the head when the head is oriented in the Frankfort horizontal plane) to left or right porion (the highest point on the upper margin of the cutaneous auditory meatus)

* Data from Farkas, 1981; Kolar and Salter, 1997.

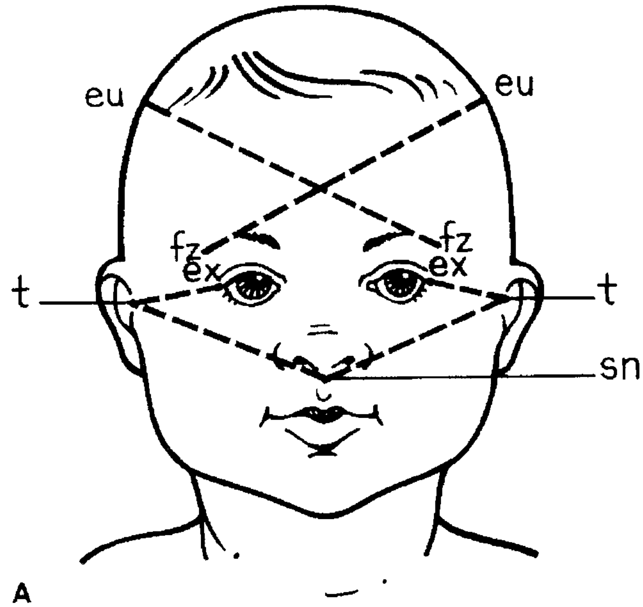

FIGURE 1 Cranial vault symmetry and orbitotragial depth asymmetry. See Table 1 for explanation of measurement points (from Littlefield et al., 1998). fz = frontozygomatic point; eu = euryon point; ex = exocanthion point; t = tragus point; sn = subnasale.

Medical School at Houston between August 1, 1995, and July 31, 1999. On initial evaluation, a detailed medical and birth history was obtained. The parents were questioned about breech positioning and multiple births. In addition, a history of torticollis was also explored. After a complete physical examination of the infant, the exam focused on the child's head shape. The forehead, occiputs, and the position of the ears were noted. Facial asymmetry and the chin point position were also checked. Finally, tightness of the sternocleidomastoid was assessed, and limitation to flexion and rotation on the affected side were noted. In patients with torticollis, flattening of the angle of the mandible and cranioscoliosis were noted.

In children less than 6 months of age, positioning and neck exercises were prescribed and the parents were asked to return for reevaluation at 6 months of age. Children with moderate or severe positional plagiocephaly who failed positioning and were older than 6 months of age were treated with helmet therapy. Initial cranial asymmetry was measured using 18 anthropometric measurements as listed in Table 1 (Farkas, 1981; Kolar and Salter, 1997). These measurements were made with spreading and sliding calipers and a linen measuring tape (GPM Instruments). Cranial vault asymmetry (Fig. 1) was determined by measuring the distance between the left frontozygomatic point and the right euryon point minus the distance between the right frontozygomatic point and the left euryon point. Orbitotragial depth asymmetry was calculated using right exocanthion point to right tragus point (T-R) minus the left exocanthion point to the left tragus point (T-L). Cranial base asymmetry (Fig. 2) was determined using Kolar's method of inion point (I) to right tragus point (T-R) minus I to T-L.

Patients presenting with moderate to severe posterior deformational plagiocephaly requiring helmet therapy were referred to Orthotic and Prosthetic Associates (Woodlands, Texas) at which a plaster of paris impression was taken of the infants's head. The mold was then sent to Cranial Technologies, where a positive mold was created and the DOC helmet fabricated. Initially the patients were followed up at weekly intervals to monitor the cranial remodeling, skin tolerance, and compliance. Anthropometric measurements were obtained at 8-week

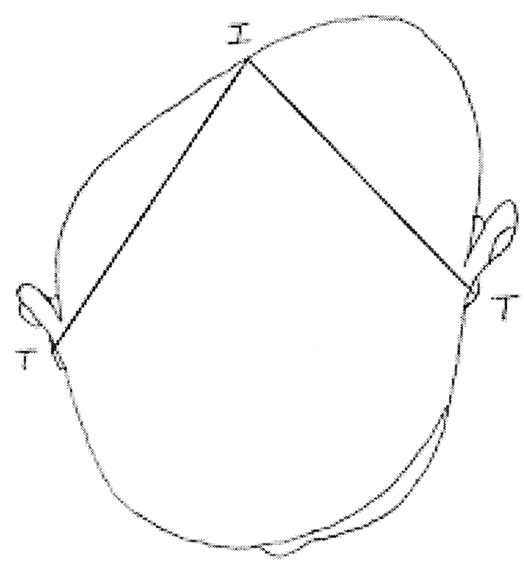

FIGURE 2 Cranial base asymmetry. I = inion; T = tragus (from Ripley et al., 1994).

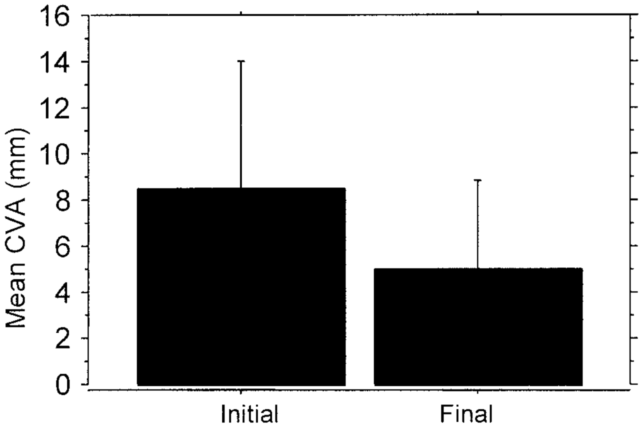

FIGURE 3 Initial and final mean cranial vault asymmetry.

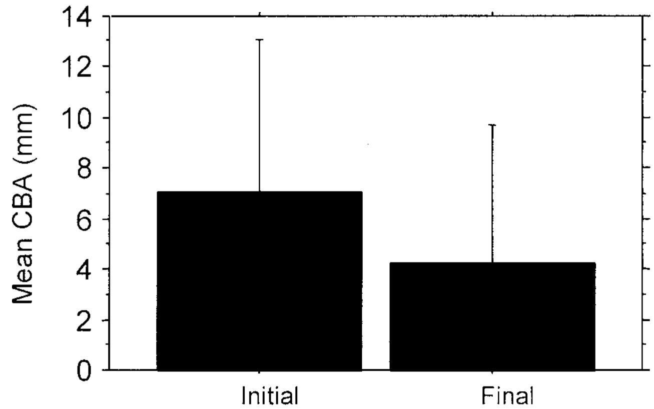

FIGURE 5 Initial and final mean cranial base asymmetry.

intervals to document the patient's progress. Additional measurements were made at the completion of the molding therapy and at 6 and 12 months after treatment.

The patient's demographic data and anthropometric measurements were complied in Microsoft Access 97 database program (Microsoft, Redmond, WA). Means and standard deviations were used to calculate the correction obtained during helmet treatment. Analysis of variance with repeated measures within age groupings was used to determine whether the age of entry was a significant factor in predicting treatment outcomes.

Results

The study included 248 infants with posterior deformational plagiocephaly treated with helmet therapy at the University of Texas Medical School at Houston between August 1, 1995, and July 31, 1999. The number of patients treated with the DOC band rapidly increased over the course of the study. In 1995 two patients (0.81%) were treated, 54 (21.77%) in 1996, 80 (32.26%) in 1997, 69 (27.82%) in 1998, and 43 (17.43%) in 1999. The criteria for inclusion in the study included: (1) absence of other craniofacial deformities or significant medical condition, (2) treatment begun prior to 1 year of age, (3) compliant DOC band usage, and (4) complete anthropometric measurements. There were 125 (50.4%) patients who met the criteria; 77 (61.6%) were male and 48 (38.4%) were female. Treatment was begun at a median age of 5.8 months (SD = 2.1). The study population included 12 (9.6%) patients with a history of prematurity and 10 (8.0%) with a multiple birth history. In addition, the breech position was involved in four (3.2%) infants and congenital torticollis in four (3.2%) infants. Right posterior deformational plagiocephaly was seen in 99 infants (79.2%) and left posterior deformational plagiocephaly was present in 26 infants (20.8%). The average length of treatment was 4.5 months (SD = 1.8).

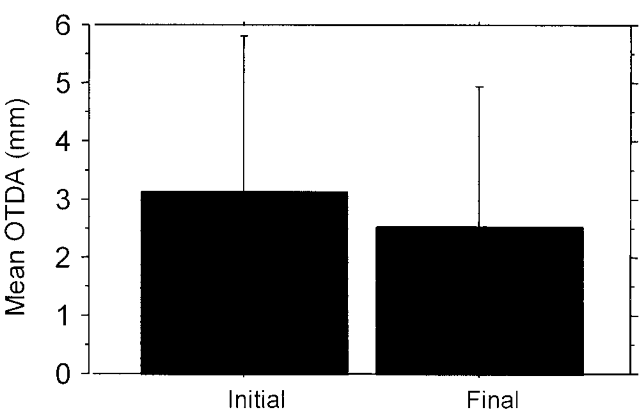

FIGURE 4 Initial and final mean orbitotragial depth asymmetry.

By the end of helmet therapy, the mean pretreatment cranial vault asymmetry of 8.53 mm had significantly ($p = .0002$) decreased to 4.98 mm (Fig. 3). An initial orbitotragial depth asymmetry of 3.12 mm was decreased slightly but not significantly to 2.54 mm (Fig. 4). Finally, the mean pretreatment cranial base asymmetry of 7.08 mm was significantly ($p < .0001$) reduced to 4.23 mm (Fig 5). No skin breakdown was noted in the course of the study.

To evaluate whether there was any relationship between treatment outcomes and the age of treatment, two age groups were employed. Age group 1 consisted of three age categories: 0 to 5 months, 5 to 9 months, and 9 to 12 months. Age group 2 consisted of two age categories: 0 to 6 months and 6 to 12 months. Analysis of variance for repeated measures with an alpha value of 5% was performed on the two age groups. These age groupings were employed to distribute the infants equally in each category. The age at which helmet therapy was instituted did not produce a statistically significant difference in the treatment of cranial vault, orbitotragial depth, and cranial base asymmetries (Table 2).

TABLE 2 Significance of Age Grouping in Asymmetry Correction

	CVA	*OTDA*	*CBA*
Age group 1	$p = .0502$	$p = .9340$	$p = .1093$
Age group 2	$p = .7159$	$p = .8622$	$p = .8393$

Discussion

The mean age at initial diagnosis was 5.8 months, which is similar to previous studies (Ripley et al., 1994), as was the male preponderance (61.6% males and 38.4% females; Littlefield, et al., 1998; O'Broin et al., 1999; Golden et al., 1999; Kelly et al., 1999b). Mulliken et al. (1999) attributed the male preponderance in patients with deformational plagiocephaly to the fact that the male head is larger and grows more rapidly than the female. Male fetuses are also less flexible than female fetuses and, as a result, have more deformational anomalies (Boere-Boonekamp and Linden-Kiiper, 2001).

The predominance of right posterior deformational plagiocephaly (79%) was comparable to Littlefield et al. (1998). However, it was higher than in other reports (Kelly et al., 1999b, with 69%; Mulliken et al., 1999, with 61%; O'Broin et al., 1999, with 60%). O'Broin et al. (1999) stated that right posterior deformational plagiocephaly develops more frequently in newborns because the right occipital and left frontal constraint is seen in 85% of vertex position deliveries (left occipital anterior). He based his explanation on Bruneteau and Mulliken's study (1992) of frontal plagiocephaly.

The incidence of preterm births in this series was 9.6%. Littlefield et al. (1998) reported an incidence of 5.9%. Pollack et al. (1997) and Kane et al. (1996) reported that the incidence of premature births in patients with deformational plagiocephaly was 8.7% and 18.6%, respectively. Breech presentation was noted in 3.2% of the infants, and Kane et al. (1996) reported a figure of 5.9% in their series. In the authors' study, there were 10 (8%) infants with multiple births, which is similar to the 7.7% reported by Kane et al. (1996), Littlefield et al. (1998), and O'Broin et al. (1999).

Congenital torticollis was diagnosed in 3.2% of the patients. This figure was low, compared with Kane et al. (1996), who reported a 15.9% incidence of congenital torticollis. Mulliken et al. (1999) reported a 19% incidence of ipsilateral and an 8% incidence of contralateral congenital torticollis. He suggested that intrauterine deformation is a determining factor in congenital torticollis. Golden et al. (1999) reported a 12% incidence of congenital torticollis and a 64% incidence of sternocleidomastoid imbalance. Finally, O'Broin et al. (1999) cited a 20.5% incidence of congenital torticollis.

It is difficult to compare the authors' results correcting cranial vault asymmetry with other non-DOC studies because many of these reports were subjective (Clarren et al., 1979; Argenta et al., 1996; Turk et al., 1996; Pollack et al., 1997; Moss, 1997; Mulliken et al., 1999; O'Broin et al., 1999; Vles et al., 2000). The present study demonstrated a 41.56% reduction in cranial vault asymmetry (Fig. 3), which is similar to Mulliken et al.'s figure of 41.66%. However, this amount of correction is less than reported in other DOC studies (Ripley et al. 1994, with 55.06%; Littlefield et al., 1998, with 60.24%; Kelly et al. 1999a, with 62.5%; Kelly et al., 1999b, with 60.98%). The age groupings at which molding therapy was begun was not significant in predicting treatment outcomes for cranial vault asymmetry (Table 2). The level of significance of age group 1 ($p = .0502$) was notable, but the distribution of infants within the age categories made this level unreliable (F value = 3.066).

Orbitotragial depth asymmetry was improved only 18.72% (Fig. 4). This correction was less than other DOC molding therapy studies (Ripley et al., 1994, with 61.19%; Littlefield et al., 1998, with 41.97%; Kelly et al., 1999a, with 45.45%; Kelly et al., 1999b, with 44.19%). In addition, the age at which treatment was begun was not significant in predicting treatment outcomes for orbitotragial depth asymmetry (Table 2). This result was probably because of the lack of significance between the age categories within the age groups ($p = .0015$)

Several possible explanations may account for these inconsistent results. The tragus is a mobile point, making it difficult to accurately measure the orbitotragial distance. The short length of this measurement and the inherent error associated with anthropometric measurements amplify any discrepancies. The difficulty of measuring near an infant's eyes results in larger standard deviations. Finally, other DOC studies averaged three repeated measurements, which may have reduced the error associated with this measurement.

DOC helmet therapy resulted in a significant reduction in cranial base asymmetry (Fig. 5). Similar previous studies (Littlefield et al., 1998; Golden et al., 1999; Kelly et al., 1999a, 1999b) have reported 53.97%, 46.52%, 48.39%, and 46.55%, respectively, reduction in cranial base asymmetry. As was the case for cranial vault and orbitotragial depth asymmetries, the age treatment was begun was not significant in predicting treatment outcomes (Table 2). Each of the age groupings had a low F value, making the level of significance unreliable.

Because different measurements for determining cranial base asymmetry were employed, a comparison of the study's cranial base results with those of previous authors is not possible. In this study, the I to the tragus was used to determine cranial base asymmetry. Previous studies referred to above have used subnasale to T-R and T-L. The use of I was designed to reduce the distraction encountered in locating the infant's subnasale point. In addition, because the I is a bony landmark in the region of the greatest asymmetry, it is easily located. The authors felt that the use of I-TR increases the accuracy of this measurement.

Molding therapy in this series was most effective in improving cranial fault asymmetry (40.23%) and was least effective in improving orbitotragial depth asymmetry (18.72%). These findings were similar to previous reports, although the effectiveness of the DOC band in this series was less than previously reported (Littlefield et al., 1998; Golden et al., 1999; Kelly et al., 1999a, 1999b). It is clear that the remodeling process depends not only on the molding helmet but also on the clinician. The effectiveness of the helmet is based on the accuracy of the original plaster of paris impression and the subsequent cranial molding.

Anthropometric measurement is currently the best tool available to objectively evaluate deformational plagiocephaly and its treatment outcomes. The inaccuracies inherent in anthropometric studies can be reduced by other methods of measurement. The use of computer tomography can greatly increase the accuracy of measuring the results of DOC helmet therapy. However, the radiation dosage and the need for sedation in infants make this modality impractical. Three-dimensional photography may eventually prove useful in quantifying the severity of deformational plagiocephaly and its treatment outcomes. Unfortunately, current protocols often fail to reflect the underlying deformity and its correction. However, the current anthropometric measurements are still preferable to individualized protocols used by Moss (1997) and Mulliken et al. (1999). These anthropometric assessments accurately reflect the deformity but are difficult to reproduce, given the variable surface landmarks.

The purpose of this study was to determine the effectiveness of dynamic orthotic cranioplasty in infants with moderate to severe posterior deformational plagiocephaly using anthropometric measurements. Although the DOC band did not significantly correct orbitotragial depth asymmetry, it did significantly correct cranial vault and cranial base asymmetries. The age at which treatment was begun did not have an effect on the amount of correction, which was in contrast to other DOC studies (Littlefield et al., 1998; Golden et al., 1999; Kelly et al., 1999a, 1999b). Future studies are needed to evaluate existing and potential craniofacial asymmetries associated with infants with plagiocephaly.

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