Positional Plagiocephaly: Experience with a Passive Orthotic Mattress

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Abstract: Positional plagiocephaly (deformational or occipital plagiocephaly) is the most common head-shape deformity, which is presented to specialist craniofacial units. The aim of management is to reduce pressure on the affected area in the expectation that brain growth will drive normalization of the head shape. Current management includes a variety of protocols based on repositioning advice or helmet orthotics. The aim of this study is to document changes in head shape associated with use of a passive orthotic mattress for the management of positional plagiocephaly of a series of 30 patients at Alder Hey Children's Hospital between April 2008 and June 2010. Cranial vault asymmetry was assessed before treatment and was classified into mild, moderate, or severe plagiocephaly. Follow-up demonstrated a significant improvement in cranial vault asymmetry in those treated with the passive orthotic mattress.

Key Words: Positional plagiocephaly, deformational plagiocephaly, cranial vault asymmetry, orthotic mattress

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Positional plagiocephaly (PP) (deformational or occipital plagiocephaly) is the most common head-shape deformity, which is presented to specialist craniofacial units. Since 1992 and the introduction of the "Back to Sleep" campaign for the sudden infant death syndrome, there has been an increase in the number referrals of PP to craniofacial units.[1,2] Although the true prevalence remains unknown, estimates of up to 50% have been reported.[3] The etiology of PP may be due to external pressure on a developing skull with the result that a deformational change in the skull occurs in the area of pressure.

Etiological risk factors associated with PP are premature birth, primiparity, male sex, sound sleepers, torticollis, and preferential sleeping side.[3–7]

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The primary clinical importance of PP is the need to distinguish it from synostotic plagiocephaly, which presents clinical challenges.[8] Other factors necessitating referral include high levels of parental anxiety relating to esthetics, development and function, and also, the exclusion of other etiological factors.

The aim of management is to reduce pressure on the affected area in the expectation that brain growth will drive normalization of the head shape. Current management includes a variety of protocols based on repositioning advice or helmet orthotics. Another management option is to use a Sleepcurve mattress, which is a passive orthotic mattress designed to encourage redistribution of pressure on wider area of an infant's occiput by providing a concave surface into which the skull can grow, driven by normal brain growth (Figs. 1A, B; 2A, B).

The aim of this study was to document cranial symmetry before and after use of a Sleepcurve mattress in patients with a diagnosis of PP.

MATERIALS AND METHODS

All patients referred between April 2008 and June 2010 with diagnosis of PP were considered for inclusion in the study. Exclusion criteria included prematurity, age of more than 12 months, evidence of craniosynostosis, ocular or vertebral torticollis, and developmental status inconsistent with use of an orthotic mattress (ie, infants already rolling over at night).

Parents were provided with our unit protocol that includes education about PP and information leaflets detailing traditional advice about repositioning and "tummy time" while awake. When muscular torticollis was identified, physiotherapy was provided. Use of the mattress was offered in addition to the standard unit protocol. Routine follow-up arrangements at 6 months were made.

For the purposes of this study, cranial vault asymmetry (CVA) was assessed using the right and left oblique measurements according to the method of Moss[8] using the Aesculap AA842 cranial calliper. This involves measuring maximum distance from the frontozygomatic sutures on each side to the eurion on the contralateral side and subtracting the smaller from the larger figure giving a numerical value reflecting CVA in millimeters. Severity of asymmetry was classified according to whether it was severe (CVA > 12 mm), moderate (CVA = 6–12 mm), and clinically insignificant (CVA < 6 mm).

Method error analysis was carried out by repeating measurements on 5 patients by the 2 observers with the second measurement taken an hour after the first.

There was a group of 10 patients who also presented with torticollis and whose results were similar to those of the nontorticollis group. Neck physiotherapy is routinely prescribed for such patients, but because no attempt was made to account for this in the improvement in head shape, we have not included those results.

RESULTS

Thirty patients with a mean age of 5 months (range, 2–11 mo) were recruited to the study. There were 9 female infants and 21 male infants. No patients were lost to follow-up (Table 1).

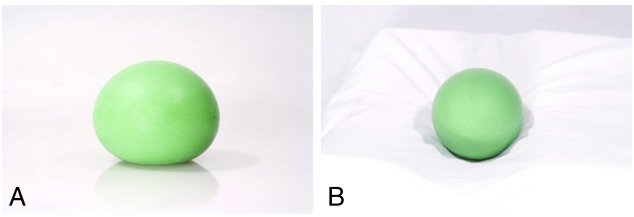

FIGURE 1. Infant's posture on (A) a flat mattress and (B) an orthotic mattress.

The mean asymmetry at the start of treatment was 16 mm (range, 4–28 mm). At the review appointment, all patients except one had a reduction in CVA. There were no patients in whom CVA worsened.

The mean asymmetry at review was 5 mm (range, 0–18 mm). The mean improvement of symmetry was 11 mm (range, 0–25 mm).

Nineteen patients presented with severe asymmetry with a mean CVA of 20.5 mm. At the end of the study period, the mean CVA in this group was 6.85 mm.

Eight patients presented with moderate asymmetry (6 mm < CVA < 12 mm) with a CVA mean of 9.5 mm. At the end of the study period, this had reduced to a mean of 2.75 mm.

The improvement in plagiocephaly was statistically highly significant with a Student's *t*-test, $P < 0.001$.

DISCUSSION

The PP is a clinically important entity. First, it is the commonest head-shape deformity in children with an incidence ranging from 0.3% to 48%,[1,5,10–14] and second, it can be very difficult to differentiate it from the rare synostotic posterior plagiocephaly with the attendant risks of raised intracranial pressure,[9] progressive skull deformity, and facial scoliosis. The increased incidence of PP since the 1992 "Back to Sleep" campaign combined with the difficulty of making a diagnosis and heightening sensitivity to appearance resulted in growing anxiety both on the part of physicians and of parents. This has resulted in an increase in referral rate for PP to UK craniofacial units in the last 2 decades.

The consensus about PP from the 4 UK designated craniofacial centers is that it is a benign, self-limiting condition with no adverse sequelae, especially on development or facial growth. This was reinforced by a position statement from the NHS direct advisory service written in 2008.[14] Nevertheless, demand for management of this condition continues unabated and places demand on limited resources designated, primarily, for surgical management of complex skull vault conditions.

Many treatments have been advocated for PP including repositioning, physiotherapy for torticollis, headbands, helmets, mattress, and rarely, surgery. Some physicians advocate a stepwise treatment such as supervised tummy time and repositioning for infants with moderate asymmetry, reserving helmet therapy for more severe asymmetry.[19] The American Academy of Pediatrics recommends that infants only be placed supine to sleep and that an infant should have at least 30 minutes of supervised tummy time to prevent plagiocephaly and to promote the development of motor skills. A cautionary note is that infants who usually sleep supine but occasionally sleep prone have an 18-fold increased risk of sudden infant death syndrome when sleeping prone.[6]

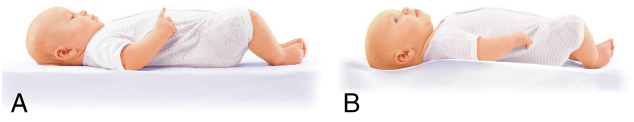

FIGURE 2. Illustration showing a water-filled balloon on (A) a flat surface and (B) in an orthotic mattress. The images mimic the development of deformational plagiocephaly and the mitigating impact of the Sleepcurve mattress.

Repositioning therapy involves parents actively repositioning their child's head off the flattened area and may involve using wedges to prevent them turning back to their affected side. This was the mainstay of treatment in our unit before this study. Repositioning has been shown to be inferior to other techniques when used as the control group for comparison with helmets. Improvement in head shape was noted with repositioning but less so than with the helmet.[18,19]

Helmet therapy involves the customization of a helmet, usually after a three-dimensional scan of the infant's head. This can be an active or passive orthotic device, depending on whether a load is applied to a part of the skull or whether a void is simply formed into which brain growth then drives the skull. Helmet therapy has been strongly advocated by many groups and has had a large amount of attention in the media. However, there are relatively few studies with a control population for comparison of results.[15,18,19] In the study by Steinbok et al,[16] there was minimal difference between the repositioning group and those who used a helmet, although the helmet group had a slightly higher, nonstatistically significant mean asymmetry at the start of the study.

The mattress is designed as a passive orthotic device with a depression in which an infant's head lies. It is designed to encourage redistribution of pressure according to a curved area and, in this way, to minimize the formation of a flat area secondary to a repetitive sleeping

TABLE 1. Patient Demographics and Changes to CVA After 6 Months of Treatment With a Sleepcurve Mattress

Patient	Age, mo	Sex	CVA Pre	CVA Post	Change	Follow-Up, mo
1	2	F	7	1	6	6
2	3	F	5	1	4	6
3	3	M	17	6	11	6
4	3	M	13	2	11	6
5	4	M	11	3	8	6
6	4	M	4	4	0	6
7	4	M	8	2	6	6
8	4	M	12	4	8	5
9	4	M	17	9	8	6
10	4	F	11	0	11	6
11	4	M	17	6	11	7
12	4	F	24	7	17	6
13	4	M	22	2	20	6
14	4	F	24	3	21	7
15	5	F	6	1	5	6
16	5	M	17	11	6	6
17	5	M	18	2	16	4
18	5	M	18	2	16	6
19	5	M	28	8	20	6
20	5	F	23	1	22	6
21	6	M	20	18	2	6
22	6	M	18	12	6	6
23	6	M	10	2	8	6
24	6	M	13	0	13	3
25	6	M	21	4	17	6
26	6	M	28	3	25	6
27	7	M	11	9	2	6
28	8	F	26	18	8	6
29	10	F	21	15	6	6
30	11	M	25	8	17	6
Mean	**5**		**16.5**	**5.5**	**11**	**6**

F, female; M, male; Pre, pretreatment; Post, postreatment.

position. Advantages include low cost, ease of use, availability of multiple mattress sizes, and the ease of compliance on the part of the child. It is possible that the slight extension of the neck redistributes some of the head weight over the shoulders allowing for the free movement of the head.

The main disadvantages of helmet therapy relates to the cost and compliance. A typical treatment program with helmets can be in excess of £2,000 including the need for multiple assessments and refitting. There are also challenges with regard to compliance, as the infant may have to wear the helmet for up to 23 hours a day. Complications of helmet therapy, including dermatitis and pressure sores, are reported at 1%.[4] By contrast, the mattresses have a maximum price of £130 (Sleepcurve) depending on the size, and given the passive nature of the device, compliance is not a problem. Sleepcurve recommends that the mattress is discontinued as soon as the infant starts rolling over primarily because this is the point at which deformational forces naturally become less of a problem. In this series, there have been no complications, and we are not aware of any contraindications to the use of the device. In our unit, some additional indications have arisen, including use in patients where an extended prone period of nursing is expected, typically premature infants, and infants in an intensive care setting, to avoid deformational plagiocephaly. This principle also applies to any neonate or infant with no head movement, as may be the case in neurologic disease or on long-term ventilation.

Our results for the treatment of deformational plagiocephaly with the passive orthotic mattress demonstrated a significant improvement in head shape and compare favorably with other methods of treatment. We found that all patients, except one, showed improvement in asymmetry during the study period and that the mean improvement in CVA was 11 mm, which equated to 68% improvement, moving most patients from the severe (asymmetry) into the minimal asymmetry group with typical expected outcomes, as shown in Figure 3. This result is identical to the 68% of improvement in transcranial difference described by Rogers et al[20] with the use of the modifiable cranial cap and is similar to reported outcomes where helmets were used to treat PP.[19,21]

An important variable in our study related to the ability to reproduce consistent measurements, with specific reference to oblique cranial measurements in children with plagiocephaly due to inherent slope of the skull in the contralateral occipitomastoid region. In addition, lack of compliance in children compounds this problem. To address this, we conducted a method error on the 2 observers involved in the study and found a random scatter of results with up to 5-mm difference in measurements. There was no bias toward 1 observer's higher or lower readings. The scatter was random in the method error assessment, and the mattress study results showed improvement in all patients except one. Therefore, it was judged unlikely that measurement error would significantly affect the overall trend and that the improvements in head shape were true results. Further studies on PP would be enhanced by three-dimensional photographic measurements to improve the accuracy and consistency of results.

In addition, our results represent a series with no control group for comparison. Within the Liverpool craniofacial service, we identified many patients for whom traditional advice of repositioning and tummy time was used. These patients would have been drawn from a separate historical series and, invariably, were older than those for whom an orthotic mattress was deemed to be appropriate and were therefore excluded. Anthropometric measurements in this particular patient group suggested, however, that there were no observed improvements in CVA during the period compared with patients who were treated with the mattress. We would advocate a randomized controlled trial including age-matched mattress and conventional advice patients to further substantiate the findings.

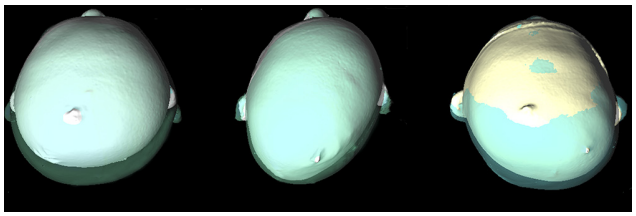

FIGURE 3. Photographs showing pretreatment images with semitransparent superimposed overlay images posttreatment with the orthotic mattress in 3 patients. The green highlighted area demonstrates the extent of posterior calvarial remodeling with rounding of the back of the head and normalization of the axis of the ears. The technique used involved overlay of 3dMD three-dimensional photographs pretreatment and posttreatment, positioned by aligning key landmarks (pronasale and pogonion) for accurate positioning using the Vultus three-dimensional software package and then rotating the entire composite to provide the desired view with shading to demonstrate change in shape.

CONCLUSIONS

Our preliminary study on the use of the passive orthotic mattress indicates that it is an effective low-cost treatment of PP, which avoids many of the compliance issues associated with other treatments. Further studies are needed to elucidate the natural history of PP particularly because some of our historical data collected during our study indicate that patients may deteriorate if they are prescribed repositioning therapy alone. Further studies should incorporate the use of reproducible instrumentation such three-dimensional cameras to minimize the problems of method error.

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