Review

Conservative interventions for positional plagiocephaly: a systematic review

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This review aimed to synthesize current research evidence to determine the effectiveness of conservative interventions for infants with positional plagiocephaly. A systematic review was conducted, where papers were sourced from 13 library and internet databases. Research was included if published in English between 1983 and 2003. Level of evidence and quality of each paper was assessed to determine studies' magnitude of inherent bias. Results were synthesized in a narrative format and were considered with respect to homogeneity of participants, response rate, and outcome measures. Sixteen papers met inclusion criteria: 12 were case series and four were comparative studies. The methodological quality of the studies was moderate to poor, thus their results should be interpreted with caution. A consistent finding was that counterpositioning ± physiotherapy or helmet therapy may reduce skull deformity; however, it was not possible to draw conclusions regarding the relative effectiveness of these interventions. Further investigation is required to compare the effect of helmet therapy with counterpositioning alone or when combined with physiotherapy. First, there is a need to develop an outcome measurement battery which incorporates psychometrically-sound measures from the perspectives of clinicians and patients.

Positional plagiocephaly (sometimes referred to as deformational plagiocephaly or non-synostotic plagiocephaly) is a condition characterized by changes in skull shape and symmetry.[1,2] It typically occurs in infants and results from mechanical factors which, when applied over a period of time in utero, at birth, or postnatally, alter the shape of the skull.[3] Infants may have altered skull shape at birth[4] that is thought to revert to 'normal' in the early post-natal period.[3,5] Therefore, by definition, positional plagiocephaly refers to infants with changes in skull shape who are older than six weeks of age.[6] Their cranial sutures are open and appear normal, and no craniosynostosis is present.[7]

The deformity associated with positional plagiocephaly ranges in location and severity: from bilateral flattening of the posterior cranium (positional brachycephaly) to unilateral occipital flattening, anterior progression of the ipsilateral ear, and various degrees of ipsilateral forehead bossing.[7] Because of the changes in skull shape and symmetry, this disorder causes concern for parents, many of whom seek treatment to reduce skull deformity and improve cosmesis.[8]

Many clinicians adopt a 'wait and see' approach to the treatment of these infants,[9] as positional plagiocephaly does not appear to be associated with long-term physical or cognitive problems.[10] However, when treatment is recommended, conservative interventions are advocated as the sutures of the skull are open and normal.[7] Conservative intervention is defined as 'the management of a patient to combat a disorder or injury, which avoids radical measures and procedures'[11] (such as surgery). In clinical terms, conservative intervention refers to therapies offered by allied health clinicians. For positional plagiocephaly, conservative interventions could include reassurance and education of the parents, counterpositioning, physiotherapy, and helmet therapy.[12]

Counterpositioning involves active repositioning of the child during sleep and play, to apply pressure to the prominent areas of the skull and allow flattened areas of the skull to remodel.[13,14] Physiotherapy may include stretching of tight cervical musculature, and promotion of a variety of positions for play, thereby reducing forces on the flattened areas of the skull.[15] An additional method of promoting skull remodeling is the application of an orthotic helmet. This device applies pressure to the abnormal prominences and provides relief where cranial growth is required.[16,17]

Although a variety of interventions exist to manage infants with positional plagiocephaly, there is no synthesized evidence that directs clinicians to the most effective intervention. As there is an increase and at our centre (Royal Children's Hospital, Melbourne, Australia) in the number of infants presenting for treatment with positional plagiocephaly internationally[3,12,14,15], it is important that the most effective interventions are delivered to all infants. The aim of this investigation was to systematically review all available published literature on the effectiveness of conservative interventions for infants with positional plagiocephaly, in order to make recommendations regarding treatment.

Table I: Study design, quality score, and results of studies

Author	*Study design (hierarchy of evidence[a])*	*Quality score[b]*	*Main findings*
Carson et al.[23]	Case series (IV)	7	Infant age 2–4 mo: 27/28 had good to excellent outcome Infant age 5–6 mo: 20/22 had good to excellent outcome Infant age 7–8 mo: 13/16 had good to excellent outcome Infant age 9–12mo: 2/2 had good outcome *The assistive device is effective in reducing skull deformities in infants with moderate to severe positional plagiocephaly*
David and Menard[24]	Case series (IV)	5	Infants managed with positioning±physiotherapy, deformity was hardly noticeable Infants managed with surgery (following failed positioning±physiotherapy) responded well but had some residual deformity *Positioning±physiotherapy is effective in reducing skull deformity*
Graham and Lucas[25]	Prospective case series (IV)	6	Mild plagiocephaly (n=19): 100% recovered with conservative treatment Moderate plagiocephaly (n=14): 38% recovered with conservative treatment Severe plagiocephaly (n=36): 30 children were treated with helmets and of these 61% recovered *Conservative treatment is effective in treating mild plagiocephaly. Helmet treatment is effective for severe plagiocephaly*
Hellbusch et al.[26]	Retrospective case series (IV)	10	Excellent result: 33% (n=6) Good result: 22% (n=4) Satisfactory result: 33% (n=6) No change: 12% (n=2) *Repositioning is effective in treatment of positional plagiocephaly*
Jalaluddin et al.[27]	Retrospective comparative study (III–2)	3	Asymmetry in orthotic group=5.47mm Asymmetry in non-orthotic group=5.43mm *Repositioning of head and neck stretches are as effective as orthotic devices*
Kelly et al.[28]	Retrospective case series (IV)	10	CVA pretreatment: 8.8mm (SD 3.78), posttreatment: 3.3mm (SD 2.9; p=0.0001) SBA pretreatment: 6.2mm (SD 2.9), posttreatment: 3.2mm (SD 2.0; p=0.0001) OTA pretreatment: 43.4mm (SD 2.2), posttreatment: 2.4mm (SD 2.7; p=0.0001) *Dynamic orthotic cranioplasty decreases skull asymmetry*
Littlefield et al.[16]	Retrospective case series (IV)	7	CVA pretreatment: 8.5mm (SD 4.34), posttreatment: 3.38mm (SD 3.21) SBA pretreatment: 6.17mm (SD 2.98), posttreatment: 3.30mm (SD 2.13) OTA pretreatment: 4.36mm (SD 2.46), posttreatment: 2.53mm (SD 1.90) *Dynamic orthotic cranioplasty is an effective, non-surgical treatment for positional plagiocephaly*
Loveday and de Chalain[14]	Retrospective case series (III–2)	6	ACTIVE COUNTERPOSITIONING (n=45) CVA index pretreatment: 7.3%, posttreatment: 5.4%, Cranial index pretreatment: 88.2%, posttreatment: 86.2% Average management time: 63.7wks HELMETS (n=29) CVA index pretreatment: 8.0%, posttreatment: 6.2%, Cranial vault index pretreatment: 89.6%, posttreatment: 87.8% Average management time: 21.9wks *CVA index and cranial index decreased with active counterpositioning and helmet therapy. Helmets have an outcome comparable to active counterpositioning, although the management period is approximately three times shorter*

[a]National Health and Medical Research Council hierarchy of evidence.[20] [b]Maximum score of 16 indicates excellent quality: Critical Review Form – quantitative studies.[22] CVA, cranial vault asymmetry; OTA, orbitotragial asymmetry; SBA, skull base asymmetry.

Method

DATABASES

Papers which investigated the effects of conservative intervention for infants with positional plagiocephaly were sourced from library and internet databases. First, the Cochrane Library (http://www.update-software.com/publications/cochrane) and the Database of Abstracts of Reviews of Effectiveness (http://www.york.ac.uk/inst/crd/darehp.htm) were searched to determine whether a systematic review on this topic had been recently completed and none was found. Subsequently, 13 databases were searched for quantitative studies on the effectiveness of conservative treatment for positional plagiocephaly. They included MEDLINE, CINAHL, Proquest 5000, ISI Current Contents, ISI Web of Science, Expanded Academic ASAP, ScienceDirect, PubMed, Journals@ovid, Strathclyde, OAISTER, Proquest Digital Dissertation, and Australian Digitial Theses Program.

SEARCH STRATEGY

Because databases have their own search characteristics, search strategies were developed for each database, according to the protocol established by Brettle and Grant.[18] These search

Table I: continued

Author	*Study design (hierarchy of evidence[a])*	*Quality score[b]*	*Main findings*
Moss[13]	Comparative study with historical control (III–3)	5	ACTIVE COUNTERPOSITIONING GROUP (n=66) CVA pretreatment: 9.2mm, posttreatment: 4.7mm HISTORICAL CONTROL (HELMET) (n=46) CVA pretreatment: 8.9mm, posttreatment: 4.0mm Note different landmarks were used for measurement between the two studies *CVA decreased with active counterpositioning and helmet therapy. Active counterpositioning may produce improvements in CVA similar to helmet therapy*
Mulliken et al.[29]	Comparative study (III–2)	10	HELMET GROUP (n=36) Transcranial difference pretreatment: 1.2cm, posttreatment: 0.6 cm ACTIVE COUNTERPOSITIONING (n=17) Transcranial difference pretreatment 1.2cm, posttreatment: 1.0 cm *Infants with helmet therapy had a significantly greater decrease ($p<0.001$) in posterior cranial asymmetry than infants treated by active counterpositioning*
O'Broin et al.[1]	Retrospective case series (IV)	6	n=33 (Response rate 85%) *Significant improvement in parents' perception of severity of deformity with counterpositioning±physiotherapy ($p=0.05$). Eight parents reported no deformities. Most parents reported that their child had a mild deformity*
Pollack et al.[9]	Case series (IV)	8	35 infants with positional therapy+physiotherapy developed normal or near normal appearance after 2–3mo 34 infants with significant residual deformity after conservative treatment received helmet therapy. 29 of these achieved normal or near normal appearance *Good cosmetic results can be achieved in majority of patients with positional plagiocephaly using non-operative modalities*
Ripley et al.[17]	Case series (IV)	4	CVA pretreatment: 8.9mm (SD 3.6), posttreatment: 4.0mm (SD 2.1) CBA pretreatment: 6.3mm (SD 2.9), posttreatment: 2.9mm (SD 1.4) OTA pretreatment: 6.7mm (SD 2.2), posttreatment: 2.6mm (SD 1.1) *Dynamic orthotic cranioplasty corrects positional deformation of cranial vault, skull base and upper face*
Teichgraeber et al.[2]	Case series (IV)	10	CVA pretreatment: 8.53mm, posttreatment: 4.98mm ($p=0.0002$) CBA pretreatment: 7.08mm, posttreatment: 4.23mm ($p<0.0001$) OTA pretreatment: 3.12mm, posttreatment: 2.54mm ($p>0.05$) Age of commencement of helmet therapy did not influence rate of change of asymmetry *Dynamic orthotic cranioplasty significant reduces cranial vault and cranial base asymmetries in infants with moderate–severe deformational plagiocephaly*
Terpenning[30]	Case series (IV)	6	CVA pretreatment: 14.7mm (SD 3.8), posttreatment: 3.6mm (SD 2.8; $p=3.4\times10^{-6}$) SBA pretreatment: 5.2mm (SD 3.5), posttreatment: 2.0mm (SD 0.7; $p=0.004$) OBA pretreatment: 4.7mm (SD 2.6), posttreatment: 1.7mm (SD 1.3; $p=0.002$) *Static orthotic cranioplasty is effective for infants with deformational plagiocephaly*
Vles et al.[31]	Comparative study (III–2)	8	Helmet group (n=85) pretreatment: 4.2, posttreatment: 7.5 Non-helmet group pretreatment: 4.7, posttreatment: 6.3 Mean change between groups: $p<0.0001$ *Improvement was significantly better in helmet group*

strategies are available from the corresponding authors on request. Synonyms were developed for the key terms 'positional plagiocephaly', 'treatment', 'physiotherapy', 'counterpositioning', and 'helmet therapy'. In databases that use subject headings (MEDLINE, CINAHL), key terms and their synonyms were mapped to subject headings. Subject headings, key terms, and their synonyms were all used in the final search strategy. For databases where subject headings were not included, key terms and their synonyms were used in the final search strategy. If possible, truncation symbols were included. All searches were limited to research reports (abstracts or full papers) published in English, over the last two decades (January 1983 to December 2003). This enabled the most relevant, high-quality, and up-to-date evidence to be sourced.[19] In addition, reference lists of papers sourced were searched to identify other papers regarding the effectiveness of conservative intervention for positional plagiocephaly.

REVIEW METHOD

Studies identified from the search process were independently assessed according to inclusion criteria. To be included, studies needed to: (1) have used a quantitative study design; (2) have investigated the effect of conservative interventions for positional plagiocephaly; and (3) have reported results of children under the age of one year, as this is the time when it is recommended that conservative treatment commences.[9,17] Inclusion of studies into this review was reached by consensus between two reviewers (AEB, SMH).

All included studies were critically appraised according to two methods. The first used the National Health and Medical Research Council hierarchy of evidence.[20] This scale ranks studies based on the magnitude of inherent bias contained in their study design.[21] Systematic reviews have the least amount of inherent bias and are ranked at the top of the hierarchy of evidence (level I). This is in contrast to case series, which are considered the least controlled study design, with the most inherent bias and are ranked level IV.[20]

The second approach was to examine the methodological quality of the study using the Critical Review Form – quantitative studies.[22] This tool evaluates internal and external validity of a study and its findings. Reviewers were required to answer 16 closed-ended questions to provide a snapshot of the overall quality of each study.[22] Questions were scored as either a 1 (completely fulfils the criterion) or 0 (does not fulfil the criterion). The scores for these questions were tallied to produce a total score which indicated overall quality of the study. The maximum score of 16 indicated excellent quality.

In addition, a description of all the included studies was undertaken including: number and type of participants; interventions; outcome measures used; time of assessment; and main results. Both reviewers independently extracted all information. Where any disagreement occurred, consensus was reached by discussion. To determine the effectiveness of conservative interventions for infants with positional plagiocephaly, data were synthesized in a narrative format.

Results

NUMBER OF PAPERS SOURCED

The search strategy yielded a total of 976 papers. Of these, 46 papers met inclusion criteria. After removal of papers that were sourced from more than one database, 16 papers were included in this review.[1,2,9,13,14,16,17,23–31]

HIERARCHY OF EVIDENCE

High order study designs, such as systematic reviews of randomized controlled trials, randomized controlled trials, and pseudo-randomized controlled trials, were not used to investigate the effects of conservative interventions for positional plagiocephaly. Most of the studies ($n=12$) used a case series

Table II: Methodological quality of papers sourced

Studies	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*Total*
Carson et al.[23]		+	+		+								+	+	+	+	7
David and Menard[24]			+		+	+							+		+		6
Graham and Lucas[25]	+	+	+										+	+	+		6
Hellbusch et al.[26]	+	+	+		+					+		+	+	+	+	+	10
Jalaluddin et al.[27]	**+**					**+**									**+**		**3**
Kelly et al.[28]	+		+	+	+	+					+	+	+	+	+		10
Littlefield et al.[16]		+	+		+			+					+		+	+	7
Loveday and de Chalian[14]	+				+			+				+	+	+			6
Moss[13]					**+**							**+**	**+**	**+**	**+**		**5**
Mulliken et al.[29]	**+**				**+**			**+**		**+**	**+**	**+**	**+**	**+**	**+**	**+**	**10**
O'Broin et al.[1]	+	+	+		+						+					+	6
Pollack et al.[9]	+	+			+					+		+	+	+	+		8
Ripley et al.[17]		+	+							+			+				4
Teichgraeber et al.[2]	+	+	+		+						+	+	+	+	+	+	10
Terpenning[30]	+	+	+							+	+	+					6
Vles et al.[31]	**+**	**+**	**+**		**+**						**+**	**+**	**+**	**+**	**+**		**9**
Mean total																	7 (SD 2.3)

Critical Review Form – quantitative studies.[22] **Bold** text indicates comparative studies. 1, Purpose clearly stated; 2, Literature review relevant; 3, Research design appropriate to answer aims; 4, No bias introduced into study; 5, Sample described in detail; 6, Sample size justified; 7, Informed consent gained; 8, Used reliable outcome measures; 9, Used validated outcome measures; 10, Intervention described in detail; 11, Results reported in terms of significance; 12, Analysis appropriate; 13, Clinical importance reported; 14, Conclusions appropriate; 15, Clinical implications reported; 16, Acknowledgement of limitations of the study.

design to report the effects of conservative interventions (Table I).[1,2,9,14,16,17,23–26,28] This type of study design lacks a comparison group.[20] Thus, these studies should be interpreted with care, as they may be the result of factors other than the treatment administered, such as the natural history of the disorder, co-interventions, measurement error, or chance.[20,21]

Only four authors[13,27,29,31] used a comparative study design (Table I), where the effect of helmet therapy was compared with that of counterpositioning ± physiotherapy. Although this is a more robust study design,[20] considerable biases were present. For example, there was no randomization of participants to the intervention groups. Rather, allocation to intervention groups was based on either parents'[29,31] or clinicians'[27] treatment preferences. In addition, Moss[13] compared the results of neck stretching and head positioning to a historical control of infants who received helmet therapy four years previously. However, the same anatomical landmarks for anthropometric measurements were not used in both arms of the study.[13] As the study designs of the papers sourced were low on the hierarchy of evidence, this indicates that considerable biases were present within each study.

METHODOLOGICAL QUALITY

The methodological quality of the papers sourced was moderate to poor, with the average quality score being 7 (standard deviation [SD] 2.3) from a maximum of 16 (Tables I and II). Quality scores ranged from 3[27] to 10[2,26,28,29], with six studies scoring at least 8 out of 16.[2,9,26,28,29,31] Study quality was slightly higher, on average, in the studies that used a case series design, compared with those that were comparative in nature (mean quality score was 7.1, SD 2.0, compared with 6.5, SD 3.1 respectively).

Although some studies scored highly on methodological quality, very few studies fulfilled criteria 4 (no bias introduced into the study), 6 (sample size justified), 7 (informed consent gained), 8 (used reliable outcome measures), and/or 9 (used validated outcome measures; see Table II). In most studies, treating clinicians assessed the intervention result using outcome instruments that had no documented evidence of validity or reliability.[1,2,9,13,17,23–27,30,31] Moreover, six studies had affiliations with orthotic companies,[16,17,28–31] which may have biased results. None of the authors provided a statistical justification of the sample sizes used, although three authors justified sample size in pragmatic terms.[24,27,31] Informed consent was not documented in any of the papers reviewed.

EFFECTIVENESS OF CONSERVATIVE INTERVENTIONS

The conservative interventions investigated consisted of various types of counterpositioning ± physiotherapy[1,2,9,10,13,14,23–27,29] and helmet therapy[2,9,13,14,16,17,25,27–31] (Table III). In most papers, counterpositioning and physiotherapy were described briefly and often did not contain information about the specific techniques used or their frequency and duration. Not all participants who were treated with counterpositioning received physiotherapy and scant information was provided regarding the indications for physiotherapy referral.[1,2,9,13,14,23–27,29] Helmet therapy was also variably described, and could consist of a headband or dynamic orthotic cranioplasty. Only three authors provided information regarding the method of manufacture of the helmet[9,17,29] and no information was provided regarding helmet cost. Potentially, these factors could influence management decisions, due to resource implications. Moreover, the interventions described by most of the authors could not be replicated in clinical practice.

Although the results of the sourced studies should be interpreted with caution (due to low order study designs and poor to moderate methodological quality), trends were present regarding the effectiveness of conservative interventions for infants with positional plagiocephaly. The evidence from case series suggests that counterpositioning ± physiotherapy could be effective in reducing skull deformities[1,9,23–26] (Table I). Graham and Lucas[25] suggest that counterpositioning is particularly effective in infants with mild plagiocephaly.

It also appears that helmet therapy could be effective in reducing skull deformities in infants with positional plagiocephaly (Table I),[2,16,17,28,31] particularly in infants with moderate to severe deformities.[2] These trends are consistent, despite the variable age of participants, method of diagnosis of positional plagiocephaly, severity of plagiocephaly, response rate, and outcome measures used to determine effectiveness (Table III).

When outcomes of the comparative studies were synthesized, relative effectiveness of different types of conservative interventions was less clear. Mulliken et al.[29] and Vles et al.[31] concluded that helmets are more effective than counterpositioning because they 'correct' the deformity more rapidly than other conservative interventions. Both of these studies have moderate quality, scoring 10 and 8 respectively on the Law et al.[22] scoring system (Table I). These findings contrast with the results gained by Moss[13] and Jalaluddin et al.,[27] who concluded that counterpositioning is as effective as helmet therapy (Table I). Although these studies are of lower methodological quality (scoring 5 and 3 respectively), their results are supported by the results of a moderate quality case series.[14]

The discrepancy of results could be explained by a number of factors. None of the authors stated the exact age at which treatment commenced (Table III). The ability of the skull to remodel its shape may be effected by age,[9,17] and this factor may vary between studies. The diagnosis of positional plagiocephaly was variable, being made by radiological investigation,[13,29] radiological and clinical evaluation,[31] or the method was not stated.[27] Moss[13] conducted a study on infants with mild to moderate plagiocephaly, whereas Jalaluddin et al.,[27] Mulliken et al.,[29] and Vles et al.[31] did not state the severity of the disorder (Table III). Therefore, clinicians cannot be certain that a homogeneous population was recruited, and this may affect comparison of results between studies.

In general, sample sizes of the comparative studies were large (mean 204, SD 170, range 66–447), and response rates were fair (mean 68%, SD 23; range 47–100%); these were similar to case series parameters (mean sample size 199, SD 266, range 12–760; mean response rate 75%, SD 27; range 34–100%; Table III). Response rates may have been inflated by authors who conducted analyses on 'complete' data, which had 100% response rates.[2,9,13,14,24,30] Many of these authors conducted retrospective case series where drop-outs or the collection of incomplete information were not recorded. No author conducted analyses on infants who were lost to follow-up. These infants may have responded differently to the intervention provided which would impact on the conclusions drawn from the results.[32]

Different outcome measures were used to assess the effectiveness of the intervention. Jalaluddin et al.[27] and Moss[13] evaluated cranial vault asymmetry, Mulliken et al.[29] measured transcranial difference, and Vles et al.[31] assessed parents'

perceptions of their child's skull deformity. Anthropometric measurements, which are assessed by the clinician, may provide a different perspective on the skull deformity when compared with the perceptions of parents.[33]

When outcome measures were pooled from all the reviewed studies, it was found that there is no criterion standard outcome measurement for infants with positional plagiocephaly. Approximately half the authors used various anthropometric measures, such as cranial vault asymmetry,[2,13,14,16,17,27,28,30] skull base asymmetry,[2,16,17,28,30] orbitotragial asymmetry,[2,16,17,28,30] as well as cranial and transcranial difference.[29] Only three authors provided evidence of the accuracy/reliability of their measures.[14,16,29] Thus, in most cases it was not known whether the observed change was greater than the measurement error, therefore influencing interpretation of results.[34] Other outcome measures used included clinicians'[9,23] or parents'[1,9,27,31] rating of infants' skull asymmetry (no consistency on the measurement scales was used) or visual inspection of photographs.[24] Graham and Lucas[25] did not describe the method used to evaluate the effect of the intervention provided. No author combined anthropometic measures with measures of the parents' perceptions of skull deformity. Therefore, the degree of skull deformity or any change in deformity associated with treatment was difficult to ascertain.

Discussion

The search strategy yielded a moderate number of conservative intervention studies for infants with positional plagiocephaly. Potentially, all possible research on positional plagiocephaly may not have been sourced. However, we adhered to systematic review guidelines which aim to reduce the likelihood of omitting evidence, by searching a large number of databases.[35,36] Therefore, it is unlikely that recently published evidence regarding the treatment of positional plagiocephaly was omitted from this review.

The effectiveness of conservative treatment for positional plagiocephaly was uncertain due to the low order of study designs. In addition, most studies had moderate to poor methodological quality as measured by the Law et al.[22] critical appraisal tool. It is acknowledged that different quality results may have been found if a different appraisal tool had been used.[34] However, the tool by Law et al. was chosen as it is standardized, in that it contains instructions for the interpretation of its items. This is in contrast to many other critical appraisal tools. [37]

Based on the low order study designs, moderate to poor quality of evidence, variable outcome measures, and lack of substantial information provided by the authors, it was not possible to combine the results of the study sourced in a meta-analysis.[20,21] Therefore, the results were synthesized in a

Table III: Participants, interventions, and outcome measures used

Author	*Age, y*	*Diagnosis*	*Severity*	*Sample size, n*	*Response rate, %*	*Treatment*
Carson et al.[23]	<1	Clinical	Moderate to severe	122	56	Assistive device (made of foam) worn at night
David and Menard[24]	<2	Radiological	Mild to severe	202	100	Counterpositioning ±physiotherapy or surgery if positioning had failed
Graham and Lucas[25]	–	–	Mild to severe	69	81	Conservative therapy or helmet therapy if conservative treatment failed
Hellbusch et al.[26]	–	Clinical	Mild to severe	28	64	Counterpositioning for 3mo
Jalaluddin et al.[27]	–	–	–	447	68	Orthotic treatment (headband or helmet)
Kelly et al.[28]	<1	–	–	756	34	Dynamic orthotic cranioplasty
Littlefield et al.[16]	–	–	–	760	38	Dynamic orthotic cranioplasty
Loveday and de Chalain[14]	–	Radiological	–	74	100	Orthotic helmet
Moss[13]	–	Radiological	Mild to moderate	66	100	Neck stretching and head positioning
Mulliken et al.[29]	–	Radiological	–	114	47	Positioning therapy ± physiotherapy (if torticollis was present)
O'Broin et al.[1]	<1	Radiological	–	39	85	Sleep position correction ± physiotherapy (if diagnosed with torticollis)
Pollack et al.[9]	<1	Radiological	–	71	100	Positional therapy ± physiotherapy (infants with torticollis) for 2–3mo
Ripley et al.[17]	<1	–	–	124	14–40	Dynamic orthotic cranioplasty
Teichgraeber et al.[2]	<1	–	Moderate to severe	125	100	Positioning and neck exercises: infants <6mo of age
Terpenning[30]	<1.5	–	–	12	100	Static orthotic cranioplasty
Vles et al.[31]	–	Clinical, radiological	–	187	56	Helmet therapy (parents chose treatment)

CVA, cranial vault asymmetry; OTA, orbitotragial asymmetry; SBA, skull base asymmetry; –, not stated.

narrative format to identify trends regarding the effectiveness of conservative interventions for positional plagiocephaly.

It appears that counterpositioning ± physiotherapy or helmet therapy may have beneficial effects at reducing positional plagiocephaly. However, little information was provided regarding the description of treatment, therefore limiting replication. In addition, the cost of helmet therapy, which could potentially range from a few hundred to many thousands of Australian dollars, was not included and could affect the type of treatment chosen by clinicians and/or parents. At present, clinicians cannot seek guidance from the literature when treating infants with positional plagiocephaly regarding specific treatment techniques, frequency of treatment, and duration.

There were conflicting results when comparing the relative effectiveness of these interventions. This may be due to the lack of comparative studies ($n=4$), which used potentially variable participants (varying in age, severity of positional plagiocephaly, method of diagnosis), lack of analysis on dropouts, and different outcome measures. In addition, there was no randomization of participants to treatment groups. Thus it is not known whether the changes observed from the intervention were above that of natural recovery. Based on these results, it is not possible to recommend the most effective conservative intervention for infants with positional plagiocephaly.

This systematic review highlighted that there is no criterion standard outcome measure to quantify skull shape or the magnitude of skull asymmetry. Various anthropometric variables were frequently used; however, there was little evidence of their validity or reliability. Valid outcome measures are necessary to ensure that skull asymmetry is reflected in the measurements,[38] whereas outcome measures must be reliable to ensure that clinicians take the same measurements in a consistent manner over a period of time.[39] Moreover, it is necessary to ascertain the error associated with measurement, as a true change in status only occurs when the magnitude of change exceeds that of measurement error.[34] Therefore, further research is required to determine the most valid and reliable measures for quantifying skull asymmetry.

Current evidence suggests that positional plagiocephaly is a cosmetic problem.[10] Therefore, outcome measurement should reflect parents' perceptions of the cosmetic appearance of their infants, rather than relying solely on clinically measured physical variables.[40] Four authors included such a measure in their assessment battery[1,9,27,31] but all of these measurements differed in their scale of measurement. Therefore, it appears that further development of these outcome measures is required to quantify changes in skull shape and symmetry.

Table III: continued

Control	*Outcome instruments*	*Time of assessment*
No comparison group	Clinician's observation of head shape	Baseline and at discharge. No time frames stated
No comparison group	Photographs	Baseline and at discharge
No comparison group	–	–
No comparison group	Parents' opinions of head shape, facial characteristics, ear position, pre- and posttreatment	At time of review
Non-orthotic treatment (repositioning of head and neck stretches)	CVA	3–5y follow-up (mean 4y)
No comparison group	CVA, SBA, OTA	6wk intervals
No comparison group	CVA, SBA, OTA	Monthly intervals to 2y of age or at discharge
Active counterpositioning	CVA index and cranial index	Every 3–12mo
Historical control of 46 children treated with helmets in 1994 for plagiocephaly	CVA	At baseline and at 6–8wk intervals until discharge
Helmet therapy	Transcranial difference: long transcranial length – short transcranial length	3mo intervals
No comparison group	Parents' perceptions of severity of deformity on presentation and at follow-up	Baseline and at discharge (minimum 1y)
Helmet therapy for infants in whom positional therapy ± physiotherapy was ineffective	Parents' and clinicians' satisfaction of child's appearance. Least favourable response recorded	At discharge
No comparison group	CVA, SBA, OTA	4–5wk intervals, ending at 24mo of age
Helmet therapy: infants aged >6mo in whom counterpositioning ineffective	CVA, SBA, OTA 12mo post discharge	8wk intervals until discharge, 6 and
No comparison group	CVA, SBA, OTA	Monthly
Non-helmet treatment	Parents' perception of child's skull deformity	Before and after treatment. No time frames provided

Conclusion

Many authors have documented the effect of conservative interventions on infants with positional plagiocephaly. Counterpositioning ± physiotherapy or helmet therapy may reduce skull asymmetry. It was not possible to draw conclusions regarding the relative effectiveness of these interventions because of moderate to poor methodological quality and many potential biases in the studies sourced. Further investigation is warranted to compare the effect of helmet therapy with counterpositioning ± physiotherapy in infants with positional plagiocephaly. However, before this can be undertaken, further work is required to develop an outcome measurement battery which measures valid and reliable variables which are important to both clinicians and patients.

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