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Exploring the newborn head diameters in relation to current obstetric forceps' dimensions: a systematic review

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Condensation

Based on available newborn bipareital and mentovertical diameters, we believe current dimensions of obstetric forceps need reviewing because of their potential contribution to neonatal and maternal injuries.

Contribution to authorship

KMK Ismail: project development, manuscript editing

J Chester: data analysis, manuscript editing

D Yates: data collection, manuscript writing

AQT Ismail: project development, data collection, data analysis, manuscript writing and editing

Abstract

Objective

The aim of this study was to systematically search the literature for studies that reported term neonate head size and shape, in an attempt to determine the most appropriate dimensions for the obstetric forceps.

Study design

We searched the Ovid Medline, Ovid Embase and Ebscohost CINAHL databases from inception to February 2016. We predefined inclusion criteria to identify studies in which head width and length of asymptomatic, term neonates were measured soon after birth using direct, non-photographic methods. A bespoke quality assessment score was used to evaluate the identified studies.

Results

Seven studies were identified which measured head width (biparietal diameter) in 551 neonates; giving a mean value of 94.0mm (range 90.7mm – 95.5mm). We identified one study which measured head length (mentovertical diameter) in 38 neonates; which gave a mean value of 134.5mm (range 129mm – 139mm).

Conclusion

This data, in conjunction with measurements of Neville Barnes' and Wrigley's forceps from our previous study, indicates current obstetric forceps' blades are too long, and close together. Potentially, this could be contributing to neonatal and maternal injuries associated with operational vaginal deliveries.

Keywords

Obstetric forceps; operative vaginal delivery; head width; biparietal diameter; head length; mentovertical diameter; systematic review

Introduction

The Chamberlen family invented obstetric forceps in the 1600's, and since then there have been several hundred versions. Currently, the two most commonly used types in the UK are Neville Barnes' (NBF) and Wrigley's forceps (WF). The latter tends to be used to assist extraction of the head during caesarean section, while NBF (similar in design to the later produced Simpson forceps; more commonly used in the U.S.A.) are reserved for operative vaginal deliveries (OVD). Despite increasing rates of caesarean section and use of vacuum extraction devices, forceps still account for ~7% (1 in 14) of deliveries in England [1].

There are specific situations where OVD tends to be associated with better overall outcomes than caesarean section. A 1996 meta-analysis found that compared to caesarean section, women who delivered vaginally (with or without instrumental assistance) had lower anxiety and increased interaction with their babies, and were more likely to breastfeed [2]. These women also had shorter hospital stay and fewer readmissions [3, 4]. Moreover, women who've avoided a previous caesarean section due to forceps assisted delivery are more likely to deliver vaginally, and also have reduced risk of intrapartum complications in future pregnancies [5, 6]. Indeed, repeat caesarean section is one of the major factors implicated in the increasing rates of surgical delivery [7].

OVD is associated with several maternal and fetal complications. Compared to forceps, vacuum extraction devices are associated with less vaginal and perineal trauma, post-partum haemorrhage and 3rd and 4th degree tears (even in the presence of an episiotomy) [8-11], however results in higher rates of retinal haemorrhage, cephalhaematoma and subgaleal haemorrhage (incidence of 16/10,000 deliveries) [12-14]. Forceps have been linked to scalp lacerations, facial nerve palsy, corneal injury, skull fracture and cervical spine injury, however are also associated with less failure and quicker delivery than vacuum extraction, and hence still regularly used in several countries, e.g. the UK [15]. Nonetheless, given the above, many obstetricians prefer to use vacuum extraction devices than forceps, or perform caesarean sections rather than OVD deliveries in general, in fear of litigation, and the belief that these are safer options [14, 16]. In the

UK, according to the UK National Health Service Litigation Authority report, the total value of claims between 1st April 2000 and 31st March 2010 for OVD was £93,659,223 (approximately £10,000,000 annually) [12].

While some of the aforementioned complications might be inherent to the very process of OVD, or the fetal and maternal circumstances for which OVD was performed; we believe that in the case of forceps deliveries, some of these could be contributed to by their absolute dimensions (the interblade distance corresponds to biparietal diameter at 29 – 31 weeks' gestation), as well as the lack of standardisation in such dimensions between different pairs of forceps, which we have previously reported [17-19]. Therefore, the aim of this study was to systematically search the literature for studies that reported term neonate head size and shape, in an attempt to determine the most appropriate dimensions for the obstetric forceps.

Methods

We searched the Ovid Medline, Ovid Embase and Ebscohost CINAHL databases from inception to February 2016. A search of the Cochrane Database of Systematic Reviews yielded no relevant articles.

The search was designed to capture all articles relating to the measurement of the size or shape of the skull or cranium of the neonate regardless of population, gender, viability or morbidity. No limits in relation to study or publication type, language or date of publication were applied at the database searching stage.

We searched for the subject heading of Cephalometry (selecting the exploded subject) and combined this with a free text search of the terms; Cephalometry, Craniometry, Cephalometric analysis, head circumference measurement or cranial dimension in multiple database fields (including but not limited to) article title, abstract and keywords. We also searched subject headings relating to Anthropometry of the Skull or Head and combined this free text searches for Morphometrics or Morphometry (again combined with the subject headings for skull or head). Finally, subject headings for Infant, Newborn were searched and combined with free text term searches for Newborn or Neonate. These were added to the search to create a set of search results relevant to the research question.

The Medline search was adapted for use with other database (Supplementary Table 1). All references and available abstracts were downloaded into EndNote to allow for identification and removal of duplicate references.

We were particularly interested in two dimensions; head width, or biparietal diameter - BPD (which should correspond to the interblade distance in the closed position), and head length (which should correspond to blade length). The most commonly used dimension for this was the mentovertical diameter, however, in older papers / textbooks the term occipitomental diameter (OMD) was used for the same parameter.

Our inclusion criteria were:

1) Data collection on term, healthy babies (i.e. not syndromic, or with head shape abnormalities, e.g. craniosynostosis)

2) Data collection on head shape / size other than only head circumference

3) Measurements made soon after birth (arbitrarily set at <48 hours)

4) Measurements made by direct method (i.e. using an instrument such as calipers, as opposed to inferring from photographic or radiological methods)

We were aware that with older studies, measurements conducted after vaginal delivery may reflect an excessive degree of moulding not evident in current obstetric practice. Our initial aim was to exclude these studies, however taking into account the difficulty of determining a single date after which it was the norm for intervention in 'prolonged' labour, and the homogeneity between results of older and more recent studies, we decided against this.

We only included studies in which measurements were made soon after birth, since the head shape and size during this time are most likely to reflect that of the unborn baby at the time of applying forceps (i.e. included a degree of moulding). We did not limit our results by country, with the knowledge that anthropometric racial differences would result in a degree of variation of measurements, but this is reflected in the multicultural nature of British society.

Results

A total of 3983 records were identified through database searching (2779 Medline, 1135 Embase, 69 CINAHL) and reduced to 3199 following removal of duplicates. Each title and abstract were assessed by two independent reviewers (AQI and JC) and full articles of all references that were likely to fulfill predefined inclusion criteria were obtained. Any discrepancies were referred to a third party (KMI) for final decision. Full texts of the chosen articles were again assessed by two independent reviewers (AQI and JC) against the same inclusion criteria to obtain a final list. Of the 3199 references identified by database searching, 57 were determined to be of relevance. Fifty of these were later excluded for different reasons (Figure 1), leaving 7 studies that were suitable for data extraction. The quality of included studies was assessed using a bespoke quality assessment scoring system (given the lack of a suitable alternative), including relevant criteria for assessing the accuracy and reliability of newborn head measurements [table 2]. This included mode of delivery, and delay from birth to measurement (loss of impact of head moulding); number of investigators conducting measurements (interoperator variability); and whether any methods were used to assess the accuracy and reliability of measurements (e.g. repeated, or checked by second investigator). This scoring system was not validated, however, no studies were excluded based on the quality score.

Data on head width were available from 7 studies, involving 551 neonates [20-26]. The included studies were from Africa, Europe, UK and USA, and their dates ranged from 1962 to 2009. Four studies specified the type of delivery in their inclusion criteria, and this included caesarean section (elective, or all) and vaginal delivery [20, 22, 25, 26]. In three of the studies measurements were made within 3 hours of birth [20, 24, 26], in one study it was within 24 hours of birth [22], and within 48 hours in the remaining three studies [21, 23, 25]. Taking into account the number of measurements in each study, we calculated a mean BPD of 94.0mm (range 90.7mm – 95.5mm, SD 1.65) [Table 1]. We identified only one study which measured head length, in 38 babies [26]. The study population was from the US, from 1977. The type of delivery was vaginal and elective caesarean section, and measurements were made within one hour of birth.

They found a difference of 10mm between the two types of delivery, but, given the very small sample size - 23 born by vaginal delivery, 15 by elective caesarean section - it is doubtful there was sufficient power to identify significant differences, and as such we only included an averaged figure of 134.5mm [Table 1].

Discussion

Our findings in light of what is already known

The mean BPD calculated in this study (94mm) is near the lower margin for the 50th centile BPD values for term fetuses (37 – 42 weeks gestational age) measured antenatally by Chitty et al. (93.2mm – 99.7mm) and Kurmanavicus et al. (94.2mm – 100.1mm) [18, 19]. We expected this value to be lower due to moulding of the head during labour. Moulding was investigated in the 1970s by Sorbe & Dahlgren on 319 babies assessed immediately following vaginal delivery and three days later [27]. They reported no significant difference in BPD measurements in either their primiparous or multiparous subgroups. This contrasted with the orbitovertical and maxillovertical measurements, which were significantly longer at birth in babies of primiparas compared to multiparas (by 2.6mm), and significantly longer in babies of primiparas at birth compared to the measurements three days later (by 2.1 - 2.4mm), but not so in babies of multiparas. A study by Kriewell et al. also looked at BPD and MVD at birth and day 3 in babies born by vaginal delivery and elective caesarean section [26]. They found a significant difference in both measurements for both groups when comparing day 0 and day 3. However their BPD measurements at birth were not significantly different between babies that had undergone labour compared to those who hadn't, in contrast to the MVD values (which differed by 10mm:– 139mm vs. 129mm respectively). Their MVD values are similar to measurements given in a wide selection of obstetric textbooks (130-140mm – mode: 135mm) [28-39].

Van Pelt's observational study from 1860 provides us with historical data with which we are able to compare our findings [40]. He looked at BPD and OMD in 646 babies. The type of delivery was not specified, but measurements were taken '*after sufficient time allowing any head moulding to resolve*'. While this meant the study did not meet our inclusion criteria, nevertheless, the values for BPD (94.6mm) and OMD (137.8mm) are remarkably similar. Jordaan (1962) averaged the BPD from the work of 35 previous investigators to obtain a value of 93.6mm [22].

All of the above would indicate that if a significant degree of moulding occurs during labour, then it must resolve very quickly before it can be measured (especially for BPD), even when those measurements are taken a few hours after birth. Nonetheless, this is unlikely from a physiological point of view as the quick compression - decompression of the babies head is a known risk for intracranial problems [41, 42]. The more likely alternative is that in modern obstetrics, where an “obstructed labour” is not meant to occur, it is rare that a significant degree of moulding occurs; however when it does, it affects MVD more so than BPD.

Strengths and weaknesses of our study

To our knowledge this is the first systematic review looking at observational data on the size of newborn babies’ heads, other than head circumference. We specifically focused on studies in which BPD and/or MVD were measured because of our aim to utilise this data to examine the appropriateness of obstetric forceps dimensions. Our study utilised a robust research methodology (a comprehensive search strategy, two independent reviewers for studies selection, and quality assessment). The main weakness of our study is the paucity of data, specifically with regards MVD, which is nevertheless an important finding to highlight. Moreover, this potential weakness is ameliorated by the length of time over which our data spans (four decades). Indeed, it is interesting to report the similarity between our results for BPD over that time-frame, and their correlation with more historical data from Van Pelt’s and Jordaan’s study [22, 40], and data on BPD of term fetuses used in modern obstetric practice [18, 19]. Finally, a potential weakness is the exclusion of non-English studies due to financial constraints, however, it is unlikely that significant studies would have been missed because of this.

Impact on future practice / research

When comparing our results with measurements made for Neville Barnes’ and Wrigley’s forceps pairs from our previous study [table 3], we can see that with regards to blade length, some Wrigley’s forceps are up to 31.5mm longer, and Neville Barnes’ forceps up to 42.5mm longer than the mean newborn head length. With regards to the distance between the blades, Neville Barnes’ forceps are up to 21mm smaller, and Wrigley’s forceps up to 26mm smaller than the mean newborn head width. The relationship between the dimensions of currently used Wrigley's and Neville-Barnes forceps we previously reported [17], and the fetal head measurements identified in this study, are demonstrated in Figure 2.

Undoubtedly these discrepancies are important to consider in the context of fetal head compression, fetal soft tissue trauma, blade slippage, and trauma to the vagina and perineum. Despite the limitations of our study, it is possible to utilise such data to review the dimensions of the obstetric forceps to minimise the risk of head compression to a term fetus. Interestingly, these dimensions are almost a combination of Wrigley's blade length and Neville Barnes' interblade diameter (Table 3, Figure 2). However, it is imperative that the impact, if any, of changing forceps dimensions on maternal outcomes should also be rigorously evaluated.

In conclusion, these findings add further weight to our argument that there is room for optimising current obstetric forceps' dimensions to mitigate risk of maternal and neonatal complications in term OVDs. It is also important to highlight that, in current maternity care, moulding does not seem to have a significant impact on fetal head dimensions. However, it is important to interpret our findings with caution due to the limited amount of data identified.

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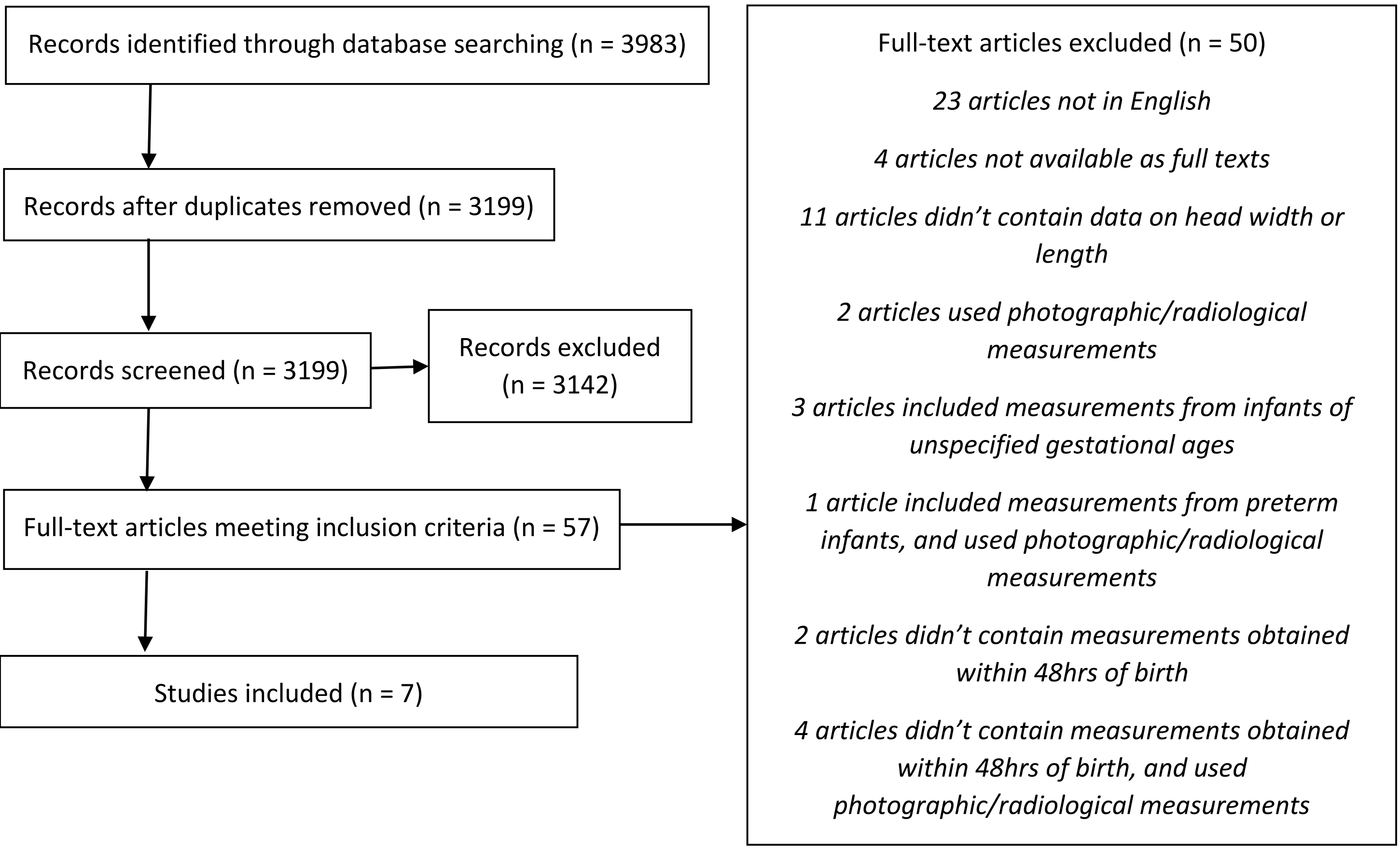
Figure 1: PRISMA flow diagram



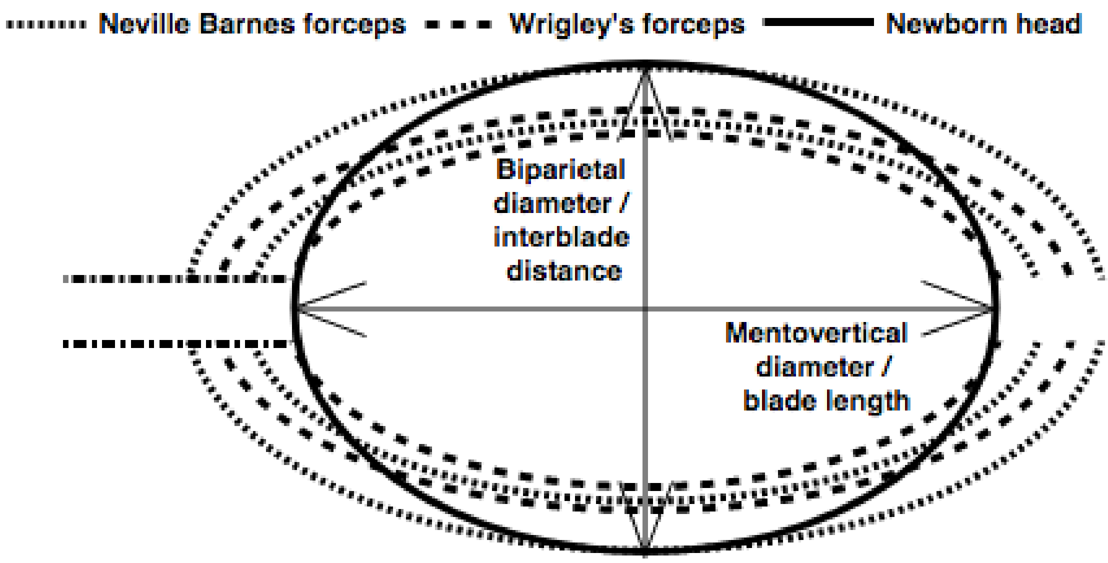


Figure 2: graphical representation (to scale) of the newborn head, superimposed on Neville Barnes and Wrigley's forceps (showing the range in size between smallest and largest dimensions measured for each type [17])

Head Width								
Study		**Year**	**Country**	**Patients**	**Measurement**	**Type of delivery**	**Age at time of measurements**	**Average (mm)**
1	Jordaan et al.	1962	South Africa	100	biparietal diameter	elective caesarean section	<24 hours	91.9
2	De Souza et al.	1976	England	18	biparietal diameter	elective caesarean section	<3 hours	93.6
3	Largo & Duc	1977	Switzerland	30	biparietal diameter		birth	94.0
4	Kriewall et al.	1977	USA	38	biparietal diameter	vaginal delivery and elective caesarean section	<1 hour	93.5
5	Dangerfield & Taylor	1983	England	212	head breadth		<48 hours	95.5
6	Todros et al.	1985	Italy	108	biparietal diameter	caesarean section	<48 hours	94.9
7	Sinha et al.	2014	India	45	head width		24-48 hours	90.7
							Mean	***94.0 (SD 1.65)***

Head length								
Study		**Year**	**Country**	**Patients**	**Measurement**	**Type of delivery**	**Age at time of measurements**	**Average (mm)**
1	Kriewall et al.	1977	USA	38	mentovertical diameter	vaginal delivery and elective caesarean section	<1 hour	134.5
							Mean	***134.5***

Table 1: Measurements of neonatal BPD and MVD from included studies

Studies	Sample size	Mode of delivery specified	Age at which measurement taken	Number of investigators carrying out measurements	Methods used to assess accuracy and reliability of measurements	Quality assessment score total (range 0 – 7)
	• <50 = 0 *• 50-99 = 1* *• 100-149 = 2* *• >150 = 3*	*• No = 0* *• Yes = 1*	*• >24 hours = 0* *• <24 hours = 1*	*• Not specified / >1 = 0* *• 1 = 1*	*• Not specified / none = 0* *• Specified = 1*	
Jordaan et al.	2	1	1	0	0	**4**
De Souza et al.	0	1	1	1	1	**4**
Largo & Duc	0	0	1	0	0	**1**
Kriewall et al.	0	1	1	0	1	**3**
Dangerfield & Taylor	3	0	0	0	1	**4**
Todros et al.	2	1	0	1	1	**5**
Sinha et al.	0	0	0	1	0	**1**

Table 2: Bespoke quality assessment scores for included studies

	Neville Barnes' forceps		Wrigley's forceps		**Possible dimensions of term forceps (mm)**
	Mean measurement (n=50) (mm)	Current manufacturing specifications (n=4) (mm)	Mean measurement (n=50) (mm)	Current manufacturing specifications (n=5) (mm)	
Blade length	163 *(SD=7, range 153 - 177)*	160-170	146 *(SD=5, range 138 - 166)*	130-160	**135 (range 129 - 139)**
Greatest distance between the blades	83 *(SD=4, range 73 - 93)*	85-90	77 *(SD=3, range 68 - 84)*	80-95	**94 (range 91 - 96)**

Table 3: Possible dimensions of obstetric forceps for aiding delivery of term babies based on data identified by our review; compared with measurements of Neville Barnes' and Wrigley's forceps and data from European forceps manufacturers (modified from Table 1 in Ismail & Ismail [17]).