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Research Article

Which Factors Influence the Change of Neonatal Head Shape During the First Week of Life?

Frémondière Pierre[1,2*], Lionel Thollon[3] and François Marchal[2]

[1]Aix Marseille University, School of Midwifery, France

[2]Aix Marseille University, CNRS, EFS, ADES, France

[3]Applied Biomechanics Laboratory (UMR-T24), France

***Corresponding author**: Pierre Fremondiere, UMR 7268 Faculty of Medicine, North Department, CS80011 Bd Pierre Dramard 13344 Marseille Cedex 15., France, Tel: +33 4 91 69 88 90; Fax: +33 4 91 60 80 62; E-mail: pierrefremondiere@yahoo.fr

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Abstract

Aim and scope: The aim of this work is to assess the influence of factors (age at first measurement, timelaps between measurements, sex and birthweight of the neonate, delivery outcome) on the neonatal head shape change, using several cephalometric variables related to birth mechanism.

Materials and Methods: Sixty newborn infants are measured twice, with a timelaps between measurements of ca. 64 hours, and 13 cephalometric variables are considered. Multiple linear regressions with change from baseline are performed because the age at the first measurement is inconstant.

Results: The suboccipitobregmatic diameter is significantly correlated with the age at the first measurement. Only two cephalometric variables are correlated with the timelaps between measurements: the bitragion diameter and the head circumference. The biparietal diameter is significantly correlated with the birthweight, and the mentovertical diameter is significantly correlated with the sex "female". Concerning the delivery outcomes, the suboccipitofrontal diameter is significantly correlated with the caesarean section, and the occipitofrontal diameter is significantly correlated with the Thierry's spatula extraction.

Conclusion: During the first week of life, the shape of the head of newborn infants changes, with the head circumference increasing and the biparietal diameter decreasing. This change could be explained by the antero-posterior reduction of the head during birth. We show that factors such as delivery outcome, birthweight or sex of the neonate could affect the neonatal head shape change. Contrary to previous studies, this work highlights the importance of considering the instrumental extraction when the neonatal head shape change is investigated.

Keywords: birth, cephalometry, head, moulding, newborn, shape

Introduction

During the first week of life, the shape of the head of newborn infants changes from a near circular to an elliptical one [1]. This change of the shape could have different consequences. For example, the head circumference is a classic measurement after birth, but alteration in head circumference could lead to alteration of postnatal head growth estimation [2]. Head could have a positional asymetry when infant lies on one side or the other because the skull bones are separate, and the skull is not rigid [3]. Infants suffering from craniosynostosis could also experience specific skull deformities [4]. The study of the neonatal head shape change could help to understand fetal-pelvic relationship during the birth, since the moulding of the head, as it passes through the birth canal, leads to a "rebound effect" when head returns to its original shape during the first week of life [2,4]. Previous studies focus on the impact of delivery outcomes, gestational age at birth, or breech position on the neonatal head shape change [2,4]. But none of these studies considered the plausible factors of head shape change together in the same regression analysis, with a large number of cephalometric variables. The aim of this work is to study the neonatal head shape change after birth, using several cephalometric variables related to birth mechanism and assess the influence of factors considered together in the same analysis.

Materials and Methods

Sample and foetal variables

The newborn infants studied are singletons of both sexes, without craniosynostosis, born between 37 and 42 weeks of gestational age at St Joseph's Hospital (Marseille, France) from the 29th of March 2011 to the 10 of December 2013. Sixty infants are included in the study. Thirty infants are male and 30 are female. Thirteen cephalometric variables are measured twice (Figure 1). Contrary to previous studies, we consider the mentooccipital diameter, which is the diameter of the head at the inlet where flexion of the vertex is neutral [5] (i.e. bregma presentation which is the most dystocic vertex position). The newborn measurements were performed during the postpartum period using anthropometric tools (a cephalometric compass, a tape mesure). Age at first measurement, timelaps between measurements, and sex of the neonate are noted. The delivery outcome (vaginal birth, caesarean section, Thierry's spatula or vacuum extraction) and birthweight are collected from medical record. This study was approved by the South Mediterranean II Ethical Committee for the Protection of Persons and written informed consent was obtained from the mother and the father.

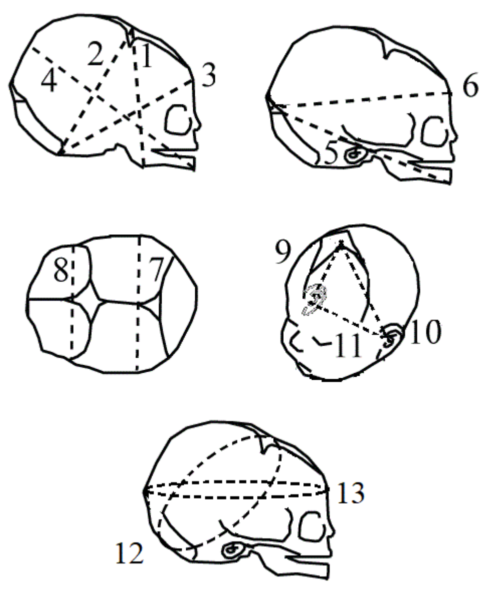

Figure 1: The thirteen cephalometric variables. (1) submentobregmatic (smb) (2) suboccipitobregmatic (sob) (3) suboccipitofrontal (sof) (4) mentovertical (mv) (5) mentooccipital (moc) (6) occipitofrontal (of) (7) biparietal (bip) (8) bitemporal (btem) (9) right tragion-bregma (rtb) (10) left tragion-bregma (ltb) (11) bitragion (btra) (12) suboccipitobregmatic circumference (soc) (13) head circumference (hc)

Statistical analysis

The aim of this work is to assess factors influencing the change of the head shape of newborn infants. The explanatory variables are these factors (age at first measurement, timelaps between measurements, sex and birthweight of the neonate, delivery outcome) and the dependant variables are the difference between two measurements (i.e. the diameters, see Figure 1). Regressions between dependant variables and explanatory variables are performed with multiple linear regressions with change from baseline because age at the first measurement (baseline) is inconstant. Multiple linear regressions are performed in two steps. First, the linear regression between an explanatory variable and a dependant variable adjusted for the baseline is performed (unadjusted model). Then, only variables with a p-value greater than 0,2 are selected for the next step [6]. Secondly, these variables are considered in the regression analysis together (adjusted model or "all things being equals" model). The p-value <0.05 was considered statistically significant. Statistical tests were performed using XLSTAT 2013.1.02 software (Addinsoft, 2013).

Results

The mean age at the first measurement is 10 hours (+11 hours, n=60) and the mean timelaps between measurements is 64 hours (+21 hours, n=60). The mean birthweight is 3373g (+478g, n=60). Twenty-three (38%) infants born by vaginal birth, 11 (18%) born by caesarean section, 6 (10%) born by Thierry's spatula extraction and 20 (33%) born by vacuum extraction. The mean birthweight is 3328g (+489) for males and 3417g (+470) for females. Seven females and 4 males born by caesarean section. Table 1 summarizes the results of the multiple linear regression models with change from baseline for the 13 cephalometric variables. As previously mentioned, the word "diameter" refers to the difference between the first and the second measurement. Table 2 shows that the suboccipitobregmatic diameter is significantly correlated with the age at the first measurement (B=0,058; p=0,008). Only two cephalometric variables are correlated with the timelaps between measurements: the bitragion diameter (B=-0,042; p=0,039) and the head circumference (B=0,056; p=0,047) (Table 3 and 4). Table 5 shows that the biparietal diameter is significantly correlated with the birthweight (B=-0,002; p=0,038), and the mentovertical diameter is significantly correlated with the sex "female" (B=2,764; p=0,025; see Table 6). Concerning the delivery outcomes, the suboccipitofrontal diameter is significantly correlated with the caesarean section (B=2,455; p=0,012 see Table 7), and the occipitofrontal diameter is significantly correlated with the Thierry's spatula extraction (B=2,097; p=0,048; see Table 8).

Table 1: summary of results of the multiple linear regressions with change from baseline for the 13 cephalometric variables

Cephalometric variables	SMB	SOB	SOF	MV	MOC	OF	BIP	BTEM	RTB	LTB	BTRA	HC	SOC
Age at the first measurement	ns	8.10^{-3}	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Timelaps between measurements	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	4.10^{-2}	5.10^{-2}	ns
Weight at birth	ns	ns	ns	ns	ns	ns	4.10^{-2}	ns	ns	ns	ns	ns	ns
Delivery outcomes													
Vaginal birth	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Caesarean section	ns	ns	1.10^{-2}	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Thierry's spatula extraction	ns	ns	ns	ns	ns	5.10^{-2}	ns	ns	ns	ns	ns	ns	ns
Vacuum extraction	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Sex													
Female	ns	ns	ns	2.10^{-2}	ns	ns	ns	ns	ns	ns	ns	ns	ns

Male	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table 2: regression model explaining the change of the value of the suboccipitobregmatic diameter

	Unadjusted regression			
	Coeff	**95% CI**		***p* value**
Constant	_	_	_	_
Age at first measurement	0.058	-0.101	-0.015	0.008
Timelaps between	0.015	-0.009	0.039	0.217
Birthweight	8.10^{-5}	-0.001	0.001	0.861
Vaginal birth	0.506	-0.619	1.631	0.371
Caesarean section	0.785	-0.636	2.207	0.273
Thierry's spatula extraction	1.090	-0.209	2.808	0.209
Vacuum extraction	0	_	_	_
Sex female	0.223	-0.732	1.178	0.641
Sex male	0	_	_	_

Table 3: regression model explaining the change of the value of the bitragion diameter

	Unadjusted regression				**Adjusted regression**			
	Coeff	**95% CI**		***p* value**	**Coeff**	**95% CI**		***p* value**
Constant	_	_	_	_	3.598	0.659	6.536	0.017
Age at first measurement	-0.022	-0.088	0.044	0.515	-0.049	-0.122	0.025	0.189
Timelaps between	0.024	-0.006	0.053	0.112	-0.042	-0.081	-2.10^{-3}	0.039
Birthweight	-0.001	-0.002	0.001	0.295	_	_	_	_
Vaginal birth	-0.232	-1.940	1.476	0.786	-0.011	-1.681	1.659	0.990
Caesarean section	-1.631	-3.790	0.527	0.136	-0.583	-2.899	1.734	0.616
Thierry's spatula	-2.167	-4.777	0.442	0.102	-2.029	-4.563	0.506	0.114
Vacuum extraction	0	_	_	_	0	_	_	_
Sex female	-0.033	-1.515	1.450	0.965	_	_	_	_
Sex male	0	_	_	_	_	_	_	_

Table 4: regression model explaining the change of the value of the head circumference

	Unadjusted regression				**Adjusted regression**			
	Coeff	**95% CI**		***p* value**	**Coeff**	**95% CI**		***p* value**
Constant	_	_	_	_	-8.292	-16.362	0.222	0.044
Age at first measurement	0.013	-0.081	0.106	0.788	0.015	-0.085	0.116	0.716
Timelaps between	0.079	0.031	0.128	0.002	0.056	0.001	0.111	0.047
Birthweight	0.002	-4.10^{-4}	0.004	0.102	0.001	-0.001	0.004	0.240
Vaginal birth	1.405	-0.960	3.769	0.239	1.603	-0.751	3.957	0.178
Caesarean section	3.219	0.231	6.207	0.035	1.376	-1.779	4.530	0.386
Thierry's spatula	-1.671	-5.283	1.941	0.358	-1.452	-4.909	2.005	0.403
Vacuum extraction	0	_	_	_	0	_	_	_
Sex female	1.892	-0.149	3.932	0.069	1.315	-0.646	3.275	0.184
Sex male	0	_	_	_	0	_	_	_

Table 5: regression model explaining the change of the value of the biparietal diameter

	Unadjusted regression				**Adjusted regression**			
	Coeff	**95% CI**		***p* value**	**Coeff**	**95% CI**		***p* value**
Constant	_	_	_	_	6.430	2.316	10.544	0.003
Age at first measurement	0.006	-0.041	0.053	0.79	2.10-3	-0.051	0.051	0.993
Timelaps between	-0.023	-0.049	0.003	0.082	-0.016	-0.044	0.011	0.246
Birthweight	-0.001	-0.003	4.10^{-4}	0.006	-0.001	-0.002	2.10^{-3}	0.038
Vaginal birth	0.578	-0.611	1.767	0.334	0.352	-0.840	1.544	0.556
Caesarean section	-0.828	-2.33	0.675	0.274	-0.091	-1.700	1.517	0.910
Thierry's spatula	-1.57	-3.386	0.247	0.089	-1.638	-3.388	0.112	0.066
Vacuum extraction	0	_	_	_	0	_	_	_
Sex female	-0.066	-1.125	0.993	0.902	_	_	_	_
Sex male	0	_	_	_	_	_	_	_

Table 6: regression model explaining the change of the value of the mentovertical diameter

	Unadjusted regression				**Adjusted regression**			
	Coeff	**95% CI**		***p* value**	**Coeff**	**95% CI**		***p* value**
Constant	_	_	_	_	0.131	-4.392	4.654	0.954
Age at first measurement	0.024	-0.085	0.133	0.667	-0.004	-0.117	0.109	0.944
Timelaps between	-0.010	-0.072	0.052	0.742	-0.024	-0.085	0.037	0.430
Birthweight	-5.10^{-5}	-0.003	0.003	0.966	_	_	_	_
Vaginal birth	-0.219	-3.126	2.687	0.880	_	_	_	_
Caesarean section	1.427	-2.245	5.100	0.439	_	_	_	_
Thierry's spatula	1.198	-3.241	5.638	0.591	_	_	_	_
Vacuum extraction	0	_	_	_	_	_	_	_
Sex female	2.574	0.223	4.924	0.032	2.764	0.357	5.171	0.025
Sex male	0	_	_	_	0	_	_	_

Table 7: regression model explaining the change of the value of the suboccipitofrontal diameter

	Unadjusted regression				**Adjusted regression**			
	Coeff	**95% CI**		***p* value**	**Coeff**	**95% CI**		***p* value**
Constant	_	_	_	_	-0.121	-4.948	4.706	0.960
Age at first measurement	-0.052	-0.107	0.003	0.062	-0.067	-0.126	-0.007	0.809
Timelaps between	0.025	-0.006	0.055	0.108	0.005	-0.027	0.038	0.737
Birthweight	-0.001	-4.10^{-4}	0.002	0.192	1.10^{-3}	-0.001	0.001	0.809
Vaginal birth	-0.051	-1.367	1.264	0.938	-0.038	-1.437	1.36	0.956
Caesarean section	2.636	0.974	4.298	0.002	2.455	0.568	4.342	0.012
Thierry's spatula	1.638	-0.371	3.648	0.108	1.637	-0.416	3.69	0.116
Vacuum extraction	0	_	_	_	0	_	_	_
Sex female	0.513	-0.711	1.737	0.405	_	_	_	_
Sex male	0	_	_	_	_	_	_	_

Table 8: regression model explaining the change of the value of the occipitofrontal diameter

	Unadjusted regression	**Adjusted regression**

	Coeff	**95% CI**		***p* value**	**Coeff**	**95% CI**		***p* value**
Constant	_	_	_	_	-4,568	-9,414	0,278	0,064
Age at first measurement	-0,013	-0,066	0,039	0,619	-0,006	-0,066	0,055	0,848
Timelaps between	0,024	-0,006	0,053	0,112	0,016	-0,017	0,049	0,345
Birthweight	0,001	4.10^{-4}	0,002	0,126	0,001	0,001	0,002	0,158
Vaginal birth	0,426	-0,948	1,800	0,537	0,677	-0,736	2,091	0,341
Caesarean section	0,851	-0,886	2,587	0,330	0,149	-1,745	2,043	0,875
Thierry's spatula	1,898	-0,201	3,997	0,075	2,097	0,022	4,173	0,048
Vacuum extraction	0	_	_	_	0	_	_	_
Sex female	0,773	-0,391	1,938	0,189	1,149	-0,423	1,931	0,204
Sex male	0	_	_	_	0	_	_	_

Discussion

In this study, we find a negative correlation between the biparietal and birthweight and between the bitragion and timelaps. Results show a positive correlation between head circumference and timelaps. These findings are consistent with results of previous studies. De souza et al. [2] found that head circumference increases during the first week of life. This increasing head circumference, with the decreasing biparietal diameter is explained by the antero-posterior reduction of the head during birth, resulting in its lateral flattening during the early postnatal period [2,4]. Figure 2 summarizes this "rebound effect" explained by the fetal-pelvic constraint during the delivery, and the resulting effect during the first week of life.

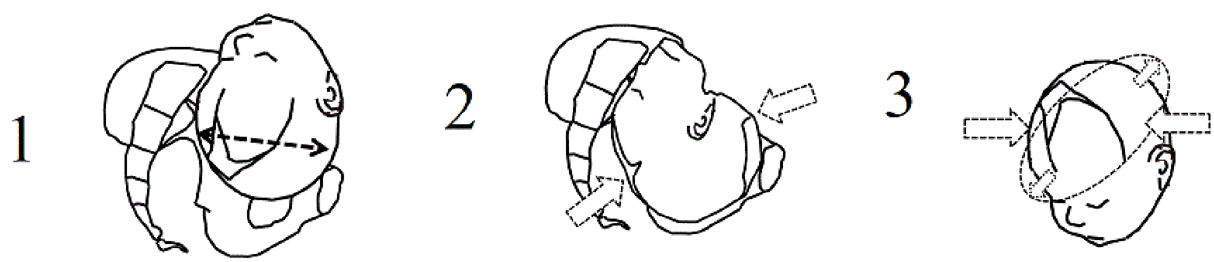

Figure 2: Obstetrical explanation of the "rebound effect" during the first week of life. (1) Lateral expansion of the fetal head during engagement. **(2)** Reduction of the suboccipitobregmatic diameter. **(3)** During the first week of life, biparietal flattening and head circumference expansion is observed.

Recent studies are based on cephalometric measurement of neonates [7,8]. In these studies, cephalometric variables are compared to pelvic measurements to analyse the variability of the foetal-pelvic relationship and its consequences on clinical outcomes. Given the correlation between the bitragion or head circumference and timelaps, measurements of these variables should be made during the same hour of life in future studies, or not considered in the analysis if the age at the first measurement is inconstant.

Some pathological condition could induce specific skull deformities. Indeed, a long narrowhead dolichocephaly, can be caused by sagittal craniosynostosis, whereas occipital flattening maybe caused by bilateral lambdoid craniosynostosis [4]. We do not included infants suffering from craniosynostosis. This confounding factor is not present in this work. However, futher studies should consider the dominant position of the neonate during the rest. Indeed, the head of the neonate may become flattened occipitally as a result of static supine positioning [4].

In this work, we find a positive correlation between the suboccipitofrontal and caesarean section and between the occipitofrontal and Thierry's spatula extraction. These findings contradict those of Kriewall et al. [4]. For these authors, occipitofrontal diameter did not change during the postnatal period. However, these authors did not consider infants born by instrumental extraction. The use of Thierry's spatula during childbirth could have a major impact in the neonatal head shape change. Pu et al. [9] show that fetal head moulding is correlated with the intensity of force applied on the skull.

Here we find a positive correlation between the mentovertical and the female sex. Caesarean section in female group is twice as high as in male group and the mean birthweight of the female group is higher than the male group. Therefore, the female infants should have experienced a higher fetal-pelvic constraint during birth than the male infants. This difference during birth should explain the result concerning the mentovertical diameter.

In this work, we do not find a correlation with bitemporal diameter or submentobregmatic diameter and any possible factors. This is consistent with the result of Kriewall et al. [4]. These diameters may not change significantly during postnatal period.

Conclusion

We show that factors such as delivery outcome, birthweight or sex of the neonate could affect the neonatal head shape change. This change is related to fetal head moulding during birth and fetal-pelvic constraint. Contrary to previous studies, this work highlights the importance of considering the instrumental extraction when the neonatal head shape change is investigated.

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