Anterior Fontanel: Size and Closure in Term and Preterm Infants

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ABSTRACT. Size and closure of the anterior fontanel from birth to 24 months of age and their relationships to growth parameters, bone age, and gestational age are reported in 111 term and 128 preterm infants. Great variability of both fontanel size and age when fontanel closed was observed. There were no significant differences in size and age at closure of the anterior fontanel between term and preterm infants or between the sexes. At ages beyond term, fontanel size was negatively correlated with weight and length; however, only a few correlations reached statistical significance. No significant relationships were noted between anterior fontanel size and head circumference or bone age. Age at closure of the anterior fontanel was also not significantly related to any of the growth parameters or bone age. *Pediatrics* 1986;78:904–908; *anterior fontanel, preterm infant.*

Assessment of the size of the anterior fontanel is part of the routine examination of the infant. This assessment is used together with the head circumference measurement as an index of cranial development from birth and to the second year of life. An unusually small fontanel for age may be secondary to brain growth retardation,[1] craniosynostosis,[2] or hyperthyroidism.[3] A large fontanel without increased cranial pressure may be a feature of a variety of disorders,[4] such as skeletal anomalies (eg, achondroplasia,[5] cleidocranial dysostosis,[6] osteogenesis imperfecta[7], chromosomal anomalies (eg, trisomies 9p, 13, 18, 21),[4] hypothyroidism,[8] or intrauterine malnutrition.[9] In the last group, a large fontanel was found to be associated with decreased epiphysial ossification.[9]

Only few data have been published on normal anterior fontanel dimensions for age, from birth through the second year of life,[5,10] and on the relationship between postnatal fontanel size and physical growth parameters and bone age.[9] The purpose of the present study was to answer the following questions: (1) How does the anterior fontanel develop with respect to size and closure from birth to 24 months of age in healthy term infants? (2) What is the significance of prematurity and sex distribution with respect to anterior fontanel development? (3) What is the relationship between size and age at closure of the anterior fontanel and physical growth parameters, bone age, and gestational age?

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INFANTS

In the Second Zurich Longitudinal Study, various aspects of somatic, psychologic, and neurologic development are studied from birth to adulthood. The study consisted of a cohort of 111 term neonates (56 boys and 55 girls) and 131 preterm neonates (77 boys and 54 girls) randomly selected between October 1974 and September 1978 in the University Hospital and the Pflegerinnenschule of Zurich. During the first 2 years, none of the term group and three of the preterm group (two boys and one girl) were lost to study at the age of 3 months after term because of adoption (two infants) and death (one infant) (total loss 1.2%).

The medical characteristics of the infants at birth are presented in Table 1. The sample selected was representative for the Swiss neonatal population for the following reason: weight, length, and head circumference at birth, both for the term and preterm group, were comparable to the Swiss perinatal growth chart.[11] For the preterm infants, 15.3% had a birth weight below the tenth centile of the Swiss growth chart, and for term infants, 9% were below the tenth centile.

For the term infants, pregnancy, labor, and neonatal adaptation were free of complications. The deliveries were spontaneous and vaginal with vertex presentation. The preterm infants (gestational age between 27 and 36 weeks) represented a high-risk group with a significantly lower perinatal optimal-

TABLE 1. Medical Characteristics of Infants at Birth

Variables and Sex	Term Infants			Preterm Infants			$P<$
	Mean	SD	Range	Mean	SD	Range	
Gestational age (wk)							
M	40.0	1.1	37.6–42.6	33.9	2.2	28.7–36.8	.001
F	40.0	1.0	37.1–41.8	33.2	2.6	27.1–36.8	.001
Wt (g)							
M	3,405	359	2,700–4,330	2,056	452	1,110–2,940	.001
F	3,203	340	2,420–4,120	1,850	500	1,050–3,460	.001
Length (cm)							
M	50.9	1.5	46.5–54.0	44.7	2.5	37.5–50.0	.001
F	50.0	1.6	46.5–53.0	43.2	3.3	36.0–53.0	.001
Head circumference (cm)							
M	34.8	1.2	31.0–36.5	31.4	1.8	26.2–34.5	.001
F	34.1	1.0	31.0–36.3	30.0	2.3	25.5–35.5	.001
Perinatal optimality score (optimum = 120)							
M	111.1	4.6	106–118	95.6	10.0	72–113	.001
F	112.8	3.5	106–118	94.6	11.6	76–109	.001
No. of infants							
M	56			75			
F	55			53			

ity score (a modified version of the Prechtl scale[12]) than the term infants (Table 1). For example, 83% of the preterm infants had respiratory distress syndrome at birth and 28% required artificial ventilation. The distribution of socioeconomic status defined by paternal occupation and maternal education was comparable in both the term and preterm group to that of the population of the city of Zurich.

During the first 2 years after birth, no significant differences in weight, length, and head circumference between preterm and term infants were observed. Neurologic development was assessed at 1, 3, 6, 9, 12, 18, and 24 months of age. Based on an extensive neurologic examination as defined by Prechtl and Beintema,[13] 16 boys and five girls in the preterm group (16%), but none of the term infants, were diagnosed as having cerebral palsy by 6 months of age. Ten boys and four girls showed signs of a mild spastic diplegia, four boys and one girl had moderate spastic diplegia, one boy was moderately ataxic and hypotonic, and another one had a severe spastic tetraplegia (due to congenital rubella). A detailed description of motor development in these infants is given elsewhere.[14]

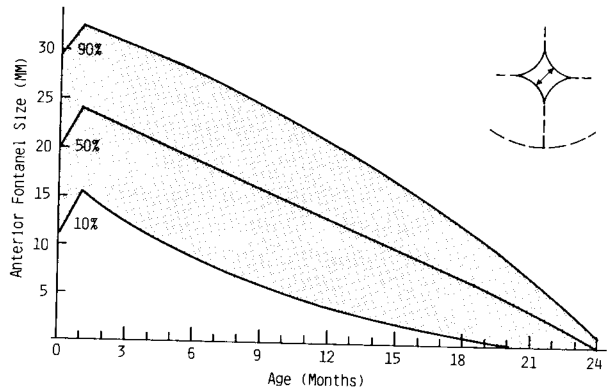

Fig 1. Centiles of anterior fontanel size from term to 24 months of age for both sexes. Inset, Measurement of oblique diameter.

METHODS

Gestational age was determined by maternal dates and the method of Dubowitz and associates.[15] The perinatal optimality score was a modified version of Prechtl's score[13] consisting of three subscores (pregnancy, birth, and neonatal period) and a total score.[14]

The size of the anterior fontanel, weight, length, and head circumference were measured at birth (within 24 hours), at term, and at the ages of 1, 3, 6, 9, 12, 18, and 24 months after term (within 2 weeks of the exact date). Fontanel dimensions were recorded as oblique diameters of the fontanel (Fig. 1). Both oblique diameters were measured twice with a caliper.[16] The measurements were recorded to the nearest millimeter. The average of both diameters was used as mean fontanel size. The closure of the anterior fontanel was defined by the inability to ascertain the oblique diameters.

Weight was assessed by means of an infant scale of the balance beam type with an accuracy of 0.01 kg. Supine length was measured on a Harpenden supine measuring table. One observer firmly held the crown of the head against the headboard and positioned the head so that the upper margin of the external auditory meatus and the lower margin of the orbit of the eye were perpendicular. The other observer stretched the body and the legs of the child and brought the sliding footboard into firm contact with the soles of the feet. The measurements were read to the nearest millimeter. A narrow (6-mm) plastic tape calibrated in millimeters was used to measure the head circumference. The tape was placed around the child's head at the same level on each side. It crossed the forehead superior to the supraorbital ridges and passed the prominence of the occiput posteriorly. The tension of the tape was such that the hairs were firmly pressed against the skull. The largest circumference was noted.

Radiographs of the right knee were taken at the ages of 3, 6, 9, 12, 18, and 24 months in 47 term infants (22 boys and 25 girls) and 56 preterm infants (33 boys and 23 girls). Informed consent for taking the radiographs was obtained from the parents in all children. Bone age was assessed by the method of Roche et al.[19]

Statistical analyses were performed by two-tailed t test, Spearman rank correlations, and χ^2 test. Z scores for weight were calculated as follows: (birth weight − mean weight)/standard deviation of weight for the corresponding gestational age at birth.[11]

RESULTS

Size and age at closure of the anterior fontanel in term and preterm infants from birth to 24 months of age are given in Table 2. After reaching term, fontanel size in preterm infants did not differ significantly from that of term infants. The variability was large but similar in both groups. A slight, increase of the median size was observed at the age of 1 month in term infants only. This increase might be due to the fact that the fontanel size was assessed within 24 hours after birth, ie, at an age molding of the skull was not yet resolved. The subsequent progressive decrease in size was similar in both groups and comparable in boys and girls. Percentile curves for fontanel size based on the data of the term group are given in Fig 1.

Closure of the fontanel was first noted in about 1% of the babies at 3 months after term. The anterior fontanel was closed in 38% of the infants at 12 months in 96% at 24 months. The median age of fontanel closure was 13.8 months in the term group. Boys of the term group tended to have higher percentages of closed fontanels than the girls. There were no consistent significant differences between term and preterm infants (Table 2). The wide range of ages at which fontanel closure may occur is demonstrated in Fig 2. No relationship could be established between the fontanel size at an early age and the age of its closure. Therefore, the size of the fontanel was not predictive of the age at which the fontanel would be closed. Some of the large fontanels at the ages of 1, 3, and 6 months closed earlier than small fontanels.

TABLE 2. Anterior Fontanel Size and Incidence of Closure From Birth to 24 Months of Age in Term and Preterm Infants*

Age (mo) and Sex	Term Infants		Preterm Infants	
	Fontanel Size (mm)	Closed Fontanel (%)	Fontanel Size (mm)	Closed Fontanel (%)
Term				
M	19.3 ± 6.6	0	22.6 ± 7.6	0
F	20.9 ± 7.9	0	21.2 ± 6.5	0
1				
M	23.5 ± 7.4	0	22.5 ± 7.6	0
F	24.0 ± 5.1	0	21.8 ± 6.5	0
3				
M	20.4 ± 7.5	2	21.4 ± 9.3	0
F	21.1 ± 6.8	0	19.6 ± 7.0	2
6				
M	19.4 ± 7.6	13	19.4 ± 8.1	7
F	18.6 ± 7.3	2	17.0 ± 6.6	4
9				
M	14.2 ± 6.4	21	15.6 ± 7.7	24
F	14.9 ± 7.3	13	14.2 ± 6.2	13
12				
M	12.5 ± 5.9	41	13.3 ± 7.5	34
F	13.2 ± 6.7	35	10.5 ± 5.2	41
18				
M	9.1 ± 3.6	72	11.9 ± 7.2	79
F	8.2 ± 2.7	67	11.0 ± 5.9	84
24				
M	(7.5 ± 3.5)	96	(13.3 ± 5.8	96
F	(20.5)	98	(7.5 ± 3.5)	96

* Results are means ± SD. No. of term infants: 56 boys, 55 girls; No. of preterm infants: 75 boys, 53 girls. Results in parentheses are data collected on less than four infants.

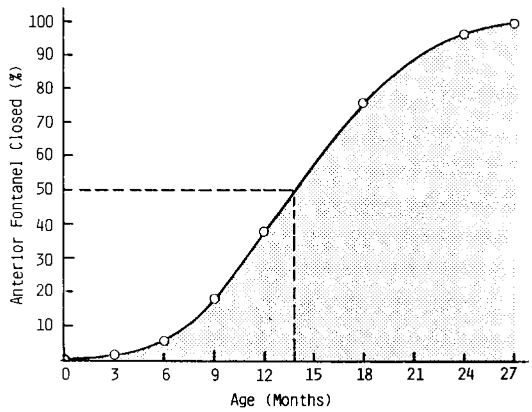

Fig 2. Age at closure of anterior fontanel (cumulative percentage).

The relationships between fontanel size and growth parameters as well as bone age at birth and for the first 24 months after term in term and preterm infants are shown in Table 3. At birth and at term, there were low positive correlations between fontanel size and weight and length. To take the appropriateness of birth weight for gestational age into account, Z scores were computed. A low,

TABLE 3. Correlations Between Size of Anterior Fontanel and Weight, Length, Head Circumference, and Bone Age From Birth to 24 Months of Age in Term and Preterm Infants of Both Sexes

Age (mo)	Correlations Between Fontanel Size and			
	Wt	Length	Head Circumference	Bone Age
Term Infants				
At term	.01	.11	.13	
1	−.17	−.14	−.04	
3	−.11	−.12	−.05	−.05
6	−.09	−.05	.07	.01
9	−.07	−.19*	.03	−.10
12	−.12	−.16	−.09	−.06
18	−.15	−.10	−.07	−.37*
24	−.19	−.03	−.03	−.23
Preterm infants				
At birth	.16	.13	.22*	
At term	.06	.09	.06	
1	−.10	−.16	.06	
3	−.11	−.11	.07	−.07
6	−.16	−.19*	.08	−.11
9	−.17	−.17	.08	.04
12	−.14	−.15	.05	.21
18	−.13	−.15	.04	.07
24	−.33†	−.37†	.10	.08

* $P < .05$.
† $P < .01$.

nonsignificant positive correlation was noted between fontanel size and Z scores of birth weight. When the term and preterm infants were divided into two groups, namely, those with a birth weight above the tenth percentile (appropriate for gestational age) and those with a birth weight below the tenth percentile (small for date), the latter showed a slightly larger, but not significantly different, fontanel size than those infants appropriate for gestational age. After term, weight and length were consistently negatively correlated with fontanel size in term and preterm infants. However, the correlation coefficients were low, mostly nonsignificant, and of no clinical relevance. No consistant relationships were observed between fontanel size and head circumference or bone age.

At birth, a significant correlation was found between fontanel size and gestational age for premature infants only ($P < .01$). Later, fontanel size was not related to gestational age neither in term nor preterm infants. No relationship could be established between age at fontanel closure, on the one hand, and weight, length, head circumference, or bone age, on the other hand. Therefore, in heavy and tall babies with a large head and an advanced bone age, fontanels did not close significantly earlier than those of smaller babies with a retarded bone age.

DISCUSSION

Examination of the anterior fontanel is used routinely when considering disturbances in intracranial pressure and disorders of cranial development. The diagnosis of abnormal fontanel size as a clue to altered morphogenesis assumes the knowledge of normal variations in its size from birth to its closure. For term infants, too few data have as yet been collected on fontanel size ranges from 1 to 2 years of age. No study of fontanel size for premature infants from birth to the age of 2 years has been published. This paper presents data on normal anterior fontanel size and its closure from birth to the second year of life and on its relationship to prematurity, sex, physical growth parameters, and bone age.

The fontanel dimensions were recorded as the average of both oblique dimensions as proposed by Elsäser[16] and not in terms of mean length (anterior posterior dimension) and width (transverse dimension)[5,19a] or area.[9] Edges of fontanel and parietal bones are easier to define using fingertips than fontanel corners. Measurements of surface area of the fontanel are too cumbersome for routine examination but can be derived from oblique dimensions as shown by Philip.[20]

The broad range of normal variability in fontanel size for age has been previously noticed.[5] The tendency for the fontanel to enlarge during the first postnatal month (Fig 1 and Table 1) need not necessarily raise concern in the presence of normal development of head circumference. Early observers[16,21] found that the dimensions of the anterior fontanel increased from birth to about 9 months of age, a finding explained by the high incidence of rickets in the children studied in the 19th century.[21] In agreement with other authors,[5] a progressive decrease of fontanel size was noted in our infants beyond the first month after term.

To our knowledge, five studies have reported on closure of the anterior fontanel in term infants.[10,21-24] Each of these studies suffered from methodologic deficiencies such as large time intervals,[21] small sample size,[23,24] and poorly defined populations and examination methods.[10,22] The variation in time of fontanel closure was remarkable in our study (Fig 2). For example, the fontanel was considered to be closed as early as 3 months of age in 1% of the infants and was still open in 4% at the age of 24 months. Reviewing the literature before 1923, Scammon[22] reported a lower percentage of closed fontanels during the first and second years of life, which might be explained by a high incidence of rickets at that time. If the presence of an unusually small or large fontanel can be a valuable clue for the clinician in the recognition of a variety of disorders, caution should be used in ascribing more significance to such a sole finding, considering the high variability in a normal population.

Size and timing of closure of the anterior fontanel did not differ between preterm infants reaching term and term infants. Sex distribution had no effect on fontanel size, as already noticed for term infants.[5] Closure tended to occur earlier in term boys compared with girls, but none of these differences were statistically significant. The same trend has been reported for mean age of fontanel closure.[23]

In a series of studies on fontanel area and growth parameters in intrauterine growth retardation, Philip[9,20,25] suggested that the disturbance is likely related to delay of both enchondral and membranous ossification as evidenced by an inverse relationship between fontanel area and the degree of epiphyseal ossification of the knee. In the present study, in which the majority were appropriately grown newborn infants, no consistent correlation was observed between postnatal fontanel size (oblique dimensions) and bone age (knee) (Table 3), as previously reported for the 1-year-old infant.[23]

An inverse correlation between birth weight and large fontanel has been observed in intrauterine growth-retarded children.[9] In our study, with mostly appropriately grown newborn infants, fontanel size, weight, and length were positively correlated at birth and consistently negatively correlated with each other at postterm ages in term and preterm infants. However, these correlations were low and statistically nonsignificant (Table 3). A statistically significant relationship between fontanel closure and height at 1 and 2 years of age has been previously observed for girls but not for boys.[21]

No significant relationship could be established among fontanel size, timing of closure, and head circumference. Fontanel size was not predictive of the age at which the fontanel would be closed. Size and timing of anterior fontanel closure were not significantly related to head circumference. A small and/or closed fontanel was not necessarily accompanied by a small head circumference. It ought to be emphasized that these findings refer to a normal population. As outlined in the introduction, under pathologic conditions, clinically relevant relationships may be noted between size and closure of the anterior fontanel and other growth parameters such as head circumference, eg, in a child with hydrocephalus.

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REFERENCES

1. Penrose LS: Microcephaly. *Folia Hered Pathol* 1956;5:79–85
2. Freeman JM, Borkowf S: Craniostenosis: Review of literature and report of 34 cases. *Pediatrics* 1962;30:57–70
3. Robinson DC, Hall R, Munro DS: Grave's disease: An unusual complication: Raised intracranial pressure due to premature fusion of skull sutures. *Arch Dis Child* 1969;44:252–257
4. Smith DW: *Recognizable Patterns of Human Malformation*, ed 3. Philadelphia, WB Saunders Co, 1982, p 618
5. Popich GA, Smith DW: Fontanels: Range of normal size. *J. Pediatr* 1972;80:749–752
6. Forland M: Cleidocranial dysostosis: A review of the syndrome and report of a sporadic case with hereditary transmission. *Am J Med* 1962;33:792–799
7. McKusick VA: *Heritable Disorders of Connective Tissue*, ed 3. St Louis, CV Mosby, 1966, p 230
8. Smith DW, Popich G: Large fontanels in congenital hypothyroidism: A potential clue toward earlier recognition. *J Pediatr* 1972;80:753–756
9. Philip AGS: Fetal growth retardation: Femurs, fontanels and follow-up. *Pediatrics* 1978;62:446-453
10. Scammon RE, cited by Brock J: *Biologische Daten für den Kinderarzt.* Berlin, Springer-Verlag, 1954, p 148
11. Largo RH, Wälli R, Duc G, et al: Evaluation of perinatal growth. *Helv Paediatr Acta* 1980;35:419–436
12. Prechtl HFR: The optimality concept. *Early Hum Dev* 1980;4:201–205
13. Prechtl HFR, Beintema DJ: The neurological examination of the fullterm newborn infant, in *Clinics in Developmental Medicine.* London, Spastics Society, W Heinemann Medical Books Ltd
14. Largo RH, Molinari L, Weber M, et al: Early development of locomotion: Significance of prematurity, cerebral palsy and sex. *Dev Med Child Neurol* 1985;27:183–191
15. Dubowitz LMS, Dubowitz V, Goldberg C: Clinical assessment of gestational age in the newborn infant. *J. Pediatr* 1970;77:1–10
16. Elsässer CL: Der weiche Hinterkopf, in *Ein Beitraq zur Physiologie und Pathologie der ersten Kindheit.* Lenzhalde, Germany, Stuttgart & Tübingen, 1843, p 9
17. Deleted in proof
18. Tanner JM, Whitehouse RH, Takaishi M: Standards from birth to maturity for height, weight, height velocity, and weight velocity: British children, 1965 (Part I & II). *Arch Dis Child* 1966;41:454–613
19. Roche AF, Wainer H, Thissen D: *Skeletal Maturity: The Knee Joint as a Biological Indicator.* New York, Plenum Medical Book Co, 1975

19a. Faix RG: Fontanel size in black and white term newborn infants. *J Pediatr* 1982;100:304–306

20. Philip AGS: Fontanel size and epiphyseal ossification in neonates with intrauterine growth retardation. *J. Pediatr* 1974;84:204–207
21. Acheson RM, Jefferson E: Some observations on the closure of the anterior fontanel. *Arch Dis Child* 1954;29:196–198
22. Aisenson MR: Closing of the anterior fontanel. *Pediatrics* 1950;6:223–226
23. Tan KL: Wide sutures and large fontanels in the newborn. *Am J Dis Child* 1976;130:386–390
24. Davies DP, Ansari BN, Cooke TJH: Anterior fontanel size in the neonate. *Arch Dis Child* 1975;50:81–83
25. Philip AGS: Fontanel size and epiphyseal ossification in neonatal twins discordant by weight. *J. Pediatr* 1975;84:417–419