CT Measurements of Cranial Growth: Microcephaly

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Computed tomographic (CT) head scans were measured to determine the cranial dimensions of four children with microcephaly. These measurements were compared with cranial dimensions of normal children. CT proved to be useful in determining the developmental status of children with neurologic problems relative to their normal counterparts on the basis of cranial dimensions.

Normal cranial size as determined from computed tomographic (CT) scans for subjects of different ages has been described [1]. We submit four clinical cases whose proven microcephaly further validates these published values. The cranial area and dimensions measured on CT scans correlate well with published head circumference growth charts obtained by measuring maximal cranial circumferences with tape measures [2–10].

Materials and Methods

CT head scans were obtained with a GE 8800 scanner using a 9.6 sec, high-resolution mode. A standardized position with an approximate 5°–10° tilt from the canthomeatal line was used. The midventricular head section that demonstrated the largest size of the frontal horns of the lateral ventricles was selected for evaluation of head size. Using the built-in cursor, the edge of the outer cranium was traced and the enclosed cranial area was calculated by the computer. In addition, the maximum anteroposterior and lateral diameters of the cranium were also measured by the computed or grid measurement or both. The same window setting (level at 35 and width 100) was used for screen viewing and filming.

Case Reports

Case 1

A 13-month-old girl was diagnosed at age 3 weeks as having congenital brain infection of uncertain etiology. She was mentally retarded and had a seizure disorder. Her head circumference was 37.7 cm, less than the third percentile for her age, and was at the 50th percentile for 1½ months of age [2]. CT (fig. 1) showed diffuse periventricular calcifications associated with severe ventriculomegaly and the thickening of the calvarium. Her head was microcephalic, as determined by calculated head area (89 cm^2), a value less than the fifth percentile for her age, and at the 50th percentile for age 2 months. The product was 124 cm^2 (12.6 × 9.8 cm), again less than the fifth percentile for her age and at the 50th percentile for 2 months of age. The probable radiographic diagnosis was toxoplasmosis, but viral infectious diseases could not be excluded.

Case 2

A 2-year-old girl was considered small for gestational age at birth. She did well for the first 3 months of life, at which time she developed fever, seizures, and vomiting. Bilateral subdural hematomas were found at another institution; their etiology was never established. Subsequently, she showed marked psychomotor retardation, and her seizures were very difficult to control, despite numerous anticonvulsants. CT (fig. 2) showed marked ventriculomegaly

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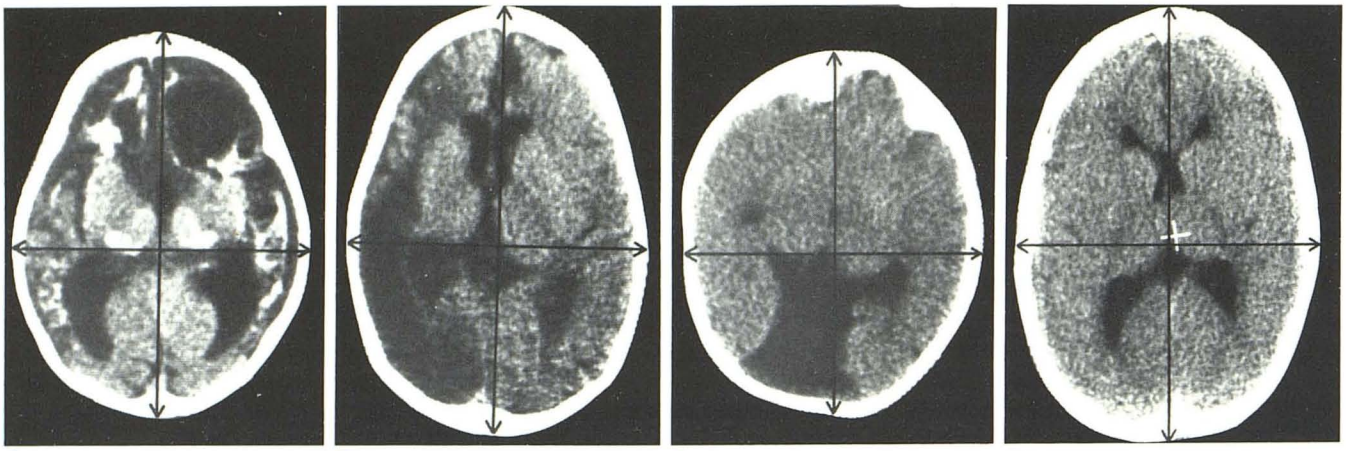

Fig. 1.—Case 1, 13-month-old girl with congenital brain infection, diffuse periventricular calcifications, ventriculomegaly, and thickened calvarium. Cranial product and area are 124 cm^2 and 89 cm^2, respectively.

Fig. 2.—Case 2, 2-year-old boy with posttraumatic microcephaly and marked diffuse brain atrophy. Product and cranial area are 136 cm^2 and 106 cm^2 respectively.

Fig. 3.—Case 3, 1-year-old girl with diagnosis of congenital microcephaly. Product and cranial area are 123 cm^2 and 97.2 cm^2, respectively.

Fig. 4.—Case 4, 12-year-old boy with severe mental retardation and microcephaly. Product measurement is 201 cm^2 and cranial area is 154 cm^2.

and right cerebral atrophy with probable old infarction of the right temporooccipital region. There was diffuse thickening of the calvarium. Her head circumference measured 29.8 cm, less than the third percentile for her age and at the 50th percentile for age 3 months [2]. Her head area was 106 cm^2, less than the fifth percentile for age and in the 50th percentile for 3 months of age. Her product was 136 cm^2 (14 × 9.7 cm), again less than the fifth percentile for her age and at the 50th percentile for 3½ months of age.

Case 3

A 1-year-old girl was noted at birth to have a cleft palate, microcephaly, syndactyly of her second toes, and a number of other minor dysmorphic features in her face. She later developed diabetes insipidus. Chromosome studies were normal. Her head circumference measured 37 cm, less than the third percentile for her age and in the 50th percentile for age 1½ months [2]. CT (fig. 3) showed a developmental anomaly of the frontal horns of the lateral ventricles and hypoplasia of both occipital lobes. Her head area was 97.2 cm^2, less than the fifth percentile for her age and in the 50th percentile for age 2½ months. The product was 123 cm^2 (12.2 × 10.1 cm), again less than the fifth percentile and at the 50th percentile for 3 months of age.

Case 4

A 12-year-old severely retarded boy was admitted because of persistent vomiting. Both he and his similarly institutionalized sister had physical features of the Smith-Lemli-Opitz syndrome and an identical chromosomal abnormality (addition to chromosome 22). His head was microcephalic, with a measured circumference of 47.8 cm, less than the third percentile for his age and at the 50th percentile for 16 months of age [2]. The head area and product (fig. 4) were 154 cm^2 and 201 cm^2 (17.0 × 11.8 cm), respectively. Both measurements are less than the fifth percentile for his age and at the 50th percentile for 18 months of age.

Discussion

Although CT scans of the head have been shown to be of great value in diagnosing childhood neurologic problems, their effectiveness in assessing the normality of cranial sizes has not been emphasized. Before the availability of modern CT scanners, the automatic measurement of cranial size was not easily achievable. The evaluation of growth status of the cranium by radiologists was limited and always depended on the reported head circumference measured by clinicians. Modern scanners, with their built-in cursor ability to measure distances and areas, provide an opportunity for those who review CT scans to determine cranial sizes directly from the scans. Problems of the brain associated with cranial dimensions, such as microcrania, can therefore be assessed easily from CT scans. Cases 1 and 2 demonstrated microcephaly, severe brain atrophy, and ventriculomegaly. These symptoms suggest that brain growth was retarded or arrested after trauma or infection. The patterns of brain growth can thus be estimated by CT head scans. The cranial growth pattern assessed by CT head areas correlates well with the head circumference assessed via tape measurement. Hence, the CT measured head area should be useful and can be used as a supplementary tool for measurements of head circumference.

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