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CT Measurements of Cranial Growth: Alternative Measurement Method

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We have reported the growth pattern of cranium as measured by computed tomography (CT) from birth to 18 years [1]. In the previous report, the CT cranial area was obtained using a built-in cursor and manually tracing the outer edge of the subject's cranial vault. Proper selection of CT slice location and careful tracing provide values that reflect the maximum dimensions of the cranium. To ensure its precision, careful manual control during the tracing maneuver is required, and up to 1 min may be needed to complete one circle of the cranial vault. Although the absolute time needed (i.e., less than 1 min) is tolerable, it interrupts the routine flow of diagnostic procedures. CT software with automatic edge-detection programs are readily available now and area measurements can easily be accomplished via keyboard controls, a task that can be incorporated into routine diagnostic and/or filming procedures. In our experience, automatic tracing of boundaries can be accomplished more faithfully and more conveniently if we instruct the computer to trace the entire head area, that is, cranium plus the soft tissue of the subcu-

taneous scalp, than if we instruct the computer to trace just the cranial vault. One reason that could account for the above observation is the existence of air surrounding the head (CT number, -1000 H), which provides a higher contrast compared with that between scalp and vault (CT numbers ranging from -50 to $+1500$ H). Such drastic differences in the CT numbers thus ensure the accuracy of the automatic tracing of head areas.

Technique

We measured the cranial area of 100 subjects using the same criteria as in our previous report [1], with the addition of an automatically traced head area program. All the patients

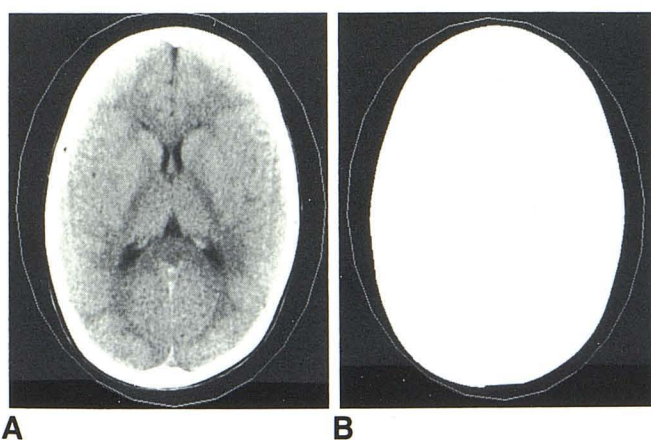


Fig. 1.—**A**, Midventricular CT scan of lateral ventricles selected for automatic measurement of head area. **B**, Automatic measurement of head area via computer software.

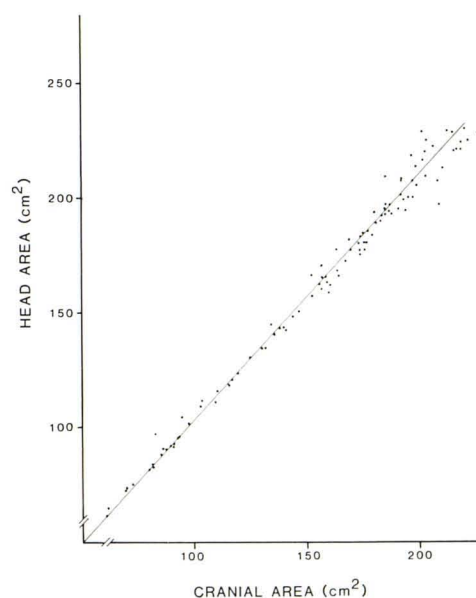


Fig. 2.—Comparison of automatically traced CT head area versus manually traced CT cranial area.

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TABLE 1: Mean Head Areas and Their Normal Ranges as Measured by CT

Age of Subject	Mean Areas in cm ² (Range)*
≤2 years old (no. of months):	
1	80.1 (66.8–93.3)
2	99.5 (86.3–112.8)
3	111.0 (97.8–124.3)
4	119.1 (105.8–132.3)
5	125.3 (112.1–138.6)
6	130.4 (117.2–143.7)
7	134.8 (121.5–148.0)
8	138.6 (125.3–151.9)
9	141.9 (128.7–155.1)
10	144.9 (131.6–158.1)
11	147.5 (134.3–160.8)
12	149.9 (136.7–163.2)
13	152.2 (138.9–165.4)
14	154.3 (141.0–167.6)
15	156.2 (134.8–169.5)
16	158.0 (144.8–171.3)
17	159.7 (146.4–173.0)
18	161.3 (148.0–174.5)
19	162.9 (149.6–176.1)
20	164.3 (151.0–177.5)
21	165.6 (152.4–178.9)
22	167.0 (153.8–180.3)
23	168.3 (155.0–181.5)
24	169.5 (156.2–182.7)
≥3 years old (no of years):	
3	172.9 (155.2–190.2)
4	179.6 (162.1–197.1)
5	184.9 (167.4–202.4)
6	189.4 (171.9–206.9)
7	193.0 (175.5–210.5)
8	196.2 (178.7–213.8)
9	199.0 (181.5–216.5)
10	201.6 (184.1–219.1)
11	203.8 (186.5–221.3)
12	205.9 (188.4–223.4)
13	207.8 (190.5–225.5)
14	209.7 (191.6–226.6)
15	211.2 (193.7–228.7)
16	212.8 (195.3–230.3)
17	214.3 (196.8–231.8)
18	216.8 (199.3–234.3)

* Range reflects the 90% of the population closest to the mean.

were scanned in the standard supine position with an approximately 5°–10° tilt from the canthomeatal line. The midventricular slice of the CT scan that shows the most prominent frontal horns of the lateral ventricle was selected for the estimation of both the cranial and head areas, since it reflects the maximum size of the cranium. A representative slice of the CT head scan is shown in figure 1A. Using a built-in cursor, an area of interest can be traced that encompasses the entire head. Using one of the software analysis programs (e.g. "density mask" of the posteroanterior software package in the GE 9800 scanner), the computer can automatically calculate the head area of highlighted pixels within the area of interest. An example is shown in figure 1B. Figure 2 shows that the two areas are related with the slope being 0.943 (i.e., cranium/head = 0.943). This relation is apparently independent of subject age. This simple relation allows us easily to modify our previously published "cranial" table to a new "head" table as shown in table 1. Therefore, for those electing to measure CT head size as an indication of the growth pattern, values in table 1 should be useful.

REFERENCES

1. Hahn FJ, Chu WK, Cheung JY. CT Measurements of cranial growth: normal subjects. *AJNR* 1984;5:155–157, *AJR* 1984; 142:1253–1256