Development of the pineal gland: measurement with MR.

M Sumida, A J Barkovich and T H Newton

AJNR Am J Neuroradiol 1996, 17 (2) 233-236
http://www.ajnr.org/content/17/2/233

Development of the Pineal Gland: Measurement with MR

Masayuki Sumida, A. James Barkovich, and T. Hans Newton

PURPOSE: To use MR imaging in the analysis of the size of the normal pineal gland in infants, children, and adolescents. **METHODS:** We retrospectively analyzed the size of the pineal gland in 249 patients (129 male and 120 female) aged 2 weeks to 20 years old. The maximum length (L), height (H), and width (W) of the gland were determined from a combination of sagittal, coronal, and axial MR images obtained on a 1.5-T scanner. The volume was calculated by using the formula 1/2 × L × H × W. **RESULTS:** The size of the pineal gland was significantly smaller in patients younger than 2 years old than in older patients. The size of the pineal gland increased until 2 years of age and remained stationary between the ages of 2 and 20 years. We found a large variation in size among all age groups. No difference in size was noted between males and females. **CONCLUSION:** This study establishes norms for pineal gland size in infants younger than 2 years old and in children and adolescents 2 to 20 years old as detected with MR imaging. Knowledge of the size of the normal pineal gland is important in the detection of abnormalities of the pineal gland, particularly neoplasms.

Index terms: Pediatric neuroradiology; Pineal gland, magnetic resonance; Brain, anatomy

AJNR Am J Neuroradiol 17:233–236, February 1996

Radiologic studies of the pineal gland have traditionally focused on calcification, in particular on the evaluation of pineal calcification over time. In one large review, pineal calcification was not seen on computed tomography scans of children younger than 5 years old but was noted with increasing frequency, almost logarithmically, with age (1). In this study, we used magnetic resonance (MR) imaging to analyze the evolving size of the pineal gland in infants, children, and adolescents.

Materials and Methods

We retrospectively studied 249 consecutive patients (129 male and 120 female) ages 2 weeks to 20 years old who had been examined with MR imaging over a period of 2 years. The distribution of patients by age and sex is given in Table 1. We excluded patients with any known endocrinologic disorder or malignant tumor as well as those who were undergoing radiation therapy or chemotherapy.

MR images were obtained at 1.5 T. T1-weighted spin-echo images at 600/minimum/2 (repetition time/echo time/excitations) were obtained in at least two planes using a 256 × 192 matrix, a field of view of 20 cm, a 5-mm section thickness, and a 1-mm gap. The pineal gland of each patient was measured from the hard copy of the film with the use of calipers. The maximum length (L) and height (H) were measured on the T1-weighted sagittal images, and the width (W) was measured on the T1-weighted coronal or axial images. On the basis of findings by Lundin and Pedersen (2), the volume was calculated according to the formula 1/2 × L × H × W.

Results

In patients younger than 2 years old the size of the pineal gland was as follows: L = 4.8 mm ± 0.9, H = 2.9 mm ± 0.6, W = 3.7 mm ± 0.9, volume 26.9 mm^3 ± 12.4 (mean ± standard deviation). In patients 2 to 20 years old, the size of the gland was larger and remained stable (average L = 6.1 mm ± 1.2, average H = 3.7 mm ± 0.8, average W = 4.8 mm ± 1.1, average volume = 56.6 mm^3 ± 27.6) (Fig 1). There was

Received February 1, 1995; accepted after revision August 25.

Presented in part at the 1994 Symposium Neuroradiologicum, Kumamoto, Japan.

From the Department of Neurosurgery, Hiroshima University School of Medicine, Japan (M.S.), and the Department of Radiology, University of California, San Francisco (A.J.B., T.H.N.).

Address reprint requests to Masayuki Sumida, MD, Department of Neurosurgery, Hiroshima University School of Medicine, 1–2–3 Kasumi, Minami-ku, Hiroshima, 734, Japan.

AJNR 17:233–236, Feb 191996 0195-6108/1996/1702–0233

TABLE 1: Distribution of Patients by Age and Sex

Age, y	No. of Males	No. of Females	Total
0	7	7	14
1	7	5	12
2	7	4	11
3	5	8	13
4	10	3	13
5	6	5	11
6	6	7	13
7	7	5	12
8	8	5	13
9	8	3	11
10	4	8	12
11	5	6	11
12	6	5	11
13	5	8	13
14	4	6	10
15	6	5	11
16	5	7	12
17	4	6	10
18	5	7	12
19	7	4	11
20	7	6	13
Total	**129**	**120**	**249**

TABLE 2: Mann-Whitney U Test for the Volume of the Pineal Gland

Group 1	Group 2	*P* Value
Males	Females	Not significant
0–1 y	2–20 y	.0001
0 y	1 y	Not significant
1 y	2 y	.0017
2 y	3 y	Not significant
2–10 y	11–20 y	Not significant

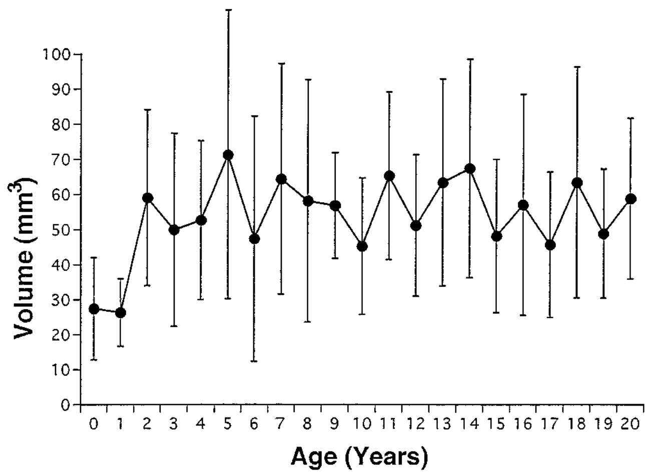


Fig 1. Graph shows the relationship between age and average volume (with 1 standard deviation) of the pineal gland.

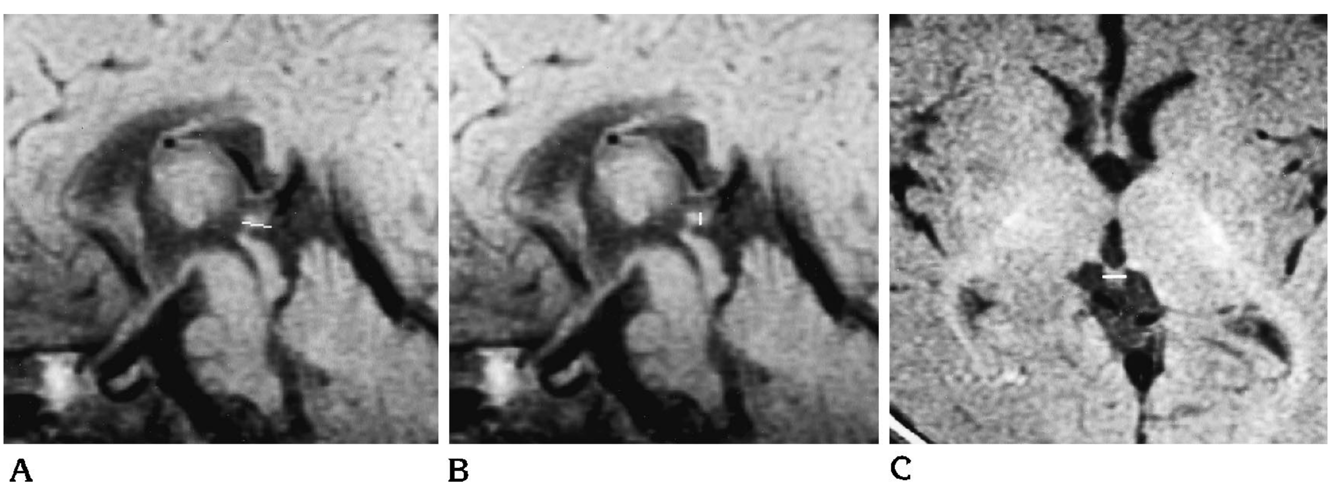
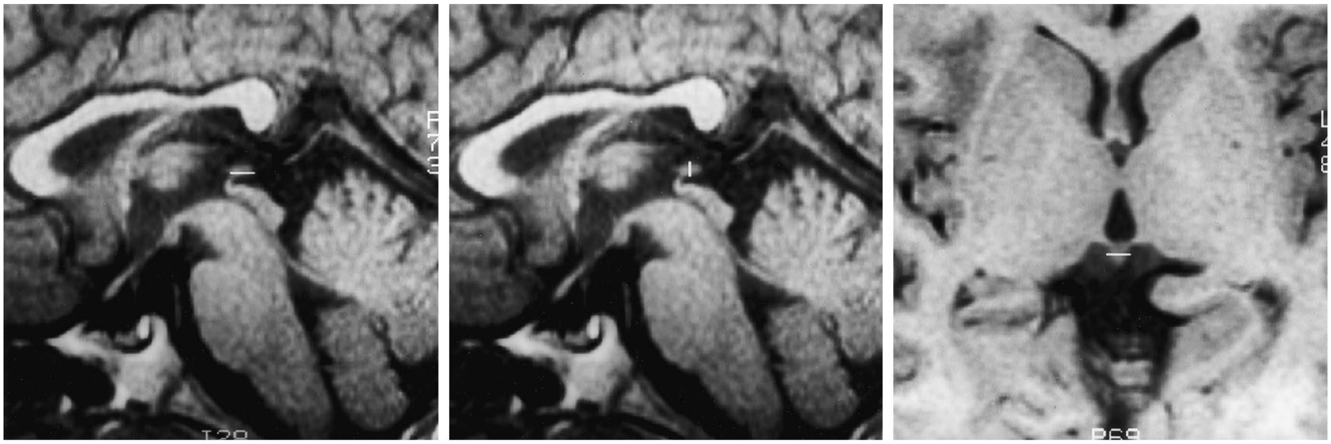
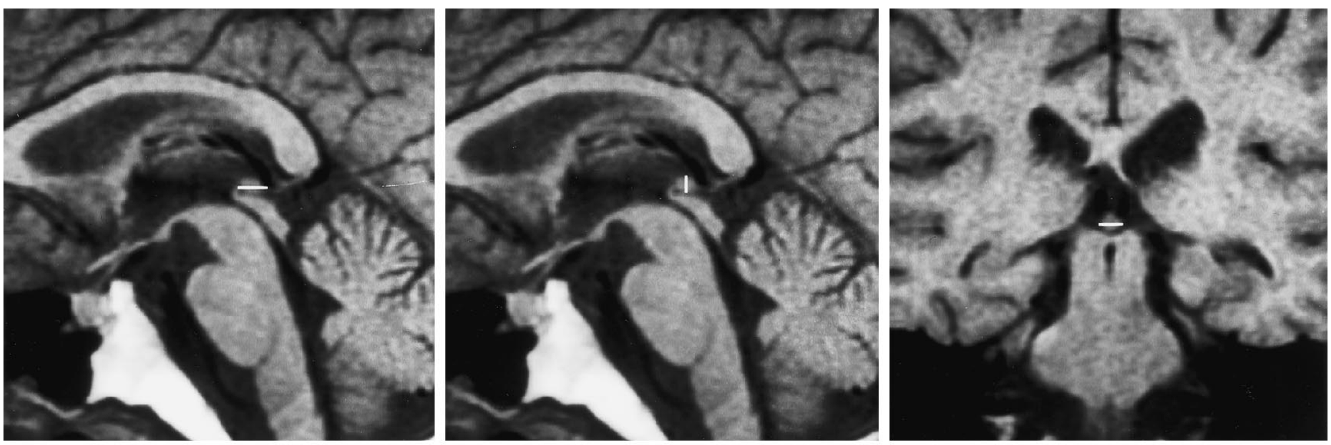


Fig 2. MR images of the pineal gland in a 3-month-old girl with hypoxia (volume, 16.9 mm^3).
A, The length of the pineal gland (*white line*) is 4.5 mm on T1-weighted sagittal image.
B, The height of the pineal gland (*white line*) is 2.5 mm on T1-weighted sagittal image.
C, The width of the pineal gland (*white line*) is 3 mm on T1-weighted axial image.



A B C

Fig 3. MR images of the pineal gland in a 4-year-old girl with myelomeningocele (volume 37.5 mm^3).
A, The length of the pineal gland (*white line*) is 5 mm on T1-weighted sagittal image.
B, The height of the pineal gland (*white line*) is 3 mm on T1-weighted sagittal image.
C, The width of the pineal gland (*white line*) is 5 mm on T1-weighted axial image.



A B C

Fig 4. MR images of the pineal gland in a 19-year-old man with cerebral contusion (volume 68.3 mm^3).
A, The length of the pineal gland (*white line*) is 6.5 mm on T1-weighted sagittal image.
B, The height of the pineal gland (*white line*) is 3.5 mm on T1-weighted sagittal image.
C, The width of the pineal gland (*white line*) is 5 mm on T1-weighted coronal image.

a large variation in size among all age groups (minimum L = 3.5 mm, minimum H = 2 mm, minimum W = 2 mm, minimum volume = 10 mm^3; and maximum L = 8.5 mm, maximum H = 6 mm, maximum W = 7.5 mm, maximum volume = 138 mm^3).

The Mann-Whitney *U* test showed no significant difference in the size of the gland for male and female subjects (Table 2). The gland was significantly (*P* = .0001) smaller in patients younger than 2 years old than in patients 2 to 20 years old (see Figs 2–4).

Discussion

The pineal gland develops from the most caudal portion of the roof of the third ventricle, from an area of ependymal thickening that undergoes evagination during the seventh week of gestation (3). At this stage, the structure of the gland is that of a patent cavity that connects to the third ventricle and is lined by thickened ependyma. The developing pineal parenchyma is formed of tubules that are gradually transformed into solid cell masses, separated by connective tissue and nerve twigs. By the middle of the first decade of life, the structure of the pineal gland approaches that of a mature gland, consisting of pinocytes arranged into lobules separated by delicate connective tissue septa and thin-walled blood vessels.

Autopsy studies have shown that the average size of the pineal gland is 7.4 mm in length, 6.9 mm in width, and 2.5 mm in height (4). Tapp and Huxley (5, 6) have found that the weight of the pineal gland increases gradually from puberty to old age. Although we know that the percentage of calcification does not change after the age of 30 years, no autopsy-based studies have revealed information about the evolving size of the pineal gland during development.

MR imaging has provided a marked improvement in the ability to locate and characterize tissue. For instance, small noncalcified structures that cannot be detected with computed tomography are seen clearly on MR images, especially in the midline on sagittal sections (7). In the pineal region, where a variety of tumors occur, including germ cell tumors and pinealomas (8, 9), knowledge of the normal size of the developing gland can help to distinguish healthy tissue from tumor. On T1- and T2-weighted images, tumors of the pineal region are usually similar in signal intensity to the gland itself (8, 9). In addition, the lack of a blood-brain barrier in the normal pineal gland results in an inability to separate a normal gland from a neoplasm on the basis of enhancement characteristics.

In this study, we established the average size of the normal pineal gland in infants, children, and adolescents. Pineal gland size increased from birth until 2 years of age and remained constant from ages 2 to 20 years. The reason for this result is unknown. Until 10 years ago, it was believed that the pineal gland played an important role in the onset of puberty (10, 11). It is well known that the size of the pituitary gland, another neuroendocrinologic organ, reflects the function of its hormonal secretions (12, 13). However, our result indicates that this is not the case with the pineal gland, since gradual enlargement during the ages of 2 to 20 years does not occur.

References

1. Zimmerman RA, Bilaniuk LT. Aged-related incidence of pineal calcification detected by computed tomography. *Radiology* 1982; 142:659–662
2. Lundin P, Pedersen F. Volume of pituitary macroadenomas: assessment by MRI. *J Comput Assist Tomogr* 1992;16:519–528
3. Langman J. *Medical Embryology,* 3rd ed. Baltimore: Williams & Wilkins, 1975;175–178, 318–364
4. Yamamoto Y, Kageyama N. Microsurgical anatomy of the pineal region. *J Neurosurg* 1980;53:205–221
5. Tapp E, Huxley M. The weight and degree of calcification of the pineal gland. *J Pathol* 1971;105:31–39
6. Tapp E, Huxley M. The histological appearance of the human pineal gland from puberty to old age. *J Pathol* 1972;108:137–144
7. Hayakawa K, Konishi Y, Matsuda T, et al. Development and aging of brain midline structures: assessment with MR imaging. *Radiology* 1989;172:171–177
8. Tien RD, Barkovich AJ, Edwards MSB. MR imaging of pineal tumors. *AJNR Am J Neuroradiol* 1990;11:557–565
9. Zee CS, Segall H, Apuzzo M, et al. MR imaging of pineal region neoplasms. *J Assist Comput Tomogr* 1991;15:56–63
10. Wurtman RJ, Moskowitz MA. The pineal organ. *N Engl J Med* 1977;296:1329–1333, 1383–1386
11. Kitay JI. Pineal lesions and precocious puberty: a review. *J Clin Endocrinol Metab* 1954;14:622–625
12. Swartz JD, Russell KB, Bosile BA, et al. High-resolution computed tomographic appearance of the intrasellar contents in women of childbearing age. *Radiology* 1983;147:115–117
13. Elster AD, Chen MYM, Williams DW. Pituitary gland: MR imaging of physiological hypertrophy in adolescence. *Radiology* 1990; 174:681–685