Normal Pituitary Stalk: High-Resolution MR Imaging at 3T

N. Satogami, Y. Miki, T. Koyama, M. Kataoka and K. Togashi

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BACKGROUND AND PURPOSE: Knowing the normal imaging appearance of the pituitary stalk is important for the diagnosis of pituitary infundibular lesions, and more accurate assessment of the stalk may be possible at 3T than at 1.5T. Our purpose was to evaluate the normal pituitary stalk by use of high-resolution MR imaging at 3T.

MATERIALS AND METHODS: Sagittal MPRAGE images and high-resolution oblique-axial T2-weighted images of the pituitary stalk were acquired in 29 healthy volunteers (16 men and 13 women; mean age, 28 years; age range, 21–43 years) at 3T. The diameter and length of the pituitary stalk and the depth of the infundibular recess were measured. Signal intensity of the stalk was visually evaluated on T2-weighted images.

RESULTS: The AP and transverse diameters of the pituitary stalk were 2.32 ± 0.39 mm and 2.16 ± 0.37 mm at the pituitary insertion, respectively, and 3.25 ± 0.43 mm and 3.35 ± 0.44 mm at the level of the optic chiasm. No significant differences were observed between the AP and transverse diameters at each level. The length of the stalk was 5.91 ± 1.24 mm, and the depth of the infundibular recess was 4.69 ± 0.87 mm. The stalk showed central hyperintensity with a peripheral rim of isointensity in 20 subjects (69%) and homogeneous isointensity in 9 subjects (31%).

CONCLUSIONS: The data of the current study can serve as standard measurements of the normal pituitary stalk. The central hyperintensity and peripheral rim may represent the infundibular stem and pars tuberalis, respectively.

ABBREVIATIONS: AP = anteroposterior; FLAIR = fluid-attenuated inversion recovery; GRAPPA = generalized autocalibrating partially parallel acquisitions; MPRAGE = magnetization-prepared rapid acquisition gradient echo; SNR = signal-to-noise ratio.

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From the Department of Diagnostic Imaging and Nuclear Medicine (N.S., Y.M., T.K., K.T.), Kyoto University Graduate School of Medicine, Kyoto, Japan; Department of Radiology (Y.M.), Osaka City University Graduate School of Medicine, Osaka, Japan; and Department of Radiology (M.K.), University of Cambridge, Addenbrooke’s Hospital, Cambridge, United Kingdom.

Please address correspondence to Yukio Miki, Department of Radiology, Osaka City University Graduate School of Medicine, Osaka, Japan; and Department of Radiology, University of Cambridge, Addenbrooke’s Hospital, Cambridge, United Kingdom. E-mail: mikiy@kuhp.kyoto-u.ac.jp

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BRAIN
sections, 208; averaging, 1; and acquisition time, 4 minutes 26 seconds. The GRAPPA algorithm was applied with a reduction factor of 2. The pituitary stalk was identified on the median MPRAGE image, and then high-resolution T2-weighted oblique-axial fast spin-echo images, perpendicular to the long axis of the pituitary stalk, were obtained to cover the entire pituitary stalk with the following parameters: TR, 6000 ms; TE, 104 ms; turbo factor, 11; FOV, 130 × 130 mm; matrix, 448 × 448; section thickness, 2 mm; no gap; sections, 10; averaging, 1; and acquisition time, 11 minutes 12 seconds. The GRAPPA algorithm was not applied.

**Imaging Analysis**

We performed all imaging assessments using OsiriX Imaging software, version 2.7.5 (http://www.osirix-viewer.com/).

**Measurements**

The diameter and the length of the pituitary stalk and the depth of the infundibular recess of the third ventricle were assessed for each subject (Fig 1). Both the AP and transverse diameters of the pituitary stalk were measured on T2-weighted oblique-axial images at 2 levels (at its insertion on the pituitary gland and at the level of the optic chiasm). These levels were chosen for measurement because Simmons et al7 measured the transverse diameter of the pituitary stalk on 1.5T MR imaging at these 2 levels. The length of the pituitary stalk and the depth of the infundibular recess were evaluated on the median sagittal MPRAGE image. The length of the pituitary stalk was defined and measured as the distance from the tip of the infundibular recess to the junction of the pituitary stalk and the pituitary gland along the course of the pituitary stalk. Six of 29 subjects (2 men and 4 women) had a convex superior margin of the pituitary gland in the current study, but there were no subjects in whom the superior gland margin protruded through the diaphragma sellae. Thus, the junction of the pituitary stalk and gland was angular and was identifiable in all subjects. The depth of the infundibular recess was defined and measured as the distance from the tip of the infundibular recess to the floor of the third ventricle at the anterior edge of the infundibular recess. Because the posterior wall of the infundibular recess often made a smooth transition to the floor of the third ventricle, or the tuber cinereum, the third ventricular floor at the posterior edge of the recess or at the midpoint of a line defined by the anterior and posterior margins was difficult to adopt as the superior extent of the infundibular recess. The ratio of the length of the stalk to the depth of the infundibular recess was also calculated for each subject.

**Signal Intensity**

We visually assessed the signal intensity of the pituitary stalk relative to the cerebral white matter at its insertion on the pituitary gland by using the T2-weighted oblique-axial image. The most inferior level of the pituitary stalk was selected for signal intensity evaluation because the infundibular recess of the third ventricle variably extends into the pituitary stalk, and CSF in the infundibular recess may cause a partial volume effect at a more superior level of the stalk. The level was cross-referenced with the midsagittal MPRAGE image and confirmed to lie below the tip of the infundibular recess.

**Statistical Analysis**

We conducted a comparison of the AP and transverse diameters at each level of the stalk by using the paired t test. A value of $P < .05$ was considered to show a statistically significant difference. We performed statistical analysis using SPSS software (version 12; SPSS, Chicago, Illinois).

**Results**

**Measurements**

The measurements are summarized in the accompanying Table. There was no significant difference between the AP and transverse diameters at each level of the stalk (at the pituitary insertion, $P = .104$; at the level of the optic chiasm, $P = .316$).

**Signal Intensity**

On T2-weighted oblique-axial images, the pituitary stalk showed central hyperintensity with a peripheral rim of isointensity compared with the cerebral white matter in 20 (69%) of 29 subjects (Fig 2). In the other 9 subjects (31%), the pituitary stalk showed homogeneous isointensity (Fig 3). CSF flow artifacts in the suprasellar cistern were variably observed on T2-weighted images, but these did not impair the evaluation of the signal intensity of the pituitary stalk.
Discussion

We assessed the normal pituitary stalk in detail by using high-resolution MR images at 3T. 3T MR imaging provides a higher SNR compared with 1.5T MR imaging, resulting in improved spatial resolution and image quality.9,10 3T MR imaging has previously been found to be superior to standard 1.5T imaging for the evaluation of sellar and parasellar anatomy, and improved surgical planning for sellar lesions.11,12 To the best of our knowledge, the length of the pituitary stalk, the depth of the infundibular recess, and the signal intensity of the pituitary stalk on T2-weighted images were evaluated on MR images for the first time in the current study.

The diameter of the normal pituitary stalk measured on oblique-axial images was 2.32 ± 0.39 mm for the AP diameter and 2.16 ± 0.37 mm for the transverse diameter at the pituitary insertion.

The diameter of the normal pituitary stalk measured on oblique-axial images was 2.32 ± 0.39 mm for the AP diameter and 2.16 ± 0.37 mm for the transverse diameter at the pituitary insertion. The AP diameter was 3.25 ± 0.43 mm and the transverse diameter was 3.35 ± 0.44 mm, respectively, at the level of the optic chiasm. Peyster et al6 found that the upper size limit of the diameter of the normal pituitary stalk on axial CT images was 4.0 mm at the level of the dorsum sella and 4.5 mm at the suprasellar level. On 1.5T MR imaging, Tien et al3 reported that the upper limit of the width of the normal pituitary stalk was 2.8 mm at the midpoint and 3.5 mm near the median eminence, whereas the transverse diameter measured by Simmons et al7 on coronal images was 1.91 ± 0.40 mm near

| Measurements of the normal pituitary stalk | Mean ± SD | Range |
|-------------------------------------------|-----------|-------|
| Diameter at the pituitary insertion (mm)  |           |       |
| Anteroposterior                           | 2.32 ± 0.39 | 1.65–3.17 |
| Transverse                                | 2.16 ± 0.37 | 1.56–3.04 |
| Diameter at the level of optic chiasm (mm)|           |       |
| Anteroposterior                           | 3.25 ± 0.43 | 2.25–4.08 |
| Transverse                                | 3.35 ± 0.44 | 2.39–4.21 |
| Length of the stalk (mm)                  | 5.91 ± 1.24 | 3.26–8.66 |
| Depth of the infundibular recess (mm)     | 4.69 ± 0.87 | 3.28–6.52 |
| Ratio of the length of the stalk to the depth of the infundibular recess | 1.30 ± 0.39 | 0.70–2.19 |

Fig 2. T2-weighted oblique-axial images of the pituitary stalk of a 34-year-old healthy woman. Consecutive images with 2-mm intervals are presented from superior (A) to inferior (E), along with a reference line of each imaged level on the midsagittal MPRAE image. The infundibular recess (arrow) ends at the midstalk level. The parenchyma of the pituitary stalk at its insertion on the pituitary gland shows central hyperintensity with a peripheral rim of isointensity (arrowhead) compared with the cerebral white matter.

Fig 3. T2-weighted oblique-axial image of the pituitary stalk of a 34-year-old healthy man. The pituitary stalk shows homogeneous isointensity with the cerebral white matter at its insertion on the pituitary gland.
the insertion on the pituitary gland and 3.25 ± 0.56 mm near the optic chiasm. The optic chiasm results of the current study support the earlier observation. However, the current findings at the pituitary insertion are larger than those of Simmons et al, and this difference may be the result of the difference in spatial resolution between 1.5T and 3T MR imaging and/or the difference in the imaging plane. No significant differences were observed in the current study between the AP and transverse diameters at both levels, and we postulate that stalk thickening can be evaluated in any direction on the basis of our results.

We measured the length of the pituitary stalk and the depth of the infundibular recess and also calculated the ratio between these measurements, which showed considerable variability. The optic chiasm and the tuber cinereum form the infundibular recess in the anteroinferior floor of the third ventricle. Because the infundibular recess can vary greatly in shape and size, the degree of its extension inferiorly along the pituitary stalk may contribute to the size and contour of the pituitary stalk. Shibata and Maravilla reported a case of a third-ventricle infundibular diverticulum that mimicked stalk thickening. The knowledge of the normal size of the infundibular recess is important for the assessment of pituitary infundibular lesions.

Some authors have previously assessed the signal intensity of the normal pituitary stalk on MR images. Simmons et al reported that the stalk is typically hypointense relative to the posterior pituitary lobe and the optic chiasm on T1-weighted images. Araki et al reported that the normal pituitary stalk showed hyperintensity on FLAIR images in 73% of the cases, presumably related to a prolonged T2 value of the pituitary stalk. However, the precise evaluation of the pituitary stalk on T2-weighted images has been difficult on standard 1.5T MR imaging because of insufficient spatial resolution.

In the current study, high-resolution T2-weighted images revealed the pituitary stalk to have central hyperintensity with a peripheral rim of isointensity compared with the cerebral white matter in 69% of the subjects. It remains unclear why the pituitary stalk shows this concentric zonal structure. The pituitary stalk is composed of the infundibular stem of the neurohypophysis and the pars tuberalis of the adenohypophysis. The adenohypophysis is divided into 3 parts: the pars distalis, the pars intermedia, and the pars tuberalis (Fig 4). The pars distalis forms the intrasellar adenohypophysis, whereas the pars intermedia is vestigial in humans. The pars tuberalis, the continuation of the pars distalis, is a delicate layer of pituitary tissue permeated by numerous capillary loops of the hypophyseal-portal plexus, and though it encircles the infundibular stem, its extent is variable. On the other hand, the infundibular stem is the pathway of oxytocin and vasopressin, which are produced in the supraoptic and paraventricular nuclei of the hypothalamus, to the posterior pituitary lobe. The central hyperintensity and peripheral isointense rim of the pituitary stalk may represent the infundibular stem and pars tuberalis, respectively. Although the reason for a prolonged T2 value of the infundibular stem is still unclear, Araki et al presumed that the fluid-rich characteristics of the pituitary stalk, such as pituitary portal veins and hypothalamic hormones, may cause the prolongation of the T2 value of the stalk. The hyperintensity of the infundibular stem may reflect histologic characteristics such as the axonal diameter or the thickness of the myelin sheath, similar to the hyperintensity of the normal corticospinal tract in the internal capsule. The hypophyseal portal system is unlikely to influence the signal intensity of the central pituitary stalk because it predominantly encircles the pituitary stalk and permeates the pars tuberalis.

The data of the current study on the normal pituitary stalk can serve as a standard in the diagnosis of stalk thickening, which is clinically important for proper diagnosis and treatment of various infundibular pathologic conditions. High-resolution T2-weighted images may contribute to the diagnosis of some pituitary infundibular diseases, though there have been no documented accounts referring to any specific disorders that decrease the signal intensity of the pituitary stalk on FLAIR images. The concentric zonal anatomy of the pituitary stalk visualized on high-resolution T2-weighted images may allow speculation of the site of origin of some suprasellar tumors, such as supradiaphragmatic pituitary adenoma and pituiycytoma.

There were several limitations to our study. First, histopathologic correlation of the pituitary stalk was absent. We could not obtain specimens of the imaged pituitary stalk because all subjects were healthy volunteers. Second, the effect of age on the appearance of the pituitary stalk was not evaluated. Children and elderly people were not included in our subjects. The size, shape, and signal intensity of the normal pituitary gland changes dramatically depending on age or physiologic status, and the pituitary stalk may show similar changes. This will be a subject for future investigation.

Conclusions
In conclusion, we have evaluated the normal pituitary stalk in detail by using 3T MR imaging, thereby providing a standard for the size of the normal pituitary stalk. The pituitary stalk
frequently shows central hyperintensity with a peripheral rim of isointensity on high-resolution T2-weighted images, which may represent the infundibular stem and pars tuberalis, respectively.

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