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M Suzuki, T Takashima, M Kadoya, S Takahashi, S Miyayama  
and S Taira

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# MR Imaging of Olfactory Bulbs and Tracts

Masayuki Suzuki<sup>1</sup>  
Tsutomu Takashima  
Masumi Kadoya  
Shiroh Takahashi  
Shiroh Miyayama  
Sakae Taira

Olfactory bulbs are easily detected on coronal T1-weighted MR images. They are situated almost symmetrically opposite either side of the lower end of the olfactory sulci, and, on sagittal images, they are observed as thin soft-tissue bands immediately beneath the frontal lobe base. On axial images they are shown as oval, paramedian structures of intermediate intensity. Visualization of the olfactory tract, however, is not always possible. Our study reveals that, on axial images, detection of the olfactory bulb depends on technical factors; we recommend a  $256 \times 256$  matrix, a 3-mm-thick slice, and less than a 0.6-mm gap.

Despite the lack of complete visualization of olfactory bulbs and tracts, MR may be effective in demonstrating diseases of these entities.

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The radiology literature contains several reports of MR visualization of the cranial nerves [1-3]. However, to our knowledge, there are no reports of the MR appearance of the olfactory nerve. The purpose of this article is to describe the MR appearance of the normal first nerve and to evaluate its detectability on axial MR images.

## Materials and Methods

Sixty-five patients were studied with MR imaging to diagnose suspected intracranial diseases, such as cerebellopontine angle tumor or facial spasm. We used a GE 1.5-T superconductive scanner with a head coil. All images were obtained with a short spin-echo technique of 500/20 (TR/TE),  $256 \times 128$  or  $256 \times 256$  matrices, two or four excitations, 3-mm slice thickness with gaps of 0, 0.3, 0.5, 0.6, 1.0 or 1.5 mm, and fields of view of 12, 16, or 20 cm. In several cases, sagittal and coronal images were also obtained with a short TR/TE spin-echo technique and 3- or 5-mm-thick slices.

We examined the MR detectability of the olfactory bulb on the axial image in all 65 cases. An oval-shaped paramedian structure of intermediate intensity on the axial image was defined as an olfactory bulb. Comparison was made between two groups, one with a  $256 \times 256$  matrix (group 1) and the other with a  $256 \times 128$  matrix (group 2). Comparison was made between another two groups, one with a gap of less than 0.6 mm (group 3) and the other with a gap of 1 mm or more (group 4).

## Results

The olfactory bulbs are easily detected on coronal MR images. They are situated almost symmetrically opposite either side of the lower end of the olfactory sulci (Fig. 1). Their appearance correlates well with anatomic coronal sections [4]. On sagittal images they are seen immediately beneath the base of the frontal lobe, where they appear as thin, soft-tissue bands (Fig. 2). This appearance also correlates with anatomic parasagittal sections [4]. It is necessary to use appropriate

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<sup>1</sup> All authors: Department of Radiology, School of Medicine, Kanazawa University, Takara-machi, Kanazawa, Ishikawa, 920 Japan.

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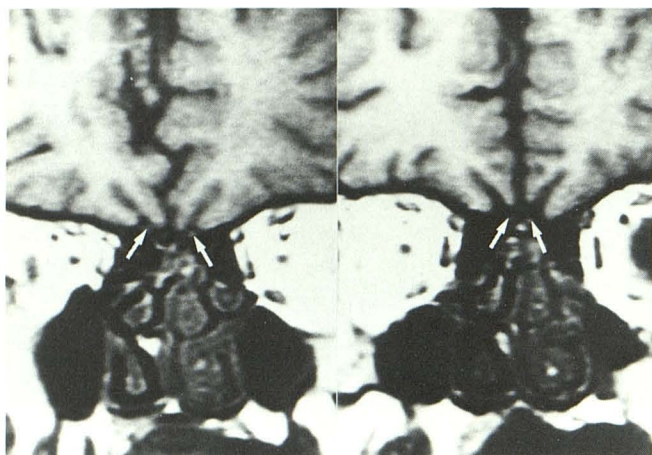


Fig. 1.—Coronal T1-weighted image. Olfactory bulbs (arrows) are well visualized almost symmetrically opposite either side of the lower end of the olfactory sulci. Olfactory tracts (not shown) are located posteriorly to bulbs.

positioning, employing the coronal and sagittal images, to demonstrate the olfactory bulb on axial images. On these, it is shown as an oval structure of intermediate signal intensity (Fig. 3). Visualization of the olfactory tract, however, is not always possible.

We were able to visualize the olfactory bulb on 70 sides of group 1 patients (Fig. 4) and 34 sides of group 2 patients (Table 1). The difference between the two groups was statistically significant (chi-square test,  $p = .01$ ). The olfactory bulb was visualized on 85 sides of group 3 patients and 19 sides of group 4 patients (Table 2). This difference was less significant (chi-square test,  $p = .10$ ). In some cases, we were unable to visualize the olfactory bulb despite the use of appropriate scan techniques (Fig. 5).

### Discussion

The olfactory nerves originate from the olfactory cells situated in the mucous membrane on the olfactory region of the nasal cavity [5]. The fibers from these neurons pierce the

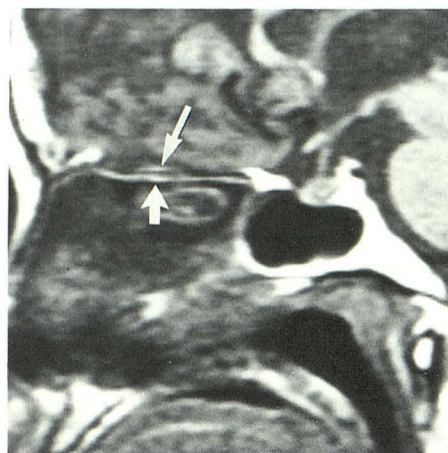


Fig. 2.—Sagittal T1-weighted image. A thin band (long thin arrow) is situated beneath base of frontal lobe. Marrow of frontal bone is shown as a slightly brighter band (short wide arrow).

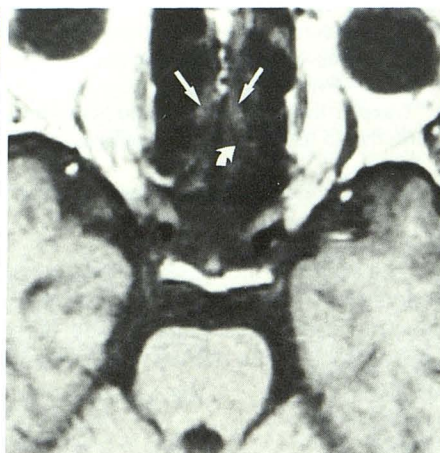


Fig. 3.—Axial T1-weighted image. Oval-shaped olfactory bulbs (straight arrows) are clearly shown in base of anterior cranial fossa. A portion of the olfactory tract is also visualized (curved arrow).

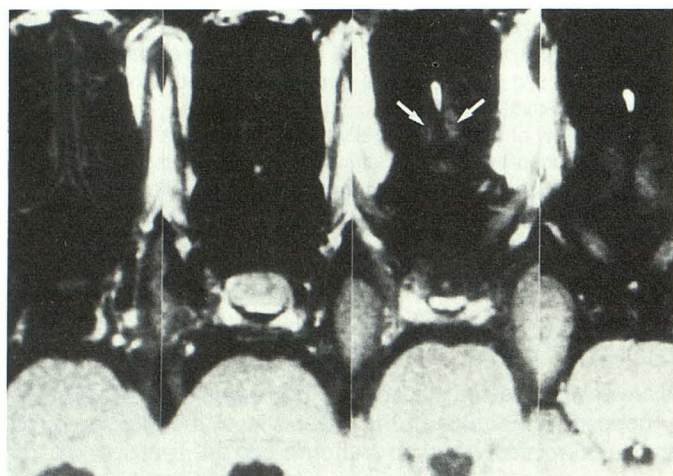


Fig. 4.—Axial T1-weighted image (256 × 256 matrix, four excitations, 3-mm-thick slice, 0.5-mm gap). The bulbs are well visualized (arrows).

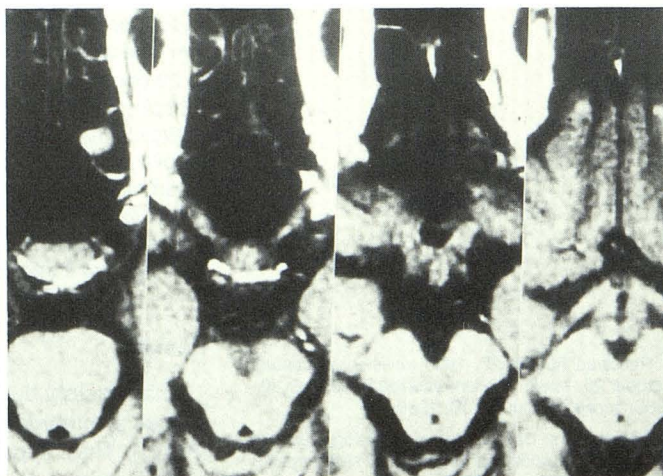


Fig. 5.—Axial T1-weighted images (256 × 256 matrix, four excitations, 3-mm-thick slice, 0.5-mm gap). Bulbs are not visualized despite appropriate scan technique.



**TABLE 1: Influence of Matrix Size on Detectability of Olfactory Bulb on T1-Weighted Images**

Technical Factors	Visualized	Not Visualized	No. of Sides
Group 1 Matrix = 256 × 256 Excitations = 2 or 4 Field of view = 20	70	10	80
Group 2 Matrix = 256 × 128 Excitations = 2 or 4 Field of view = 12, 16, or 20	34	16	50
Total	104	26	130

**TABLE 2: Influence of Gap Size on Detectability of Olfactory Bulb on T1-Weighted Images**

Technical Factors	Visualized	Not Visualized	No. of Sides
Group 3 Matrix = 256 × 256 or 128 Excitations = 2 or 4 Field of view = 16 or 20 Gap size = less than 0.6 mm	85	17	102
Group 4 Matrix = 256 × 256 or 128 Excitations = 2 or 4 Field of view = 12 or 20 Gap size = more than 1 mm	19	9	28
Total	104	26	130

cribriform plate of the ethmoid bone to end in the glomeruli of the olfactory bulb. The olfactory bulb is a flattened mass situated below the anterior end of the olfactory sulcus of the frontal lobe. The olfactory tract is a narrow band that originates from the posterior end of the olfactory bulb and passes posteriorly. Its posterior end is termed the olfactory trigone.

According to the topographic anatomy of the cranial nerves [6], the olfactory bulb is 6–14 mm long, 3–7 mm wide, and 2.1–2.3 mm thick; the tract has an average length of 25 mm and an average width of 3 mm.

Anatomically, the olfactory nerves are vulnerable to injury from trauma or infection of the nasal cavity or paranasal sinuses [7]. Knowledge of the morphology of the olfactory nerves is important for evaluating patients with anosmia and hypothalamic hypogonadism (Kallmann syndrome) [8]. Prior to MR, there were no effective imaging methods to detect the olfactory bulbs and tracts. The olfactory sulcus could be demonstrated in the brow-up frontal view of a pneumogram [9], but the olfactory bulbs and tracts themselves were impossible to visualize.

With MR it is possible to delineate the olfactory bulb and tract, but on axial images visualization of the olfactory bulb depends on the technical factors. Our study reveals that the following technical factors are needed: a 256 × 256 matrix, a 3-mm-thick slice, and less than a 0.6-mm gap. On the axial image, it is difficult to delineate the whole length of the olfactory tract because of partial volume effect. If a thinner section is available, complete visualization of the olfactory nerve may be accomplished. Nevertheless, MR may still be effective in demonstrating diseases of the olfactory bulb and tract.

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