TECHNICAL NOTE

Classification of the venous architecture of the pineal gland by 7 T MRI

Classification de l’architecture veineuse de la glande pinéale en IRM 7 T

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Introduction

The markedly improved resolution obtained with ultra-high-field magnetic resonance imaging (MRI), such as 7 T, can reveal many details of anatomical structures, such as the hippocampus and thalamus, with unprecedented resolution and contrast [1–3]. In this report, we describe the anatomical structure of pineal glands on 7 T MR images as has never been seen before.

There is an unusually wide variation in the structure of pineal glands when observed by ultra-high-resolution 7 T MRI in vivo (Fig. 1). This prompted us to investigate the variability in the morphology of pineal glands and related vascular structures, as previously reported in postmortem human studies [4,5]. The present report presents the results of classification of the various venous blood-drainage morphologies on in vivo pineal gland images from 34 young healthy volunteers. This observation was made possible by the recently available ultra-high-field MRI at 7 T. As shown in Fig. 2 (upper), visualization of the pineal gland was largely limited by the poor resolution of the currently available commercial scanners, such as the 1.5 and 3.0 T MRI machines [6,7]. Ultra-high-field 7 T MRI, especially with its markedly

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Figure 1  Widely varying shapes of pineal glands, as typically observed by 7 T MRI with T2* sagittal view: (a) nonspecific inner structure with streamlined external shape; (b) net-like inner structure with elliptical external shape; and (c) completely filled inner structure with a sharp external shape. PB: pineal body; PC: posterior commissure; SC: superior colliculus.

Table 1  MR imaging parameters used in the study.

<table>
<thead>
<tr>
<th></th>
<th>7 T MRI sagittal T2* image</th>
<th>3 T MRI sagittal T2* image</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR (ms)</td>
<td>750</td>
<td>5790</td>
</tr>
<tr>
<td>TE (ms)</td>
<td>21.6</td>
<td>103</td>
</tr>
<tr>
<td>Voxel resolution</td>
<td>0.25 mm × 0.25 mm × 2 mm</td>
<td>0.34 mm × 0.34 mm × 2 mm</td>
</tr>
<tr>
<td>Matrix size</td>
<td>896 × 1024</td>
<td>560 × 640</td>
</tr>
</tbody>
</table>

TR: repetition time; TE: echo time.

enhanced T2* imaging capability, however, allows visualization of details in the inner structures of the pineal gland (Fig. 2, lower), thereby permitting examination of the variations found in the inner structures of pineal glands.

Figure 2  Comparison of images of pineal glands and their surroundings obtained in the same subject with 3 and 7 T MRI, respectively. The horizontal red lines indicate the anterior commissure (AC)—posterior commissure (PC) line; the vertical dotted red lines and red dots indicate landmark brain structures such as the AC, mammillary body (MB), thalamus (TM), PC and inferior colliculus (IC); the yellow boxes on the left of the images indicate the expanded view of the images seen on the right.

Case report a technical note

Altogether, 34 healthy volunteers (22 men and 12 women) were studied. The average age of the men was 25 years, and the average age of the women was 23 years. The study was approved by the Gachon University Gil Hospital Institutional Review Board and the Korea Food & Drug Administration. MRI was performed with a Siemens 7.0 T MRI (Magnetom; Siemens, Erlangen, Germany) scanner, using a home-built eight-channel transmitting-receiving (TX-RX) head coil.

A set of sagittal T2* contrast-enhanced MR images was obtained from each volunteer. In addition, to compare the quality of the ultra-high-resolution images with conventional MR images, a few additional 3.0 T MRI (Verio; Siemens) images of the pineal gland were also obtained. The MR imaging parameters used in the study are summarized in Table 1. A typical dataset from the same subject is also displayed to show the resolution and contrast differences in images from the 3 and 7 T MRI scanners (Fig. 2). After collecting the images from the 34 volunteers, the various shapes and morphologies of the pineal vein were then classified (Fig. 3). In the postmortem human study mentioned above [4], it was also found that the structure of the pineal vein can be classified into three types, mainly based on the location of the draining veins. We therefore attempted to classify our sagittal-view pineal gland images according to that study’s classification system, and found a close correlation between the two (Fig. 3, Table 2): Type I (15 men and 3 women); Type II (5 men and 7 women); and Type III (2 men and 2 women). Such an in vivo imaging classification of the pineal gland venous architecture in correlation with that of the postmortem studies is unique, thanks to the higher anatomical MRI resolution obtained at 7 T.
Three types of pineal gland images obtained by 7 T MRI and categorized by vascular distribution or structure: (A) Type I, pineal vein drains directly into the great cerebral vein of Galen; (B) Type II, pineal vein drains into the internal cerebral vein; and (C) Type III, pineal vein drains into both the great cerebral vein of Galen and internal cerebral vein. Single-slice MR images of pineal glands: (left) the green bar and small white box indicate the location of pineal vein roots; (middle) images at minimum-intensity projection of 17 slices each, thickness 2 mm, can visualize two landmark veins: the red dotted lines indicate the internal cerebral vein (upper) and the basal vein (lower); the pineal veins are indicated by thin solid red lines (middle). Images on the right are drawings of the three types of pineal veins (left) described by Tamaki et al. [4] with our modified images (right). G: great cerebral vein of Galen; B: basal vein; P: pineal vein; IC: internal cerebral vein; CP: corpus pineal.

Discussion

The present results demonstrate the wide variation in the shape and vasculature of the pineal gland, which was strongly correlated with the previous postmortem human study. These results also show some gender differences in terms of type of venous structure. In other words, the pineal vein in men has a type I tendency, whereas the vein in women has a type II tendency. Nevertheless, as melatonin from the pineal gland is involved in sexual development [8], there is, as yet, no confirmed explanation for the gender difference in pineal gland venous patterns.

This is the first human in vivo pineal vein imaging study using 7 T MR imaging. This novel observation of the pineal gland using ultra-high-field 7 T MRI suggests that it has unusually wide variations in shape and venous structure, thus leading us to consider that it might be an important factor in the diagnosis of pineal gland-related diseases and disorders. The pineal vein is a tiny structure, but it plays an important role in the modulation of the human body. In addition, noninvasive pineal vein imaging may permit the early diagnosis of pineal gland abnormalities, such as pinealoma and tumor of the posterior third ventricle [4].

Table 2 Results of classification of pineal gland into three different types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Men (n)</th>
<th>Women (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>Type II</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Type III</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>12</td>
</tr>
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</table>

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Acknowledgments

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References


