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Magnetic resonance imaging predicts chronic dizziness after benign paroxysmal positional vertigo

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ABSTRACT

Objectives: We aimed to evaluate the clinical implications of magnetic resonance imaging (MRI) findings in patients with benign paroxysmal positional vertigo (BPPV).
Methods: A total of 120 patients diagnosed with BPPV completed MRI at the emergency room between December 2012 and June 2015 and met our criteria for inclusion in this study. Epidemiologic characteristics, the results of audio-vestibular testing, and MRI findings were retrospectively analyzed.
Results: The most common findings were white matter hyperintensities (70.0%), sinusitis (34.2%), and brain atrophy (25.0%). There were no significant differences in MRI findings or epidemiologic characteristics according to BPPV subtype ($p > 0.05$). A multiple regression analysis revealed that BPPV recurrence (odds ratio, 6.88; 95% confidence interval, 1.67–34.48; $p = 0.009$) and brain atrophy (odds ratio, 4.39; 95% confidence interval, 1.11–21.28; $p = 0.036$) were positively associated with dizziness lasting longer than 3 months.
Conclusion: Brain atrophy was independently associated with long-lasting dizziness after BPPV. Although the mechanism is unclear, brain atrophy may have relevance to otoneurotologic disease-related changes in brain structure.

1. Introduction

Benign paroxysmal positional vertigo (BPPV) is the most common cause of vertigo. The prevalence of BPPV has been reported to be 10.7–64.0 per 100,000 populations with a lifetime prevalence of 2.4% [1]. The peak age of onset is typically between 50 and 70 years, with elderly individuals and females having an increased risk of development (female-to-male ratio of 2:1 to 3:1) [1,2].

The diagnosis of BPPV requires otoneurotologic evaluation including the Dix-Hallpike test and/or the supine head roll test as well as a detailed assessment of medical history. Radiological evaluation is not always performed due to a lack of definitive reported findings for BPPV and the nature of the main pathophysiology, which typically includes dislodgement of the otoconia from the utricular macula.

However, questions regarding the usefulness of magnetic resonance imaging (MRI) for the diagnosis of dizziness as well as BPPV have remerged in recent years. Colledge et al. demonstrated that routine MRI results were insufficient for the identification of dizziness etiology: no significant differences were observed between patients with and without dizziness lasting >3 months [3]. Furthermore, the head impulse test, gaze-evoked nystagmus, and skew deviation were identified as more sensitive than diffusion-weighted MRI for the detection of acute central lesions in patients with acute vestibular symptoms [4]. Given these considerations, it is clear that evaluation by a well-trained otoneurotologist may be more important than MRI for the differential diagnosis and treatment of dizziness. However, diffusion-weighted MRI has valid utility for evaluating brain structural abnormalities, and can be performed without contrast and in a cost-effective manner based on the experience of the examiner. Indeed, diffusion-weighted MRI has been frequently used to distinguish stroke or acute cerebellar lesions from other causes of dizziness, which is vital for the implementation of early and appropriate treatment intervention.

In retrospect, a majority of studies reporting MRI findings in BPPV have referred to case-series reports of other central lesions misdiagnosed as BPPV upon initial evaluation. Otherwise, MRI studies in BPPV have rarely been performed. Thus, even though BPPV is highly suspected when atypical clinical findings such as unusual nystagmus are observed during otoneurotologic evaluation, MRI scanning may be indicated in cases of symptom deterioration or vertigo intractable to an appropriate particle repositioning maneuver (PRM) in order to

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identify culpable central lesions or subtle inner ear pathologies [5,6]. Consistent with this hypothesis, three-dimensional MRI has been used to identify fracture, stenosis of the semicircular canals, and/or filling defects in cases of intractable BPPV [7]. A recent MR angiography study in elderly BPPV patients reported the frequent observation of stenosis/occlusion of the vertebral artery (VA) in up to 21.2% of cases and postulated that hypoplasia or tortuosity of the VA was associated with the occurrence of BPPV due to compromised posterior circulation [8].

Therefore, we evaluated the clinical implications of MRI findings in patients who visited the emergency room (ER) of a university hospital complaining of acute dizziness due to BPPV. Our study addresses the relationship between incidental MRI findings and the clinical manifestation of BPPV.

2. Material and methods

2.1. Patients

We retrospectively enrolled patients who visited the ER at a university hospital between December of 2012 and June of 2015 complaining of acute-onset dizziness who completed MRI and were subsequently referred to the "dizzy" clinic at department of otorhinolaryngology due to the absence of acute lesions and received a diagnosed as BPPV. All patients were admitted to the hospital for evaluation and treatment. The exclusion criteria were as follows: 1) a previous history of BPPV; 2) a duration of follow-up < 1 year; 3) insufficient medical records; 4) patients who did not complete an MRI evaluation at the ER. This study was approved by the Institutional Review Board of Eulji University (IRB number: 2016-06-016). The IRB granted a waiver of written informed consent based on the retrospective design of this study.

2.2. Otoneurotologic examinations

The otoneurotologic evaluation [9,10] comprised bed side examinations such as smooth pursuit, spontaneous nystagmus, gaze-evoked nystagmus, the head impulse test, the head-shaking nystagmus test, the Romberg test, and routine laboratory examinations; when appropriate, infrared goggles (SLMED, Seoul, Korea) were used. In addition, all patients completed the Dix-Hallpike test and the head-roll test in order to identify the affected semicircular canals (SCCs).

One audiologist with >10 years of experience performed the bithermal caloric test with warm water (44 °C) and cold water (30 °C); the results were recorded by videonystagmography (CHARTR VNG; ICS Medical, Schaumburg, IL, USA). Canal paresis (CP) was calculated using Jongkees formula; >25% CP was considered to be abnormal [9,10].

For the measurement of cervical vestibular evoked myogenic potentials (cVEMPs), the patient was placed in the supine position and the head was tilted to the opposite side with an active electrode placed on the midpoint of the sternocleidomastoid muscle, a reference electrode on the sternum, and a ground electrode placed in the center of the forehead. Navigator Pro software (Bio-logic Systems Corp., IL, USA) was used to calculate cVEMP responses and VEMP amplitudes were measured by playing a 500 Hz tone burst at 95 dBnHL through a pair of headphones. The stimulation pattern had a rise/fall time of 4 ms and a plateau time of 2 ms. cVEMP asymmetry exceeding 30% or a lack of cVEMP response were considered to be abnormal [9,10].

2.3. BPPV classification

According to the results of the otoneurotologic examination, patients were classified into five groups: anterior canal BPPV (AC-BPPV), posterior canal BPPV (PC-BPPV), geotropic horizontal canal BPPV (geotropic HC-BPPV), apogeotropic horizontal canal BPPV (apogeotropic HC-BPPV), and atypical BPPV. PC-BPPV was diagnosed if torsional up-beating nystagmus was observed in the Dix-Hallpike test. Horizontal nystagmus beating towards the ground was classified as geotropic HC-BPPV. Nystagmus beating towards the ceiling was classified as apogeotropic HC-BPPV. If down-beating nystagmus was observed in the Dix-Hallpike test or during the deep head-hanging position, patients were diagnosed as AC-BPPV. Patients with atypical or absent nystagmus were classified as atypical BPPV regardless of typical BPPV history.

2.4. MRI protocol

MRI was performed as previously described [9] using either a 3-T system (MAGNETOM Skyra, SIEMENS, Erlangen, Germany) or a 1.5-T system (SONATA, SIEMENS, Erlangen, Germany) with a standard head coil. MRI sequences included axial T1- and T2-weighted images, sagittal T1- and T2-weighted images, fluid-attenuated inversion recovery (FLAIR) images, and diffusion-weighted images (DWI), with or without subsequent contrast enhancement spin-echo T1-weighted images. MRI parameters were as follows for the 3-T and 1.5-T systems, respectively: T1-weighted images (repetition time [TR] = 250 and 486 ms, echo time [TE] = 3.2 and 7.7 ms, flip angle = 70 and 75°, matrix size = 512 × 259 and 256 × 168); T2-weighted images (TR = 4500 and 4770 ms, TE = 108 and 125 ms, flip angle = 132 and 150°, matrix size = 384 × 384 and 256 × 179); FLAIR images (TR = 6240 and 9000 ms, TE = 95 and 122 ms, flip angle = 150°, matrix size = 256 × 224 and 512 × 259); and DWI images (TR = 4500 and 8200 ms, TE = 98 and 99 ms, flip angle = 90°, and matrix size = 128 × 127 and 192 × 154 at b = 0 or 1000 s/mm^2. The other parameters were the same for all sequences: section thickness = 5 mm, gap = 1 mm, field of view = 175 × 200 mm. A neuroradiologist with >20 years of clinical experience reviewed all whole-brain MRI sequences.

2.5. Follow-up period and definition of complete recovery

Patients were discharged from the hospital when objective nystagmus was not observed and/or if dizziness resolved. All patients were instructed to attend regular follow-up visits at the "dizzy" clinic at 2 weeks, 1 month, 3 months, 6 months, and 12 months or more post-discharge even if they did not experience dizziness symptoms in their daily life. More detailed follow-up visits at the clinic were recommended if residual symptoms persisted after discharge or if dizziness symptoms recurred.

2.6. Statistical analyses

Data are expressed as the mean ± standard deviation or as percentages. Comparisons between nominal scales were performed using the Chi-square test. A retrograde conditional multiple regression analysis was performed on the prognostic factors selected by a bivariate analysis. All statistical analyses were performed using SPSS software (version 24.0, SPSS Inc., Chicago, IL, USA) and the level of statistical significance was set at $p < 0.05$.

3. Results

3.1. Patient characteristics

A total of 153 patients were initially enrolled in the study (Fig. 1.). After thoroughly reviewing the patient medical charts, 33 patients were excluded. Finally, data from 120 patients (28 males and 92 females) were included in the final analysis (Table 1). The mean age was 51.5 ± 9.41 years. With regard to BPPV laterality, 70 patients exhibited right-side BPPV whereas 50 patients exhibited left-side BPPV. The mean follow-up period was 16 ± 3.70 months. With regard to etiology, 115 patients (95.8%) indicated that their dizziness was prompted by standing up or turning their head and 5 patients (4.2%) reported abrupt

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