White matter hyperintensities (WMH) are common among the elderly. Although WMH play a key role in lowering the threshold for the clinical expression of dementia in Alzheimer’s disease (AD)-related pathology, the clinical significance of their location is not fully understood. This study aimed to investigate the association between WMH and cognitive function according to the location of WMH in AD.

Methods Subjects underwent clinical evaluations including volumetric brain magnetic resonance imaging study and neuropsychological tests using the Korean version of the Consortium to Establish a Registry for Alzheimer’s Disease Assessment Packet. WMH were calculated using automated quantification method. According to the distance from the lateral ventricular surface, WMH within 3 mm, WMH within 3–13 mm, and WMH over 13 mm were classified as juxtaventricular WMH (JVWMH), periventricular WMH (PVWMH), and deep WMH (DWMH), respectively.

Results Total WMH volume was associated with poor performance in categorical verbal fluency test ($\beta=-0.197$, $p=0.035$). JVWMH volume was associated with poor performances on categorical verbal fluency test ($\beta=-0.201$, $p=0.032$) and forward digit span test ($\beta=-0.250$, $p=0.012$). PVWMH volume was associated with poor performances on categorical verbal fluency test ($\beta=-0.185$, $p=0.042$) and word list memory test ($\beta=-0.165$, $p=0.042$), whereas DWMH volume showed no association with cognitive tests. PVWMH volume were also related to Clinical Dementia Rating Scale Sum of Boxes score ($\beta=0.180$, $p=0.026$).

Conclusion WMH appear to exhibit different associations with the severity of dementia and cognitive impairment according to the distance from ventricle surface in AD.

Keywords Alzheimer’s disease; White matter hyperintensities; Cognitive function.
companions of aging. Indeed, chronological age is the strongest correlate of WMH severity and almost elderly people have some degree of WMH burden. At the point of prevalence of WMH, according to the Rotterdam scan study, designed to study the determinants and consequences of age-related brain abnormalities in the elderly, show that the prevalence of WMH increases by 0.2% per year of age and for the subjects aged 80–90 years, they had 100% of subcortical WMH. However, unlike these initial point of view, recent studies consistently reported that WMH were correlated with clinical and cognitive functions among elderly people. Furthermore, recent investigations proved that large areas of disease in the WMH of the brain must be considered as neuroimaging markers of brain frailty.

Pathologically, Alzheimer’s disease (AD) is defined by the presence of amyloid plaques and neurofibrillary tangles, which emerge in the hippocampal formation and spread throughout posterior and anterior cortex. However, accumulating evidence indicates that, in addition to the pathological features that define the disease such as amyloidosis, factors associated with poor cognitive aging (in the absence of frank dementia) may play a primary role in the pathogenesis and progression of AD. At the top of the list of these factors are WMH. According to the previous studies, they have confirmed a dose-dependent relationship between WMH and clinical outcome including cognitive function.

Considering that WMH are generally much more severe and widespread in patients with AD, we hypothesized that both prevalence and severity of WMH is predominant in AD, and that it might be one of the major processes accelerating cognitive decline. Indeed, WMH has emerged as a particularly strong correlate of cognitive function in AD and is the focus of our discussion in this study. However, most previous investigations of WMH burden have been cross-sectional analyses among nondemented older adults which are difficult to establish the association because of the low amount of WMH, and other, there are limitations in the volumetric analysis of the brain because they mainly used qualitative or semi-quantitative visual rating scales for measuring WMH or used quantitative volumetric methods to examine the regional distribution of WMH only.

Furthermore, we wondered whether the impact of WMH volume on cognitive function differed according to the specific anatomical regions of WMH. WMH have been frequently divided into periventricular WMH (PWMH) and deep WMH (DWMH). Such dichotomous definitions are somewhat arbitrary and vary across studies, which potentially contributes to inconsistencies in results. A new subclassification of WMH, which may have better etiological and functional relevance than the simple dichotomization, was suggested to reduce possible heterogeneities of PWMH and DWMH and to improve the value of WMH as etiological or prognostic markers in research and clinical settings. Specifically, this subclassification stratifies WMH into juxtaventricular (JVWMH, within 3 mm from the ventricular surface), PVWMH (3–13 mm from ventricular surface), and DWMH (13 mm or further from the ventricular surface) locations. According to the new subclassification of WMH, we investigated the association between three subclassified WMH and cognitive function, respectively.

The aim of this study was twofold: 1) to investigate the quantitative association between WMH and cognitive function in AD, 2) to investigate whether there is any difference in the association between subclassified WMH and cognitive function in AD.

METHODS

Subjects

Subjects with AD above 60 years old were consecutively recruited from the dementia clinic of Jeju National University Hospital (Jeju-do, Korea; JNUH) between January 2018 and January 2020. All subjects underwent a standardized clinical interview, physical and neurological examinations, and laboratory tests, including MRI, according to the Korean version of the Consortium to Establish a Registry for Alzheimer’s Disease Assessment Packet (CERAD-K). The CERAD-K Neuropsychological Assessment Battery (CERAD-K-N), Stroop test, and digit span test, were also administered by 4 neuropsychologists. The CERAD-K-N consists of 9 neuropsychological tests, as follows: verbal fluency test, 15-item Boston naming test, Korean version of the Mini-Mental State Examination (MMSE-KC), word list memory test, constructional praxis test, word list recall test, word list recognition test, constructional recall test, and trail making test.

All available information was reviewed by a panel of two experienced dementia research neuropsychiatrists to diagnose AD, according to the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer’s Disease and Related Disorders Association criteria (NINCDS-ADRSA) and the Clinical Dementia Rating Scale Sum of Boxes (CDR-SOB) was determined. We included subjects with probable AD and possible AD, but excluded those with history of stroke, focal neurological signs, and major psychiatric illnesses such as schizophrenia, bipolar disorder, substance abuse, and other types of dementia. Specifically, we excluded cases of vascular dementia that met the diagnostic criteria for the National Institute of Neurological Disorders and Stroke/Association Internationale pour la Recherche et l’Enseignement en Neurosciences criteria (NINCDS-AIREN). Efforts were made to designate the primary cause of dementia in each case instead of AD.
of assigning mixed dementia. Cases with ambiguous causes such as dementia not otherwise specified and mixed dementia were excluded in this study.

All subjects were fully informed about the study protocol and written statements of informed consent were signed by either the subjects or their legal guardians. The study protocol was approved by the institutional review board of the JNUH (JEJUNUH 2023-02-004).

**MRI acquisition**

MRI scans were obtained at JNUH on a 3.0 Tesla Philips Intera scanner (Philips, Amsterdam, Netherlands). Three-dimensional (3D) T1-weighted anatomical images (acquisition voxel size=1.0×0.5×0.5 mm; 1.0 mm sagittal slice thickness with no inter-slice gap; repetition time=4.61 ms; echo time=8.15 ms; number of excitations=1; flip angle=8°; field of view=240×240 mm; and acquisition matrix size=175×256×256 mm in the x-, y-, and z-dimensions) and 3D fluid-attenuated inversion recovery (FLAIR) images (voxel dimension=1×1×3 mm³; repetition time=9,900 ms; echo time=125 ms; inversion time=2,800 ms; number of excitations=1; flip angle=90°; field of view=240 mm; axial plane matrix=256×256 mm; thickness=3 mm; and no interslice gap) were acquired. Patient motion during the acquisition can induce artifacts and reduce image quality and diagnostic relevance. To minimize this issue, we initially took measures to ensure that all participants received thorough education on imaging techniques and postures, provided by a specialized imaging technician. In addition, we ensured the involvement of a qualified specialist in the field of radiology to accurately identify and interpret all images, and any cases where limitations were encountered in the analysis were excluded from the subjects. The number of excluded cases was three in total, all of which were determined to be unsuitable for analysis due to patient movement in the images.

**MRI processing and analysis**

Total brain volume (TBV), estimated intracranial volume (eICV), and total hippocampal volume (HV) were calculated using 3D T1-weighted images with FreeSurfer version 7.0.0 software (Athinoula A. Martinos Center for Biomedical imaging, Boston, MA, USA). 3D FLAIR images were co-registered to the T1 weighted images by affine transformation using statistical parametric mapping version 12 (SPM12; Wellcome Institute of Neurology, University College London, UK; http://www.fil.ion.ucl.ac.uk/spm/doc/) for MATLAB (MathWorks Inc., Natick, MA, USA). WMH segmentations were performed on the co-registered 3D FLAIR images using the lesion prediction algorithm of the lesion segmentation toolbox (http://www.statistical-modeling.de/lst.html) for SPM12. We used an in-house Matlab code to further partition the WMH into three categories, as proposed by Kim et al. First, the ventricle was segmented from the subjects’ T1-weighted image. Next, a distance map of each WMH voxel from the ventricle was calculated. Then, each WMH voxel was assigned to one of the following three categories depending on their distance from the ventricle: JVWMH were defined as areas that are less than 4 voxels away from the ventricle; PVWMH as areas that are between 4 and 13 voxels away from the ventricle; and DWMH as areas that are more than 13 voxels away from the ventricle (Figure 1). For each WMH voxel, its Euclidean distance from the nearest ventricle voxel was calculated. Thus, the distance map contains values that encode the Euclidean distance of each voxel from the nearest ventricle voxel.

**Other measures**

Determining apolipoprotein E genotype was performed by one stage polymerase chain reaction from the venous blood according to the methods described by Wenham et al. The apolipoprotein E genotype was determined for all the subjects. Depressive symptoms were assessed using the Korean version

![Figure 1. Subclassified WMH volume. Justaventricular WMH (blue), periventricular WMH (light green), deep WMH (red). WMH, white matter hyperintensities.](image_url)
of the short form of geriatric depression scale (sGDS-K; range, 0–15; increasingly worse), and comorbidity status was assessed using Charlson’s comorbidity index (CCI, increasingly worse). CCI was used to quantify comorbid condition. Each condition is assigned a weight from 1 to 6, which are summed to calculate a total CCI score for each participant. Its widespread use and validation across multiple studies and settings to its utility and reliability.

**Statistical analysis**

Prior to following analyses, the ratio of WMH volume to eICV was calculated to account for variation in head size and the ratio was logarithmically transformed because of its non-normal distribution (Supplementary Figure 1). Continuous variables were analyzed using analysis of variance, and chi-squared tests were used to examine differences in categorical variables. To identify the variables associated with WMH, we performed multiple linear regression analysis using age, sex, years of education, apolipoprotein E ε4 allele status, total HV, CCI, sGDS-K, CDR-SOB as covariables. To explore the different associations of subclassified WMHs with cognitive tests, we performed comparisons of regression coefficients for the subclassified WMH between linear regression models. All statistical analyses were performed using STATA version 15.1 (Stata Corp., College Station, TX, USA).

**RESULTS**

**Demographic characteristics of the subjects**

A total of 171 patients with AD were enrolled in the present study. The mean age of was 80.7±6.6 years and 70.8% were female. Total WMH volume was 20.7±18.2 mL, of which JVWMH accounted for 42.7%, PVWMH 51.0%, and DWMH 6.3%, respectively. The frequency of apolipoprotein E ε4 allele was 43.3%. The demographics and clinical characteristics of the subjects are detailed in Table 1.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total WMH volume (mL)</td>
<td>20.7±18.2</td>
</tr>
<tr>
<td>JVWMH volume (mL)</td>
<td>8.9±5.5</td>
</tr>
<tr>
<td>PVWMH volume (mL)</td>
<td>10.6±1.2</td>
</tr>
<tr>
<td>DWMH volume (mL)</td>
<td>1.3±2.4</td>
</tr>
<tr>
<td>eICV (mL)</td>
<td>1495.7±171.0</td>
</tr>
<tr>
<td>TBV (mL)</td>
<td>994.7±97.8</td>
</tr>
<tr>
<td>HV (mL)</td>
<td>5.1±0.8</td>
</tr>
<tr>
<td>Apolipoprotein E ε4 allele</td>
<td>74 (43.3)</td>
</tr>
<tr>
<td>CCI</td>
<td>3.9±1.4</td>
</tr>
<tr>
<td>sGDS-K</td>
<td>5.6±4.1</td>
</tr>
</tbody>
</table>

Values are presented as number (%) or mean±standard deviation. CDR-SOB, Clinical Dementia Rating Scale Sum of Boxes; WMH, white matter hyperintensities; JVWMH, juxtaventricular white matter hyperintensities; PVWMH, periventricular white matter hyperintensities; DWMH, deep white matter hyperintensities; eICV, estimated intracranial volume; TBV, total brain volume; HV, hippocampal volume; CCI, Charlson’s comorbidity index; sGDS-K, Korean version of the short form of geriatric depression scale.

**Quantitative association between the WMH volume and other factors**

The results of the correlation analysis showed that WMH volume had a positive correlation with age (r=0.448, p<0.001). WMH values were also positively correlated with JVWMH (r=0.928, p<0.001), PVWMH (r=0.974, p<0.001), DWMH (r=0.744, p<0.001), and CDR-SOB (r=0.290, p<0.001) (Supple-
**DISCUSSION**

With the rapid increase of the aging population, patients with AD have also been increasing, which leads to significant social and financial burden. As treatments targeting amyloid and tau in AD have not been successful, research is shifting towards other risk factors, such as WMH. Accumulating evidence indicates that WMH plays a crucial role in lowering the threshold for the clinical expression of dementia in AD-related pathologies. Moreover, greater WMH volume is associated with accelerated cognitive decline and concurrent cognitive dysfunction, independent of traditional risk factor for AD, such as biomarkers. This study emphasizes the distinct role of WMH in AD through quantitative analysis.

WMH have traditionally been classified as PVWMH or DWMH based on their proximity to the ventricles in previous studies. These classifications have different risk factors and cognitive impacts, but the arbitrary nature of this dichotomy leads to inconsistencies across studies. Therefore, there is a growing need for a new valid subdivision within WMH according to pathology and etiology to increase comparability between studies. A new subclassification stratifies JVWMH (within 3 mm from the ventricular surface), PVWMH (3–13 mm from ventricular surface), and DWMH (13 mm or further from the ventricular surface). This refined approach, based on pathology and etiology, improves comparability between studies and enhances the value of WMH as etiological and prognostic markers. The subclassification has shown clinical relevance in assessing frailty in AD and understanding pathophysiology in older adults.

WMH in AD have also been associated with accelerated cognitive decline and concurrent cognitive dysfunction, independent of traditional risk factors. We investigated not only an association between total WMH and cognitive function, but also associations of cognitive function with subclassified WMH (JVWMH, PVWMH, and DWMH) defined by a new classification. JVWMH and PVWMH volume accounted for most of total WMH, 93.7%. From the first quartile to the fourth quartile of WMH volume, the relative proportion of JVWMH volume to total WMH volume decreased, but the relative proportion of PVWMH volume increased, and the relative proportion of DWMH remained relatively constant. This finding suggests that in periventricular areas, WMH develop with gradual and continuous accumulation from the ventricular surface toward the deep white matter region, and DWMH develop early but maintain a small and relatively constant percentage of total WMH.

WMH volume was significant associated with eICV (p < 0.001), so WMH volume was adjusted to eICV before analyz-
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...ing the associations between WMH volume and each item of neuropsychological tests. Total WMH and subclassified WMH volumes were not associated with total HV. Greater total WMH and PVWMH volume were closely associated with the severity of AD, independent of hippocampal atrophy in this study.

According to previous studies on the effect of WMH volume on cognitive function, WMH volume is associated with multiple domains of cognitive function, such as executive func-

![Figure 2](image-url)
Table 3. The associations between WMH volume and neuropsychological tests in patients with Alzheimer’s disease

<table>
<thead>
<tr>
<th></th>
<th>Total WMH volume</th>
<th>JVWMH volume</th>
<th>PVWMH volume</th>
<th>DWMH volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef</td>
<td>S.E</td>
<td>β</td>
<td>p</td>
</tr>
<tr>
<td>Categorical verbal fluency</td>
<td>-1.801</td>
<td>0.843</td>
<td>-0.197</td>
<td>0.035*</td>
</tr>
<tr>
<td>Boston naming test</td>
<td>-1.111</td>
<td>0.700</td>
<td>-0.132</td>
<td>0.116</td>
</tr>
<tr>
<td>MMSE-KC</td>
<td>-1.223</td>
<td>1.203</td>
<td>-0.083</td>
<td>0.312</td>
</tr>
<tr>
<td>Word list memory</td>
<td>-1.619</td>
<td>0.830</td>
<td>-0.161</td>
<td>0.053</td>
</tr>
<tr>
<td>Constructional praxis</td>
<td>-0.705</td>
<td>0.587</td>
<td>-0.099</td>
<td>0.232</td>
</tr>
<tr>
<td>Word list recall</td>
<td>0.057</td>
<td>0.314</td>
<td>0.019</td>
<td>0.856</td>
</tr>
<tr>
<td>Word list recognition</td>
<td>-1.285</td>
<td>0.657</td>
<td>-0.183</td>
<td>0.053</td>
</tr>
<tr>
<td>Constructional recall</td>
<td>-0.139</td>
<td>0.390</td>
<td>-0.034</td>
<td>0.723</td>
</tr>
<tr>
<td>Trail making A</td>
<td>3.302</td>
<td>24.484</td>
<td>0.011</td>
<td>0.893</td>
</tr>
<tr>
<td>Trail making B</td>
<td>17.856</td>
<td>17.113</td>
<td>0.125</td>
<td>0.300</td>
</tr>
<tr>
<td>Digit span test forward</td>
<td>-0.780</td>
<td>0.448</td>
<td>-0.170</td>
<td>0.085</td>
</tr>
<tr>
<td>Digit span test backward</td>
<td>0.215</td>
<td>0.377</td>
<td>0.069</td>
<td>0.571</td>
</tr>
<tr>
<td>Stroop word</td>
<td>-0.716</td>
<td>7.276</td>
<td>-0.012</td>
<td>0.922</td>
</tr>
<tr>
<td>Stroop color</td>
<td>-0.803</td>
<td>4.827</td>
<td>-0.017</td>
<td>0.868</td>
</tr>
<tr>
<td>Stroop word and color</td>
<td>4.909</td>
<td>3.936</td>
<td>0.146</td>
<td>0.216</td>
</tr>
</tbody>
</table>

WMH volume was log transformed and adjusted to eICV before performing analysis. *p-value was obtained by multiple linear regression analysis with each item of neuropsychological tests as a dependent variable and ratio of logarithmic WMH volume to eICV, ratio of total brain volume to eICV, ratio of hippocampal volume to eICV, sex, age, years of education, presence of Apolipoprotein E ε4 allele, CCI, and sGDS-K as independent variables. *p<0.05. WMH, white matter hyperintensities; JVWMH, juxtaventricular white matter hyperintensities; PVWMH, periven- tricular white matter hyperintensities; DWMH, deep white matter hyperintensities; Coef, regression coefficient; S.E, standard error; β, standardized regression coefficient; MMSE-KC, Korean version of Mini-Mental State Examination; eICV, estimated intracranial volume; CCI, Charlson’s comorbidity index; sGDS-K, Korean version of the short form of geriatric depression scale.
tion, psychomotor speed, memory, language function, attention, and overall cognitive function.\textsuperscript{25,26} The differences on WMH-related cognitive function between studies might result from their methodological differences in the evaluation of WMH and cognitive function as well as different samples. The relationship between WMH and cognition may be less specific, but WMH volume mainly affects executive function and psychomotor speed suggesting that WMH volume is closely related to frontal lobe dysfunction.\textsuperscript{27} This finding can be explained by the hypothesis that WMH tend to be more distributed more in the frontal lobe than in other brain regions, which causes metabolic degradation in the prefrontal cortex with the pathology of ischemic vascular injury,\textsuperscript{28} eventually leading to frontal-subcortical circuit dysfunction.\textsuperscript{29} In line with previous studies, total WMH volume was strongly associated with concurrent worse performance on verbal fluency test and immediate memory test in this study, reflecting impairments of semantic memory, and immediate memory. This poor performance on verbal fluency test is also linked to executive dysfunction because fluency tasks require using a variety of executive control processes.\textsuperscript{30}

Subclassified WMH volumes defined by new subclassification of WMH\textsuperscript{12} were differently associated with concurrent cognitive deficits. Greater JVWMH were associated with poor performances in categorial verbal fluency test and forward digit span test, reflecting impaired semantic memory, executive function, and working memory. Greater PVWMH volume, like total WMH volume, was related to deteriorations in semantic memory, executive function, and immediate memory. The distinct association between JVWMH and PVWMH is evident solely in executive function, which could be attributed to differing pathologies, despite the presence of similar microstructures.

In this study, JVWMH and PVWMH-related cognitive domains are summarized as semantic memory and representative elements of frontal lobe function such as executive function, working memory and immediate memory.\textsuperscript{31} However, DWMH volume was not associated with any cognitive domains. Only PVWMH among subclassified WMH affected the overall severity of AD. These findings are concordant with previous findings that PVWMHs are more strongly associated with concurrent cognitive deficits and have a larger effect on all-cause dementia than DWMH.\textsuperscript{13}

Abundant long associative fibers are in the periventricular region, and injuries (seen as JVWMH and PVWMH) on this region can disrupt a wide area of the networks, leading to cognitive decline.\textsuperscript{29,33,34} On the contrary, the short association fibers (U-fibers) existing beneath the gray matter of the cortex connect the cortices of adjacent gyri.\textsuperscript{35} Those injuries (seen as DWMH) affect a relatively small area of the networks, so there are fewer negative effects on cognitive function.\textsuperscript{36}

We performed additional analysis to examine whether WMH volume and HV, well-known core pathologies of AD, affect different domains of cognitive function. From this analysis, hippocampal atrophy affected different items of cognitive tests such as word list memory test and word list recognition test, compared to WMH volume (Supplementary Table 2). There were no common cognitive tests associated with WMH and hippocampus volume. This result is consistent with a previous longitudinal cohort study on the cognitively normal elderly and on the elderly with pre-mild cognitive impairment.\textsuperscript{27} Take together with this study and previous other studies, WMH pathology plays an additive role in the development and progression of AD, independent of AD core pathologies. WMH play a key role in lowering the threshold for the clinical expression of dementia in AD.\textsuperscript{28}

Amyloid and tau pathology-focused treatments have not been successful for recent 20 years. Therefore, it is increasingly important to manage other risk factors for AD. WMH are an established risk factor for AD and may be attributed to various risk factors such as hypertension, fasting glucose, and dyslipidemia, smoking, inflammatory markers, low levels of vitamin B12, and decreased physical activities.\textsuperscript{29}

This study has revealed different associations between newly subclassified WMH volumes and cognitive function. These novel insights were gained through a precise methodology involving quantitative volumetric measurements of WMH volume.

This study had some limitations. First, there has been no consensus on the subclassification criteria for WMHs thus far, and the criterion used in this study has yet to be verified. Therefore, further studies including non-AD subjects and longitudinal studies are needed to validate this criterion for WMHs. Second, we did not apply multiple comparison correction methods used in statistics to control the probability of making at least one type I error when conducting multiple tests simultaneously. Applying multiple comparison correction methods resulted in certain outcomes that had initially shown significance in our study ceased to maintain their significance. Considering the partially exploratory nature of our investigation, we believe it could be more suitable to present these findings for future studies, even if they do not attain stringent significance thresholds. Hence, it is essential to approach the interpretation of the results cautiously, and further studies are necessary to validate and expand upon our findings. Third, we did not consider other brain pathologies, such as amyloid and tau burden, which have been considered as a core pathology of AD. Further studies with biologically defined AD are needed to precisely investigate the relationship between subclassified WMH and cognition. Fourth, our subjects with AD were recruited from a single dementia clinic and there is
some limitation to generalize our findings. Further studies on a large sample from multiple centers that replicate our results are needed.

In conclusion, WMH are differently associated with severity of dementia and cognitive impairment according to the distance from ventricle surface in patients with AD. Greater JVWMH and PVWMH are related with concurrent impairments in semantic memory and frontal function independent of the HV. However, DWMH volume is not associated with any cognitive function. Only PVWMH among subclassified WMH affect the severity of AD. This study establishes the different effects of subclassified WMH on the concurrent cognitive function. Further studies are also required to investigate the potential value of subclassified WMH as a predictor of future accelerated cognitive decline and a therapeutic target in AD.

Supplementary Materials
The Supplement is available with this article at https://doi.org/10.30773/pi.2024.0082.

Availability of Data and Material
The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

Conflicts of Interest
Ki Woong Kim, a contributing editor of the Psychiatry Investigation, was not involved in the editorial evaluation or decision to publish this article. All remaining authors have declared no conflicts of interest.

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