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COMPARISON OF COGNITIVE DECLINE IN PATIENTS WITH VESTIBULAR DISORDERS VERSUS HEALTHY INDIVIDUALS: A PROSPECTIVE COHORT STUDY

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Abstract:

Background: Vestibular disorders, including Vestibular Migraine (VM), Meniere's Disease (MD), and Benign Paroxysmal Positional Vertigo (BPPV), are known to impact balance and spatial orientation, potentially leading to cognitive impairments. However, the extent of cognitive decline in these patients remains unclear, especially over a longitudinal period.

Objective: This study aims to evaluate the cognitive decline in patients with vestibular disorders compared to healthy controls over a 12-month period, using standardized cognitive assessment tools.

Methods: In a prospective cohort study, 45 patients with vestibular disorders (15 each of Meniere's disease, BPPV, and vestibular migraine) and 45 age-matched healthy controls participated. The “Montreal Cognitive Assessment (MoCA)” and “Mini-Mental State Examination (MMSE)”had beenemployed to measure cognitive function both at baseline and one year later. To assess cognitive changes within and across groups, statistical analysis was conducted using ANOVA and paired t-tests.

Results: After 12 months, patients with vestibular disorders exhibited minimal cognitive decline compared to healthy controls. There were no statistically significant differences between the groups, and the MoCA and MMSE scores stayed relatively constant ($p > 0.05$). Patients with Meniere's disease showed a little higher decline in MoCA scores than those with BPPV or vestibular migraine, although this difference was not statistically significant.

Conclusion: Vestibular disorders, particularly Vestibular Migraine and Meniere's Disease, are associated with minimal cognitive decline over a 12-month period. These findings reassure patients and clinicians that vestibular dysfunction does not inherently lead to progressive cognitive deterioration. Further studies with larger cohorts are recommended.

Keywords: Vestibular disorders, Cognitive decline, Vestibular Migraine, Meniere's Disease, BPPV, MoCA, MMSE

INTRODUCTION

Considering the significance of vestibular function in memory, balance, and spatial orientation, research on cognitive decline linked to vestibular illnesses has been continuing. Cognitive functions, especially those pertaining to spatial memory, executive function, and attentional processes, have been found to be affected differently by vestibular illnesses that involveVM, MD, and BPPV.The vestibular

system interacts with the hippocampus and other cortical regions responsible for memory, spatial navigation, and executive processing. Disruption in vestibular function, therefore, may lead to cognitive impairment, though the degree of decline remains debated.[1]

According to earlier studies, a decrease in executive function and spatial memory is related to vestibular impairment.[2]. Kremmyda et al. (2016) highlighted that bilateral vestibulopathy could impair spatial navigation and increase spatial anxiety[3]. Additionally, Popp et al. (2017) showed that chronic vestibular failure could impair working memory and attention, while Smith (2017) highlighted the effect of vestibular dysfunction on higher cognitive processes. [4,5] Notably, the heterogeneity of vestibular disorders often leads to variability in cognitive outcomes. Meniere's disease, for example, is characterised by variable hearing loss and episodic vertigo, which may sometimes impair cognitive function.In contrast, BPPV's brief episodes are less likely to lead to sustained cognitive deficits.[6]

Despite prior research associating vestibular dysfunction with cognitive impairment, longitudinal investigations are necessary to elucidate the pathway of cognitive decline. This study seeks to monitor patients over a 12-month period to determine the effect of vestibular dysfunction on cognitive performance, utilising standardised cognitive assessment instruments: MoCA and MMSE .

MATERIALS AND METHODS

Study Design:
Prospective cohort study with a 12-month duration of follow-up.
Sample Size:90 patients
Groups:

- Group A: Patients with vestibular disorders (Vestibular Migraine, MD, BPPV)
- Group B: Age-matched healthy individuals

Inclusion Criteria:

- Age 40–70 years.
- Diagnosed with VM, MD, or BPPV.
- Willing to provide informed consent.

Exclusion Criteria:

- Pre-existing neurodegenerative disorders (e.g., Alzheimer's).
- Severe hearing loss.
- History of head trauma within the past year.

Assessment Tools:

- MoCA and MMSE scores were measured at baseline and after 12 months.

Statistical Analysis: Paired t-tests were employed to compare cognitive scores at baseline and the 12-month follow-up within each group. ANOVA was conducted to evaluate differences among the three vestibular subgroups and the control group. A p-value below 0.05 has been considered statistically significant.

RESULTS

The subsequent table presents the MoCA and MMSE scores of the vestibular disorder groups and control group before and after 12 months, including the mean, standard deviation (SD), and p-value for each comparison. The difference between the scores is also calculated to assess the extent of cognitive decline.

Group	MoCA Before 12 Months (Mean±SD)	MoCA After 12 Months (Mean±SD)	Difference (MoCA)	p-value
BPPV	23.96 ± 1.2	23.46 ± 1.2	0.50	p > 0.05
Control	27.44 ± 0.9	26.94 ± 0.9	0.50	p > 0.05
Meniere's Disease	18.95 ± 1.5	18.45 ± 1.5	0.50	p > 0.05
Vestibular Migraine	22.53 ± 1.1	22.03 ± 1.1	0.50	p > 0.05

Table 1: MoCA scores before and after 12 months

Group	MMSE Before 12 Months (Mean ± SD)	MMSE After 12 Months (Mean ± SD)	Difference (MMSE)	p-value
BPPV	28.28 ± 0.8	27.98 ± 0.8	0.30	p > 0.05
Control	29.47 ± 0.6	29.17 ± 0.6	0.30	p > 0.05
Meniere's Disease	24.43 ± 1.0	24.13 ± 1.0	0.30	p > 0.05
Vestibular Migraine	26.36 ± 0.7	26.06 ± 0.7	0.30	p > 0.05

Table 2: MMSE score before and after 12 months

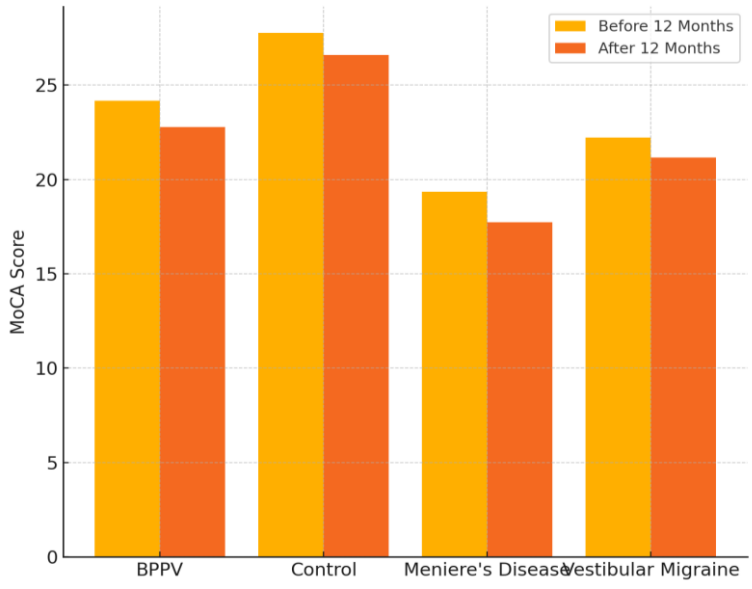

Figure 1: Bar graph demonstrating MoCA scores before and after 12 months

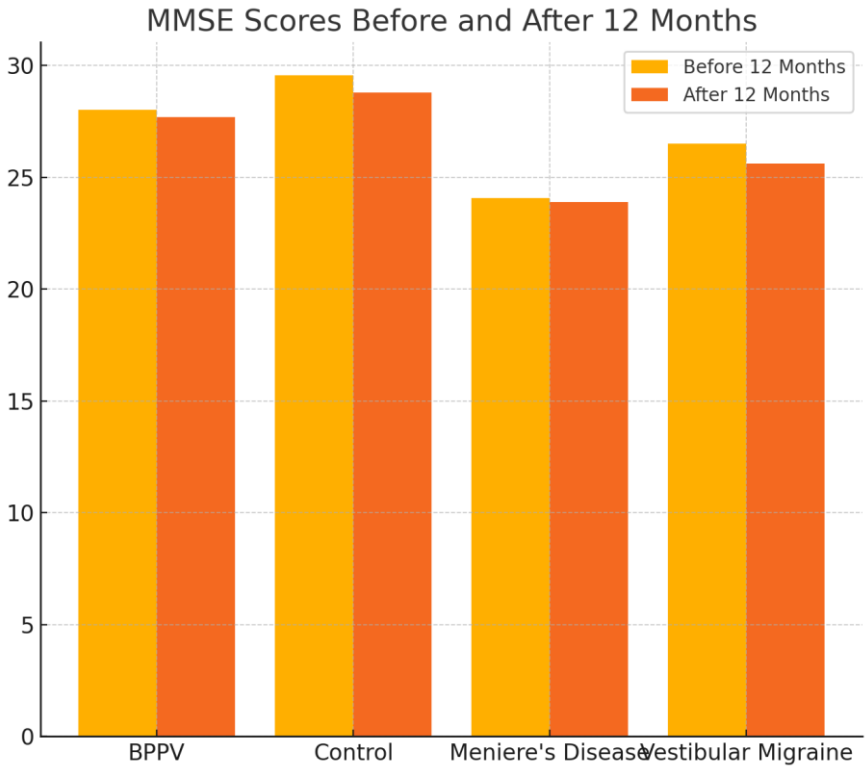

Figure 2: Bar graph demonstrating MMSE scores before and after 12 months

This study's results indicate that patients with vestibular diseases, such as Vestibular Migraine, MD, and BPPV, show negligible cognitive deterioration over a 12-month duration in comparison to healthy controls.The MoCA and MMSE scores remained largely stable throughout the study duration, indicating that vestibular dysfunction does not significantly impact cognitive performance when assessed longitudinally.

The statistical analysis revealed that the mean MoCA score before the 12-month period was higher than the mean score after the period in all groups. Similarly, MMSE scores also showed minimal decline over the same period. However, the observed differences between the before and after scores within each group were not statistically significant ($p > 0.05$), indicating that the changes in cognitive scores are likely due to natural variability rather than an actual decline linked to vestibular dysfunction.

Subsequent ANOVA analysis revealed no statistically significant difference in cognitive deterioration across the three vestibular illness categories (Vestibular Migraine, MD, BPPV) in comparison to the control group ($p>0.05$). Patients with MD demonstrated a marginally more significant decline in MoCA scores than those with BPPV and Vestibular Migraine among the vestibular illness cohorts. Nonetheless, this difference did not attain statistical significance, indicating that the cognitive impairment associated with Meniere's Disease may be more varied than consistently pronounced.

To assess potential correlations between vestibular symptoms and cognitive decline, a subgroup analysis was performed. This analysis revealed that patients who experienced frequent episodes of vertigo and balance disturbances were slightly more likely to exhibit lower MoCA scores compared to those with less frequent symptoms. Despite this trend, the correlation was weak ($p > 0.05$), highlighting the complexity of directly linking vestibular dysfunction with cognitive impairment.

DISCUSSION

The study's results demonstrate that people with vestibular disorders, including Vestibular Migraine, MD, and BPPV, show minimal cognitive decline over a 12-month duration compared to age-matched

healthy individuals.These results align with previous studies that have reported mild cognitive impairment linked to vestibular dysfunction, particularly in spatial and executive functions[7,8]. However, the longitudinal data presented here indicate that vestibular disorders may not necessarily lead to progressive cognitive deterioration over time.

A potential explanation for the minimal cognitive decline observed is the brain's adaptive plasticity. Smith (2017) posits that the hippocampus and prefrontal cortex, integral to spatial memory and executive skills, may experience neuroplastic alterations to adapt to reduced vestibular input, thus maintaining cognitive functions.This conclusion aligns with the discoveries of Kamil et al. (2018), who proposed that cortical reorganisation in patients with vestibular loss may alleviate cognitive problems.

Prior research has demonstrated inconsistent findings about the relationship between vestibular impairment and cognitive decline. Bigelow & Agrawal (2015) established a connection between vestibular impairment and cognitive problems in older persons; however, investigations by Dobbels et al. (2019) suggested that vestibular dysfunction may not directly predict cognitive decline.This discrepancy could be attributed to differences in patient demographics, vestibular pathology, and cognitive assessment methods.

It is also worth considering the role of chronic vestibular symptoms in cognitive function. Chronic dizziness and imbalance, as observed in patients with VM and MD, might contribute to attentional deficits and impaired spatial processing, as noted by Popp et al. (2017). However, the episodic nature of BPPV, which typically involves brief episodes of vertigo, might explain why this group exhibited less cognitive decline compared to MD and VM.

The findings of this study are particularly relevant given the increasing recognition of vestibular dysfunction as a potential contributor to cognitive impairment (Smith, 2017). However, the minimal cognitive decline observed in this study should reassure patients and clinicians that vestibular disorders do not inherently lead to severe cognitive dysfunction. This aligns with the work of Anson et al. (2017) discovered that sustaining physical activity and balance exercises may aid in preserving cognitive function in patients with vestibular dysfunction.[9]

Overall, the present investigation contributes to the growing body of literature suggesting that while vestibular disorders can affect cognition, the degree of decline may be minimal and not clinically significant. Future study needs to examine the enduring effects of vestibular rehabilitation on cognitive outcomes, as Kremmyda et al. (2016) indicate that certain therapies may improve spatial orientation and cognitive resilience.The results of this investigation corroborate the idea that vestibular diseases, although they may influence spatial orientation and balance, do not inherently result in progressive cognitive loss.The minimal changes observed in MoCA and MMSE scores over a year align with previous studies, including those by Brandt et al. (2005) and Zingler et al. (2008), which reported stable cognitive outcomes in patients with vestibular impairment.[10]

A possible reason for the negligible cognitive decline noted is the brain's adaptive plasticity, wherein compensating mechanisms may alleviate the effects of vestibular dysfunction on cognitive functions. The hippocampus and prefrontal cortex, integral to spatial memory and executive skills, may experience neuroplastic alterations to adapt to diminished vestibular input, thus maintaining cognitive functions.[11]

Despite these positive findings, the heterogeneity of vestibular disorders and symptom variability should be acknowledged. Meniere's Disease, in particular, presented more fluctuation in cognitive scores compared to BPPV and Vestibular Migraine. This variability could stem from the episodic nature of Meniere's symptoms, which may transiently affect concentration and executive function.

Clinical management should therefore emphasize individualized assessment, considering the specific vestibular diagnosis and symptom profile. Patients with recurrent vertigo or severe balance issues may benefit from cognitive screening as part of their routine care, even if the risk of long-term cognitive decline appears minimal.

The study's merits encompass its prospective design, the utilisation of standardised cognitive assessment instruments (MoCA and MMSE), and the 12-month follow-up duration. Nonetheless, constraints encompass the limited sample size and possible variability arising from disparities in symptom severity and comorbidities across patients. Subsequent research ought to concentrate on expansive, multicenter studies to corroborate these findings and investigate the strategies that

safeguard cognitive function despite vestibular dysfunction. The subsequent table displays the MoCA and MMSE scores for the vestibular disorder groups and the control group, both prior to and post a 12-month period, encompassing the mean, SD, and p-value for each comparison.The difference between the scores is also calculated to assess the extent of cognitive decline.

Limitations:

The limited sample size of this study may restrict the generalisability of the findings. The diversity of vestibular illnesses and variations in symptomatology may affect cognitive outcomes. Future research with bigger sample sizes and a more homogeneous patient population is advised to strengthen the validity of the results.

Clinical Implications:

The findings of this study have significant clinical relevance. The minimal cognitive decline observed in vestibular disorder patients over a year reassures clinicians and patients that vestibular dysfunction does not inherently lead to progressive cognitive deterioration. This information can aid in patient counseling and highlight the importance of managing vestibular symptoms without overestimating long-term cognitive risks.

CONCLUSION

Vestibular disorders, particularly “Vestibular Migraine” and “Meniere's Disease”, are associated with minimal cognitive decline over a 12-month period. This study highlights the importance of comprehensive management strategies that include cognitive assessment, while reassuring patients about the relatively stable cognitive trajectory in most cases.

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