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The finger-to-nose test improved diagnosis of cerebrovascular events in patients presenting with isolated dizziness in the emergency department

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ABSTRACT

It is difficult to identify patients with isolated dizziness caused by cerebrovascular events. The estimated risk of cerebrovascular events in isolated dizziness patients is not completely understood. We aimed to evaluate the association of the finger-to-nose test (FNT) in diagnosing cerebrovascular events in isolated dizziness patients in emergency departments (EDs). We combined 2 datasets from a single center for consecutive isolated dizziness patients, with the same inclusion and exclusion criteria. Those who met any of the following criteria were excluded: no FNT data, age < 16 years, and psychological trauma. The primary outcome was cerebrovascular event, which was defined as cerebral stroke due to cerebral infarction, cerebral hemorrhage, vertebral artery dissection, or transient ischemic attack. In the combined dataset, there were 357 patients complaining of isolated dizziness and 31 cerebrovascular events. After adjusted by 5 previously reported risk factors for cerebrovascular event, (age, hypertension, hyperlipidemia, diabetes mellitus, nystagmus), a multivariable logistic model analysis showed that the existence of FNT abnormalities was significantly associated with cerebrovascular events (odds ratio, 25.3; 95% confidence interval, 7.3–88.2; $p < 0.001$). There was a significant increase in predictive accuracy, with an AUC increase of 0.116 in the in a ROC analysis ($p = 0.023$). The existence of FNT abnormalities is considered as a strong risk factor that could be useful for predicting cerebrovascular events in isolated dizziness patients. We recommend the FNT for screening isolated dizziness patients in EDs to judge whether they need to undergo further diagnostic evaluation.

Keywords: cerebral stroke, dizziness, isolated dizziness, finger-to-nose test

Abbreviations:
FNT: finger-to-nose test
ED: emergency department
CT: computed tomography

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MRI: magnetic resonance imaging
ROC: receiver operating characteristic
AUC: area under the curve
OR: odds ratio
CI: confidence interval

INTRODUCTION

Dizziness is one of the most common symptoms that cause patients to visit emergency departments (EDs). One study reported that approximately 3.3% or more of ED visits in the United States involved a presentation of acute dizziness,[1] of which 3–5% were caused by cerebral stroke.[2] Computed tomography (CT) and magnetic resonance imaging (MRI) of the brain are the gold standard tests for diagnosing cerebral stroke in these patients; however, it is not feasible to perform these tests for everyone presenting to the ED with acute dizziness because these tests are time-consuming and costly.[3] In real-world clinical practice, patients with dizziness who need imaging examinations based on other clinical information, such as history of present illness and past medical history, need to be recognized.

Patients presenting with dizziness but no concomitant motor deficits or dysarthria, ie, "isolated dizziness",[4] represent one of the most challenging populations for clinicians because they present no symptoms except for dizziness to help guide diagnosis. Given that approximately 10% of infarctions in the territories of the cerebellar arteries exhibit no clinical neurological symptoms,[5] it is clinically important to identify patients presenting with isolated dizziness who have a higher risk of cerebral infarction. The traditional approach based on the quality or type of dizziness symptoms (vertigo, presyncope, or disequilibrium) is considered unsuitable for predicting dizziness caused due to cerebrovascular events.[6] Previous studies have shown that some clinical variables such as age, hyperlipidemia, hypertension, diabetes mellitus, and nystagmus are associated with an increased risk of cerebral infarction in patients presenting with isolated dizziness.[7,8] However, all these studies included only a small number of cerebral infarctions. The risk of cerebral infarction in patients with isolated dizziness has not yet been fully determined and requires further evaluation.

The finger-to-nose test (FNT) is a basic and simple physical examination that has been conventionally used to examine cerebellar function.[9] In the FNT, patients are asked to alternately touch their own nose and the evaluator's stationary or moving finger while lying supine, or while sitting or standing. However, no studies have focused on the usefulness of FNT in evaluating isolated dizziness, except for one exploratory study.[10] In this retrospective study, Jo et al determined several factors associated with the incidence of acute cerebral infarction via FNT tests using the data of 468 patients with isolated vertigo/dizziness.[10] However, the effect of FNT abnormality was evaluated by a univariate analysis and not by a multivariable analysis. In other words, it remains unclear whether FNT abnormality is an independent risk factor for stroke in patients with isolated dizziness. Therefore, the aim of this study was to determine the effect of FNT abnormality on cerebral stroke and to assess its additive predictive value in patients with isolated dizziness presenting to the ED after adjusting for other risk factors of cerebral stroke identified in previous studies conducted in patients with dizziness.

MATERIALS AND METHODS

Study design and population

All the data were collected from a single medical emergency center (Kainan Hospital, Yatomi City, Japan). The medical emergency center was open 24 h a day and had approximately 22,000 patient visits annually. We combined two datasets from a single center for consecutive patients with isolated dizziness, in which we collected data using the same inclusion and exclusion criteria. One dataset was retrospectively collected from December 1, 2014, to March 31, 2015, and the other dataset was prospectively collected from January 1, 2017, to March 31, 2017. Isolated dizziness was defined as dizziness with no apparent unilateral paralysis or dysarthria.[4] Patients who complicated of isolated dizziness were eligible to participate in the study. Those who met any of the following criteria were excluded: no FNT data, age < 16 years, and psychological trauma. This study was approved by the ethics committee of Kainan Hospital.

FNT procedure and the criteria of abnormalities

All FNT procedures were performed by residents with more than one year of ED work experience. The patients were asked to alternately touch their own nose and the examiner's finger several times. The examiner's finger was held at the extremes of the patient's reach and was occasionally moved to a different location. If the patient followed the examiner's instructions smoothly, it was judged as normal. If the patient showed hesitation, tremor, undershooting, or overshooting in this test, it was judged as abnormal, which may suggest a lesion in the cerebellar hemispheres.[11]

Baseline covariates for adjustment

We adjusted for the five risk factors indicated in previous studies[7,8]: age, hypertension, hyperlipidemia, diabetes mellitus, and nystagmus. They were considered as covariates while evaluating the effects of the existence of FNT abnormalities. We dichotomized age as ≥60 years and <60 years, based on a previous study.[7]

Outcome measures

The primary outcome was cerebrovascular events, which referred to cerebral stroke defined as cerebral infarction, cerebral hemorrhage, vertebral artery dissection, or transient ischemic attack. The outcome was diagnosed after ED arrival by one or 2 neuro-specialists based on CT or MRI findings. When no cerebrovascular event was diagnosed in the ED, the patient was discharged and asked by the doctor to return if the condition persisted or worsened. Given that Kainan Hospital is the only general hospital in Yatomi City, patients who did not return were considered to have improved symptoms and were judged as not having had a cerebrovascular event.

Statistical analysis

We evaluated the effect of the existence of FNT abnormalities by fitting a multivariable logistic regression model with FNT and five factors (age, hypertension, hyperlipidemia, diabetes mellitus, and nystagmus) as fixed covariates for adjustment. We also evaluated the predictive value of the existence of FNT abnormalities in a model with the five covariates by comparing the receiver operating characteristic (ROC) curves derived from fitted logistic regression models that included the five covariates with and without FNT. We evaluated the statistical significance of the differences in the area under the curve (AUC) estimates between the two logistic models using the DeLong method.[12] Statistical significance was set at 5%. All analyses were performed using R software (version 3.6.1, R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Characteristics of the study subjects

In the first retrospective cohort, 6,696 patients visited the emergency medical center between December 1, 2014, and March 31, 2015, and 273 satisfied the study inclusion criteria. Of the 273 patients, 96 were excluded from the analysis because the FNT was not performed, and 176 patients were eligible. Among the eligible patients, 20 experienced cerebrovascular events. In the second prospective cohort, we prospectively collected the data of 181 patients with isolated dizziness from January 1, 2017, to March 31, 2017. Eleven patients in this cohort experienced cerebrovascular events.

In the combined dataset, we included 357 eligible patients and 31 cerebrovascular events (Fig, 1). The distribution of cerebrovascular events was as follows: cerebral infarction, 18 events; cerebral hemorrhage, 7 events; vertebral artery dissection, 1 event; and, transient ischemic attack, 5 events (Table 1). The FNT findings and five baseline covariates for the eligible patients are summarized in Table 2. The proportion of the existence of FNT abnormalities was significantly higher in the cerebrovascular event group than that in the non-cerebrovascular event group (25.8% vs 1.5%, $p < 0.001$). The proportion of patients with diabetes as a comorbidity was higher in the cerebrovascular event group (29.0% vs 15.3%, $p = 0.071$). The proportion of patients with other factors was similar between the two groups.

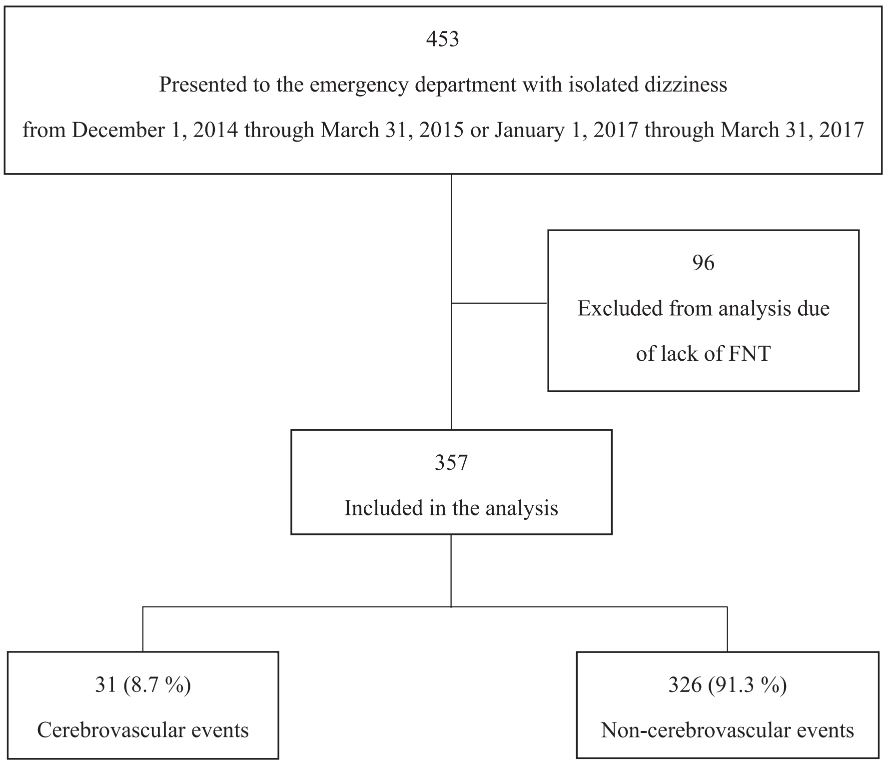

Fig. 1 Study flow

Table 1 Distribution of cerebrovascular events (n=31)

Cerebrovascular event type	Number
Cerebral infarction	18
Cerebral hemorrhage	7
Vertebral artery dissection	1
Transient ischemic attack	5

Table 2 Demographic and clinical characteristics of patients with isolated dizziness

	Cerebrovascular event (n=31)	Non cerebrovascular event (n=326)	p value
Patient demographics			
Age ≥60 years	22 (71.0)	227 (69.6)	>0.999
Gender, male, n (%)	16 (51.6)	134 (41.1)	0.261
Comorbidity			
Hypertension, n (%) [a]	13 (41.9)	142 (44.4)	0.851
Diabetes mellitus, n (%) [b]	9 (29.0)	49 (15.3)	0.071
Hyperlipidemia, n (%) [c]	8 (25.8)	59 (18.4)	0.339
Neurological examination			
Nystagmus, n (%) [d]	7 (23.3)	62 (19.3)	0.631
Finger-to-nose test, abnormal, n (%)	8 (25.8)	5 (1.5)	<0.001

Data are presented as frequencies with percentages.
Missing data: [a] n = 0 and 6; [b] n = 0 and 5; [c] n = 0 and 6; [d] n = 1 and 4.

Multivariable analysis

The results of the multivariable logistic regression analysis were summarized in Table 3. After adjusting for the five covariates, the estimated odds ratio (OR) for the existence of FNT abnormalities was 25.3 (95% confidence interval [CI], 7.3–88.2; p < 0.001). Given the estimated effect size of the FNT abnormalities, there was concern about the stability of the maximum likelihood estimate in the multivariable logistic regression model because our sample size was

Table 3 Univariate and multivariable logistic regression results for cerebrovascular event

	Univariate		Multivariable	
Clinical variable	Odds ratio (95% CI)	p	Odds ratio (95% CI)	p
Finger-to-nose test	22.33 (6.76–73.75)	<0.001	25.34 (7.28–88.24)	<0.001
Age ≥60 years	1.07 (0.47–2.40)	0.877	0.85 (0.33–2.17)	0.735
Hyperlipidemia	1.54 (0.66–3.61)	0.322	1.35 (0.49–3.70)	0.560
Hypertension	0.91 (0.43–1.91)	0.794	0.82 (0.34–1.98)	0.658
Diabetes mellitus	2.89 (1.12–7.45)	0.028	2.89 (1.12–7.45)	0.028
Nystagmus	1.28 (0.52–3.11)	0.591	1.38 (0.53–3.63)	0.510

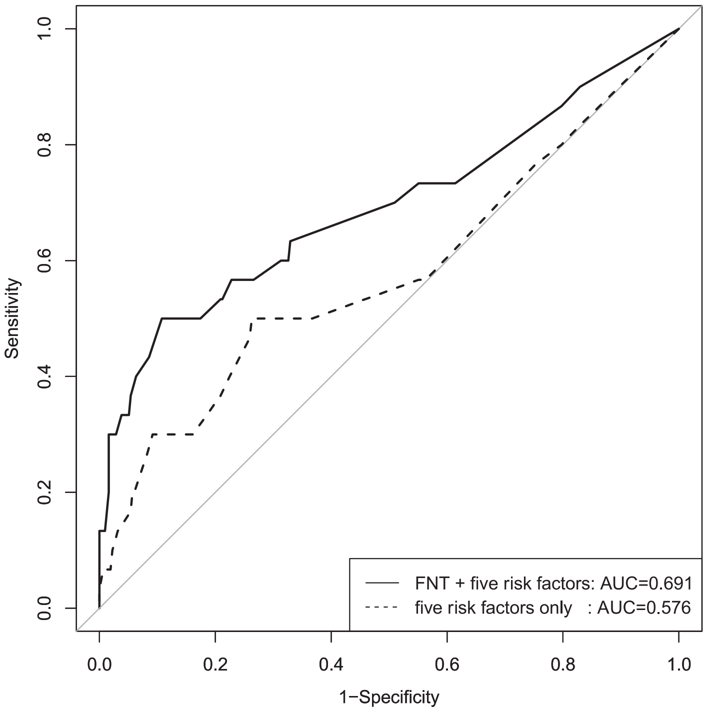

Fig. 2 FNT improved the area under the ROC curve for cerebrovascular events
ROC curves were created for logistic regression models that included only five risk factors for cerebrovascular events (dashed line) and FNT in addition to the five risk factors (solid line).

relatively small. We also used the Firth method[13,14] to reduce the bias associated with maximum likelihood estimation. We obtained a slightly smaller adjusted OR of 22.6 (95% CI, 6.8–75.6; $p < 0.001$) for the existence of FNT abnormalities. In a sensitivity analysis, we obtained similar estimated ORs for the effect of the existence of FNT abnormalities for both the retrospective and prospective cohorts (Table S1 in Supplemental Material).

Regarding the additive predictive value of the FNT, the ROC curves from the logistic regression models that included the five covariates with and without FNT are shown in Figure 2. The estimated AUC for the ROC curve with FNT results was 0.691 and the AUC for the curve without FNT results was 0.576, with a difference of 0.116. The p-value for the difference in the AUC was 0.023, which was statistically significant.

DISCUSSION

In this study, the existence of FNT abnormalities was shown to be statistically significantly associated with cerebrovascular events in a multivariable analysis. In the ROC analysis, the AUC significantly increased with the addition of FNT results to a logistic regression model with other known risk factors for cerebrovascular events, indicating that the FNT could help enhance the accuracy of diagnosing cerebrovascular events in patients with isolated dizziness.

In our multivariable logistic regression analysis, the OR for the existence of FNT abnormalities was extremely high (OR, 25.3; 95% CI, 7.3–88.2). This value is consistent with the results of a univariate analysis from the previous study by Jo et al[10] (OR, 17.2; 95% CI, 3.9–76.3). These results indicate that the significance of FNT can be regarded as a generalized fact. The FNT is one of the most traditional tests for detecting disorders in the cerebellar region and neural circuits involving the cerebellum. It has also been used to detect disorders related to cerebellar function.[11] Given that approximately 10% of isolated dizziness cases are likely caused by abnormalities in the cerebellar region.[5] it is not surprising that the OR for the existence of FNT abnormalities was reasonably high in our study; however, an additional study with a much larger sample size is warranted.

To date, five variables (age, medical history of hyperlipidemia, hypertension, diabetes mellitus, and nystagmus) have been reported as possible indicators of cerebellar vascular events in isolated dizziness.[7,8] Among these factors, age and medical history reflect comorbidities; they do not have a direct relationship with cerebellar function. In contrast, FNT is a direct indicator of cerebellar function, which may explain why the addition of FNT results significantly improved the predictive accuracy of the model based on these five factors.

The FNT is also widely used in other contexts. For instance, a previous study showed that the existence of FNT abnormalities had construct, convergent, and discriminant validity for measuring upper-limb coordination in stroke.[15] The FNT is also useful for interpreting cognitive function in Alzheimer's disease.[11] The results of the present study indicate that, considering the association of the existence of FNT abnormalities with Alzheimer's disease, the FNT has the potential to be significant in a highly aged society, although further studies are needed. The FNT is widely used not only by neurologists but also by junior neurology residents and educated paramedics.[9,10] We believe that it is useful to conduct FNT in all patients with isolated dizziness in the ED and to focus on its results. Based on these results, the FNT should be emphasized during various physical examinations. Therefore, it is advisable to perform FNT in all patients with isolated dizziness. If abnormal findings are observed, CT should be actively performed. However, if the FNT results are normal, other information should be considered to determine whether CT should be performed.

Limitations

This study has several limitations. First, we analyzed data from a single institution. Therefore, the reliability of our results may be limited. To obtain stronger evidence, further research conducted at multiple centers is needed. Second, although our sample size was similar to that of previous studies, the number of events was still low, and the number of covariates examined was limited. However, the estimated effect size for the FNT was much greater than the effect size for the five factors identified in previous studies. Thus, the existence of FNT abnormalities could be considered a strong predictor of cerebral stroke in the ED. Thirdly, this study did not focus on other neurological examinations. It would be of great interest to evaluate whether the accuracy of predicting cerebrovascular events can be further improved by incorporating other neurological examinations along with the FNT.

CONCLUSION

The existence of FNT abnormalities was a strong independent risk factor that improved the predictive accuracy for the detection of cerebrovascular events in patients with isolated dizziness. We recommend the FNT for screening patients with isolated dizziness in EDs to determine whether they need to undergo further diagnostic evaluation.

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CONFLICTS OF INTEREST STATEMENT

We declare that we have no conflicts of interest.

REFERENCES

1 Newman-Toker DE, Hsieh YH, Camargo CA Jr, Pelletier AJ, Butchy GT, Edlow JA. Spectrum of dizziness visits to US emergency departments: cross-sectional analysis from a nationally representative sample. *Mayo Clin Proc.* 2008;83(7):765–775. doi:10.4065/83.7.765.

2 Newman-Toker DE, Edlow JA. TiTrATE: A novel, evidence-based approach to diagnosing acute dizziness and vertigo. *Neurol Clin.* 2015;33(3):577–599, viii. doi:10.1016/j.ncl.2015.04.011.

3 Saber Tehrani AS, Kattah JC, Kerber KA, et al. Diagnosing stroke in acute dizziness and vertigo: pitfalls and pearls. *Stroke.* 2018;49(3):788–795. doi:10.1161/STROKEAHA.117.016979.

4 Perloff MD, Patel NS, Kase CS, Oza AU, Voetsch B, Romero JR. Cerebellar stroke presenting with isolated dizziness: Brain MRI in 136 patients. *Am J Emerg Med.* 2017;35(11):1724–1729. doi:10.1016/j.ajem.2017.06.034.

5 Lee H, Sohn SI, Cho YW, et al. Cerebellar infarction presenting isolated vertigo: frequency and vascular topographical patterns. *Neurology.* 2006;67(7):1178–1183. doi:10.1212/01.wnl.0000238500.02302.b4.

6 Edlow JA, Gurley KL, Newman-Toker DE. A new diagnostic approach to the adult patient with acute dizziness. *J Emerg Med.* 2018;54(4):469–483. doi:10.1016/j.jemermed.2017.12.024.

7 Navi BB, Kamel H, Shah MP, et al. Rate and predictors of serious neurologic causes of dizziness in the emergency department. *Mayo Clin Proc.* 2012;87(11):1080–1088. doi:10.1016/j.mayocp.2012.05.023.

8 Chase M, Goldstein JN, Selim MH, et al. A prospective pilot study of predictors of acute stroke in emergency department patients with dizziness. *Mayo Clin Proc.* 2014;89(2):173–180. doi:10.1016/j.mayocp.2013.10.026.

9 Oostema JA, Chassee T, Baer W, Edberg A, Reeves MJ. Educating paramedics on the finger-to-nose test improves recognition of posterior stroke. *Stroke.* 2019;50(10):2941–2943. doi:10.1161/STROKEAHA.119.026221.

10 Jo S, Jeong T, Lee JB, Jin Y, Yoon J, Park B. Incidence of acute cerebral infarction or space occupying lesion among patients with isolated dizziness and the role of D-dimer. *PLoS One.* 2019;14(3):e0214661. doi:10.1371/journal.pone.0214661.

11 Bergeron D, Vermette A, De La Sablonniere J, Cayer AM, Laforce R, Bouchard RW. Finger-to-nose rest findings in Alzheimer's disease. *J Alzheimers Dis.* 2017;55(4):1335–1337. doi:10.3233/JAD-160941.

12 DeLong ER, DeLong DM, Clarke-Pearson DL. Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. *Biometrics.* 1988;44(3):837–845. doi:10.2307/2531595.

13 Firth D. Bias reduction of maximum-likelihood-estimates. *Biometrika.* 1993;80(1):27–38. doi:10.1093/biomet/80.1.27.

14 Heinze G, Schemper M. A solution to the problem of separation in logistic regression. *Stat Med.* 2002;21(16):2409–2419. doi:10.1002/sim.1047.

15 Rodrigues MR, Slimovitch M, Chilingaryan G, Levin MF. Does the finger-to-nose test measure upper limb coordination in chronic stroke? *J Neuroeng Rehabil.* 2017;14(1):6. doi:10.1186/s12984-016-0213-y.

Supplemental Material

Table S1 Results of multivariable logistic regression for each of the retrospective and prospective cohorts

	Retrospective cohort (n=176)		Prospective cohort (n=181)	
Clinical variable	Odds ratio (95% CI)	p	Odds ratio (95% CI)	p
Finger-to-nose test	22.43 (4.41–113.93)	<0.001	21.87 (2.32–206.43)	0.007
Age ≥60 years	0.51 (0.15–1.76)	0.291	3.04 (0.35–26.40)	0.313
Hyperlipidemia	2.31 (0.63–8.50)	0.206	0.37 (0.04–3.66)	0.397
Hypertension	0.63 (0.18–2.17)	0.466	1.21 (0.31–4.67)	0.784
Diabetes mellitus	2.89 (0.78–10.71)	0.112	2.15 (0.48–9.63)	0.316
Nystagmus	1.87 (0.45–7.80)	0.391	1.22 (0.28–5.23)	0.790