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Visuospatial function impairment in patients with subacute-chronic isolated frontal lobe ischemic stroke: A cross-sectional study using MoCA-Ina in a private hospital

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ABSTRACT

Background. Stroke is one of the leading causes of disability, resulting in both limb disability and also cognitive impairment. Cognitive impairment can occur post-stroke due to lesions in specific cortex areas. Visuospatial function, a domain of cognitive function related to visual imaging, is commonly affected by parietal lobe lesions. However, visuospatial processing also requires sustained attention, planning, and error correction, functions of the frontal lobe. There is a paucity of studies evaluating the relationship between isolated frontal lobe stroke and patients' visuospatial function.

Objective. To analyze the relationship between subacute-chronic frontal lobe ischemic stroke and visuospatial function in post-ischemic stroke patients using the MoCA-Ina.

Material and methods. Patients from Siloam Karawaci General Hospital's neurology outpatient department with ages under 65 years, Glasgow Coma Scale of 15, diagnosis of first-time stroke based on CT scan result, and ischemic lesion confined to one brain lobe were recruited using non-probability consecutive sampling for this cross-sectional study. Patients were divided into frontal lobe and non-frontal lobe stroke subgroups. Visuospatial function was assessed using MoCA-Ina and analyzed using Mann Whitney U test.

Outcomes. Fifty patients were included; 25 had frontal lobe stroke, and 25 had non-frontal lobe stroke. The median visuospatial score was lower in the frontal lobe group (2, min/max = 0/4) compared to the non-frontal lobe group (3, min/max = 0/5), with a p-value of 0.044. There was no significant difference in visuospatial scores between different frontal hemisphere locations.

Conclusion. Subacute-chronic frontal lobe ischemic stroke affects visuospatial function in post-ischemic stroke patients.

Keywords: frontal lobe, ischemic stroke, MoCA-Ina, visuospatial function

Abbreviations (in alphabetical order):

CT	– Computed Tomography
DOT	– Design Organization Test
GCS	– Glasgow Coma Scale
MMSE	– Mini-Mental State Examination
MoCA	– Montreal Cognitive Assessment
MoCA-Ina	– Montreal Cognitive Assessment-Indonesia
SD	– Standard Deviation
SPSS	– Statistical Package for the Social Sciences
VOSP	– Visual Object and Space Perception

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INTRODUCTION

Stroke is a global burden disease, ranking as the third most prevalent contributor to disability-adjusted life years and the second most prevalent mortality cause. The lifetime risk of developing stroke has increased by 50% over the last 20 years [1,2]. Stroke can be classified according to the duration. The classification of stroke based on duration is defined as acute (within the first 2 weeks post-onset), subacute (3 to 11 weeks post-onset), and chronic (beyond 12 weeks post-onset) [3]. One of the clinical manifestations of disability is cognitive impairment and it has been discovered that several years following a stroke incident, it is common for patients to experience functional and cognitive impairment, such as motor, sensory, and language disturbance, along with deterioration in quality of life, even without another stroke attack [4,5]. Cognitive function has several domains: memory, attention, executive function, language, and visuospatial. Cognitive impairment affects cognitive function domains, with executive and attention being the most commonly affected domains [6].

Visuospatial function is crucial for processing visual information, movements, distance, and perceiving the relation of the body and environment, hence consequential for their daily tasks [7,8]. This ability is traditionally thought to be mediated by the posterior parietal cortex [9,10]. However, a study by Hamilton et al. suggests that executive function, governed by the frontal lobe, is also integral to visuospatial processing [11]. Another study also indicates that visuospatial function operates within an integrated network of parieto-occipital, parieto-frontal, parieto-premotor, and parieto-medial temporal pathways [12]. The frontal lobe's role may take part in visuospatial processing through its role in sustaining attention, planning, and correcting errors [13]. Despite these insights, there is still a notable gap in the literature regarding the impact of isolated frontal lobe ischemic stroke on visuospatial function. Therefore, this study aims to analyze the relation between subacute-chronic frontal lobe ischemic stroke and visuospatial function, as assessed by the Montreal Cognitive Assessment (MoCA), which primarily evaluates visuospatial constructional ability through drawing [9,10].

MATERIALS AND METHODS

Participants

Fifty patients from the neurology outpatient department in Siloam Karawaci General Hospital with ages less than 65 years old, Glasgow Coma Scale (GCS) of 15, were diagnosed with first-time stroke based on CT scan result and had ischemic lesion in only one brain lobe and were recruited for this cross-sectional study. Study samples were divided equally into two subgroups based on the CT scan result: frontal lobe stroke (n = 25) and non-frontal lobe stroke (n = 25). We excluded patients who were previously diagnosed with head injury and memory impairment and patients who did not consent to participate in this study.

The sample recruitment was done using a non-probability consecutive sampling technique from February until March 2020 in the neurology outpatient department in Siloam Karawaci General Hospital. Study samples were asked to complete a form to obtain their demographic information such as gender, age, last education, and duration since stroke onset. Visuospatial function as the primary dependent variable was obtained through the MoCA-Ina questionnaire, and depression as a confounding variable was measured using the Beck Depression Inventory questionnaire. MoCA-Ina scores of 26 and more mean samples did not have any cognitive disturbance, and samples with MoCA-Ina scores less than 26 mean they had cognitive disturbance. Samples with Beck Depression Inventory scores of less than 21 were classified as not depressed or mild mood disturbance, and samples with scores of twenty-one or more were classified as moderately or severely depressed. The independent variable of this study was the location of the stroke lesion, which was collected through the study samples' CT scan results.

Statistical analysis

The obtained research data was processed and analyzed using IBM Statistical Package for the Social Sciences (SPSS) software version 25. Due to abnormal data distribution, statistical analysis for MoCA-Ina components and stroke lesion location was performed using Mann Whitney U test. The result was presented using median, minimal value, and maximal value. Further analysis of the visuospatial score relationship with the frontal lobe side of the hemisphere was done using One Way ANOVA test, and the result was presented using mean, standard deviation (SD), and 95% CI. Statistical assessments of this study were all two-tailed, with p-value <0.05 considered significant.

RESULTS

This study included 50 participants divided into two groups, most of whom were male in both groups. (Table 1). The median age in both groups is 60 years old, with the youngest in the frontal lobe group being 36 years old and the non-frontal lobe group being 20 years old. Most patients in both groups (48%) have finished senior high school, with only one patient (4%) in the non-frontal lobe group having a master's

TABLE 1. Subject demographic data

Variable	Frontal lobe (n = 25)	Non-frontal lobe (n = 25)	p-value
Gender			
Male, n (%)	14 (56)	15 (60)	1.000
Female, n (%)	11 (44)	10 (40)	
Age (years old), median (min - max)	60 (36 - 64)	60 (20 - 64)	0.391
Education			
Elementary School, n (%)	2 (8)	3 (12)	
Junior High School, n (%)	3 (12)	1 (4)	0.699
Senior High School, n (%)	12 (48)	12 (48)	
Bachelor / Diploma, n (%)	8 (32)	8 (32)	
Master, n (%)	0 (0)	1 (4)	
Duration since stroke onset (months), median (min - max)	21 (2 - 292)	25 (1 - 195)	0.741
Lesion location in hemisphere			
Left, n (%)	7 (28)	10 (40)	
Right, n (%)	14 (56)	11 (44)	0.641
Bilateral, n (%)	4 (16)	4 (16)	
Beck Depression Inventory Score			
<21, n (%)	25 (100)	24 (96)	1.000
≥21, n (%)	0 (0)	1 (4)	
MoCA-Ina Score			
≤25, n (%)	25 (100)	24 (96)	1.000
26 – 30, n (%)	0 (0)	1 (4)	

degree. The duration since stroke onset did not significantly differ between the two groups, both falling within the subacute-chronic classification, with a median of 21 months for the frontal lobe group and 25 months for the non-frontal lobe group. Lesion location in the brain hemisphere also did not differ significantly between both groups. Most lesions in both groups are in the right hemisphere, with 14 patients (56%) from the frontal lobe group and 11 patients (44%) from the non-frontal lobe group. The majority of patients in both groups did not suffer from depression. However, there is one patient (4%) in the non-frontal lobe group that had moderate-severe depression. Cognitive disturbance was found in almost all patients in the non-frontal lobe group, with only one patient (4%) having normal cognitive function.

Analysis of MoCA-Ina components and stroke lesion location shows significant differences in visuospatial, attention, and language function (Table 2).

TABLE 2. Distribution of MoCA-Ina components in frontal lobe and non-frontal lobe stroke

MoCA-Ina components	Frontal Lobe (n = 25)		Non-Frontal Lobe (n = 25)		p-value
	Median	Min - Max	Median	Min - Max	
Visuospatial	2	0 - 4	3	0 - 5	0.044*
Naming	3	1 - 3	3	2 - 3	0.057
Attention	3	0 - 6	4	2 - 6	0.008*
Language	1	0 - 3	2	0 - 3	0.020*
Abstraction	2	0 - 2	2	0 - 2	0.166
Delayed Recall	0	0 - 5	0	0 - 5	0.866
Orientation	6	2 - 6	6	2 - 6	0.557

The median visuospatial scores in the frontal and non-frontal lobe groups were 2 (min – max, 0 – 4) and 3 (min – max, 0 – 5), respectively. Attention and language had a lower median in the frontal lobe group (3 and 1, respectively) compared to the non-frontal lobe group (4 and 2, respectively). The frontal lobe side of the hemisphere did not produce a statistically significant visuospatial score mean difference (Table 3).

TABLE 3. Distribution of MoCA-Ina components in frontal lobe and non-frontal lobe stroke

Frontal lobe location in the hemisphere	Visuospatial Score			p-value
	Mean	SD	95% CI	
Right	1.79	1.369	1.00 – 2.58	
Left	2.00	1.633	0.49 – 3.51	0.857
Bilateral	1.50	1.291	-0.55 – 3.55	

DISCUSSION

Our study aims to analyze the relationship between subacute – chronic frontal lobe ischemic stroke and a patient's visuospatial function using the MoCA-Ina test. MoCA-Ina is the Indonesian version of the MoCA questionnaire validated in 2010. It was chosen as the instrument in this study because it has better sensitivity in evaluating visuospatial ability than the Mini-Mental State Examination or MMSE [14,15]. Visuospatial function was once thought to be dominantly mediated by the parietal lobe, specifically the right parietal lobe [16,17]. However, we found that patients with subacute – chronic isolated frontal lobe stroke have a significantly lower visuospatial score on the MoCA-Ina test than patients with non-frontal lobe stroke, although there is no hemispheric lateralization.

Visuospatial function assessed using MoCA-Ina mainly involves the posterior parietal cortex through external cues (cube copying) and internal cues (clock drawing). When patients redraw the 3D cube, the middle occipital gyrus, cuneus, and lingual gyrus are activated, representing the parieto-occipital pathway [9]. Therefore, patients with parietal or occipital lobe damage commonly suffer from visuospatial disturbance, as confirmed by several studies [18,19]. The other component of visuospatial function assessed in MoCA-Ina, the clock drawing test, involves the parieto-frontal pathway [9]. This pathway connects the area in the prefrontal cortex overseeing spatial memory with the parieto-occipital pathway, which processes that spatial information [12,20]. The frontal lobe allows patients to retrieve any visuospatial memory and draw the clock from memory, hence vital in the clock drawing test [21].

The importance of the frontal lobe in visuospatial function is also highlighted in an experimental study performed by Hamilton, et al. They found that executive function, predominantly mediated by the frontal lobe, plays a crucial role in visuospatial function, specifically visuospatial working memory [11]. Additionally, the frontal lobe's roles in sustaining attention, planning, and error correction are integral to visuospatial processing ability [13]. Despite the recognized importance of the frontal lobe in visuospatial function, there is a paucity of data analyzing the relationship between isolated frontal lobe lesions and visuospatial functions in humans. Most studies about frontal lobe lesions only focus on their relation to behavioral changes or executive function [22–24]. Therefore, our findings corroborate the theory of the frontal lobe's significant role in visuospatial function.

This is an important discovery as the frontal lobe is commonly affected in stroke, and visuospatial function greatly affects quality of life [23]. Any lesion in the frontal lobe could disrupt the dorsal and ventral parieto-frontal pathway, resulting in gait and balance disturbance amidst the absence of visuospatial neglect. The dorsal pathway is responsible for selecting visuospatial information pertinent to movement goals, and disruption in this pathway confuses movement planning. The ventral parieto-frontal pathway's role is to process the visuospatial information sent from the dorsal pathway and inhibits the dorsal pathway when any obstacles arise. Disruption in this pathway will cause poor balance correction [25,26]. With the result of this study, when encountering stroke patients with frontal lobe lesion, physicians should never forget to evaluate the visuospatial function and consult with relevant specialists. Evaluation can be done using the MoCA-Ina test. The accessibility and ease of administration of the MoCA-Ina in various healthcare settings render it advantageous for assessing frontal lobe stroke patients' visuospatial function.

Despite our study's novelty, there is still area for improvement. Our evaluation of visuospatial function is limited to the MoCA-Ina questionnaire. As far as we know, there are other instruments that can specifically assess visuospatial function without interference from the other cognitive components to name a few: Corsi block tapping, Design Organization Test (DOT), Battery of Visuospatial Ability, and Visual Object and Space Perception battery (VOSP). Future studies in a larger health center or multiple health centers can use either of these instruments to evaluate the relationship more thoroughly between frontal lobe stroke and visuospatial function [27–30].

CONCLUSION

Subacute-chronic isolated frontal lobe stroke can affect a patient's visuospatial function compared to non-frontal lobe stroke, hence visuospatial function disturbance should always be considered when assessing frontal lobe stroke patients. Here we found no hemispheric lateralization in the visuospatial function.

Research ethics

This research has undergone ethical review by the Ethics Committee of the Faculty of Medicine, Pelita Harapan University, with reference number 046/K-LKJ/ETIK/1/2020. All respondents received an explanation about the purpose, procedure, and benefits of the research and agreed to participate. All respondents signed the informed consent before filling out the questionnaire.

Authors' contributions:
Conceptualization, MCE, YMTS, and ML; Methodology, MCE, YMTS, and ML; Software, MCE, ML; Validation, formal analysis, investigation, resources, MCE and YMTS; Data curation, ML; Writing – original draft preparation, MCE; Writing – review and editing, MCE and YMTS; Supervision, YMTS.
All authors have read and agreed to the published version of the manuscript.

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REFERENCES

1. Fan J, Li X, Yu X, Liu Z, Jiang Y, Fang Y, et al. Global Burden, Risk Factor Analysis, and Prediction Study of Ischemic Stroke, 1990-2030. *Neurology*. 2023 Jul 11;101(2):e137–50. doi: 10.1212/WNL.0000000000207387. PMID: 37197995.
2. Feigin VL, Brainin M, Norrving B, Martins S, Sacco RL, Hacke W, et al. World Stroke Organization (WSO): Global Stroke Fact Sheet 2022. *Int J Stroke*. 2022 Jan 5;17(1):18–29. doi: 10.1177/17474930211065917.
3. Wu P, Zeng F, Li Y, Yu B, Qiu L, Qin W, et al. Changes of resting cerebral activities in subacute ischemic stroke patients. *Neural Regen Res.* 2015;10(5):760. doi: 10.4103/1673-5374.156977.
4. Tsao CW, Aday AW, Almarzooq ZI, Anderson CAM, Arora P, Avery CL, et al. Heart Disease and Stroke Statistics—2023 Update: A Report From the American Heart Association. *Circulation*. 2023 Feb 21;147(8). doi: 10.1161/CIR.0000000000001123.
5. Elendu C, Amaechi DC, Elendu TC, Ibhiedu JO, Egbunu EO, Ndam AR, et al. Stroke and cognitive impairment: understanding the connection and managing symptoms. *Ann Med Surg.* 2023 Dec;85(12):6057–66. doi: 10.1097/MS9.0000000000001441.
6. Aam S, Einstad MS, Munthe-Kaas R, Lydersen S, Ihle-Hansen H, Knapskog A-B, et al. Post-stroke Cognitive Impairment-Impact of Follow-Up Time and Stroke Subtype on Severity and Cognitive Profile: The Nor-COAST Study. *Front Neurol.* 2020 Jul 17;11:699. doi: 10.3389/fneur.2020.00699. PMID: 32765406

7. Bergqvist M, Möller MC, Björklund M, Borg J, Palmcrantz S. The impact of visuospatial and executive function on activity performance and outcome after robotic or conventional gait training, long-term after stroke—as part of a randomized controlled trial. Schwenkreis P, editor. *PLoS One*. 2023 Mar 9;18(3):e0281212. doi: 10.1371/journal.pone.0281212.
8. Pal A, Biswas A, Pandit A, Roy A, Guin D, Gangopadhyay G, et al. Study of visuospatial skill in patients with dementia. *Ann Indian Acad Neurol.* 2016;19(1):83. doi: 10.4103/0972-2327.168636.
9. Bai S, Liu W, Guan Y. The Visuospatial and Sensorimotor Functions of Posterior Parietal Cortex in Drawing Tasks: A Review. *Front Aging Neurosci.* 2021 Oct 14;13:717002. doi: 10.3389/fnagi.2021.717002. PMID: 34720989
10. Punchik B, Shapovalov A, Dwolatzky T, Press Y. Visual-spatial perception: a comparison between instruments frequently used in the primary care setting and a computerized cognitive assessment battery. *Clin Interv Aging.* 2015 Nov;10:1881–6. doi: 10.2147/CIA.S92819. PMID: 26648704
11. Hamilton C, Coates R, Heffernan T. What develops in visuo-spatial working memory development? *Eur J Cogn Psychol.* 2003 Jan 10;15(1):43–69. doi: 10.1080/09541440303597.
12. Trés ES, Brucki SMD. Visuospatial processing: A review from basic to current concepts. *Dement Neuropsychol.* 2014 Jun;8(2):175–81. doi: 10.1590/S1980-57642014DN82000014.
13. Kashyap H, Kumar KJ, Rao SL, Devi BI. Visuo-spatial construction in patients with frontal and parietal lobe lesions. *Neuropsychol Trends.* 2011 Apr;(9). doi: 10.7358/neur-2011-009-kash.
14. Singh IL, Singh T, Tiwari T, Joshi D. Comparing visuospatial construction ability of MoCA and MMSE in cognitive assessment of patients with dementia of Alzheimer's type. *Alzheimer's Dement*. 2023 Jun 16;19(S4). doi: 10.1002/alz.065307.
15. Rambe AS, Fitri FI. Correlation between the Montreal Cognitive Assessment-Indonesian Version (Moca-INA) and the Mini-Mental State Examination (MMSE) in Elderly. *Maced J Med Sci.* 2017 Nov 25;5(7):915–9. doi: 10.3889/oamjms.2017.202.
16. Seydell-Greenwald A, Ferrara K, Chambers CE, Newport EL, Landau B. Bilateral parietal activations for complex visual-spatial functions: Evidence from a visual-spatial construction task. *Neuropsychologia*. 2017 Nov;106:194–206. doi: 10.1016/j.neuropsychologia.2017.10.005.
17. Wu Y, Wang J, Zhang Y, Zheng D, Zhang J, Rong M, et al. The Neuroanatomical Basis for Posterior Superior Parietal Lobule Control Lateralization of Visuospatial Attention. *Front Neuroanat.* 2016 Mar 24;10:32. doi: 10.3389/fnana.2016.00032. PMID: 27047351
18. Kumral E, Çetin FE, Özdemir HN. Cognitive and Behavioral Disorders in Patients with Superior Parietal Lobule Infarcts. *Can J Neurol Sci / J Can des Sci Neurol*. 2023 Jul 10;50(4):542–50. doi: 10.1017/cjn.2022.81.
19. Traianou A, Patrikelis P, Kosmidis MH, Kimiskidis VK, Gatzonis S. The neuropsychological profile of parietal and occipital lobe epilepsy. *Epilepsy Behav.* 2019 May;94:137–43. doi: 10.1016/j.yebeh.2019.02.021.
20. Ren Z, Zhang Y, He H, Feng Q, Bi T, Qiu J. The Different Brain Mechanisms of Object and Spatial Working Memory: Voxel-Based Morphometry and Resting-State Functional Connectivity. *Front Hum Neurosci.* 2019 Jul 19;13:248. doi: 10.3389/fnhum.2019.00248. PMID: 31379543
21. Houlton J, Barwick D, Clarkson AN. Frontal cortex stroke-induced impairment in spatial working memory on the trial-unique nonmatching-to-location task in mice. *Neurobiol Learn Mem.* 2021 Jan;177:107355. doi: 10.1016/j.nlm.2020.107355.
22. Metin Ö, Tufan AE, Cevher Binici N, Saraçlı Ö, Atalay A, Yolga Tahiroğlu A. Executive Functions in Frontal Lob Syndrome: A Case Report. *Turk Psikiyatri Derg.* 2017;28(2):135–8. PMID: 29192947.
23. García Carretero R, Beamonte-Vela B-N, Silvano-Cocinero J-D, Alvarez-Mendez A. Behavioural changes as the first manifestation of a silent frontal lobe stroke. *BMJ Case Rep.* 2019 Jan 28;12(1):bcr-2018-227617. doi: 10.1136/bcr-2018-227617.
24. Yuan P, Raz N. Prefrontal cortex and executive functions in healthy adults: A meta-analysis of structural neuroimaging studies. *Neurosci Biobehav Rev.* 2014 May;42:180–92. doi: 10.1016/j.neubiorev.2014.02.005.
25. Peters S, Handy TC, Lakhani B, Boyd LA, Garland SJ. Motor and Visuospatial Attention and Motor Planning After Stroke: Considerations for the Rehabilitation of Standing Balance and Gait. *Phys Ther.* 2015 Oct 1;95(10):1423–32. doi: 10.2522/ptj.20140492.
26. Singh-Curry V, Husain M. The functional role of the inferior parietal lobe in the dorsal and ventral stream dichotomy. *Neuropsychologia*. 2009 May;47(6):1434–48. doi: 10.1016/j.neuropsychologia.2008.11.033.
27. Arce T, McMullen K. The Corsi Block-Tapping Test: Evaluating methodological practices with an eye towards modern digital frameworks. *Comput Hum Behav Reports.* 2021 Aug;4:100099. doi: 10.1016/j.chbr.2021.100099.
28. Burggraaf R, Frens MA, Hooge ITC, van der Geest JN. A Quick Assessment of Visuospatial Abilities in Adolescents Using the Design Organization Test (DOT). *Appl Neuropsychol Child.* 2016 Jan 2;5(1):44–9. doi: 10.1080/21622965.2014.945114.
29. Trojano L, Siciliano M, Cristinzio C, Grossi D. Exploring visuospatial abilities and their contribution to constructional abilities and nonverbal intelligence. *Appl Neuropsychol Adult.* 2018 Mar 4;25(2):166–73. doi: 10.1080/23279095.2016.1269009.
30. Salimi S, Irish M, Foxe D, Hodges JR, Piguet O, Burrell JR. Visuospatial dysfunction in Alzheimer's disease and behavioural variant frontotemporal dementia. *J Neurol Sci.* 2019 Jul;402:74–80. doi: 10.1016/j.jns.2019.04.019.