Assessment of Cognitive Functions in Covid-19 Recovered Patients - A Prospective Longitudinal Study

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Abstract

Objectives: The SARSCOV-2 is known to cause Microvascular and Macrovascular thrombotic phenomena in the vascular system, which has been found to increase the chances of blood clotting in the brain. Microvascular subclinical thrombotic phenomena that lead to impairment in cognitive functions have not been studied much in this pandemic. The study aims to determine whether this SARS CoV-2 produces cognitive impairment in the person who has suffered from COVID-19. If it produces cognitive impairment, then whether it persists even after one month or not or whether it resolves.

Materials and Methods: This longitudinal prospective study was carried out after taking institutional Ethical committee clearance. People in the age group of 18 to 60 years who were diagnosed as COVID-19 Positive, and got recovered and discharged, were assessed at the time of discharge, after one month and after three months using cognitive assessment battery (PGI MEMORY SCALE, DSST, TMT, ADULT PROTEUS and MMSE).

Results: A total of 205 subjects were included in the study.71% are males, and 28.3% are females. The majority that is 36% of the study population, is between 40-49 years. Parameters like TMT and PGI MEMORY have been statistically significant between discharge day, after one month, and three months follow-up. The age group of 40 to 48 years was most affected, with a frequency of 75%.

Conclusions: The study has shown that cognitive impairment can happen after COVID 19 disease.

Keywords: Cognitive assessment, COVID-19, Microvascular thrombotic phenomena, PGI MEMORY SCALE (PGIMS), DIGIT SYMBOL SUBSTITUTION TEST (DSST), TRAIL MAKING TEST(TMT), MAZE TEST.

1. Introduction

In December 2019, Novel Coronavirus 2, also known as severe acute respiratory syndrome coronavirus-2 (SARS-COV-2), surfaced in the city of Wuhan, Hubei province in China[1]. The infection caused by this virus is named Coronavirus disease 2019(COVID-19) by WORLD HEALTH ORGANISATION(WHO)[2] . The frequency of recombination of RNA-positive

strands is high. If the host gets infected with multiple coronavirus strains, viral recombination occurs, creating problems in diagnosing the disease.

Individuals who are severely affected are more susceptible to neurological problems ranging from nausea and headaches or giddiness to more serious seizures and cerebrovascular disease (CVD). Autopsy reports on patients with severe disease revealed cerebral fluid retention and neurological degeneration.

A virus comparison showed that amino acid substitutions in SARSCORONA VIRUS were responsible for functional and pathogenic differences. The SARSCORONA VIRUS spreads through the respiratory tract, the Gastrointestinal (GI) tract, and aerosols. It infiltrates human cells by binding to the Angiotensin-converting enzyme 2 (ACE2) protein, which is found in airway epithelium, renal cells, lung parenchyma, cardiovascular and gastrointestinal systems, but not the central nervous system[3]. According to neurological research, ACE2 is primarily expressed in the cortex, but also in microglia and neuronal cells in the brain [4].

These findings imply that ACE2 expression is related to SARS CoV-2's neurotropic potential[5]. SARSCORONA VIRUS neuroinvasion implies that the virus can invade the respiratory tract to the Central nervous system and cause harm either directly or indirectly via the host's immune response. By infecting Blood Brain Barrier (BBB) endothelial cells or binding to the endothelial protein ACE2, SARSCORONA VIRUS can also enter the Central Nervous System (CNS). The SARSCORONA VIRUS cytokine storm may also degrade the BLOOD BRAIN BARRIER(BBB), raising permeability and allowing entry of pathogens into the Central nervous system via infected immune cells.

As a result, neuropathological correlates of SARSCORONA VIRUS disease include hypoxemic encephalitis, demyelinating disorders, cerebrovascular disease, acute myelitis, and others. These are due to spurious immune system reaction leading to secondary inflammatory tissue injury[6].

2. Materials and Methods

Source of Data:

Subjects who have been diagnosed as COVID-19 positive and got recovered are included in the study after taking informed consent at Shri B.M. Patil Medical College, Hospital and Research Centre, BLDE (DEEMED TO BE UNIVERSITY), Vijayapura, between November 2020 to October 2022.

Method of Collection of Data:

i. Study Population:

This study was done in Shri B.M. Patil Medical College, Hospital and Research Centre, Vijayapura, from November 2020 to November 2022 in individuals who have recovered from COVID-19 after taking institutional Ethical committee clearance.

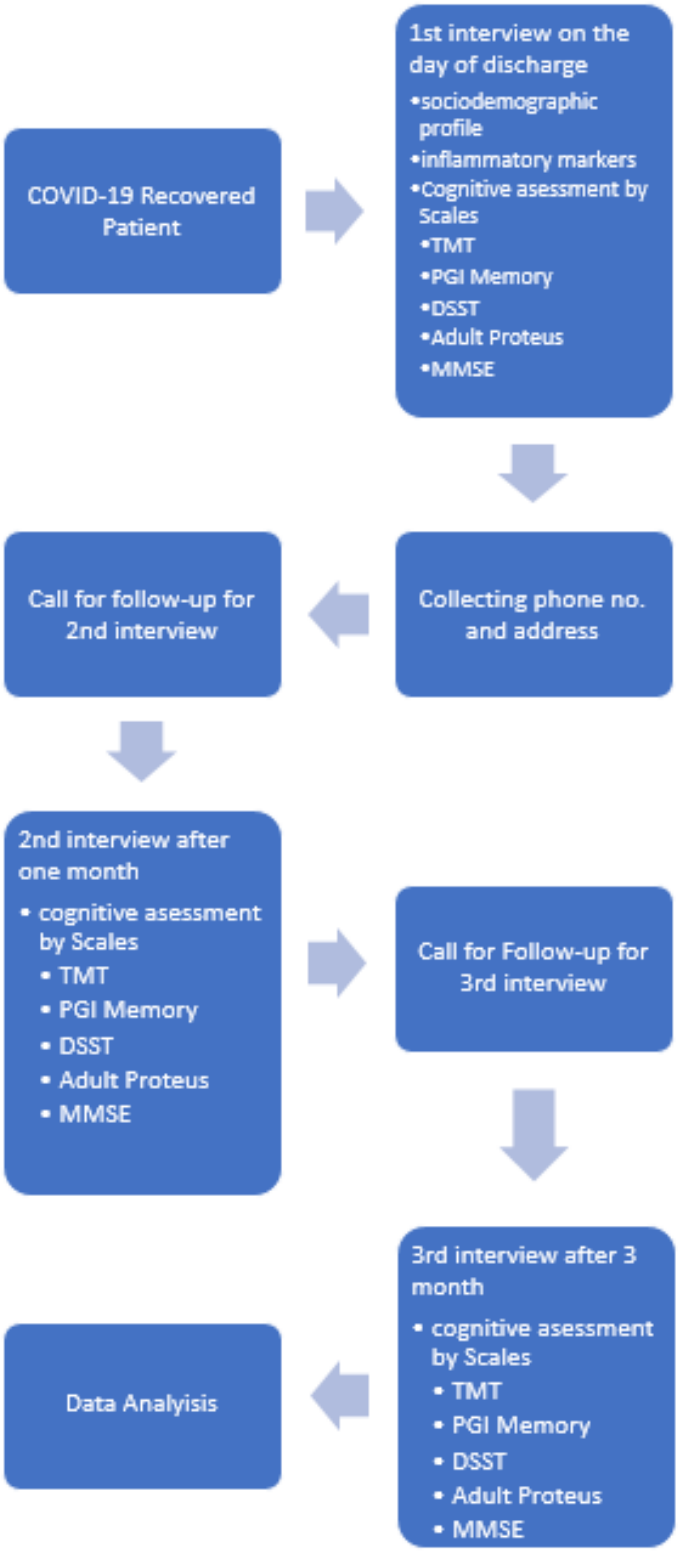
ii. Inclusion Criteria:

- People in the age group of 18 to 60 years who were diagnosed as COVID-19 Positive, got admitted at Shri B.M.Patil Medical College, Hospital and Research Center, BLDE (DU), and got recovered and discharged, were interviewed at the time of discharge, after one month and after three months.
- Subjects willing to consent.

iii. Exclusion Criteria:

- Any patients with a Pre-existing mental illness or cognitive impairment or patient with mental retardation.
- Previous history of Stroke

3. Methodology



Type of Study: Prospective longitudinal study

Tools:

The following psychological assessments were used

i. Trail Making Test (TMT):

Trails A and B are timed validated assessments of complex attention. Part A of the Trails Making Test comprises of 25 circles on a sheet of paper with numbers 1-25 written in random locations. The subject must link the circles in numerical order as fast as possible in less than 90 seconds. Part B of the Trails Making Test comprises of 25 circles on a sheet of paper with numbers 1-13 and letters A-L written in random locations. It necessitates the subject to link the circles as fast as possible in numerical and alphabetical order, alternating among numbers and letters in less than 180 seconds. With a pencil, the trails are finalized on worksheets. This tests visual scanning and visuomotor tracking, which measure the speed of processing measured in seconds.

ii. Digit-Symbol Substitution Test (DSST):

A timed neuropsychiatric test sensitive to onset of dementia is digit-symbol substitution. It consists of a top-of-the-page key of nine digit-symbol pairs, preceded by rows of digits below missing symbols. It necessitates the subject to match symbols to digits as quickly as possible using the provided key. The number of correct symbols within 120 seconds is tallied. The test is completed with a pencil on a worksheet.

The DSST assesses a variety of cognitive operations. To perform well on the DSST, you must have good motor speed, attention, and visuoperceptual functions, including the ability to scan and write or draw (i.e., basic manual dexterity). Associative learning may also have an impact on performance. For example, if pairings are quickly learned after the first few trials, the subject's performance speed will improve because he or she will no longer have to refer to the key to verify the correctness of each pairing. The conscious decision to use this learning strategy to improve performance speed necessitates the executive functions of planning and strategizing. Working memory, another executive function, is likely required to remember task rules and to keep required symbol digit pairs up to date.

iii. P.G.I. Memory Scale (PGIMS):

It defines memory as the ability to retain and reproduce impressions once perceived intentionally. It includes verbal and non-verbal material and measures remote, recent, and immediate, short-term, very short-term, intermediate-term and long-term memories. There are ten subtests, standardized on adult subjects in the age range of 20 to 45 years. Its test-retest reliability over a period of one-week ranges from 0.69 to 0.85 for ten subtests (N = 40) and for the total test about 0.90 (test-retest and split-half). The correlation of PGIMS with Boston's Memory Scale and Wechsler's Memory Scale were found to be 0.71 and 0.85, respectively. Elderly subjects obtained significantly lower scores than the younger subjects. Cases suffering from organic brain pathology and functional psychotic conditions obtained significantly lower scores than normal and neurotics. It has satisfactory cross-validity and provides quintile norms and a profile. Scores of the subjects suffering from organic brain pathology, functional psychosis and neurosis fall in the lowest, 2nd and middle quintiles, respectively. Thus, the result showed that the PGI Memory scale is a satisfactorily reliable

and valid tool to measure memory in the clinic population. (Pershad, 1977; Pershad and Wig, 1976, 1988).

In our study we used PGIMS because it is designed to Indian population and more over it is present in regional language which is easier to apply to the Indian population.

iv. Mini-Mental State Examination (MMSE):

Folstein developed the Mini-Mental State Examination (MMSE) or Folstein test in 1975. It is a 30-point questionnaire used extensively in research and clinical settings to measure cognitive impairment. It is commonly used to screen for onset of dementia. It is also used to predict the severity and progression of cognitive impairment and to track an individual's cognitive changes over time, making it an efficient method to document an individual's response to treatment.

v. Porteus Maze Test (PMT):

The Porteus Maze test (PMT) is a type of psychological assessment. Its purpose is to assess psychological planning ability and foresight. It is a nonverbal intelligence test. Stanley Porteus, a psychology professor at the University of Hawaii, created it.

The subject must solve a series of mazes as part of the test. The mazes vary in difficulty. The test lasts 15-60 minutes and allows the subject to complete as many as mazes feasible. The test is used as a supplement to the Wechsler intelligence scales.

4. Results

Age Distribution:

It was observed that majority of the patients (36.6%) belonged to the age groups of 40 to 49, followed by (32.7%) belonging to the age group 50 to 60 years. The remaining (22.9%) belonged to the age group 30 to 39 years.

Table 1: Distribution of patients according to age:

Age (YEARS)	Number of Cases	Percentage of cases
< 20	1	0.5
20 - 29	15	7.3
30 - 39	47	22.9
40 - 49	75	36.6
50 -60	67	32.7
Total	205	100.0

Gender Distribution:

It was observed that the majority were males, with 71.7% of patients (147 in number), while 28.3% of subjects were females (28 in number).

Table 2: Distribution of patients according to Gender:

Gender	Number of cases	Percentage of cases
Male	147	71.7
Female	58	28.3
Total	205	100.0

Table 3: Psychological assessments done at the time of discharge, after 1 month and after 3 months.

PARAMETERS	On discharge		After 1 month		After 3 months		Friedman test	P value
	MEAN	±SD	MEAN	±SD	MEAN	±SD		
TMT A	25.00	5.190	25.42	5.914	25.55	6.241	36.286	0.0001*
TMT B	57.16	12.848	57.54	13.576	57.66	13.836	42.000	0.0001*
PGI MEMORY	66.98	6.421	65.77	9.208	64.60	12.308	43.517	0.0001*
REMOTE MEMORY	7.00	0.000	6.90	0.304	6.78	0.678	42.000	0.0001*
RECENT MEMORY	5.00	0.000	4.90	0.304	4.77	0.680	43.000	0.0001*
MENTAL BALANCE	6.46	0.668	6.34	0.929	6.22	1.259	42.000	0.0001*
ATTENTION AND CONCENTRATION	7.91	1.320	7.75	1.601	7.62	1.905	42.000	0.0001
DELAYED RECALL	7.60	1.096	7.44	1.415	7.32	1.730	42.000	0.0001*
IMMEDIATE RECALL	5.57	1.025	5.45	1.186	5.33	1.468	36.940	0.0001*
VERBAL RETENTION FOR SIMILAR PAIRS	5.00	0.000	4.90	0.304	4.78	0.678	42.000	0.0001*
VERBAL RETENTION FOR DISSIMILAR PAIRS	10.14	1.235	9.99	1.500	9.81	1.604	40.095	0.0001*
VISUAL RETENTION	4.91	1.349	4.81	1.574	4.8	1.585	40.925	0.0001*
VISUAL RECOGNITION	7.39	1.384	7.29	1.572	7.17	1.858	41.518	0.0001*
MAZE TEST 1	11.80	2.411	12.11	3.206	12.23	3.550	42.000	0.0001*
MAZE TEST 2	15.11	3.495	15.57	4.244	15.69	4.541	40.000	0.0001*
DSST	84.61	3.092	84.18	3.494	84.03	3.708	43.000	0.0001*
MMSE	25.57	2.410	25.17	3.251	25.04	3.566	42.000	0.0001*

5. Discussion

Out of 205 patients enrolled in the study, 75 patients belonged to the age group of 40 to 49 years, followed by 67 patients in 50 to 60 years, 47 patients in the age group of 30 to 39 years,15 patients in 20 to 29 years, whereas only one patient was below 20 years, the mean age being 44.10± 9.64 years.

In Hampshire et al., a study from Germany, they did studies on large sample of 86,285 and the mean age group was 46.75±15.73 years[7].

In a study done by Shwetha Jakhmola et al.,in the year 2021, the age group of 20 to 49 years was more exposed to the virus in India.

In a study done by Hetong Zhou et al., in the year 2020 the mean age was 47± 10.54 years, which is almost similar to the results of our study[8].

In the study by Flavia Mattioli et al.,in the year 2021 the mean age was 47.76 years, the results of which are in accordance with the results of our study[9].

In contradiction to our study, the mean age was 74.5±3.8 years in a study done by Tiina Savikangas et al. in a year 2021[10].

In another study by Jinghuan Gan et al.,in the year 2021, to study the impact of the COVID-19 pandemic on Alzheimer's disease and other dementias, the mean age was 70.62±7.96 years, the mean age was more than our study because they included the patients of Alzheimer's and other dementias and moreover in our study under exclusion criteria the age cut-off was 18 years to 60 years[11].

Gender distribution:

In our study, there was a male preponderance, with 147 males and 58 females, probably because of more activity of males outdoors.

In a study done by Shwetha Jakhmola et al.,in the year 2021, the males were more exposed when compared to females because many of them serve in the society compared to the other age groups, who stayed at home. Moreover, the COVID-19 mortality analysis revealed a major population from India is in the age group 20 to 49 years compared to the other countries. Availability of adequate health facilities, access to health resources and detection of infection in developing countries than in the developed countries can be contributing factors.

In the study done by Hetong Zhou et al., 62 % of the patients were males, while 38% Were females, which also had male preponderance[8].

In contrary to the results of our study, 75% of the patients were females in study by Flavia Mattioli[9] .

Psychological assessments:

TMT:

It was observed in our study that the average time taken to complete TMT-A at the time of discharge was 25 seconds whereas an average time of 25.2 seconds was taken by the patients after one month of discharge, while the mean time taken was 25.55 after the three months of discharge. These results indicate that the time taken by the subjects to complete the test was increased after one month and three months, compared to the time of discharge, suggesting that there was a significant cognitive impairment, affecting the visual scanning and visuomotor tracking, thus affecting the speed of processing among COVID-19 recovered patients after a period of three months ($p<0.05$).

On evaluation with TMT-B,57.16 seconds was the average time taken to complete the test at the time of discharge, while the patients took 57.54 seconds on average after one month and 57.66 seconds after three months. It was found that there was a subtle increase in time taken by the subjects to complete the test at three months when compared to that at the time of discharge, and the association between the average time taken and the time period of evaluation was statistically significant. ($p<0.001$).

In a study done by Becker et al., in the year 2021 where they used TMT A and B as one of the assessment methods and found that there were relatively higher rates of impairment in cognition were present after several months of COVID-19 recovery. According to their study

deficits were present in executive functions and processing speed which were in accordance with our study[12]

Hetong zhou et al., in their study, found that the average time taken to complete the TMT was 47.82±16.55 seconds which was in accordance with our study[8].

In a study done by Adouni et al ., they found that the minimum and maximum time taken by the subjects to complete the TMT-A was 20 seconds and 309 seconds respectively whereas the minimum and maximum time taken by the subjects to complete the TMT-B was 41 and 340 seconds respectively[13].

The results of our study indicate that the information processing speed of the subjects decreases following recovery from COVID-19 infection.

TMT is used commonly as a measure of Frontal Lobe functions like Executive functions which include Planning, Organizing, Sequencing and Multitasking. It is also a measure of behavioral difficulties like Aggression, Apathy and Disinhibition.

Therefore, with the results we conclude that there is subtle decrease in the cognitive functions of Frontal Lobe in Executive functions.

PGI Memory Scale (PGIMS):

To our knowledge, ours was the first study to determine cognitive impairment among COVID-19 recovered patients with the help of PGI MEMORY SCALE.

Remote memory, the subtest of the PGI MEMORY scale, was observed to decrease among COVID-19 recovered patients after three months of discharge when compared to the time of discharge. Although the mean scores were in the percentile range of 40 to 60, the level of remote memory being good according to the PGI MEMORY SCALE, the variations of mean scores within the percentile range was suggestive of cognitive decline in remote memory after three months of discharge which was statistically significant.

While the mean scores after one month and after three months differed from the time of discharge by 0.10 and 0.23, respectively, in the recent memory subset of PGI MEMORY SCALE, the scores were in the range of 40 to 60, indicating a good level of recent memory according to PGI MEMORY SCALE despite being under the common percentile range there was a subtle decline in the cognitive function in recent memory which was statistically significant($p=0.001$).

There was also a decline of average scores in the Mental balance subset of PGI MEMORY SCALE from 6.46 on the day of discharge to 6.34 at one month and 6.22 after three months of discharge. There was a decrease in cognitive function in the mental balance subset, with the average scores falling under low to very low levels of mental balance, according to PGI MEMORY SCALE. There was a statistically significant association between the level of mental balance and the time of evaluation with the PGI memory scale

In a study done by Becker et al., in the year 2021 along with the TMT A and B they also used assessments like Phonemic and Category fluency which test language, similarly in our study the assessment Mental balance does the same. According to their study, deficits were present in the Category fluency which is in accordance with our study[12].

Attention and concentration, the subtest of the PGI MEMORY scale, was observed to decrease among COVID-19 recovered patients after three months of discharge when

compared to the time of discharge. Although the mean scores were in the percentile range of 0 to 20, the level of Attention and concentration being very low according to the PGI MEMORY SCALE, the variations of mean scores within the percentile range were suggestive of cognitive decline in Attention and concentration after three months of discharge which was statistically significant. (P=0.001).

In another subtest of the PGI MEMORY scale, the Delayed recall, the mean score on the day of discharge was 7.60,7.44 after one month and 7.32 after three months, the scores in the percentile range of 20 to 40 and 0 to 20, the level of delayed recall being low on the day of discharge and the levels decreased to very low after three months according to the PGI MEMORY scale.

In a study done by Becker et al., in the year 2021 they also used assessments for Memory encoding and recall and they found that there were deficits in these areas[12].

The immediate recall subtest of the PGI memory scale showed a decline in the levels of cognitive function at three months after discharge compared to the time of discharge. The average mean score is 5.57 at discharge,5.45 after one month and 5.33 after three months.

The mean scores lie in the percentile range of 0 to 20, rendering a very low level of immediate recall, which was statistically significant (p=0.001).

While the mean scores after one month and after three months differed from the time of discharge by 0.1 and 0.22, respectively, in the verbal retention for similar pairs subtest of PGI MEMORY SCALE, the scores were in the range of 40 to 60, indicating a good level of verbal retention for similar pairs according to PGI MEMORY SCALE despite being under the common percentile range there was a subtle decline in the cognitive function in verbal retention for similar pairs which was statistically significant(p=0.001).

With a subjective mean score of 10.14 on the day of discharge,9.99 after one month and 9.81 after three months, the mean scores fell under the percentile range of 20 to 40, indicating a low level of verbal retention of dissimilar pairs according to PGI memory scale, also suggesting a cognitive decline after three months of discharge which was statistically significant.

Visual retention, the subtest of the PGI MEMORY scale, was observed to decrease among COVID-19 recovered patients after three months of discharge when compared to the time of discharge. Although the mean scores were in the percentile range of 0 to 20, the level of Visual retention is very low according to the PGI MEMORY SCALE. The variations of mean scores within the percentile range were suggestive of cognitive decline in Attention and concentration after three months of discharge which was statistically significant. (P=0.001).

In another subtest of the PGI memory scale, the visual recognition, the subjective mean score on the day of discharge was 7.39. After one month was 7.29 and after 3 months, is 7.17, the average score being in the percentile range of 0 to 20, indicating a very low level of visual recognition according to the PGI memory scale. There was a decline in the cognitive function among the COVID-19 recovered patients after three months of discharge which was statistically significant.

In a study done by Davis et al., in 2021 by using assessment methods like Qualtrics which contains 257 questions, they also used MRI brain if memory or cognitive dysfunctions were

present and found that 88.0% of the study population showed Cognitive dysfunction and/or Memory loss [165].

In a study done by Junyoung Oh et al., in the year 2022, they found that SARS-COV-2 spike proteins can induce cognitive deficits and even causes anxiety like symptoms in the mouse by causing Hippocampal neuronal deaths which causes memory deficits as hippocampus is responsible for memory[14].

It is a comprehensive scale to measure Verbal and Non-verbal memory which are the functions of Temporal Lobe. In our study we found that there was subtle decrease in the cognition in the domains of verbal and non-verbal memory which suggest of Temporal lobe dysfunction.

MAZE TEST 1:

The average time taken to complete the maze test 1 was increased by 0.43 seconds at three months after discharge when compared to the day of discharge, and a difference of 0.31 seconds was observed between the first month of discharge and the time of discharge.

These results indicated that there was a cognitive dysfunction in the Visual memory and was statistically significant.

MAZE TEST 2:

The average time taken to complete maze test 2 was 15.11 seconds during discharge, compared to 15.57 seconds after one month of discharge and 15.69 seconds after three months of discharge.

The increase in time taken to complete the test after a period of three months suggest a cognitive dysfunction in COVID-19 recovered patients, which was statistically significant.

The maze test is used to assess the executive functions of the frontal lobe like planning, multitasking, organizing sequence and impulse control. The results of our study indicate that the functions of the frontal lobe have been affected after three months following COVID-19 infection.

In a study done by Adouni et al .,the minimum and maximum time taken by the subjects to complete the Maze test was 7 seconds and 139 seconds respectively and the mean was 59 seconds this is because the mean age in the study was 63±12.7 which suggest that higher the age group the time taken to complete the test was high and the chances of cognitive deficits were also high[13].

Maze test is also a measure of Frontal Lobe where the Executive functions and Behavior changes can be identified.

In our study we found that there was with the help of Maze Test 1 and 2, there was subtle decline in the cognition in the domains related to the Frontal Lobe.

DSST:

DSST score was calculated as the number of correctly matched symbols in 120 seconds. In our study, the mean score on discharge was 84.61, whereas the average score after one month after discharge was 84.18 and 84.03 at three months of discharge.

Similar to the other tests done to determine cognitive dysfunction, DSST also showed declining cognitive function, which was also statistically significant.

In a study done by clement Gouraud et al., the mean DSST score was 50, which was lesser than the results of our study. The contrasting results might be due to the inclusion of elderly patients in their study, where the mean age was 60 years as opposed to the mean age of 44.10±9.64 years in our study[15].

DSST is a subtest of WAIS (Wechsler Adult Intelligence scale) to assess the psychomotor speed, sustained attention and logical reasoning and visuo perceptual the parameters that have been affected amongst the patients in our study following three months of COVID-19 infection.

MMSE:

The average MMSE score was 25.57 at the time of discharge,25.17 after one month of discharge and 25.04 after three months of discharge. Although there was a subtle decline in the scores, the mean score of 25 suggests no cognitive impairment. This could be attributed to the fact that MMSE helps to detect severe cognitive dysfunctions as that seen in neurodegenerative diseases. Hence there is no cognitive impairment among the patients enrolled in our study.

In a study by clement Goudaurd et al., the mean MMSE score was 28, which was also suggestive of no cognitive impairment, the results of which are in accordance with our study[15].

In another study by Flavia Mattioli et al., where the neurological and cognitive sequelae of COVID-19 patients were studied on a four-month follow-up, there was no cognitive impairment based on the MMSE score among the patients[9].

In another study by Jhinguan Gan et al., there was a severe cognitive impairment among the subjects enrolled, which is in contrast with the results in our study.

The severe cognitive impairment could be attributed to the long-term follow-up of their patients compared to only three months of follow-up in our study[11].

In a Systematic review and Meta analysis study that is Impact of COVID-19 on Cognitive Function done by Sarah Houben in the year 2022 concluded that after COVID-19 infection the individuals are more prone to the Cognitive decline. According to this Meta analysis, MoCA (Montreal Cognitive Assessment) was the assessment which was used most and found that it could mild cognitive deficits and moreover MoCA is available in more than 100 languages. whereas the next study which was used more frequently after the MoCA was MMSE. Among both assessments MoCA could detect the subclinical deficits and can clearly discriminated when compared with MMSE[16].

In a study done by Woo et al., in the year 2020 by using Modified Telephone interview for cognitive status (TICS-M) found that subclinical sustained cognitive decline may be a common complication in a COVID-19 recovered adults of younger age[17].

Alemanno et al., in a study done in 2021 using assessment methods like MoCA and MMSE, concluded that 80% of the subjects showed cognitive impairment and 40% showed mild to moderate Depression[18].

In a study done by Amalakanti et al., in 2021 using MoCA concluded that even asymptomatic COVID-19 patients had cognitive impairments which suggest that there is a requirement of detailed Neuropsychological assessment especially in an elderly population[19].

In a study done by Del Brutto et al., in 2021 using MoCA found that there was cognitive decline in patients of mild COVID-19 infection[20].

In a study done by Dressing et al., in the year 2021 found that they could determine cognitive dysfunction after six months of COVID-19 infection, neuronal causes could be the possible reason to the high prevalence of tiredness[21].

Hampshire et al., in the year 2021 by using Great British intelligence Test found that COVID-19 patients exhibited cognitive deficits when compared to controls. They also found that people who had been hospitalized were having higher degree of cognitive deficits [7].

In a study by Vyas et al., in the year 2021 used Brain Fog symptoms questionnaire and found that Brain fog can happen as a complication in COVID-19 survivors, and it occurs in higher rates in patients who required oxygen and who were on Ventilator[22].

6. Conclusion

In this study, most of the patients belong to the age group of 40 to 49 years, with male predominance. Several neuropsychological tests have been administered to determine the cognitive functions of recovered COVID-19 patients over a period of three months.

The average scores of TMT A and B, all the subtests of the PGI memory scale, Maze tests 1 and 2, and DSST showed a subtle decline in cognitive function after three months of recovery from COVID-19.

However, according to the MMSE score, there was no cognitive impairment among the patients, which could be due to the ability of MMSE to identify severe cognitive impairment when compared to other tests that could determine even a slight decrease in cognitive function.

Our study provided helpful insight into the effect of COVID-19 on neuropsychological manifestations in the affected patients. These findings also indicate that there will be an influx of patients in the near future with more cognitive dysfunctions. Hence any cognitive complaints after the episode of COVID-19 should be considered significant, and a long-term follow-up is necessary to identify the progress of the cognitive status, which could help in early intervention and prompt treatment.

In our study, though there was a cognitive decline, whether this cognitive dysfunction is transient or would progress was not established. Hence studies of larger magnitude and longer duration are required to assess the cognitive status of a COVID-19 recovered individual.

Significant Outcomes:

1. The results of our study indicate that the information processing speed of the subjects decreases following recovery from COVID-19 infection. With the results we conclude that there is subtle decrease in the cognitive functions of Frontal Lobe in Executive functions.
2. In our study we found that there was subtle decrease in the cognition in the domains of verbal and non-verbal memory which suggest of Temporal lobe dysfunction.
3. Psychomotor speed, sustained attention and logical reasoning and visuo perceptual are the parameters that have been affected amongst the patients in our study following three months of COVID-19 infection.

Limitations:

1. In this study we have evaluated the immediate effects of SARS-CoV-2 infection on cognitive function since certain neuropsychological assessments were done only for a short period after the COVID-19 patients recovered.
2. In this study we didn't use control group.
3. In this study we didn't assess psychopathology.
4. In this study we didn't correlate with the Neuroimaging.
5. In this study we did not assess the influence of antiviral therapy and steroidal therapy on cognitive functions.

Conflict of Interest: None

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