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Teleneuropsychometry Solution in Resource-Constrained Setting – An Initial Experience in Adults With Brain Tumors

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Abstract

Background. Teleneuropsychometry constitutes a sophisticated technological innovation that enhances access to specialized neuropsychological services for patients situated in geographically remote or resource-limited contexts. When optimally utilized, teleneuropsychometry emerges as an advanced modality for bridging the gap between patient and neuropsychologists, facilitating timely preoperative cognitive evaluations. **Methods.** The study delineates two case reports of brain tumor patients who underwent teleneuropsychometric assessment prior to surgical interventions while also critically analyzing the complexities inherent in establishing such a service. **Results.** Both patients successfully completed the assessments with minimal assistance, providing valuable insights into their cognitive abilities. These insights enabled the medical team to customize surgical planning and anticipate potential risks. **Conclusion.** The findings reinforce the growing body of evidence supporting the feasibility of teleneuropsychometric assessments in a resource-constrained environment and highlights their broader applicability within the domains of neuro-oncology.

Keywords: teleneuropsychometry; brain tumor; PEBL software; neuropsychological battery

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Background

The Inter Organizational Practice Committee (IOPC) definition of teleneuropsychiatry focuses on enabling clinical interactions and neuropsychological evaluations through teleconferencing technologies. Specifically, they characterize it as "the application of audiovisual technologies to allow for the conduct of clinical interactions with patients via teleconferencing to perform neuropsychological evaluations" (Bilder et al., 2020). In parallel, the Indian Psychiatric Society partnered with the Telemedicine Society of India and National Institute of Mental Health and Neurosciences to publish operational guidelines for telepsychiatry in May 2020 (Dinakaran et al., 2020). These guidelines aim to help standardize and regulate the growing practice of telepsychiatry in India. Teleneuropsychiatry and teleneuropsychometry have the potential to transcend geographical barriers between patients and healthcare professionals. The increasing accessibility of user-friendly smartphones and advances in communication technologies have facilitated greater digital inclusions across India, enabling broader access to remote healthcare services (Nadkarni et al., 2023). In light of this, the present study aimed to evaluate the feasibility of conducting teleneuropsychometric assessments for adult patients with brain tumors in eastern India, prior to surgical interventions. The patients were admitted to a tertiary care center in the region, where neuropsychological services were unavailable. The assessments were conducted remotely by a neuropsychologist based at an institute in southern India.

Case Presentation

Case 1. A young adult, high school graduate presented with a 3-year history of intermittent headaches accompanied by multiple episodes of convulsion. On examination, the patient's Mini-Mental State Examination (MMSE) score was 25/30 without any focal neurological deficit. The patient underwent a teleneuropsychometric assessment preoperatively. The battery of tests that were administered included tests of executive function: animal names test (verbal fluency), verbal *n*-back test (verbal working memory), Corsi Block Span Test (visuospatial working memory); tests of learning and memory: Rey Auditory Verbal Learning Test (verbal learning and memory), Rey-Osterrieth Complex Figure (ROCF) test (visual memory); and visuospatial ability: Osterrieth complex figure test (CFT; visuospatial construction). Corsi Block Span Test was administered using Psychology Experiment Building Language (PEBL) while the other tests were tests from the National Institute of Mental Health and Neurosciences (NIMHANS) neuropsychology battery. The patient had deficits in verbal working memory, verbal encoding, and visuospatial construction, indicating involvement of left frontal, left anterior temporal, and right parietal lobes. The patient reported no challenges in navigating the PEBL software, despite lacking prior experience with the platform. The result of the teleneuropsychometric assessment was validated through an in-person evaluation at the hospital, suggestive of a low-grade glioma. The additional confirmation of an irregularly shaped mass in the anterior left frontal lobe was provided by an additional sequence in the form of a contrast enhanced magnetic resonance imaging (CEMRI) scan. This mass was hyperintense on T2 weighted sequences and hypointense on T1 weighted images. With the patient's consent, an awake left frontal craniotomy was planned for lesion removal. The intricate surgery was performed with the utmost care and precision under local anesthesia to allow for meticulous intraoperative neurological monitoring. By the day's end, the entire space-occupying lesion (SOL) had been removed without complication. Postoperatively, the patient recuperated promptly with no new deficits and was fit for discharge on the second day after the procedure.

Case 2. A young adult with a middle school grade level of education presented with a history of right focal seizures with secondary generalization, without any history of focal neurological deficit. On examination, the patient's MMSE score was 29/30. The patient had right-sided conductive hearing loss secondary to chronic otitis media. The teleneuropsychometric assessment included the tests described in Case 1. The patient had deficits in verbal working memory, verbal encoding, and verbal and visual memory. Their teleneuropsychometric assessment was suggestive of left frontal and bilateral temporal involvement which was corroborated by an in-person neuropsychometric assessment. During teleneuropsychometry, the patient did not require any significant assistance and was able to use the PEBL software on their own. The patient's CEMRI brain showed the presence of T1 hypointense, T2 hyperintense, and noncontrast enhancing SOL in the left inferior frontal gyrus (Figure 1D, 1E, and 1F). The person underwent left frontal awake craniotomy and gross total excision of the tumor. The patient developed dysphasia and right hemiparesis which improved at the 3-month follow-up.

Methodology

This study employed a case-based observational design to explore the feasibility of teleneuropsychometric testing in preoperative neurosurgical patients. Two patients with different levels of education were enrolled according to their neurosurgical diagnosis, experience with digital technology, and access to a stable internet connection. Testing was conducted with PEBL software on Google Meet with minimal on-site supervision. The cognitive domains assessed were verbal fluency, working memory, visuospatial, verbal list learning, and visual memory consolidation. Feasibility measures of patient navigation, need for assistance, and technical problems were assessed.

Ethical Consideration

The study was conducted in keeping with ethical guidelines for online psychological testing and in line with institutional policies. Ethical compliance was reviewed in consultation with All India Institute of Medical Sciences (AIIMS) Bhubaneshwar. Written informed consent was taken from all the participants before the tests. Confidentiality was maintained by using secure data storage and transmission. The patients were informed about the voluntary nature of the tests and could withdraw at any point of time.

Measures

Verbal Fluency (Animal Naming Test). The animal naming task was used to assess verbal fluency and has been recognized as a valuable tool for evaluating cognitive function in patients with reduced phonemic fluency and other neurological disorders (Thwaites, 2018). In cases where patients exhibit nonspecific symptoms such as headaches, the test

may serve as an early indicator of potential brain tumors. A low score—fewer than 17 animals named per minute—should prompt neuroimaging as the next step (Zienius et al., 2022).

Visuospatial Working Memory (Corsi Block Test). Visuospatial working memory was assessed using the Corsi Block-Tapping Test. This is especially useful for identifying cognitive deficits linked to neurological disorders. Block tap sequences must be replicated, and the Corsi span is the longest sequence that is accurately replicated. According to Kessels et al. (2000), this test has demonstrated usefulness in identifying cognitive impairment in a variety of neurological conditions including brain tumors. It can also be used in multilingual populations like India because of its nonverbal format. Impaired visuospatial working memory, which is frequently seen in patients with parietal or frontal lobe dysfunction, may be indicated by lower spans (usually less than five; Avons & Trew, 2006).

Verbal Learning and Memory (Auditory Verbal Learning Test [AVLT]). Verbal learning, recognition, and both immediate and delayed recall were evaluated using the AVLT. Over the course of five trials, participants were asked to recall a list of 15 words (Geffen et al., 1997). Following the introduction of a second list to evaluate interference, the first list was recalled both immediately and later. Total words remembered over five trials, delayed recall, and recognition were all factored in the scoring (Kessels et al., 2000). Healthy people typically remember 50–65 words during trials and more than 10 words after a delay (Poreh et al., 2016). Lower scores could indicate memory loss, which is frequently associated with dysfunction of the temporal lobe (Fernaeus et al., 2013). The AVLT's straightforward, language-adaptable format makes it appropriate for use in Indian contexts (Vakil & Blachstein, 2007).

Visuospatial Construction. Using the Rey-Osterrieth Complex Figure (ROCF) test, visual-spatial planning, memory, and construction were evaluated. To test visuospatial memory, participants were given a complex geometric figure to copy followed by immediate and delayed recall tasks. The accuracy and positioning of figure elements in the copy, immediate recall, and delayed recall conditions determined the score (Shin et al., 2006). According to Dassanayake et al. (2025), normative participants usually score between 32 and 36 on the copy phase. Lower recall scores suggest potential deficit in executive function or visuospatial memory (Fastenau et al., 1999). The ROCF's minimal reliance on language and nonverbal format make it appropriate for the Indian population (Langer et al., 2022).

Test Validation

The PEBL test battery was rigorously validated before being used to guarantee its validity and reliability in the study setting. Accurate assessments in India's multilingual environment depend on an understanding of linguistic background. According to research on verbal fluency tests, multilingual people who view English as their first language frequently outperform people for whom English is a second language. This underscores the necessity of integrating language skills into neuropsychological assessments to improve their precision across a range of backgrounds (Ferreira-Correia et al., 2024).

A systematic adaptation procedure was used to guarantee the linguistic and cultural appropriateness of the neuropsychological tests given through PEBL in this bilingual study. Important measures were taken to preserve the psychometric integrity of the test battery in participants who spoke Odia, even though the study concentrated on the viability of two neurosurgical cases.

Linguistic and Cultural Adaptation. Bilingual neuropsychologists and language specialists used a forward-backward translation protocol to translate the test instructions from English to Odia. To guarantee semantic and conceptual equivalency, disagreements were settled by consensus (Beaton et al., 2000). To ensure clarity and cultural relevance, the translated version was pilot tested with Odia speakers.

Viability in Participants. Two neurosurgical patients with varying educational backgrounds received the modified battery through teleneuropsychology. Language and face validity were confirmed by the fact that both participants finished tasks with little help and successfully understood instructions. Contextual sensitivity was further supported by the observation that working memory and verbal fluency performance patterns matched anticipated educational influences.

Reliability and Validity Evidence. Previous research has shown strong test–retest reliability for important PEBL tasks (e.g., attentional vigilance r = .79; pursuit rotor r = .86; Mueller & Piper, 2014; Piper et al., 2012) despite the fact that statistical reliability could not be tested in this two-case design. Due to their nonverbal culturally neutral design, PEBL tasks are ideal for use in multilingual contexts

and have also demonstrated construct and criterion validity with recognized neuropsychological tests (Piper et al., 2012).

Even in a constrained case-based framework, these procedures made sure the modified PEBL battery was feasible, linguistically appropriate, and culturally relevant for preoperative patients who spoke Odia.

Setup

The setup used for teleneuropsychometric assessment included a standard personal computer (PC) running Windows 10 operating system, equipped with a HD webcam, speakers, and microphone. Face-to-face communication was facilitated via Google Meet, while the neuropsychometric assessment utilized the NIMHANS neuropsychology battery and PEBL software was used. PEBL is an open source psychology software that contains a battery of cognitive tests which can be customized for patient specific needs (Mueller & Piper, 2014) and is compatible with Windows, Linux, and MacOS operating systems (Mueller & Piper, 2014).

To ensure seamless test administration, TeamViewer software was used to remotely share the screen with the patient, allowing real-time interaction with the PEBL interface. The assessment was conducted in a distraction free room equipped with the aforementioned hardware and a stable internet connection. A chaperone was available on site to provide technical support as needed. The neuropsychologist administered the neuropsychometric assessment session remotely via Google Meet, ensuring real-time supervision and guidance.

Results

Neuropsychological Findings and Correlation With Imaging

In the first case, the neuropsychological assessment revealed deficits in verbal working memory, visuospatial working memory (Corsi block), and significant deficit in verbal and visual memory (AVLT and CFT). Performance on the verbal *n*-back test indicated working memory deficits, while the CFT showed difficulties in the visuospatial construction and recall. These findings are indicative of left frontal, left anterior temporal, and right parietal involvement, aligning with the imaging results showing a T1 hypointense and T2 hyperintense SOL in the left anterior frontal lobe (Figures 1A and 1B). The noncontrast-enhancing nature of the lesion (Figure 1C) further supports the structural basis for the observed cognitive dysfunction.

In the second case, the neuropsychological assessment identified deficits in verbal fluency, verbal working memory, verbal encoding, and both verbal and visual memory. Notably, the patient's performance was particularly impaired on the AVLT, verbal *n*-back test, and CFT. These findings are further supported by imaging that revealed a SOL in the left inferior frontal gyrus, characterized as T1 hypointense and T2 hyperintense (Figures 1D and 1E). The lack of contrast enhancement (Figure 1F) indicates a nonenhancing lesion that correlates with the observed cognitive deficits.

Discussion

One of the key global health challenges is overcoming the logistical barriers that confront adults with brain tumors in accessing preoperative neuropsychological testing. Technology provides a solution to the barriers, enabling more effective and accessible testing for those who require it.

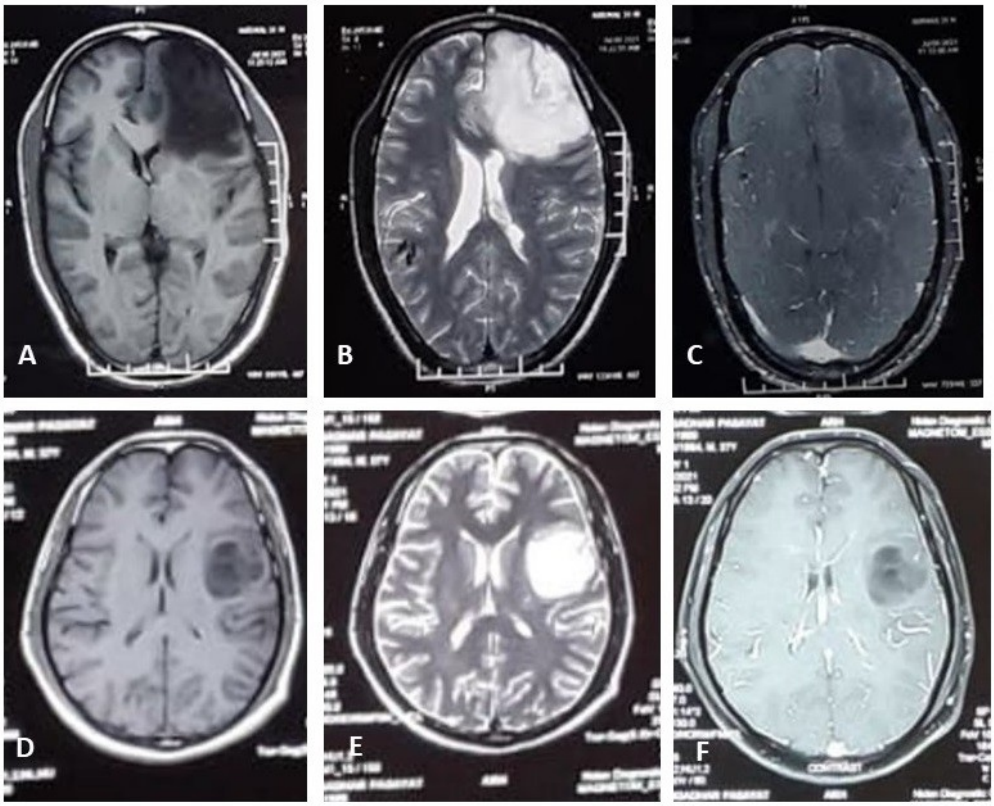
Feasibility of Teleneuropsychometric Assessement

This study involving two patients indicates that teleneuropsychometric assessment of preoperative neurosurgical patients is feasible. Despite the fact that one of the patients had a low educational background (middle grade), the patient had no difficulty in using and navigating the PEBL software. Both patients needed minimal assistance from the on-site supervisor during the conduction of the test.

Technological Penetration and Patient Adaptability

India has witnessed a surge in smartphone ownership over the last decade which has acclimated patients to utilizing technologically-enabled solutions routinely. This familiarity with technology portends well for incorporating digital platforms into clinical care. The battery of neuropsychological evaluations examined various cognitive domains through measures of verbal fluency, verbal working memory capacity, visuospatial sketchpad function, verbal list learning and subsequent recall, visual memory consolidation and retrieval abilities, and visuospatial construction skills. Following administration of the tests via the PEBL software and a Google Meet teleconference, the neuropsychologist furnished a structured interpretation of the assessment results.

Figure 1. *MRI Images Showing SOLs in Case 1 and Case 2.*



Note. SOL = space-occupying lesion. All images were acquired at 66 × 53 mm (300 × 300 DPI).
1A. Case 1. T1 weighted image showing a hypointense SOL in left frontal lobe.
1B. Case 1. T2 weighted image showing hyperintense appearance of SOL in the left frontal lobe.
1C. Case 1. Postcontrast image does not show any contrast enhancement.
1D. Case 2. T1 weighted image showing a hypointense SOL in left inferior frontal gyrus.
1E. Case 2. T2 weighted image showing hyperintense SOL in left inferior frontal gyrus.
1F. Case 2. Postcontrast image does not show any contrast enhancement.

Comparative Studies in Teleneuropsychometry

Similar teleneuropsychological assessments have been done in patients with Parkinsonism to assess their candidacy for deep brain stimulation (Sarno et al., 2022). A similar assessment of neurocognitive function was done using teleneuropsychometry in neuro-oncological patients by Gardner et al. (2021). They assessed teleneuropsychology as a direct-to-home service. They found that in 98% of the cases the neuropsychologists were able to fulfil the predetermined target of their assessment. Common problems were patient dysregulation and slow and unreliable internet. They identified the advantages of teleneuropsychometry as saving travel time, reduction in anxiety, and improved concentration due to the absence of examiner in the same room.

Reliability and Validity of Remote Assessment

Brearly et al. (2017) conducted a systematic review and meta-analysis to assess the effect of video conference administration of adult neurocognitive tests. They found that studies that utilized high-speed internet connections showed consistent performance in both teleneuropsychological and on-site assessment. On subgroup analysis, they found that verbally mediated tasks including digit span, verbal fluency, and list learning were unaffected by teleneuropsychometry. However, the Boston Naming Test score was one-tenth of a standard deviation less than the on-site score.

Implementation in the Indian Context

In the Indian setting, teleneuropsychiatry facilities have been provided to the inmates of central prisons by NIMHANS (Agarwal et al., 2019). The standard operating procedure of setting up a

teleneuropsychometric service for neurosurgical patients should include staff training in the use of software being employed for testing and communication (Smolders et al., 2024). The patients should be selected carefully and guided through the whole process. No high-level or specialized hardware is required, a regular PC with a good internet connection is sufficient for teleneuropsychometric assessment. Some limitations include the lack of Indian norms for PEBL-based tests.

Limitations

Although the PEBL test battery was thoroughly checked for linguistic and cultural appropriateness using a forward-backward translation protocol, a significant drawback that impacts the findings' wider applicability is the absence of comprehensive Indian normative data. The test was effectively modified for participants who spoke Odia, yet extensive study is required to create uniform standards for India's heterogeneous multilingual groups. The results' generalizability is limited by the case-study design, which only examined two neurosurgical patients; further research is needed to validate these findings in a variety of contexts.

Even though PEBL's nonverbal tasks are culturally fair and ideal for multilingual settings, some tasks may still need further modification to improve their applicability in remote contexts. Test performance may be impacted by variations in internet connectivity, especially in remote or underprivileged areas, which could further complicate the teleneuropsychological evaluation procedure.

The reliability, validity, and generalizability of the results can be enhanced by future research involving a larger sample size and conducted across different linguistic groups in India. Addressing task adaptation and internet infrastructure challenges will further aid in improving the teleassessment methodology.

Implications and Future Direction

This particular investigation revealed that providing teleneuropsychometric services to individuals undergoing neurosurgery can successfully be achieved remotely. Regular administration of such remote evaluations will help expand access to care in regions with inadequate penetration of healthcare. As experience increases, future neuropsychometric assessments have the potential to be applied to additional pathologies like traumatic brain injury and postoperative cognitive rehabilitation. Establishing teleneuropsychometric services demands staff training, judicious patient selection, and structured testing procedures. Standard equipment suffices, though Indian norms for PEBL-based tests are still lacking. In conclusion, teleneuropsychometric assessments for neurosurgical patients prove to be feasible and reliable. Remote neuropsychometric care can enhance access to healthcare in underprivileged areas. Further validation may allow teleneuropsychometry to be extended to other conditions, such as head trauma and cognitive rehabilitation. The application of such services warrants additional research.

Conclusion

The neuropsychological test results validate the structural brain abnormalities detected in imaging, indicating specific impairments associated with identified lesions. These findings emphasize the essential findings of neuropsychological assessment in identification and localization of cognitive deficits within neurological conditions. The results confirm that teleneuropsychological assessments are both valid and feasible for evaluating neurosurgical patients. Remote neuropsychometric services can potentially improve access to healthcare in rural and underdeveloped regions. Teleneuropsychometry may be extended to other disorders such as traumatic brain injury and cognitive rehabilitation after further validation. The use of such services needs to be planned, trained, and developed in infrastructure terms to make it accessible and useful for the masses.

Author Declarations

The authors have no competing interests to declare regarding the research, authorship, and publication of the article. The research activity did not involve any specific funding by means of any grant-giving funding body in the public, commercial, or not-for-profit sectors. Data are available in raw and processed forms on request. Requests may be made by email to the first author or corresponding author regarding neuropsychology report.

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