Neuropsychological Impact of posterior fossa lesion- A prospective study of a cohort of patients operated for posterior fossa lesions.

Submitted for M.Ch Neurosurgery
by

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DECLARATION

This thesis titled **— Neuropsychological Impact of posterior fossa lesion- A prospective study of a cohort of patients operated for posterior fossa lesions** is a consolidated report based on a bonafide study of the period from October 2020 to July 2021, done by me under the Department of Neurosurgery, Sree Chitra Tirunal Institute for Medical Sciences & Technology, Thiruvananthapuram.

This thesis is submitted to SCTIMST in partial fulfilment of rules and regulations of MCh Neurosurgery examination.

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CERTIFICATE

This is to certify that the thesis entitled **—Neuropsychological Impact of posterior fossa lesion- A prospective study of a cohort of patients operated for posterior fossa lesions** is a bonafide work of Dr Sanjay H.M and was conducted in the Department of Neurosurgery, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram (SCTIMST), under my guidance and supervision.

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Dr. Sanjay HM

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INTRODUCTION :

Infratentorial CNS tumors are very commonly seen in children. (1,2). As more and more children with posterior fossa tumors survived into adulthood owing to better surgical practices and healthcare in general (2), neuropsychological shortcomings became apparent in them. In particular, children who underwent radiation therapy had markedly reduced neuropsychological assessment scores(3). It was also evident from some studies that patients with higher grade tumors like medulloblastomas and anaplastic ependymomas fared far worse in post op neuropsychological assessment than low grade tumors (4). This was in part attributed to higher risk of damage to the cerebellum (dentato-thalamo-rubral tracts have been strongly implicated) and due to the need for post operative radiation in these patients (3). Cerebellum has for this reason now been believed to have a significant role in cognitive and executive function (5,6,7,8) in addition to motor coordination and fine motor skills (9,10). Neuropsychological assessment tries to quantify the changes in cognition and behavior resulting from CNS disease, surgery or injury, It gives you a picture of not only functional but also to a lesser extent, the structural integrity of the brain. It involves interviews, and tests, some of which are self administered and some administered by a neuropsychologist. Some of the parameters that can be assessed are executive function (planning, abstraction and conceptualisation), attention, memory, language, perception, sensorimotor function, motivation, mood state, emotion, quality of life and personality styles (10). Hence, a detailed Neuropsychological assessment, taking a duration of 2-5 hours, may highlight subtle deficits which may otherwise not be apparent on superficial clinical examination.

In our study, we will analyse tumors of the posterior fossa for possible implications of surgical technique, approach, extent of resection and complications, in addition to the well established effect of histopathology of tumor on the neuropsychological outcome in patients undergoing surgical excision of posterior fossa tumors.

AIM AND OBJECTIVES

Aim: This study aims to assess neuropsychological outcomes in patients who undergo surgical excision of posterior fossa lesions.

Objective: To assess the change in neuropsychological assessment scores in the preoperative and postoperative period for a cohort of patients undergoing surgical excision of posterior fossa lesion.

REVIEW OF LITERATURE

Incidence and CMS Definition

Greater than 25% of all childhood cancers are CNS tumors. Greater than 50% of these are in the posterior fossa(11)

CMS (cerebellar mutism syndrome) is a syndrome of transient reversible mutism, neuropsychological abnormalities, and motor abnormalities (like ataxia, hypotonia) with complete or in many cases incomplete recovery that may span from days to years, in patients undergoing surgery for cerebellar/ 4th ventricular tumors. (12)

As there was no standard definition, the incidence reported ranges from 8-32%(13,14,15). In Medulloblastomas incidence ranges from 24-39% (16,17). Another recent study showed an overall incidence of 28%. The histological type of tumor causing CMS divided into 40% Medulloblastomas, 20 % ependymoma and 16% astrocytomas. (18)

Risk Factors and Prevention (16,18,19,20,21,22,23)

Tumor Histopathology,
Brain stem infiltration,
Midline location

Others proposed(24,25,26,27)
Pre op language impairment
Low socioeconomic level
Left handedness

Other likely, albeit inconclusive, risk factors (16,20,21,22,23,27,28)
Tumor size
Neurosurgical techniques/ approaches
Radical resection

Younger age at diagnosis

Other unlikely risk factors with no conclusive evidence (16,22,23,29,30)

Hydrocephalus

Male gender

Post op CNS infection

Edema/Cerebellar fullness

Pathophysiology

Injury to the proximal dentato-rubro-thalamo-cortical pathway is the proposed mechanism for CMS. These fibres carry efferent fibres mainly from the dentate nucleus but also contain fibres from fastigial, emboliform and globose nuclei. This pathway forms the ascending pathway to cerebellar circuitry and descending pathway consists of cortico-ponto-cerebellar fibres (31,32)

Schmahmann and Sherman (33) in 1998 suggested that cerebellar circuitary is involved in complex functions such as planning of motor activity, coordination, movement and modulation of cognition and behaviour.

The manifestation of cessation of function of one part of the brain that is structurally normal due to damage at a distant site is known as diaschisis. Diaschisis is the mechanism proposed for CMS. Which is why there is a wide spectrum of presentation from lesion at one site.(34.36,37)

Neurovascular coupling related fall in perfusion and metabolism as seen on SPECT and PET studies corroborate with the proposed reversible cerebello-cerebral diaschisis in CMS showing widespread supratentorial cortical dysfunction with a frontal predominance.(34,35,37)

Recovery of mutism correlates with SPECT abnormalities of left temporal lobe, right frontal lobe and bilateral basal nuclei (36). Morris et al in 2009 further showed decreased fractional anisotropy in white matter tracts proximal to left Superior frontal gyrus and right angular gyrus.(32)

Most cases occur after surgery and it was initially believed that vermian splitting is the cause for CMS. Alternative approaches however failed to reduce it's incidence. Because of higher incidence of CMS following lesions of 4th ventricle,

juxtaventricular anatomical structures i.e proximal component of ascending cerebellar circuitry such as deep cerebellar nuclei, SCP, pontomesencephalic tegmentum were believed to be the anatomical substrate (32,37).

CMS is not just post operative but also preoperatively seen in traumatic, vascular or infectious events involving the cerebellum.(38,39,40) Transient cerebellar mutism occurred after evacuation of a vermian hematoma in an 8 year old child (41). Children are primarily affected by CMS whereas it's relatively rare in adults perhaps attributable to the incomplete maturation of the various circuits involved in neurocognition, speech and movements related to the ascending and descending cerebellar circuitry.

There is evidence for relationship of CMS directly to surgery in many cases as it occurs following surgery but before CT or RT.(41) Riva and Georgi showed that there was auditory sequential memory and language processing disorders associated after right Cerebellar tumor surgeries and problems spatial and visual memory after left sided cerebellar tumor surgeries.

Vermian damage led to transient post operative mutism which subsequently led to speech, language dysfunction and behavioural abnormalities. Mutism, dysarthria and oropharyngeal apraxia were complication following vermian para vermian structural damage. (42)

Behavioural changes were described as personality changes and emotional lability (43). Vermian damage was associated with dysregulation of affect (irritability, impulsivity, disinhibition, or attentional and behavioural modulation) (44) Children with vermian agenesis as well as adults with cerebellar cognitive affective syndrome often have a similar clinical picture. (43,45))

Many conditions associated with neuropsychiatric abnormalities like ADHD, dyslexia, Fragile X syndrome, Down's syndrome and schizophrenia have shown an association with cerebellum.(46-51)

PET and fMRI studies have further elucidated the role of cerebellum in certain cognitive tasks. (52,53)

Delayed onset of CMS further begs to question direct trauma to the cerebellar efferent pathway as the only cause. It has been hypothesised that early postoperative vasospasm may lead to ischemic, mostly reversible changes in ascending components of the circuit (54,55).

Avula et al in 2015 demonstrated that early DR in proximal efferent cerebellar pathway was highly specific in predicting subsequent CMS and thus helps identify children at risk. (56)

History(57)

Mostly identified in children. Bailey (58) identified the condition in case studies, first a four year old boy with a fourth ventricular ependymoma developed mutism like symptoms on POD 3 and another 11 year old male child with recurrent cerebellar fibrillary astrocytoma developed similar clinical picture on POD 11. Both patient's showed slow but progressive recovery. Bailey believed the condition was due to brainstem degeneration and use of electrical cautery during posterior fossa surgery increased the occurence

Fraioli and Guidetti (1975) (59) noticed that bilateral lesioning done to dentate nucleus and nucleus interpositus (as treatment for spasticity) in 2 patients in a series of 70 (rest recieved unilateral lesioning) resulted in mutism that recovered over 1-3 months.

Rekate et al (1985)(60) first coined the term cerebellar mutism when they described 6 children developing reversible speech dysfunction and ataxia with no brainstem degeneration.

About 1% of cases of cerebellar mutism can occur in adults, following surgery for cerebellar tumors (61)

There have been multiple terminologies used trying to encompasse the entire spectrum of mutism associated with cerebellar disease. (62)

- Cerebellar mutism
- Cerebellar mutism syndrome
- Cerebellar cognitive affective syndrome
- Transient cerebellar mutism and subsequent dysarthria
- Akinetic mutism
- Posterior fossa syndrome

Cerebellar mutism syndrome was considered most appropriate and replaced all the other terms to cover the spectrum by Gurdrunardottir et al(63).

Clinical features

Acute phase

Posterior fossa syndrome comprises of 3 components (64)

Neurobehavioral

Personality changes

Whining

Inconsolable high pitched crying

Irritability

Lability

Forced crying or laughter

Apathy

Attention problems

Memory problems

Disorder of vigilance (Eg: persistent pre sleep behaviour)

Motoric

Reduced spontaneous initiation of movement (like chewing, eye opening)

Urinary retention/ incontinence

Nystagmus

Dysmetria

Ataxia

Hypotonia

Cranial nerve palsies (bulbar or pseudobulbar palsies)

Visual/visuomotor complaints like cortical blindness and transient cerebellar eye closure

Long tract signs

Linguistic

Mutism (f/b subsequent Dysarthria) or only dysarthria from the beginning

Word finding difficulties

Agrammatism

Reduced verbal fluency

Adynamic spontaneous speech production

Cerebellar mutism consisted predominantly of Irritability, Ataxia and Hypotonia, Mutism. These components were subsequently combined into cerebellar mutism syndrome. Symptom onset is generally 1-11 days after posterior fossa tumor excision- Lucid interval (36)

Chen et al in 2015 reported classical symptoms of CMS preoperatively in 2 cases (65)

Long term sequelae and recovery

Symptoms of CMS may last from a few days upto 6 months but rarely can take upto 2.5 years to recover (63). Subsequent dysarthria progressively improves to a mild form of dysarthria with a slow speech rate. (66) It is hypothesised to be an apraxic condition. (37)

Complex movements of mouth and tongue recover prior to recovery of mutism. (67,68)

Moretti et al in 2002 (69) suggested children with CMS may have an acquired form of dyslexia. Robertson et al (70) found that duration of CMS symptoms played a role in long term neurological sequelae.

Palmer et al(71) showed in children with CMS neuropsychological abnormalities were more pronounced with significantly lower scores. Schreiber et al found that children with CMS had general intellectual ability and reading ability lower than average but math ability normal. (72)

These children have a tendency for emotional social and behavioural problems. (36)

Multiple studies have shown radiotherapy and/or chemotherapy further worsen CMS related long term neurological and neurocognitive outcomes in children individually and in synergy with one another and surgery. (61,62)

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MATERIALS AND METHODOLOGY

This study cohort included about 27 patients undergoing surgical excision of posterior fossa lesions. Consecutive patient series of 11 for midline sub-occipital and 10 for lateral sub-occipital approaches was used for this study. Results were compared in the form of neuropsychological outcome, morbidity as well as mortality. All patients were followed up at 2-6 weeks following surgery.

From the years 2020 to 2021, in the Department of Neurosurgery, SCTIMST, Trivandrum, we performed a prospective study to assess the difference in the neuropsychological outcome of posterior fossa surgery for midline and lateral posterior fossa lesions. This prospective study was started after getting IEC clearance. We included a qualified neuropsychologist for the detailed evaluation of pre and post-operative neuropsychological assessment.

Inclusion criteria :

All patients undergoing surgical excision of posterior fossa lesion and able to give informed consent were considered eligible participants of this study.

Exclusion criteria :

1. Patients who are having acutely elevated intracranial pressure
2. Recurrent cases who have or have not undergone prior radiation
3. Children < 3 years old.

Funding: No Funding

Workup plan: Preoperative investigations included routine blood and urine workup, and radiological assessment. Preoperative neuropsychological assessment was conducted either at admission in the neurosurgical OPD or after admission in the ward. In relation to the lab and radiological investigations, patient did not have to undergo any test in addition to what is required for surgical work up and follow-up routinely, the cost of which was borne by the patient as part of the hospital charges. None of the tests administered by the neuropsychologists was additionally charged.

When a patient meeting the inclusion criteria was admitted, the Principal Investigator (PI) was informed by the admitting team. A detailed history and neurological examination was conducted.

The PI would further explain study procedures and screen for inclusion and exclusion criteria. If the participant was eligible for inclusion, written informed consent was obtained. Neuropsychological assessment was conducted by the in-house neuropsychologist.

Details of Neuropsychological tests administered.

a. Tests for Children:

1. General IQ test:WISC-4(6years-16years)

2. Executive functions: Nimhans battery(5years-15years)

i. Sustained attention- Colour cancellation test

ii. Focused attention- Colour trails test

iii. Verbal learning memory-RAVLT

iv. Planning+Visuoconstructiveability-Block design

v. Visuo-spatial working memory-VSWMS

vi. Verbal fluency- Phonemic fluency test

vii. Narrative speech- Sentence construction test

viii. Verbal comprehension-Token test

ix. Processing speed- WISC4 subtest

b. Tests for adults:

1. General IQ test- WAIS4 (16 years to 65years)

2. Executive functions-Nimhans battery test (16 years to 65years)

i. Focussed attention- Colour trail test

ii. Sustained attention-Digit vigilance test

iii. Triads test-Divided attention

iv. Phonemic fluency-LOWA

v. Category fluency-Animal names test

vi. Verbal working memory- N Back Verbal

vii. Visual working memory-SOPT

viii. Verbal learning+Memory-RAVLT

ix. Planning – Block design test

x. Verbal comprehension- Token test

xi. Mental speed- Digit symbol substitution test

xii. Visuo-constructive ability and memory- Rey Complex figure.

Patients undergoing surgery for posterior fossa lesion underwent midline sub-occipital craniotomy and excision (in prone position) or Retro sigmoid/mastoid craniotomy and excision (in lateral position).

Post operatively patients were on regular follow up. In the first week after surgery for suture removal, at 2 weeks and 6 weeks from surgery in the NSOPD. Patient would get a routine MRI after 6 weeks from surgery. The Neuropsychological assessment was repeated at 2-12 weeks from surgery at follow up in the NSOPD. Behavioural observation was done in all cases. Patient(s) who didn't co-operative for neuropsychological examination were also noted. Post-operative lack of cooperation for test was considered as significant behavioural change.

Data collection and analysis was done by the Principal and Co investigators and Neuropsychological assessment was conducted by the in-house neuropsychologist. Surgery was performed by a department assigned neurosurgeon on a case to case basis.

Each neuropsychological battery provided a score and pre-operative scores were compared with post-operative scores. Also Pre operative scores were compared between the midline and lateral cohort.

Neuropsychological assessment

Neuropsychological assessment is a significant part of assessing how healthy the mind is. It helps in weighing the extent of cognitive deficit with regard to different skills and also allows to gauge the extent of brain damage that may have occurred. For the same, these aspects are tested using neuropsychological tests that have been curated targeting specific cognitive skills. Different areas of the human brain control and mediate various behaviours and cerebral functioning. The neuropsychological tests are all devised on such prior knowledge which helps to narrow-down the nature and impact of the injury or cognitive decline of the individual, the diagnosis of the problem and to assess the change that may occur to these skills over time (73).

Tests for attention –

Attention is one of the oldest assessment features utilised in neuropsychological testing. It is the ability by which we are able to focus and sustain our attention on a selected stimulus. The frontal and parietal regions of the right, hemisphere have been implicated in this cognitive function (74). In this particular study we have used digit vigilance, colour trails test and triads for assessing attention in adults and colour cancellation and colour trails test for the children.

Digit Vigilance Test: The digit vigilance test is a test for assessing sustained attention and psychomotor speed, measuring rapid visual tracking and accurate selection of the target. In this test, the numbers 1 to 9 are placed and ordered randomly in multiple rows on a page. The patient is asked to scan and focus on the target digits 6 and 9 and cancel them as fast as possible without cancelling any wrong numbers or omissions.

Colour Trails test: This is a test for focused attention. There are two parts to this test and it provides information regarding perceptual tracking, attention, processing speed and mental flexibility. Part 1 requires the patient to connect dots with numbers as quick as possible and in part 2 they have to alternate between the numbers and coloured circles.

The Triads test: This is an assessment tool for measuring divided attention and consists of two task that require different types of attention at the same time. One task is a verbal triad test where the patient is given three words from which they are

required to call out the word that does not belong to the category of the other two. The second task is a tactual number identification task where a single digit is written on the palm of their non-dominant hand and the subject is asked to identify the digit.

Colour Cancellation test: This is another test for sustained attention which can be used on children. Accurate visual scanning and activation and inhibition of rapid responses are two aspects it measures. The number of omissions and commissions reflect on deficits in visual scanning and selective attention and inhibition of rapid responses, respectively.

Test for Executive functions –

Executive functions are extremely crucial in nature because these are a set of skills that are required on a daily basis to learn and work. These are functions that combine a network of cognitive functions to coordinate behaviours such as planning, self-regulation of behaviour, mediating goal directed behaviour and shifting mental sets to name a few (74). Neuroanatomically, these functions are seen to be regulated by regions in the prefrontal cortex (75,76). For assessment of the same, Controlled oral word association test (COWA), Animal names and Design Fluency test in adults and Phonemic Fluency and Design Fluency in children.

Controlled Oral Word Association Test (COWAT): This test was devised by Benton & Hamsher (77) is a measure of phonemic fluency. The participant is required to generate words on the basis of phonemic similarity using the letters F, A and S. For subjects who cannot speak English, they are asked to produce words beginning with Ka, Pa and Ma in their mother tongue. They are required to generate as many words as possible without repeating the same words using a different suffix. Low scores for this test have been indicative of frontal lobe dysfunction(78).

Animal Names test This is a category fluency test (79). Category fluency tests assess semantic memory (80). In this test the participant is required to name as many animals as possible within one-minute. The names of fishes, birds and snakes are excluded and the number of names generated make the score.

Block Design test: the block design test was adapted by David Wechsler into the WAIS (Wechsler Adult Intelligence Scale) from the Kohs Block Design

Test developed in 1923 at Stanford University by Samuel Calmin Kohs (1890-1984). This test is used to assess the visuospatial and motor skills of patients. For this particular test, they are presented with coloured blocks that are all white, all red and mixed with red and white. The participant is required to arrange these blocks according to the patterns presented to them within a specific time. The time taken is noted and then compared to a normative mean value. (81)

F-A-S Phonemic Fluency test: This is a type of verbal fluency test which evaluates an individual's ability to spontaneously produce words beginning with a particular letter within a given time limit. An fMRI study utilising this particular task showed activation in the left prefrontal and right cerebellar areas (82). Similar to COWAT, the participant is asked to produce as many novel words beginning with the letter F, A, and S.

Tests for Memory -

Verbal N back Test: This is an assessment tool devised for measuring the verbal working memory of an individual. Previous imaging studies have cited two major sites where activation occurs, particularly the 2-back task. One region is the posterior parietal cortex in the left hemisphere which has been implicated in the storage of verbal material. The second region is the prefrontal cortex. Here activation has been noted in a trio of locations namely – the inferior frontal gyrus, the premotor cortex and the supplementary motor area. These regions are said to mediate implicit speech or verbal rehearsal (83). This test has been devised on the premise that word length and phonemic similarity affect verbal working memory. For this task, sequential stimuli are presented and the participant is required to identify if the stimuli presented now is the same as that presented "n" times before.

The Self-ordered pointing test (SOPT): The SOPT is a test used for assessing visual working memory. It was developed by Petrides and Milner (84) specifically targeting lesions in the frontal lobe (85). Good performance on the task entails "that the individual initiate and execute a sequence of responses, maintain a record of responses, and monitor their performance" (86). For the same, the participants are given booklets that contain sheets with the same items except in varied positions on different pages. The task is to point to an item that wasn't pointed at previously.

The Rey's Auditory verbal learning test (RAVLT): The Rey's Auditory verbal learning test, originally devised by Rey in 1964, is a test to measure the rate of learning and verbal memory in an individual. It also provides details regarding retroactive inhibition, proactive inhibition, confabulation, encoding and retrieving of verbal. In patients with left and bilateral temporal lobe epilepsy, delayed verbal recall and verbal memory loss were noted as sensitive parameters for cognitive deficits (87). The normative data for this test was developed by Schmidt in 1996. In this task, the participants are given two lists A and B, each containing 15 different words. The words of list A are read out at a rate of one word per second and participant has to repeat all the words in any order and a total of five trials are given for the same. After this, list B is administered similarly but here the participant is given only a single trial. After this, the participant is immediately asked to remember the words from list A again.

The Rey-Osterrieth Complex figure test (ROCF): An assessment tool was developed by Rey (88) and standardized by Osterrieth (89), this test is used to assess the visuospatial ability and provides information on cognitive processes such as visual memory, visuospatial constructional ability and perceptual organization(84). Three conditions have been commonly used – copy, immediate recall and delayed recall. First the participant is required to copy the stimulus figure placed in front of them. Then they are asked to recall the complex figure twice by drawing it from their memory: first is an immediate recall three minutes after copying, and the second is a delayed recall after 30 minutes. After the participant copies the figure and before the immediate recall task, another task maybe administered or the participant is kept engaged in a quick clinical interview.

Visuospatial Working memory span task: This is a test that measures the visuospatial working memory. This test is a part of the NIMHANs neuropsychological battery for children and is based on the Corsi block-tapping test. The participant is required to observe and mimic the examiner as they tap the wooden blocks in sequences that gradually increase in complexity (90). Neuroanatomically, the ventrolateral prefrontal cortex has been suggested of having high involvement (83).

Tests for Mental Speed –

Digit Symbol: The Digit- symbol substitution test is a tool for understanding associative learning. It was originally included in the Wechsler Adult Intelligence Test (WAIS). It measures a range of cognitive operations such as motor speed, attention, visuoperceptual functions, scanning and the ability to write and draw (91). Quick information processing speed is required for good performance on this task. A test sheet is given to the participants which contains the numbers 1-9 randomly. These are arranged in 4 rows of 25 squares each. A key for the number-symbol combination is given at the top of the page. The participant is required to substitute each number based on the given key.

Test for Verbal comprehension –

Token: The token test was devised by DeRenzi and Vignolo in 1962 as a test to measure an individual's comprehension of spoken instructions and their capacity to follow commands of varying complexity. It comprises tokens of varying colour, size and shape. A shortened version of the test was utilised for this study (92). This test is normally administered in cases suspected of aphasia. Apart from the ease of administration it measures multiple dimensions such as lexical meaning, grammatical structure, conjunction and the understanding of prepositions (93). The various tokens are placed in front of the participant and they are required to follow the instructions spoken by the examiner. These instructions have 6 levels which gradually increase in difficulty.

Tests for Intelligence –

The Wechsler Adult Intelligence Scale-IV (WAIS-IV) & The Weshcler Intelligence Scale for Children-V (WISC-V): The WAIS is an intelligence test that was originally published by David Wechsler in 1955 as a revision of the Wechsler-Bellevue Intelligence scale, which was published in 1939 (94). Wechsler believed that intelligence was made up of multiple abilities rather than a single general intelligence factor (95). The current version of the test, WAIS-IV, was released in 2008 and provides four major index scores – perceptual reasoning, processing speed, verbal comprehension and working memory. Additionally two broad scores are also generated which summarize general intellectual abilities – Full scale IQ which is based on the four index scores and General ability index, based on the six subtests of verbal comprehension and perceptual reasoning (96,97).

The WISC-V is an intelligence test that was devised specifically for children between the ages 6 and 16 years. Similar to the adult scale, the test include a Full-Scale Intelligence Quotient (IQ) score, age-equivalent rankings and scores for Working Memory, Verbal Comprehension, Fluid Reasoning, Visual Spatial and Processing Speed composites.

RESULTS ANALYSIS

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Table 1 shows the common pre-operative presentations in patients with midline posterior fossa lesions and fig 1 depicts the relative frequency of their distribution amongst the patients in the cohort. Headache was the most common symptom that brought the patient to the hospital followed by vomiting and gait unsteadiness. Cerebellar signs were present in 9/13 patients who were admitted. One patient each had cafe au lait spots (M8), speech disturbance in the form of dysarthria (M9) scanning speech and right hemi anesthesia (M10). Blurring of vision and diplopia were quite common and 4/13 patient's had papilledema via direct ophthalmoscopy.

One patient died due to a combination of post COVID sequelae and surgical site infection leading to systemic sepsis. Patient had recovered completely post surgery before the onset of Meningitis and SSI 5 days post surgery.

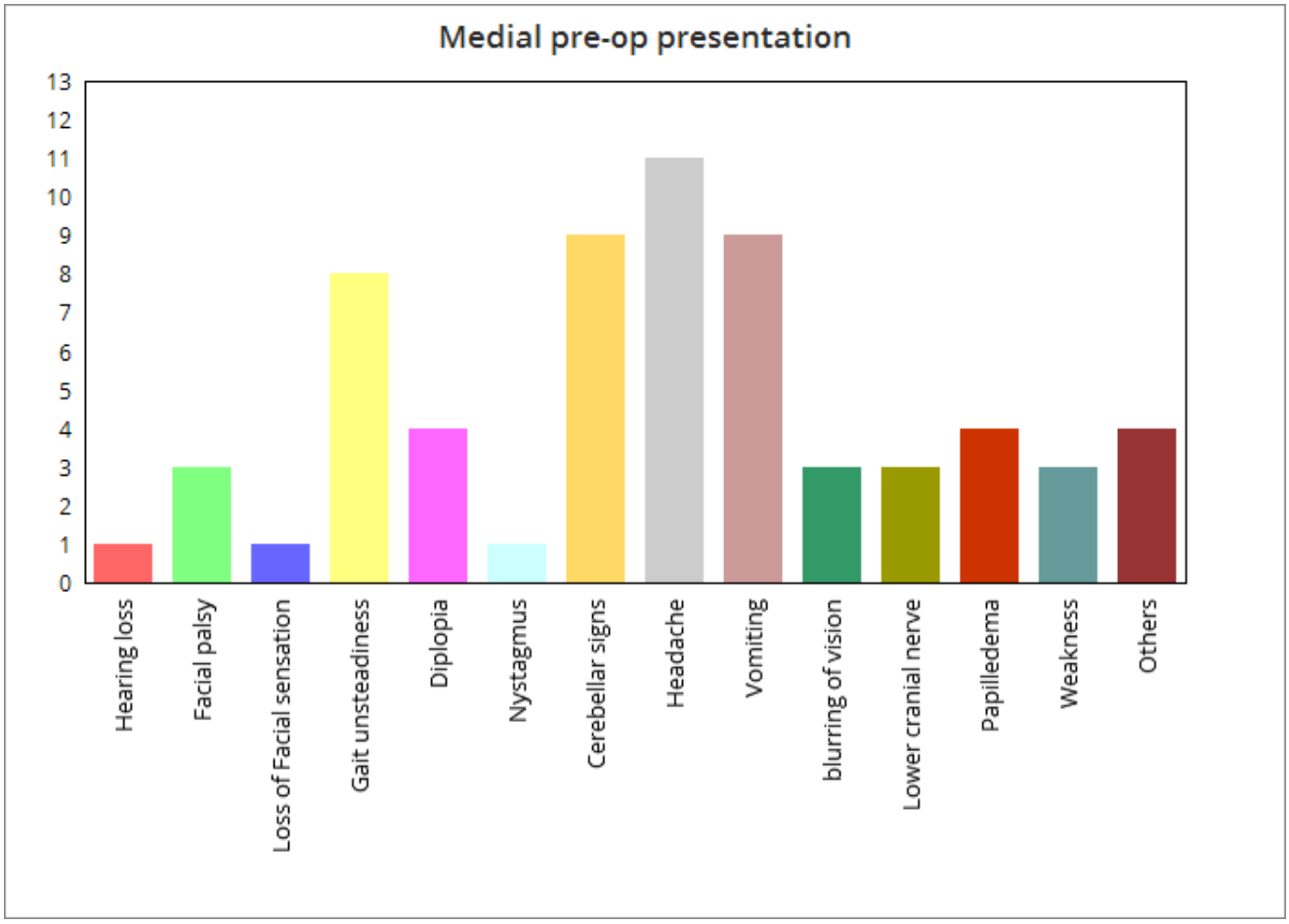


Table 1: Medial pre op presentation

SL no	Hearing loss	Facial palsy	Loss of Facial sensation	Gait unsteadiness	Diplopia	Nystagmus	Cerebellar signs	Headache	Vomiting	blurring of vision	Lower cranial nerve	DM	HTN	Papilledema	Weakness	Others
M1	N	N	N	N	N	N	N	Y	Y	Y	N	N	N	Y	N	N
M2	Y	N	N	Y	N	N	Y	Y	N	M	N	N	N	N	N	N
M3	N	N	N	Y	N	N	Y	Y	Y	N	N	N	Y	N	N	N
M4	N	Y	N	Y	Y	Y	N	N	N	N	N	N	N	N	N	N
M5	N	N	N	N	N	N	Y	Y	Y	Y	Y	N	N	Y	N	N
M6	N	Y	N	Y	Y	N	Y	Y	N	N	N	N	N	N	Y	N
M7	N	N	N	Y	Y	N	Y	Y	Y	N	N	N	N	Y	N	N
M8	N	N	N	N	N	N	Y	Y	Y	N	N	N	N	N	N	Cafe au lait spots
M9	N	N	N	Y	N	N	Y	Y	Y	N	N	N	N	N	N	Speech disturbance
M10	N	N	N	Y	N	N	Y	Y	Y	N	Y	N	N	Y	N	N
M11	N	Y	Y	N	Y	N	N	N	N	N	Y	N	N	N	Y	Reduced sensation in the right side of the body
M12	N	N	N	Y	N	N	Y	Y	Y	Y	N	N	N	N	Y	Post Covid.
M13	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N

Table 2 shows the common pre-operative presentations in patients with lateral posterior fossa lesions and fig 2 depicts the relative frequency of their distribution amongst the patients in the cohort. Hearing loss was the most common symptom that brought the patient to the hospital followed by gait unsteadiness, facial hemi Anesthesia and facial palsy. Cerebellar signs were present in 6/14 patients who were admitted. Only one patient had papilledema via direct ophthalmoscopy.

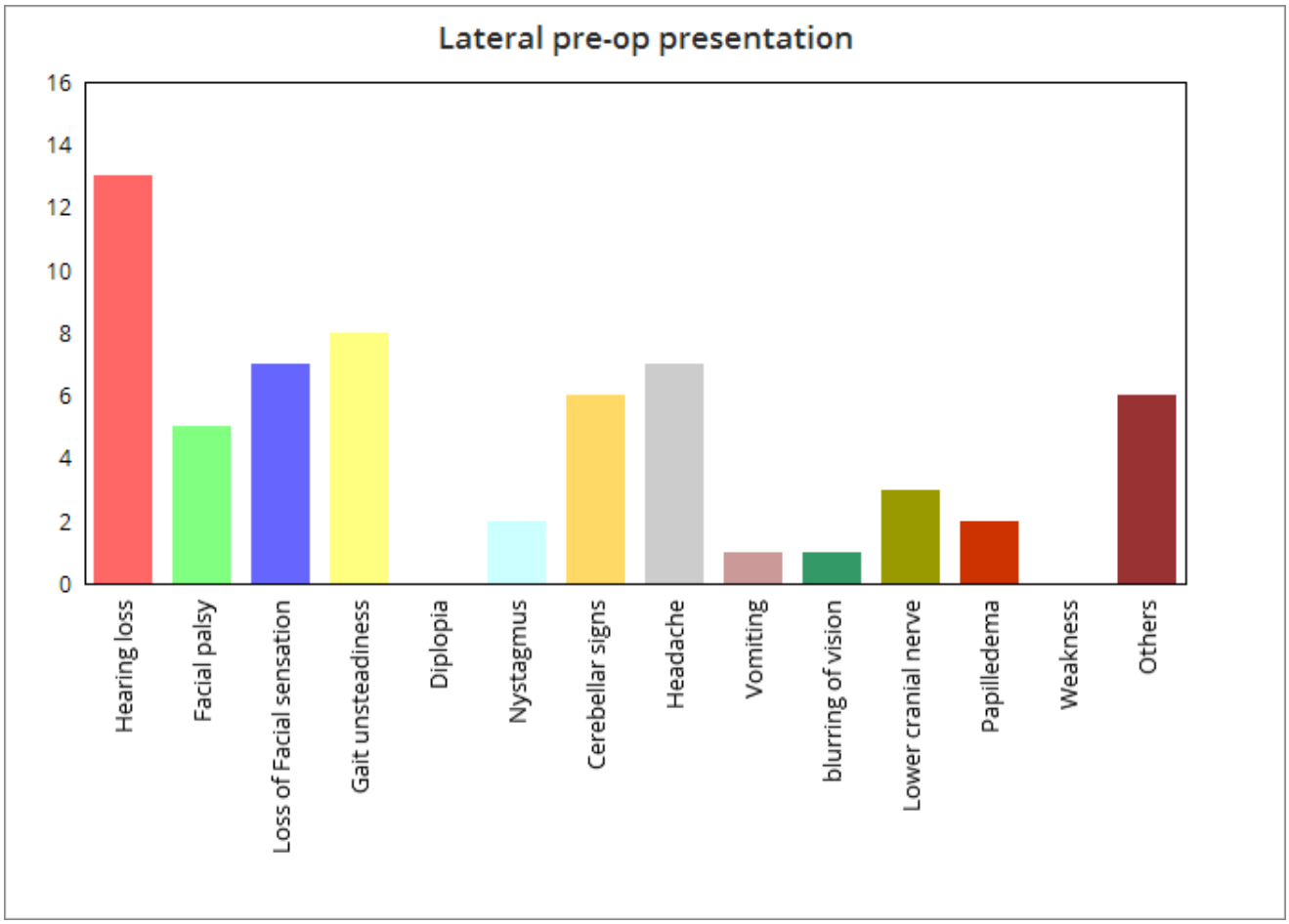


Table 2: Lateral pre op presentation-1

SL no	Hearing loss	Facial palsy	Loss of Facial sensation	Gait unsteadiness	Diplopia	Nystagmus	Cerebellar signs	Headache	Vomiting	blurring of vision	Lower cranial Nerves	DM	HTN	Papilledema	Weakness	Others
L1	Y	Y	Y	Y	N	N	Y	Y	N	N	Y	N	Y	N	N	N
L2	Y	N	Y	Y	N	N	N	N	Y	N	N	Y	Y	N	N	N
L3	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
L4	Y	N	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	N
L5	Y	Y	N	Y	N	Y	N	Y	N	N	Y	N	N	Y	N	Dizziness
L6	Y	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N
L7	N	N	Y	Y	N	N	Y	Y	N	N	N	Y	N	N	N	Romberg positive
L8	Y	Y	Y	N	N	N	N	N	N	N	N	Y	Y	N	N	Tinnitus
L9	Y	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N
L10	Y	N	N	Y	N	Y	N	Y	N	M	M	N	N	N	N	Depression
L11	Y	N	Y	Y	N	N	Y	N	N	N	N	N	N	N	N	N
L12	Y	Y	N	Y	N	N	Y	Y	N	N	N	N	N	Y	N	Giddiness
L13	Y	Y	Y	N	N	N	Y	N	N	N	N	Y	N	N	N	Tinnitus
L14	Y	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	NF2

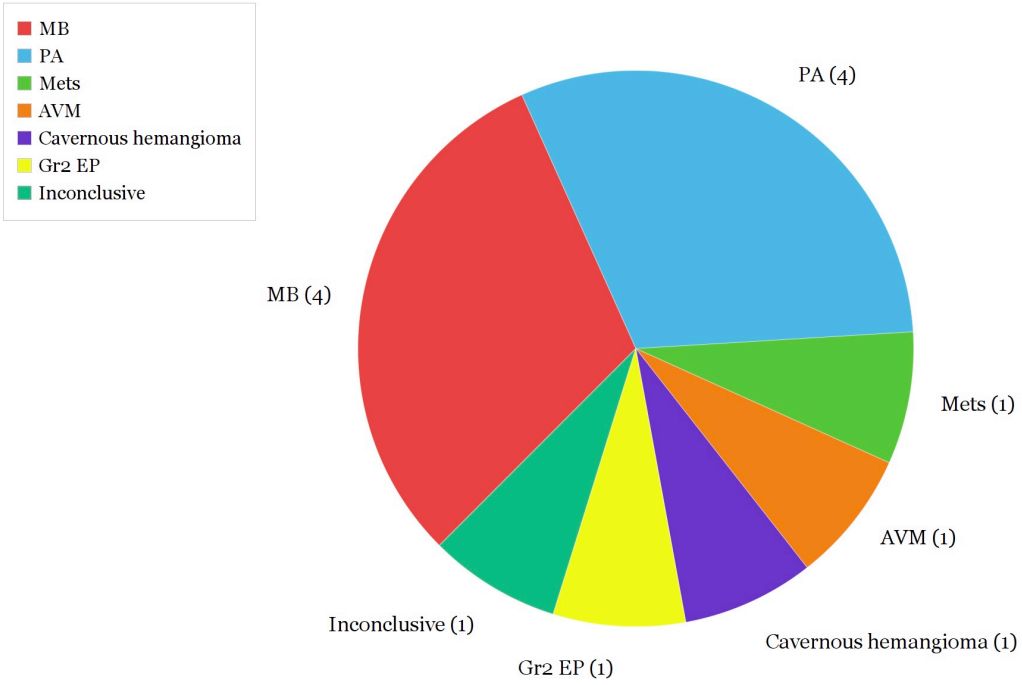


Table 3 shows histopathological examination of the resected specimen showed both pilocytic astrocytoma and medulloblastoma were equally distributed. There was one patient each with grade 2 ependymoma, metastatic lesion, cavernoma and AVM. One patient's (M11) HPE was inconclusive.

7/13 patients in midline cohort had an EVD insertion intraoperatively. 3/7 patients with EVD in situ were converted to VP shunt due to high pressure on POD4. One patient (M6) had to undergo a VP Shunt insertion 2 months later due to delayed onset hydrocephalus on follow up scan. All these patients had a medium pressure Chabbra VP shunt inserted.

Brainstem infiltration was seen in 2 patients (M5 and M7) and 1 patient (M10) had infiltration of the left middle cerebellar peduncle. One patient (M1) had tumor dissemination prior to dural opening and left PICA was completely infiltrated by the tumor and needed to be sacrificed. Plane with the brainstem was preserved, however.

GTD was possible in 10/13 patients. 2/13 patients underwent NTD. M3 patient the tumor was infiltrating the transverse sinus and hence underwent only STD. Most common approach was telo-velo-tonsillar aproach (9/13). M2 patient had a vermian pilocytic astrocytoma and hence was approached transcortically. M13 patient, the AVM was present in the right cerebellar hemisphere and was approached transcortically. M3 patient lesion was found to be extraaxial on table and was approached by cerebellar retraction following MLSO craniotomy.

Table 4 shows histopathological examination of the resected specimen. Majority of the patients who underwent RSSO craniotomy were Vestibular schwanommas. 2 patients (L5 and L9) were epidermoid cysts and one (L7) was a Transitional Meningioma. Intraoperatively EVD was inserted only for one patient (L4)

Table 3: Midline peri op events

SL no	HPR	EVD	VP Shunt	IOR	Approach	EVD pressure	Tumor characteristics
M1	MB	Y	Y	NTD	Telovelotonsillar	EVD high pressure	Tumor disseminatio n +
M2	PA	N	N	GTD	Transcortical	-	-
M3	Mets	N	N	STD	Cerebellar retraction	-	-
M4	PA	Y	N	NTD	Telovelotonsillar	-	-
M5	Gr2 EP	Y	Y	GTD	Telovelotonsillar	EVD high pressure	Brainstem infiltration at FL
M6	Cavernous hemangioma	N	Y	GTD	Telovelotonsillar	-	-
M7	MB	Y	N	GTD	Telovelotonsillar	EVD moderate pressure	Brainstem infiltration
M8	PA	Y	N	GTD	Telovelotonsillar	-	-
M9	MB	Y	N	GTD	Telovelotonsillar	-	-
M10	MB	Y	Y	GTD	Telovelotonsillar	Moderate pressure	Infiltrating left MCP
M11	Inconclusive	N	N	GTD	Telovelotonsillar	-	-
M12	PA	N	N	GTD	Transcortical	-	-
M13	AVM	N	N	GTE	Transcortical	-	-

and VP shunt was inserted for one patient (L12) on POD1 in view of poor sensorium and hydrocephalus on CT scan brain plain. IAM drilling was necessary for one patient (L5).

GTD was possible for 10/14 patients and 3/14 patients only NTD was possible in order to preserve the functional integrity of the facial nerve. 1/14 (L12) patient underwent STD due to the same reason. One Patient L13 had poor tumor brainstem interface that made dissection tedious.

Table 4: Lateral Peri op events

SL no	HPR	EVD	VP Shunt	IOR	Approach	Opening pressure
L1	Schwanomma	N	N	NTD	RSSO	-
L2	Schwanomma	N	N	GTD	RSSO	-
L3	Schwanomma	N	N	GTD	RSSO	-
L4	Schwannoma	Y	N	GTD	RSSO	High pressure
L5	Schwanomma	N	N	GTD	RSSO+IAM drilling	-
L6	Epidermoid	N	N	GTD	RSSO	-
L7	Transitional meningioma WHO gr 1	N	N	GTD	RSSO	-
L8	Shwanomma	N	N	NTD	RSSO	-
L9	Epidermoid	N	N	GTD	RSSO	-
L10	Schwanomma	N	N	GTD	RSSO	-
L11	Schwanomma	N	N	NTD	RSSO	-
L12	Schwanomma	N	Y	STD	RSSO	High
L13	Schwanomma	N	N	GTD	RSSO	-
L14	Schwanomma	N	N	GTD	RSSO	-

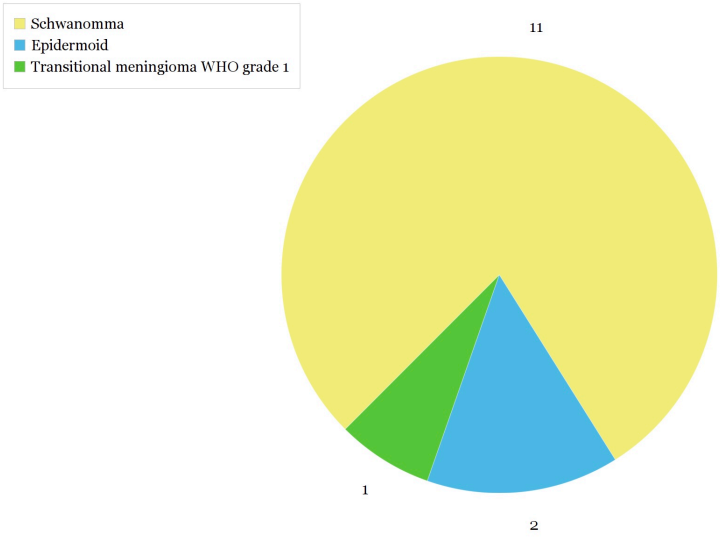


Table 5 shows postoperative complications in the midline group. 2 patients (M5, M7) developed Cerebellar mutism following surgery and took over 6 months to recover. Post operative neuropsychological outcome was not possible in one of them due to initiation of Adjuvant radiotherapy prior to recovery from CMS. Drop out from follow up neuropsychological assessment was seen in 3/13 patients. One (M7 as mentioned above had initiation of RT before recovery from Mutism, another (M6) was bed bound and could not come for follow up. Patient M12 detoriated on POD5 and was not fit enough for a detailed assessment. The patient passed away due to fulminant sepsis and post covid sequelae 3 months later after a debilitating course in the NS-ICU.

Table 6 shows postoperative complications in the lateral group. No patient developed obvious mutism. Post operative neuropsychological outcomes was not possible in 4/14 patients in view of distant residence and covid related travelling difficulties. One of them L7 was tracheostomised. due to lower cranial nerve palsy and had severe gait unsteadiness making her follow up not possible. 7/14 patients developed facial palsy in the post operative period despite 7th nerve being preserved anatomically and neurophysiologically in all the surgeries. 2/14 patients developed lower cranial palsy in the postoperative period. Most of these deficits improved gradually over time as noticed in periodical follow ups.

Table 5: Midline Post operative Outcomes

SL no	Obvious Mutism	Facial palsy	LMN palsy	Limb weaness	Gait unsteadiness	Others	Lost to f/u	DEAD
M1	N	N	N	N	N	N	-	-
M2	N	N	N	N	N	N	-	-
M3	N	N	N	N	N	N	-	-
M4	N	Y	N	N	N	Lr palsy, INO	-	-
M5	Y	N	N	Y	Y	N	-	-
M6	N	N	N	N	Y	CSF leak, Pseudomeningocoele	Wasn't fit for post op neuropsychology testing	-
M7	Y	N	N	Y	N	Recovered from CMS in 3 months , had residual right upper limb tremors	Started RT before scheduled date	-
M8	N	N	N	N	N	N	-	-
M9	N	N	N	N	N	N	-	-
M10	N	N	N	N	N	Meningitis		-
M11	N	N	N	N	N	N	-	-
M12	N	N	N	N	N	Meningitis, post COVID sequelae	Patient detoriated before scheduled date	Yes
M13	N	N	N	N	N	N	-	-

Table 6: Lateral Post operative Outcomes

SL no	Obvious mutism	Facial palsy	LMN palsy	Limb weaness	Gait unsteadiness	Others	Lost to f/u	DEAD
L1	N	N	N	N	N	N	-	-
L2	N	Y	N	N	N	Post operative keratitis , operative cavity hematoma	Y- Distance	-
L3	N	Y	N	N	N	Pseudomeningocoele	Y- Distance	-
L4	N	Y	N	N	N	Reduced sensation over V1	-	-
L5	N	Y	N	N	N	Reduced vision in the right eye	-	-
L6	N	N	N	N	N	N	-	-
L7	N	Y	Y	N	Y	Tracheostomised	Y- Patient was tracheostomised and couldn't complete the tests	-
L8	N	N	N	Y	N	N	-	-
L9	N	N	N	N	N	N	Y- Distance	-
L10	N	N	N	N	N	Mild Hydrocephalus at 6 week scan.	-	-
L11	N	Y	N	N	N	Poor plane with brainstem	-	-
L12	N	N	Y		N	Aspiration pneumonia	Y-Distance	-
L13	N	Y	N	N	N	N	-	-
L14	N	N	N		Y	N	-	-

Table 7 and 8 present the intraoperative complications, post operative complications and follow up issues as discussed above, but in a concise manner.

Table 7: Medial group post op picture

Serial No	Intra-op complications	Complications	Follow up issues
M1	Poor plane with vermis, brainstem not infiltrated. ; Left PICA infiltrated by the tumor	Hyponatremia in post op period, EVD pressure high, repeated headache	Finished RT, receiving CT
M2	Nil	Nil	Mild leak initially and re- sutured
M3	Residuals left behind Hard tumor sitting on the right transverse sinus left behind. Durgen only closure for dura	No	Breakthrough seizure after tapering Levipil after 6 months, awaiting RT
M4	Poor plane with brainstem	Right LMN facial palsy, right LR palsy, right INO	Mild residual Right LR paresis
M5	Nil	Developed Cerebellar mutism, gait ataxia, right upper limb weakness	CMS persistent , vision FC inconsistent with difficulty fixing gaze.
M6	Nil	same as pre op- No significant changes. WOund leak with pneumocephalus with pseudomeningocoele, Resutured, Needed VP shunting in Feb 2021.	No
M7	Poor planes with brainstem, intra op developed bronchospasm after EVD insertion and was turned to supine n tube changed n repositioned.	Cms developed.right upper limb paucity.	Right cerebellar tremors, otherwise recovered fully from CMS, finished RT/ CT
M8	Nil	Nil	No
M9	Tumor infiltrating left MCP and left foramen of luschka	No	Completed RT CT
M10	Nil	Meningitis	Sent for RT?CT
M11	Niil	Nil	No
M12	Nil	At admission was Hyponatremic,	Died on 29/5/21
M13	IOR, controlled	Nil	No

Table 8: Lateral group post op picture

Serial No	Intra-op complications	Complications	Follow up issues
L1	Left sigmoid sinus injury, Tumor in IAM left behind	No	No
L2	5th nerve stretched out and thin	Left facial nerve palsy HB grade 3, POD 3 patient developed anisocoria and was reintubated and electively ventilated for 2 days as CT showed operative cavity hematoma, Left eye keratopathy +	Left eye chemosis and pain, advised tarsorhapphy
L3	Right 5th nerve stretched and thinned out	Right Facial HB 3	Pseudomeningocoele at operated site
L4	EVD inserted Intra op, 5,7,8 preserved anatomically	Left HB 5 and left reduced sensation in V1 , left eye tarsorrhaphy	
L5	Anatomically and electrophysiologically preserved. Poor plane with the brainstem	Right LMN facial with EYE closure adequate	Right CN7 HB 2 palsy
L6	A small bit of the lesion attached to the labyrinthine artery left behind	Nil	No
L7	Sudden cerebellar bulge, hence cerebellum partially sucked out. Major bleed from one of the perforator of PICA	Patient could not be readily weaned off ventilator and hence tracheostomy done, poor gag post op and swallowing test done thrice reported high risk of aspiration. Hence discharged with RT.	Speech improved gradually, Dysphagia for solid and liquids improved gradually, left eye permanent tarsorrhaphy
L8	NIl	Left Upper limb distal weakness which improved over 4 days.	No
L9	Nil	Nil	No
L10	Nil	NIL	No
L11	Poor plane with brainstem	Left facial palsy	No
L12	Poor planes with 7th nerve	Aspiration pneumonia	No
L13	Nil	Right facial nerve Hb grade 4	NO
L14	Nil	Right shoulder abduction 3/5	Nil

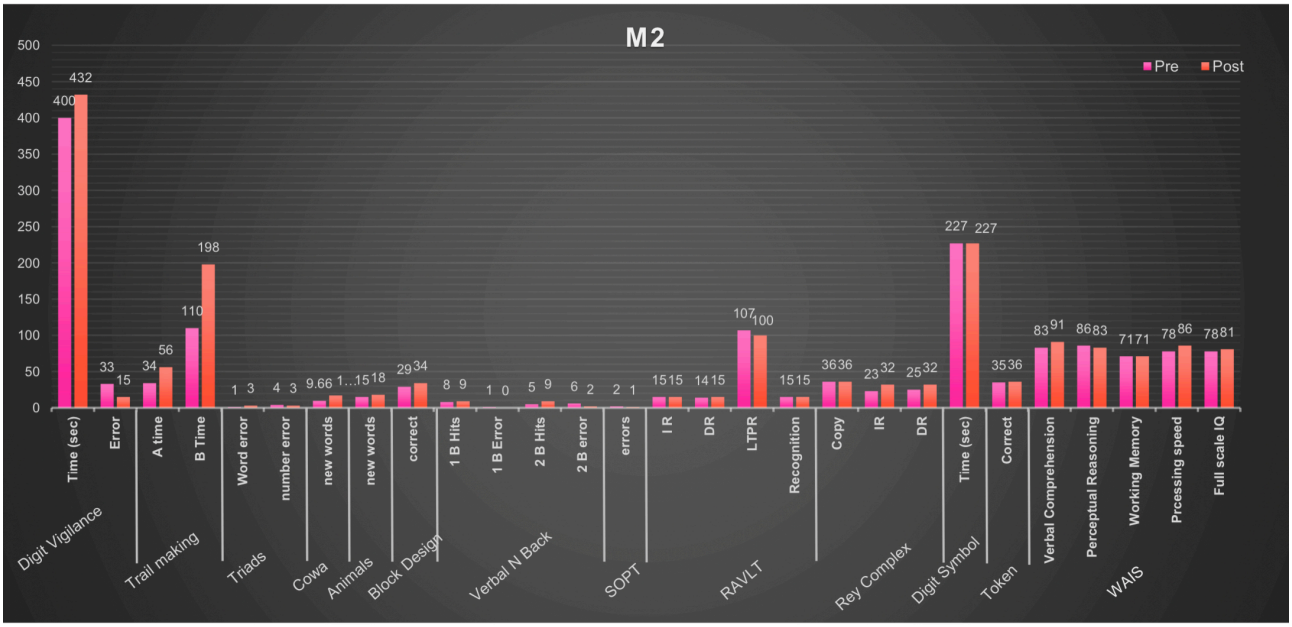
Case reports

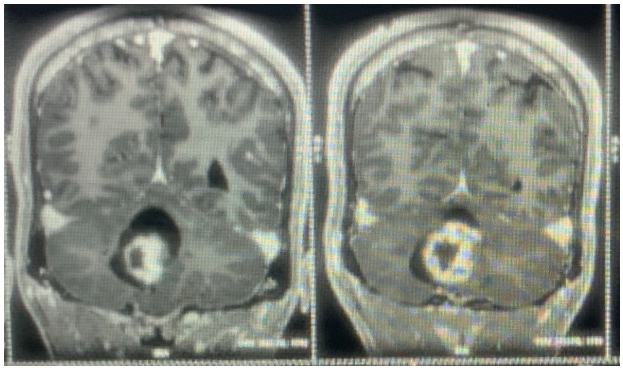
As mentioned above, the neuropsychological tests administered differed amongst children and adults. In the midline sub-occipital craniotomy cohort, 5/10 patients who were able to finish both the pre op and post op neuropsychological evaluation were children. The lateral group consisted of only adults.

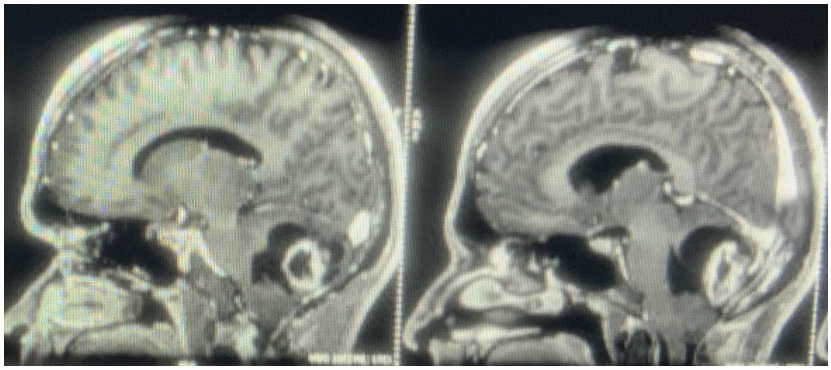
We will proceed to discuss the specific tests, patient wise before drawing collective deductions where possible.

Midline sub-occipital craniotomy cohort

Adults







1. **M2**: 23 year old male patient, educated upto the tenth standard, diagnosed with superior vermian pilocytic astrocytoma. Tumor was approached transvermian route and gross total decompression achieved.

A. Attention:

A. Digit vigilance (Sustained attention):

	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	400	91	33	6*	34	94	110	79	1	-	4	-
Post	432	81	15	15	56	62	198	18	3	-	3	-

Time increased by 32 seconds with a fall from the 91st percentile to the 81st percentile post-surgery. The error rate has reduced in the post op test.

B. Trail making test (Focussed attention and visual scanning)t: Time to connect the numbers has gone up by 22s and fallen by 32 percentile post-surgery. Time to draw line between numbers and coloured circles in an alternate manner has gone up by 88s and fallen to the 18th percentile in the post-operative period.

C. Triads (Divided attention)- The verbal triad test showed an increase in error by 1. The tactile number identification task showed a decrease in error by 1.

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
9.66	75	15	70	29	
17	95	18	95	34	

a. COWAT (Verbal fluency)- showed an increase in number of new word formation from 9.66 to 17 and an into the 95th percentile group.

b. Animal name test (Category fluency) showed an increase in the number of new-word formation by 3, accounting for an increase into the 95th percentile group.

c. Design fluency (Planning) assessed with blocks showed an increase in number of designs made from 29 to 34.

C. Memory

a. Verbal N back (Verbal working Memory): 1B hit score increased by a score of 1 causing a change in percentile rank by 55 with no error in the post-operative period signifying an accuracy of the patient being in the 95th percentile group.

Memory																							
Verbal N Back								SOPT		RAVLT								Rey Complex					
1 B Hits	P	1 B Error	P	2 B Hits	P	2 B error	P	errors	P	I R	P	D R	P	LTPR	P	Recognition	P	Copy	P	IR	P	D R	P
8	40	1	45	5	20	6	26	2	47	15	95	14	75	107	85	15	95	36	95	23	50	25	50
9	**95**	0	100	9	95	2	97	1	95	15	95	15	95	100	80	15	95	36	95	32	85	32	90

2B hit score increased by 4 causing the change in percentile by a value of 75 with a fall in error by 4 signifying an accuracy patient being in the 95th percentile group.

b. Self-ordered point test (Visual working memory): The score improved after surgery, i.e., the error reduced to 1 from 2 and the patient improved by a percentile score of 48, placing them in the 95th percentile group.

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall: score was the same in the pre op and post-operative period with no change in percentile rank.

Delayed recall improvement was seen by 1 and percentile rank increased by 20, placing them in the 95th percentile group.

Long term percent retention fell from 107 to 100 with a fall from 85th to 80th percentile group.

Recognition: scores remained unchanged in the pre and post op period.

d. Rey-Osterrieth Complex figure test (ROCF): Visio constructive ability and visual memory)

Copy score remained unchanged between pre- and post-operative periods.

Immediate recall score increased from by 9 and a percentile of 35 after surgery.

Delayed recall score increased by 7 and a percentile of 40 after surgery.

D. Speed (Mental speed)

Speed	
Digit Symbol	
Time (sec)	P
227	64
227	64

Test for Mental speed remained unchanged in the pre- and post-operative period

E. Comprehension (Verbal comprehension)

Comprehension	
Token	
Correct	P
26.5	
24.5	

Token test score increased by a score of 1

F. The Wechsler Adult Intelligence Scale – IV

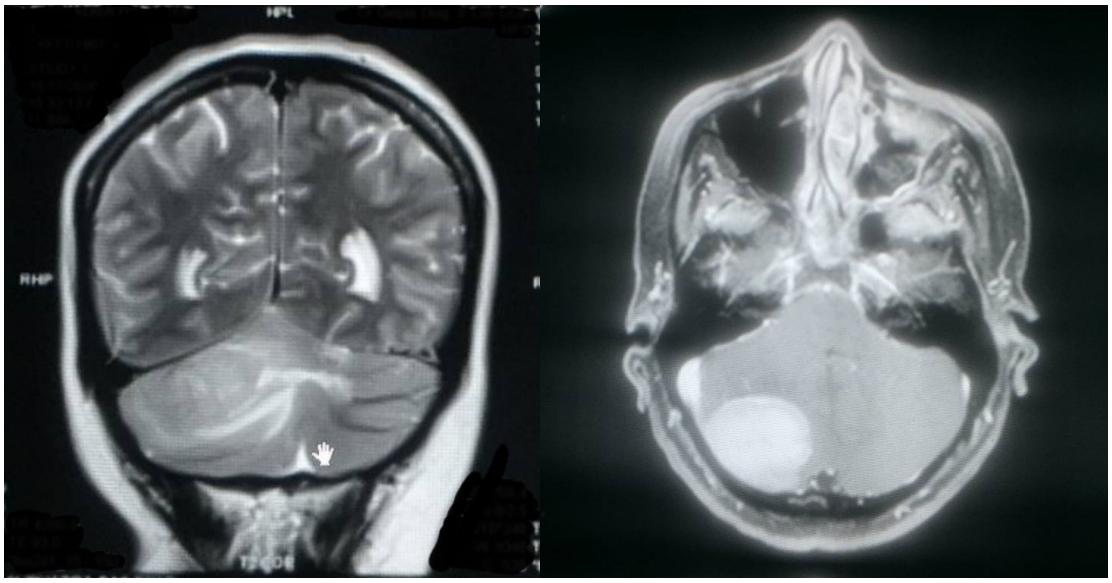
WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
83	13	86	18	71	3	78	7	78	7
91	27	83	13	71	3	86	18	81	10

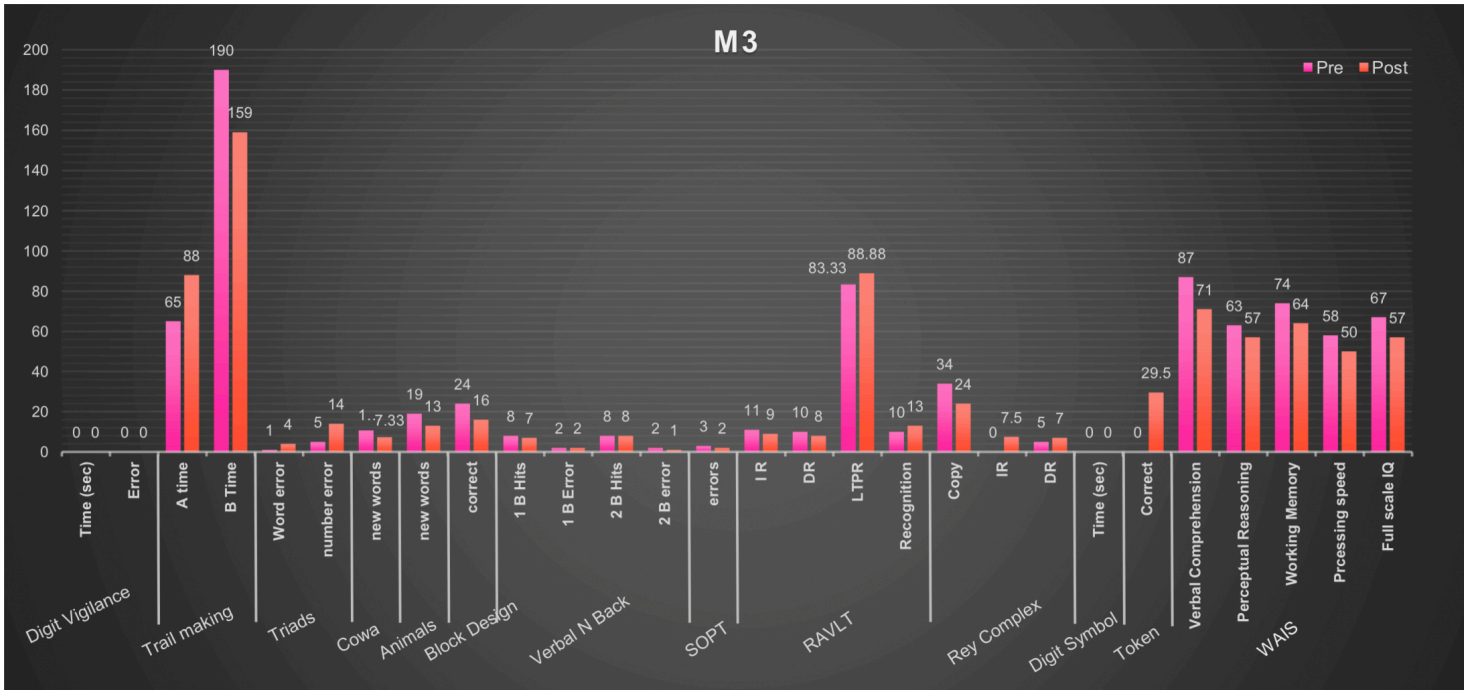
a. Verbal comprehension improved from by 8 points and a percentile jump to 27th group
b. Perceptual reasoning reduced by 3 points and a decline in percentile score from 18 to 13.
c. Working memory remained unaffected.
d. Processing speed increased by 8 points and an increase to the 18th percentile group.
e. Full scale IQ increased post-operatively by 3, and a percentile increase to the 10th group.

Pre op comments: Deficient score in Digit Vigilance indicates difficulty in sustained attention. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores. IQ score 78 indicating Borderline intelligence level.

Post op comments: No deficient scores. Significant improvement in performance compared to the pre-op assessment. Normal range of performance in all the tests without any significant deviation from the normative percentile scores. IQ score of 81 indicating Low Average intelligence level.

2. **M3**: 54 year old female patient, educated up to the tenth standard, diagnosed with Right cerebellar metastasis in a k/c/o breast Cancer. The lesion was intraoperatively found to be extraaxial and Dub total decompression was achieved with cerebellar retraction. Tumor was infiltrating transverse sinus and hence could not be completely decompressed. Patient was scheduled for post op Radiotherapy.





A. Attention:

	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	-	-	-	-	65	71	190	39	1		5	
Post	-	-	-	-	88	49	159	56	4		14	5*

A. Digit vigilance (Sustained attention): was not possible in view of refractory error.

B. Trail making test (Focused attention and visual scanning): Time to connect the numbers has gone up by 23s and had a percentile score of 159. Time to draw line between numbers and coloured circles in an alternate manner has gone down by 31s and had a percentile 56 in the post-operative period.

C. Triads (Divided attention)- The verbal triad test showed an increase in error by 3. The tactile number identification task showed an increase in error by 9 with the percentile score at 5.

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
10.66	90	19	95	24	
7.33	50	13	75	16	

a. COWAT (Verbal fluency) - showed a decrease in number of new word formation from 10.66 to 7.33 and a had a corresponding percentile score of 50.

b. Animal name test (Category fluency)showed decrease in number of new word formation from 19 to 13 accounting for a decreased percentile score of 75

c. Design fluency (Planning) assessed with blocks showed a decrease in number of designs made from 24 to 16, i.e by 8.

C. Memory

Memory			
Verbal N Back	SOPT	RAVLT	Rey Complex

Memory																								
1B Hits	P	1B Error	P	2B Hits	P	2B error	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
8	70	2	54	8	90	2	86	3	39	11	60	10	50	83.33	50	10	5*	34	60	-	-	5	5
7	30	2	54	8	90	1	94	2	97	9	30	8	25	88.88	50	13	20	24	20	7.5	**5***	7	**10***

a. Verbal N back: (Verbal working memory) 1B hit score decreased by a score of 1 causing a change in percentile score to drop to 30 with no change in error in the post-operative period signifying same accuracy percentile.

2B hit score (visual working memory) remained same causing no change in percentile score with a fall in error by 1 and a corresponding percentile score of 94.

b. Self-ordered point test: The score improved after surgery, i.e the error reduced to 2 from 3 and the patient improved to a percentile rank of 97.

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall: score reduced post-operative period by 2 with a fall in percentile score to 30.

Delayed recall deteriorated by 2 and had a percentile score of 25.

Long term percent retention increased by 5.55

Recognition: scores increased by 3 with a percentile score of 50.

d. Rey-Osterrieth Complex figure test (ROCF): (Visuo-constructive ability and visual memory)

Copy score between pre- and post-operative periods reduced by 10 with a corresponding percentile fall from 60 to 40.

Immediate recall score was 7.5 in post op period with a percentile of 5.

Delayed recall increased by 2 in the post-operative period with a percentile increase of 10.

D. Speed (Mental speed)

Test for Mental speed could not be performed because of refractory error.

E. Token test score (Verbal comprehension) was possible only in post op period because preoperatively patient was irritable and exhausted by the end of testing

Comprehension	
Token	
Correct	P
-	
29.5	

F. The Wechsler Adult Intelligence Scale – IV

a. Verbal comprehension deteriorated by 16 points and a percentile plunge to 3.

b. Perceptual reasoning reduced by 6 points and had a percentile score of 0.2

c. Working memory reduced by 10 and had a percentile change to 1 from 4.

d. Processing speed decreased by 8 points and a percentile score of <0.1

e. Full scale IQ reduced by 10 postoperatively and had a percentile of 0.2.

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
87	19	63	1	74	4	58	0.3	67	1
71	3	57	0.2	64	1	50	<0.1	**57**	0.2

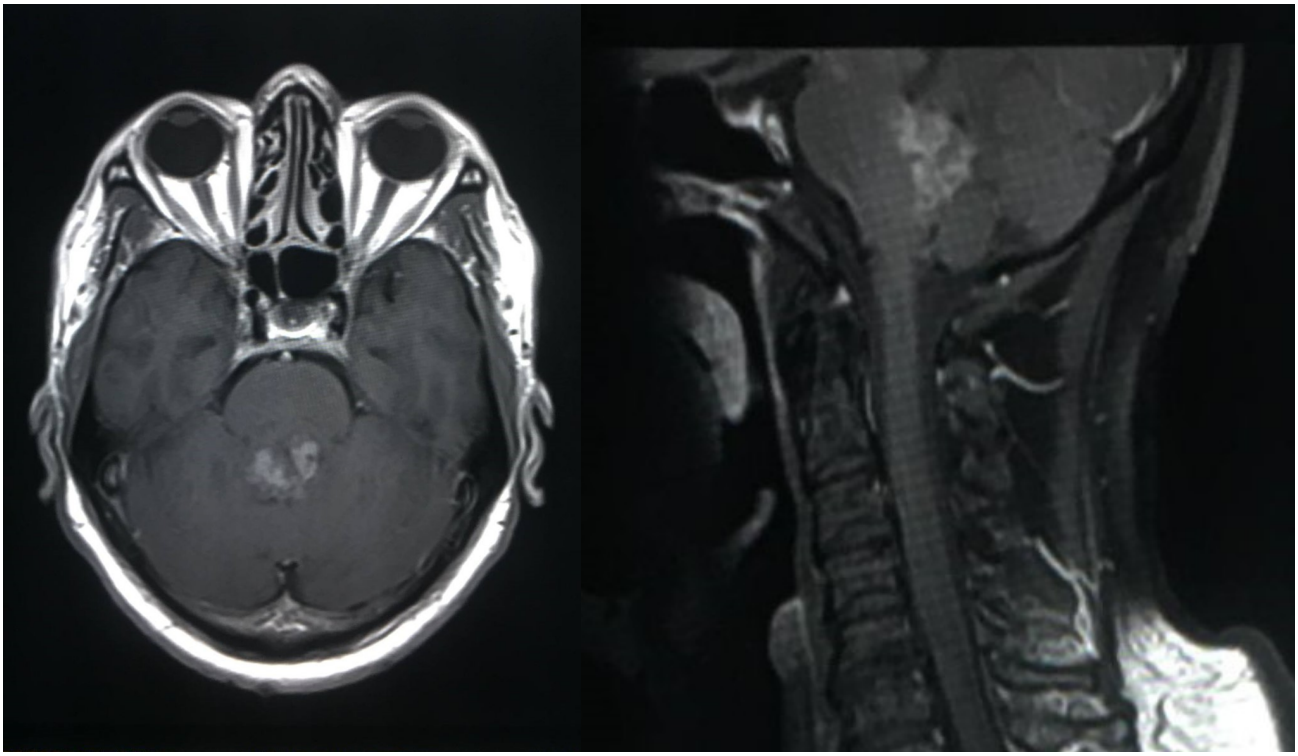
Pre comments: Deficit scores on Triads test and Rey complex figure test indicates difficulty in divided attention and visual memory. Low scores on test for planning. However, normal range of performance in all the other tests without any significant deviation from the normative percentile scores.

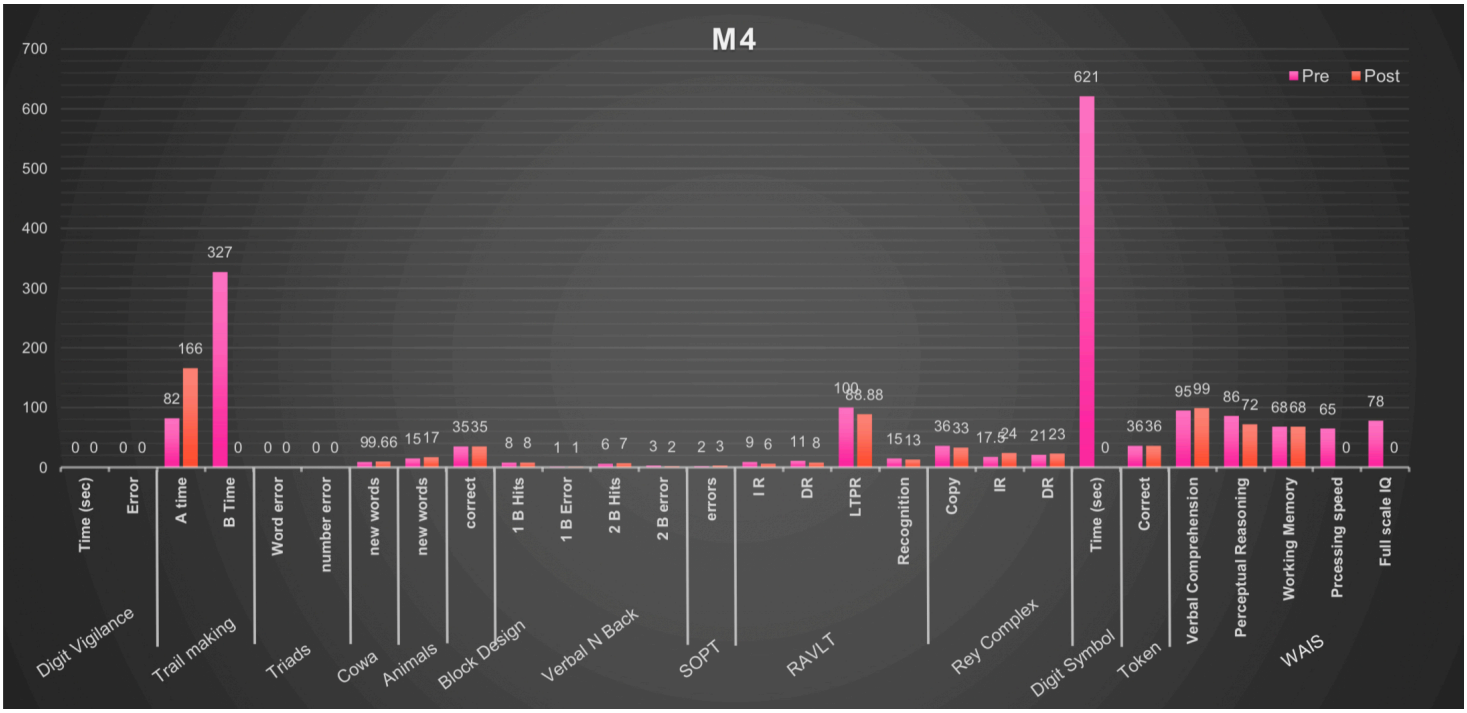
IQ score of 67 indicates Extremely Low Intelligence level.

Post comments: Deficit scores indicating difficulty in Visuo-constructive ability and Recognition. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.

IQ score of 76 indicates Borderline Intelligence level.

3. **M4**: 51 year old male patient, educated upto the college, diagnosed with 4th ventricular Pilocytic astrocytoma. EVD inserted intraoperatively, was under moderate pressure. Was removed on POD. Near total decompression achieved via telovelotonsillar approach.





A. Attention:

	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	-	-	-	-	82	54	327	5	-	-	-	-
Post	-	-	-	-	166	**7***	-	-	-	-	-	-

A. Digit vigilance (Sustained attention): could not be done because of lack of cooperation and mild refractory error.

B. Trail making test (focused attention and visual scanning): Time to connect the numbers has gone up by 84s and had a corresponding percentile score of 7 post surgery. B time could not be done post operatively because of irritability and refractory error.

C. Triads (Divided attention)- could not be done because of irritability and refractory error.

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
9	75	15	85	35	
9.66	80	17	95	35	

a. COWAT (Verbal fluency)- showed an increase in number of new word format ion from 9 to 9.66 and had a percentile score of 80. b. Animal name test showed increase in number of new word formation by 2 accounting for an increase in percentile rank to 95.

c. Design fluency (Planning) assessed with blocks showed no change in number of designs made pre and post op

C. Memory

a. Verbal N back: (Verbal working memory)

Memory			
Verbal N Back	SOPT	RAVLT	Rey Complex

Memory																								
1B Hits	P	1B Error	P	2B Hits	P	2B error	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
8	40	1	60	6	40	3	65	2	93	9	50	11	80	100	85	15	95	36	95	17.5	40	21	70
8	40	1	73	7	60	2	86	3	69	6	**10***	8	30	88.88	60	13	30	33	60	24	80	23	80

1B hit score showed no change in pre and post-operative period with 1 error in each period signifying a percentile score of 40.

2B hit score increased by 1 causing the change in percentile score to a score of 60 with a fall in error by 1 signifying a percentile score of 86.

b. Self ordered point test (Visual working memory): The score deteriorated after surgery, i.e., the error increased by 1 from 3 and the patient deteriorated to a percentile score of 69.

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal leaning)

Immediate recall: score was 9 pre-op and 6 post-operative period i.e., reduced by 3 which led to a percentile drop to 10.

Delayed recall worsened by 3 and had a percentile score of 30.

Long term percent retention fell from 100 to 88.88 with a percentile score of 60.

Recognition: scores remained reduced by 2 post op period signifying a 65-percentile fall.

d. Rey-Osterrieth Complex figure test (ROCF): (Visual-constructive ability and visual memory)

Copy score remained fell by 3 in the post-operative period and had a percentile of 60.

Immediate recall score increased from by 6.5 and had a percentile hike to 80 after surgery.

Delayed recall score increased to a value of23 and a percentile of 80 after surgery.

D. Test for Mental speed could not be done in the post op period. Patient was not cooperative.

Speed	
Digit Symbol	
Time (sec)	P
621	3
-	-

E. Token test score remained unchanged (Verbal comprehension)

Comprehension	
Token	
Correct	P
36	
36	

F. The Weshcler Adult intelligence score-4

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
95	37	86	18	68	2	65	1	78	7
99	47	72	3	68	2	-	-	-	-

a. Verbal comprehension improved from by 4 points and had a percentile score of 47.

b. Perceptual reasoning reduced from 86 to 72 points and had a percentile score of 68.

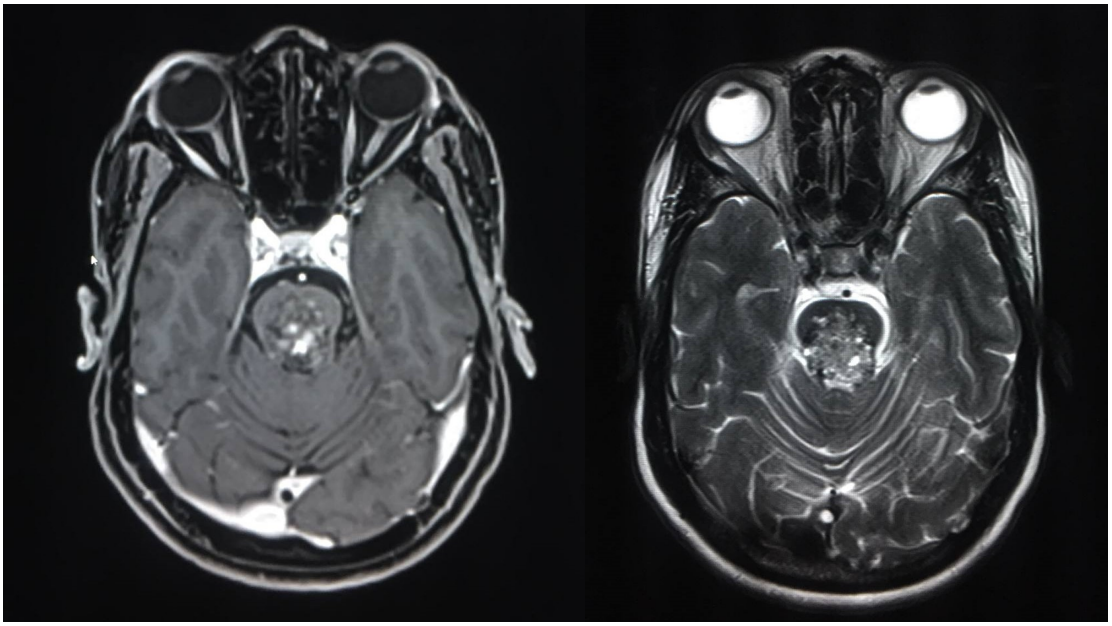
c. Working memory remained unaffected.

d. Processing speed couldn't be repeated and full scale IQ could not be measured in the post-operative period because of refractory error.

Per op comments: Deficit scores indicate difficulty in mental speed and focused attention. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.
IQ score of 78 indicates Borderline Level of intelligence.

Post op comments: Deficit scores in focused attention and verbal learning. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.

4. **M6**: 48 year old female patient, educated upto the tenth standard, diagnosed with Pontine Cavernoma, removed via telovelotonsillar approach. Patient underwent imaging at 3 months which showed hydrocephalus and needed VP shunting.



A. Attention tests could not be done due to difficulty to read and write. Post operatively patient was wheel chair bound with head holding difficulty. Patient also had difficulty in writing.

	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	-	-	-	-	-	-	-	-	-	-	-	-
Post	-	-	-	-	-	-	-	-	-			

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
3	10	15	85	3	5*
2	5	7	5		

a. COWAT (Verbal fluency)- showed an decrease in number of new word formation from 3 to 2 and a percentile fall to a score of 5.

b. Animal name test (Category fluency)showed decrease in number of new word formation by 8 accounting for an decrease in percentile to a score of 5.

c. Design fluency (Planning) assessed with blocks could not be done in post op period due to above mentioned reasons.

C. Memory

a. Verbal N back: (Verbal fluency)

Memory			
Verbal N Back	SOPT	RAVLT	Rey Complex

Memory																								
1 BHits	P	1 BError	P	2 BHits	P	2 Berror	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P	
6 -	20 -	5 -	11 -	2 -	10 -	8 -	25 -	-	-	12 5	30 5	13 7	50 5	00 7.5	90 40	15 0	95 5	8.5 -	**5*** -	5.5 -	**5*** -	4 -	**5*** -	6 -

Verbal N back tests could not be performed due to above mentioned reasons in post operative period.

b. Self-ordered point test: (Visual working memory)could not be done in both pre and post operative period.

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall: score reduced from 12 to 5 i.e by 7 in post-operative period which signified a fall to 5th percentile. .

Delayed recall worsened further by 6 and had a percentile score of 5 post operatively. Long term percent retention fell from 100 to 7.5 i.e by 92.5 points with a fall in percentile score to 40. .

Recognition: scores remained was abysmal in the post op period and reduced to 0 from 15, i.e a fall to the 5th percentile. .

d. Rey-Osterrieth Complex figure test (ROCF): (Visuo-constructive ability & Visual memory)

Could not be done in post op period in view of the above mentioned reasons.

D. Test for Mental speed could not be performed in this patient.

Speed	
Digit Symbol	
Time (sec)	P
-	-

E. Token test (Verbal comprehension) score could not be done in the post operative period.

Comprehension
Token

Comprehension	
Correct	P
29.5	
-	

F. The Wechsler Adult Intelligence Scale – IV

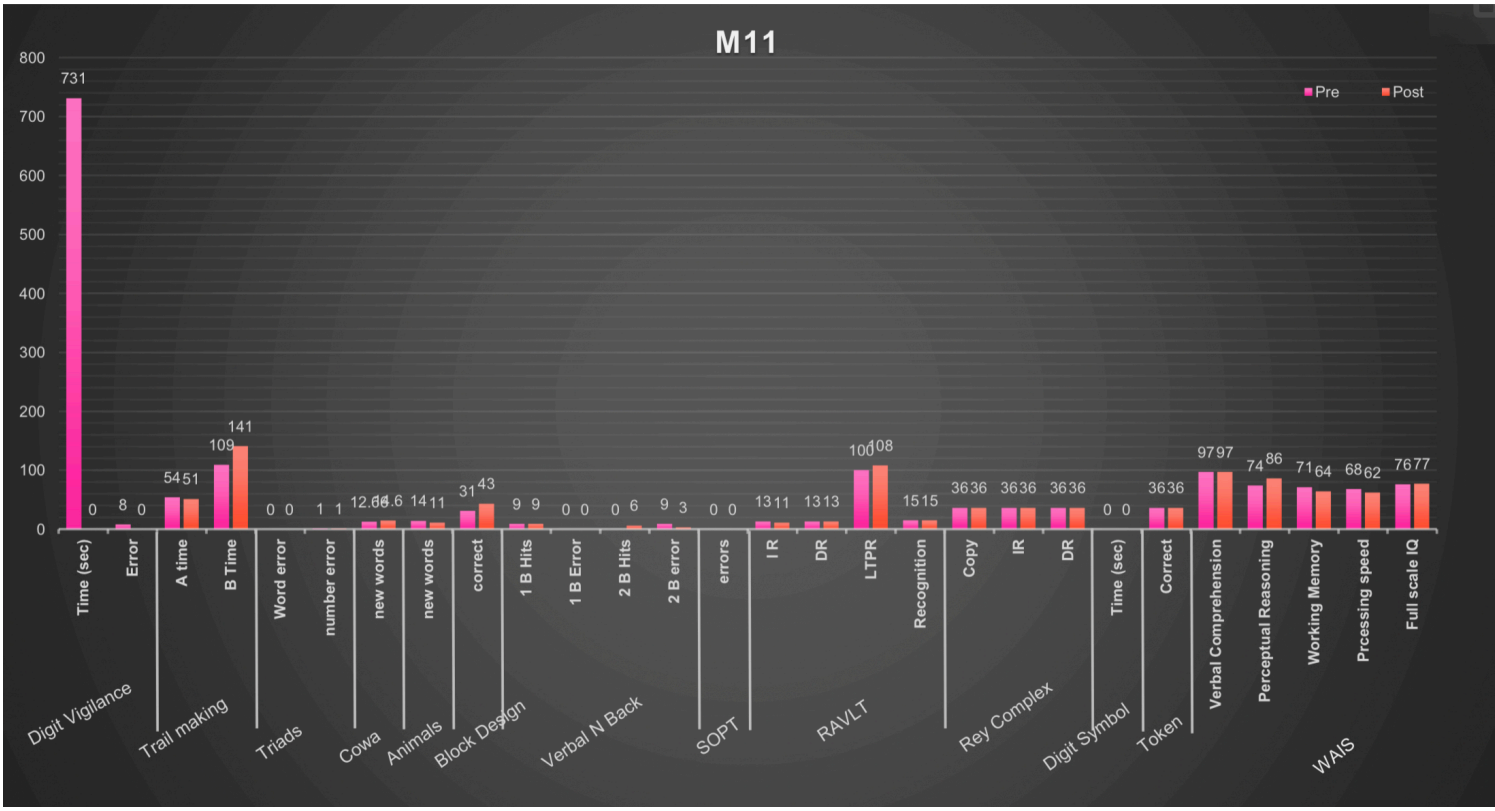
WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
56	0.2	48	<0.1	47	<0.1			46	<0.1
-	-	-	-	-	-	-	-	-	-

The test could not be done in the post-operative period. Patient not cooperative due to above enjoined reasons.

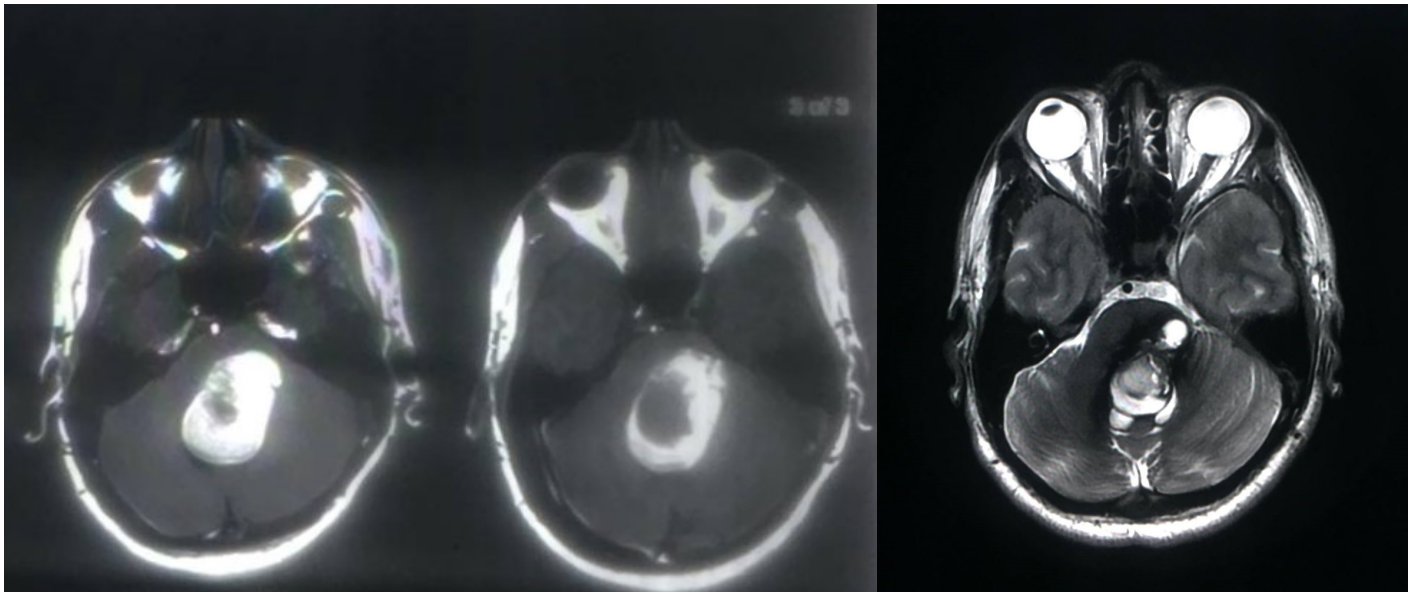
Pre op comments: Defict scores indicate difficulty in Planning, Verbal fluency, Verbal Working memory, Visuo-constructive ability and visual memory. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.

Post op comments: Deficit scores

5. **M11**: 24 year old male patient, educated upto the tenth standard, diagnosed with Pontine cavernoma. Gross total decompression achieved via telovelotonsillar approach.



A. Attention:



	Attention		
	Digit Vigilance	Trail Making	Triads

	Attention											
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	731	19	8	41	54	68	109	79	0		1	
Post	-	-	-	-	51	74	141	50	0		1	

A. Digit vigilance (Sustained attention): could not be done in the post-operative period because of decline in strength in the right hand.

B. Trail making test: (Focussed attention and visual scanning) Time to connect the numbers has reduced by 3s and with a percentile score of 74 post surgery. Time to draw line between numbers and coloured circles in an alternate manner has gone up by 32s and the percentile was 50 in the post-operative period.

C. Triads (Divided attention) - The verbal triad test showed poor results in pre and post-operative period.

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
12.66	95	14	60	31	
14.6	95	11	25	43	

a. COWAT (Verbal fluency)- showed an increase in number of new word formation from 12.66 to 14 and had a percentile of 95, both pre- and post-surgery.

b. Animal name test (Category fluency) showed decrease in number of new word formation by 3 accounting for an decrease in percentile score to 25.

c. Design fluency (Planning) assessed with blocks showed an increase in number of designs made from 31 to 43.

C. Memory

Memory			
Verbal N Back	SOPT	RAVLT	Rey Complex

Memory																							
1B Hits	P	1B Error	P	2B Hits	P	2B error	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
9	95	0	100	0	5*	9	10	0	100	13	70	13	60	100	80	15	95	36	95	36	95	36	95
9	95	0	100	6	30	3	48	0	100	11	30	13	60	108	90	15	95	36	95	36	95	36	95

a. Verbal N back: Verbal working memory)

1B hit score was the same in the pre op and post-operative period with no change in percentile score and also had 0 errors in both conditions.

2B hit score increased to 6 causing the percentile score to change to 30 with a fall in error by 6 which a corresponding percentile of 48.

b. Self-ordered point test: (Visual working memory) The score improved after surgery, i.e., was the same in the pre op and post-operative period with no change in percentile score.

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall reduced by a value of 2 with the corresponding percentile as 30.

Delayed recall remained the same in both pre- and post-operative conditions.

Long term percent retention increased from 100 to 108 with a percentile score of 90.

Recognition: scores remained unchanged in

the pre and post op period.

d. Rey-Osterrieth Complex figure test (ROCF): (Visuo-constructive ability and visual memory)

Copy score, Immediate recall and Delayed recall remained unchanged between pre and post-operative periods.

D. Speed: Test for Mental speed was to assessed due to decline in strength in the right hand.

Speed	
Digit Symbol	
Time (sec)	P
-	-
-	-

E. Token test score increased by a score of 1. (Verbal comprehension)

Comprehension	
Token	
Correct	P
36	
36	

F. The Weshcler Adult intelligence score-4

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
97	42	74	4	71	3	68	2	76	5
97	42	86	18	64	1	62	1	77	6

a. Verbal comprehension remained the same in both pre- and post-operative conditions.

b. Perceptual reasoning increased by 12 points and had a percentile score of 18

c. Working memory decreased by a value of 7 and had a percentile of 1.

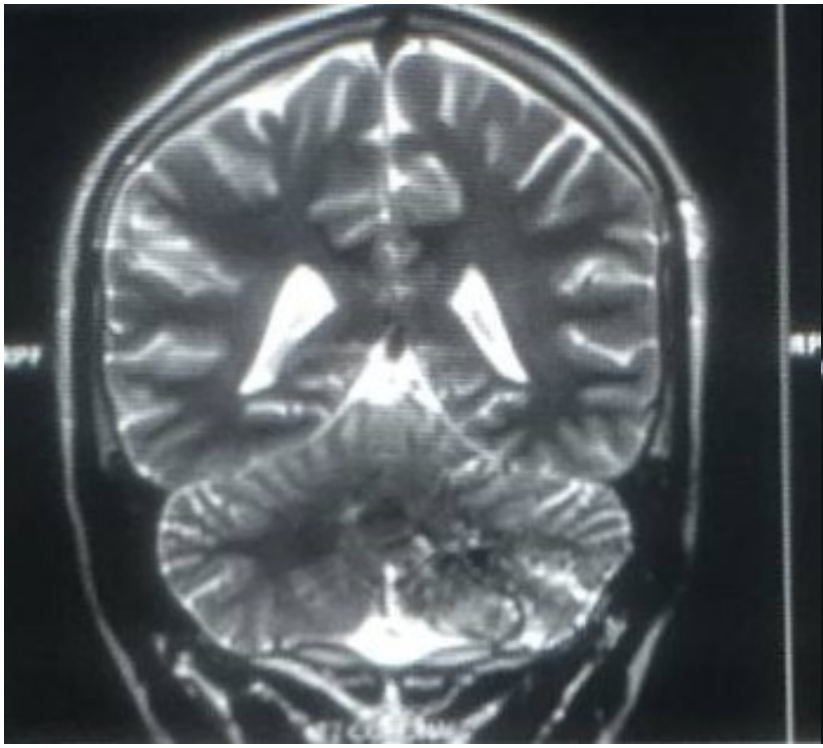
d. Processing speed decreased by 6 points and a percentile score of 1

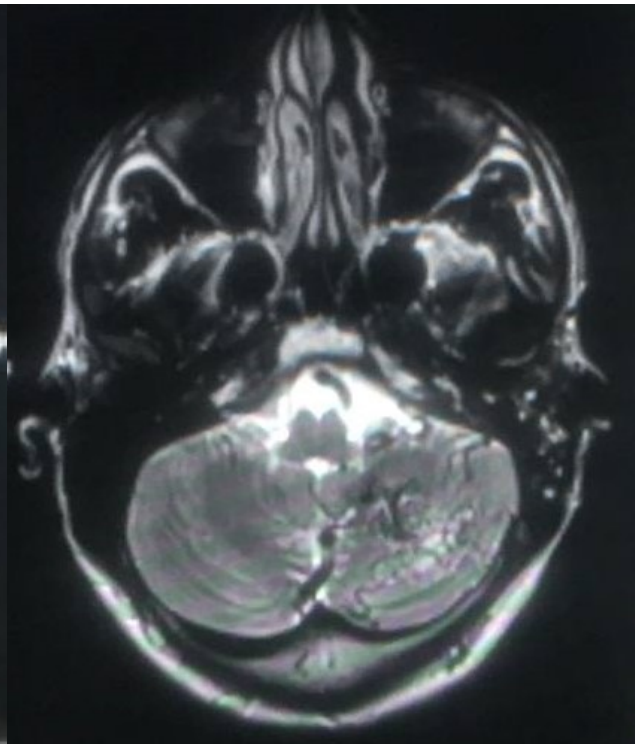
e. Full scale IQ increased postoperatively by 1, and a percentile of 6.

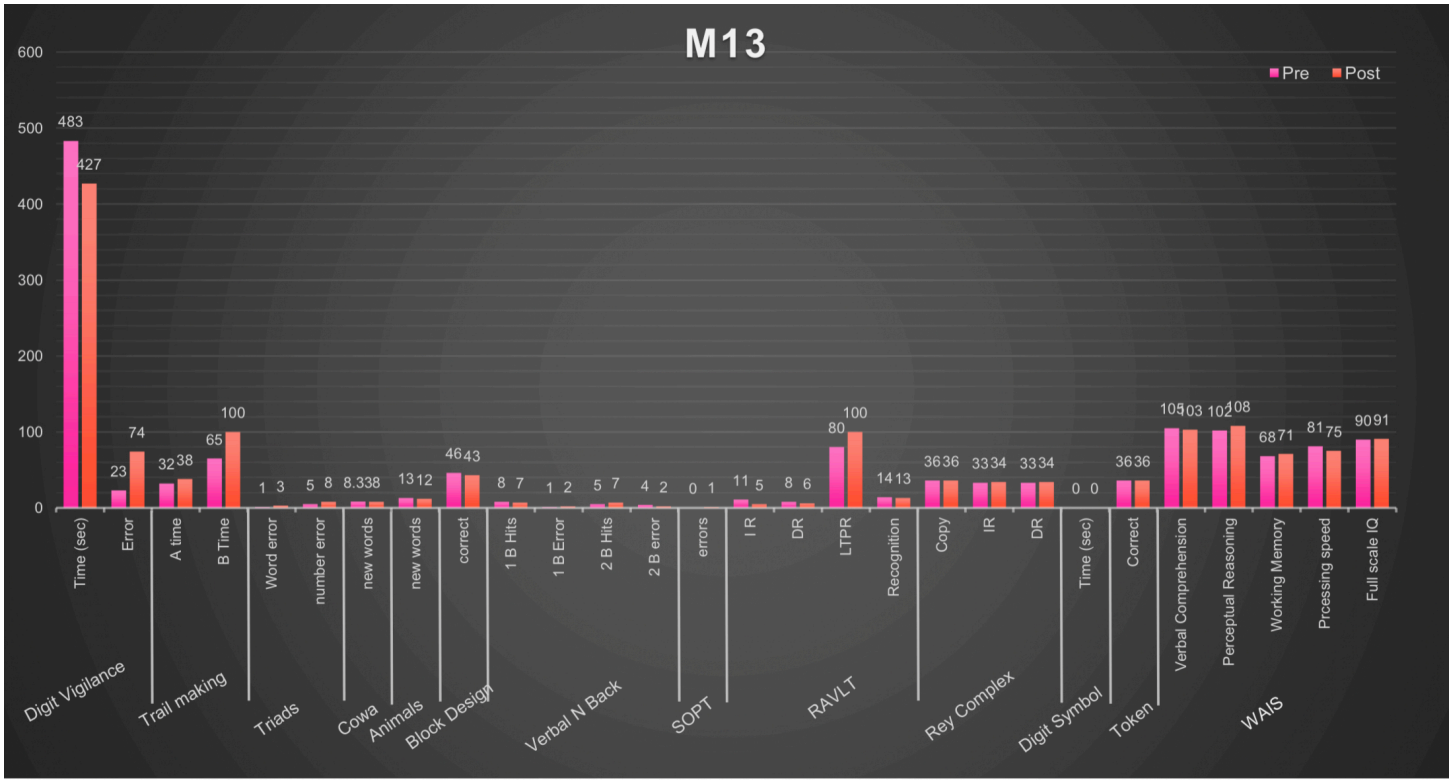
Pre- Deficient scores indicate difficulty in verbal working memory. Low scores on sustained attention. However, Visuo-constructive ability and visual memory found to be intact. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.IQ score of 76 indicate borderline level of intelligence.

Post- No deficient scores. Visuo-constructive ability and visual memory found to be intact. significant improvement noted in verbal fluency compared to pre-op assessment. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores. IQ score of 77 indicate borderline level of intelligence.

6. **M13**: 21 year old male patient, educated upto the tenth standard, diagnosed with Left Cerebellar AVM. Cerebellar cortisectomy was required to access the AVM which was completely excised.







	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	483	78	23	9	32	97	65	97	1		5	
Post	427	88	74	3	38	88	100	85	3		8	

A. Attention:

A. Digit vigilance (sustained attention) : Time decreased by 56 seconds with a percentile rise post surgery to the 88th percentile group. The error rate has increased in the post op test.

B. Trail making test (Focussed attention and visual scanning): Time to connect the numbers has gone up by 6s and percentile post surgery dropped to 88th percentile group. Time to draw line between numbers and coloured circles in an alternate manner has gone up by 35s and causing patient to fall post operative period to the 85th percentile group.

C. Triads (Divided attention) - The verbal triad test showed an increase in error by 2. The tactile number identification task showed an increase in error by 3.

B. Executive function

a. COWAT (Verbal fluency)- showed an increase in number of new word formation from 8.33

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
8.33	60	13	50	46	
8	60	12	30	43	

to 8 with no change in percentile.

b. Animal name test (Category fluency) showed decrease in number of new word formation by 1 accounting for a fall to the 30th percentile group.

c. Design fluency (Planning) assessed with blocks showed an decrease in number of designs made by 3.

C. Memory

a. Verbal N back: (verbal working memory)

Memory																							
Verbal N Back								SOPT		RAVLT								Rey Complex					
1 B Hits	P	1 B Error	P	2 B Hits	P	2 B error	P	errors	P	I R	P	DR	P	LTP R	P	Recognition	P	Copy	P	IR	P	DR	P
8	40	1	45	5	20	4	32	0	100	11	30	8	5	80	15	14	20	36	95	33	90	33	95
7	15	2	23	7	50	2	97	1	75	5	5	6	5	100	5	13	15	36	95	34	95	34	95

1B hit score decreased by a score of 1 causing a change in percentile position to the 15th percentile group. Error in the post operative period increased by 1 signifying a fall in accuracy.
2B hit score increased by 2 causing the change in percentile to 50th percentile group, with a fall in error by 2 signifying an accuracy percentile increase 97th percentile group..

b. Self ordered point test: (Visual working memory)The score reduced after surgery, i.e the error increased to 1 from 0 and the patient fell to 75th percentile group.

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal memory)

Immediate recall: score was reduced by 6 in post operative period with a fall to 5th percentile group.

Delayed recall reduced by 2 and no change in percentile .

Long term percent retention fell from 80 to 100 with a fall in percentile to 5th.

Recognition: scores reduced by 1 and a fall to 15th percentile group in the post op period.

d. Rey-Osterrieth Complex figure test (ROCF): (Visuo-constructive ability & Visual memory)

Copy score remained unchanged between pre and post operative periods.

Immediate recall score increased from by 1 and rose to 95th percentile group surgery.

Delayed recall score increased by 1 and no change in percentile.

D. Test for Mental speed could not be done because of exhaution by the end of the test.

E. Token test score (Comprehension) remained unchanged

F. The Weshcler Adult intelligence score-4

a. Verbal comprehension deteriorated by 2 points and a fall to 58th percentile group.

Speed	
Digit Symbol	
Time (sec)	P
-	-
-	-

b. Perceptual reasoning increased by 6 points and a percentile score of 70

c. Working memory increased by 3 points that signifies the 5th percentile. .

d. Processing speed increased by 6 points and a percentile score of 5

e. Full scale IQ increased postoperatively by 1, and a percentile of 2.

Comprehension	
Token	
Correct	P
36	
36	

Pre: Comments: No deficit scores. Normal range of performance in all the tests in Nimhans Neuropsychological Battery without any significant deviation from the normative percentile scores.

IQ score of 62 indicating Extremely Low Intelligence.

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
105	63	102	55	68	2	81	10	90	25
103	58	108	70	71	3	75	5	91	27

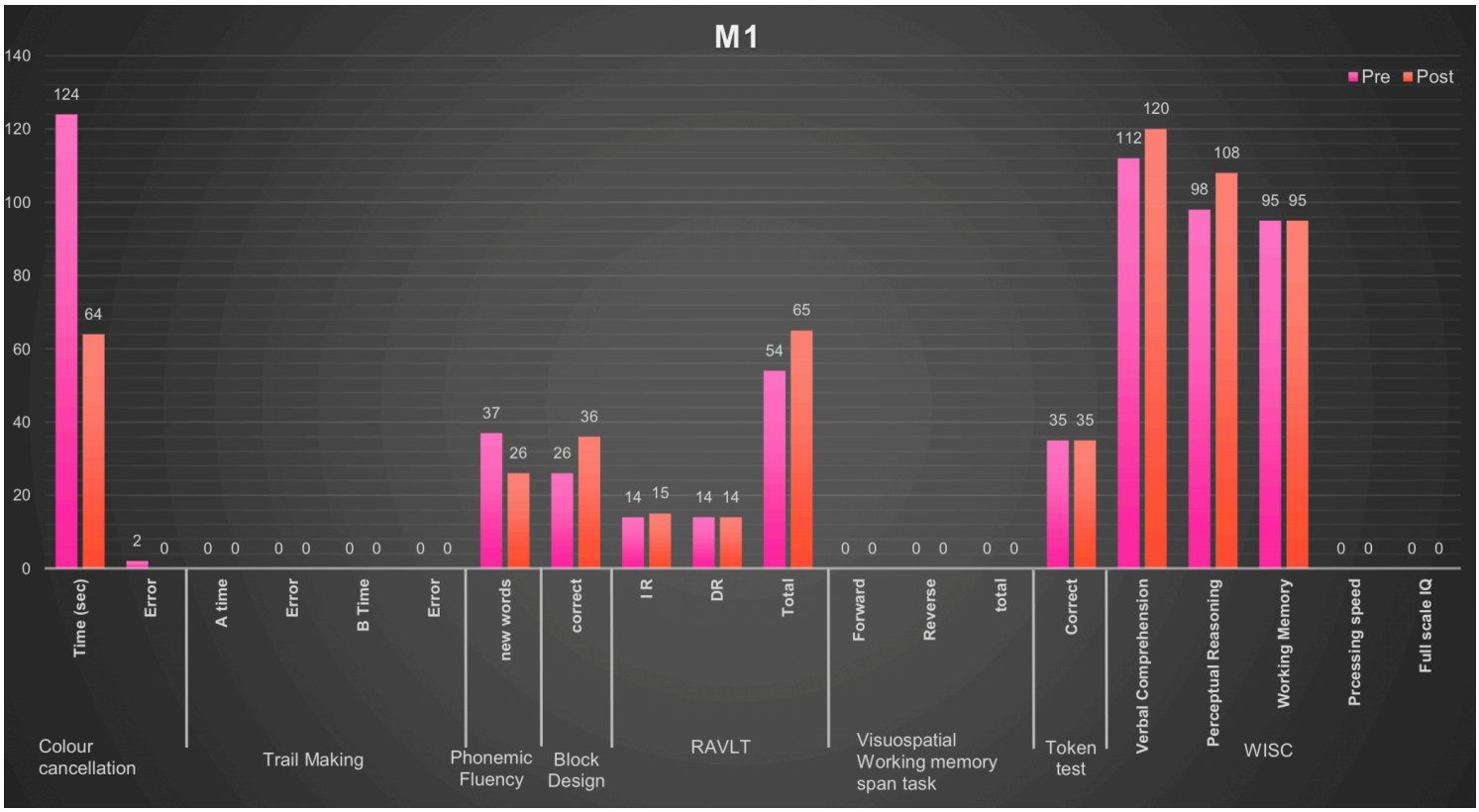
Post Comments: Deficit scores indicate difficulty in Sustaining attention, Verbal learning& memory. Non-verbal memory is found to be intact. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.

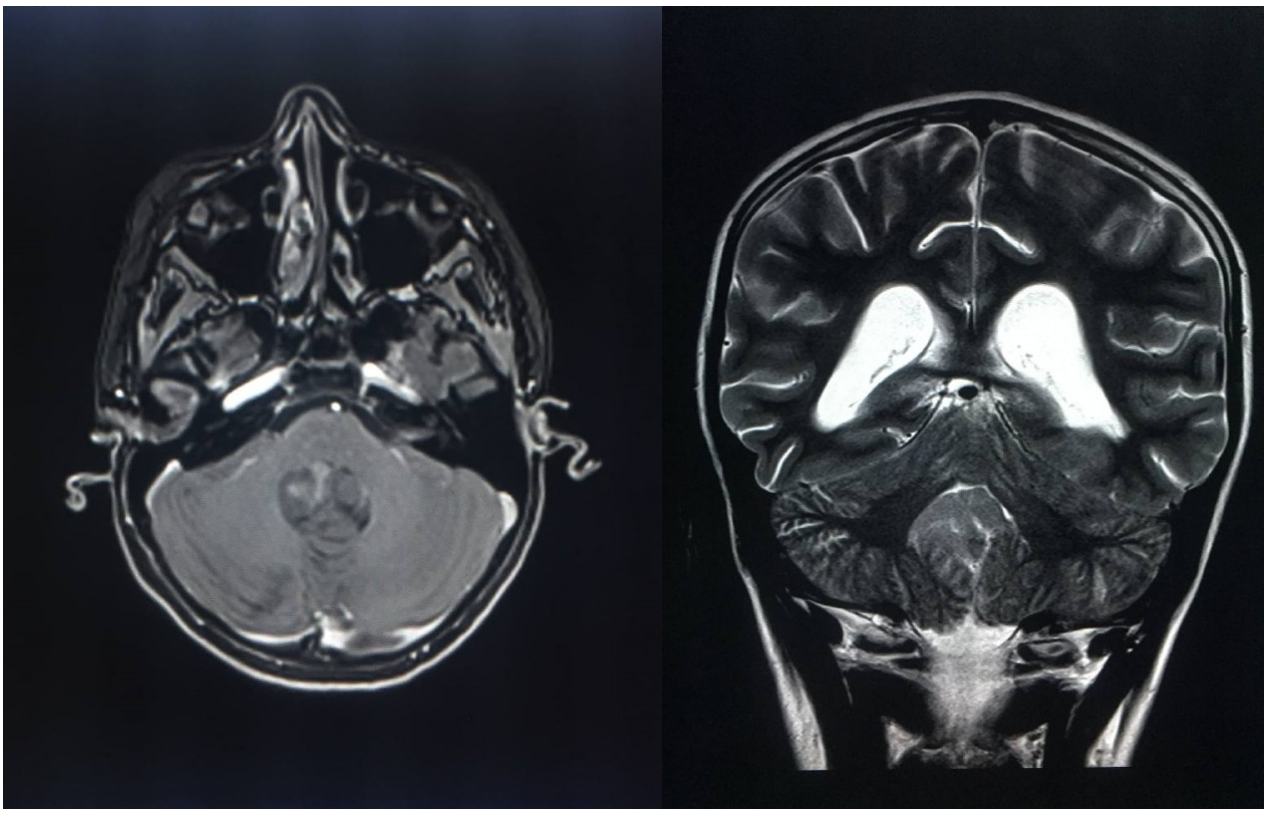
WAIS scores show low working memory and processing speed. IQ score of 90 indicate Average level of Intelligence.

Midline sub-occipital craniotomy cohort

Children

1. M1: 10 year old female patient, school going, diagnosed with 4th ventricular medulloblastoma. Patient had an EVD inserted intraoperatively, CSF opening pressure was high. EVD subsequently internalized on POD 5. Patient had tumor dissemination on opening dura and was scheduled for cranio-spinal irradiation postoperatively. Intraoperative approach was telovelotonsillar. Only a Near total decompression achieved.





A. Attention:

Midline Neuropsychological scores-5

	Attention					
	Colour Cancellation		Trail Making			
	Time (sec)	Error	A time	Error	B Time	Error
Pre	124	2	-	-	-	-
Post	64	0	-	-	-	-

A. Colour cancellation (Sustained attention) : Time improved by 60 seconds post surgery. The error rate has reduced in the post op test to zero.

B. Trail making test (Focussed attention): could not be performed because she could not hold onto a pencil or pen.

B. Executive function

Midline Neuropsychological scores-6

Executive functions		
Phonemic Fluency	Block Design	
new words	correct	P
37	26	90
26	36	95

a. Phonemic fluency (Verbal fluency) - showed an decrease in number of new word formation from 37 to 26 i.e 11.

b. Design fluency (Planning) assessed with blocks showed an increase in number of designs made from 26 to 36. This reflected to a rise to 95th percentile group.

C. Memory

Midline Neuropsychological scores-1-1

RAVLT						VSWMS			
I R	P	DR	P	Total	P	Forward	Reverse	total	P
14	-	14	95	54	90	-	-	-	-
15	-	14	95	65	95	-	-	-	-

a. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal plearning)

Immediate recall: score increased in post operative period by 1.

Delayed recall remained unchanged and percentile score remained unchanged.

b. Visuospatial Working memory span task (VSWMS) could not be performed *because she had difficulty holding onto the blocks.*

D. Token test score (Verbal Comprehension)

Midline Neuropsychological scores-3-1

Comprehension	
Token	
Correct	P
35	95
35	95

F. WISC-V

a. Verbal comprehension improved from by 8 points and a percentile jump to 91st percentile

Midline Neuropsychological scores-2-1

WISC									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Prcessing speed	P	Full scale IQ	P
112	79	98	45	95	37	-	-	-	-
120	91	108	70	95	37	-	-	-	-

group.

b. Perceptual reasoning increased by 10 points and a rise to 70th percentile group.

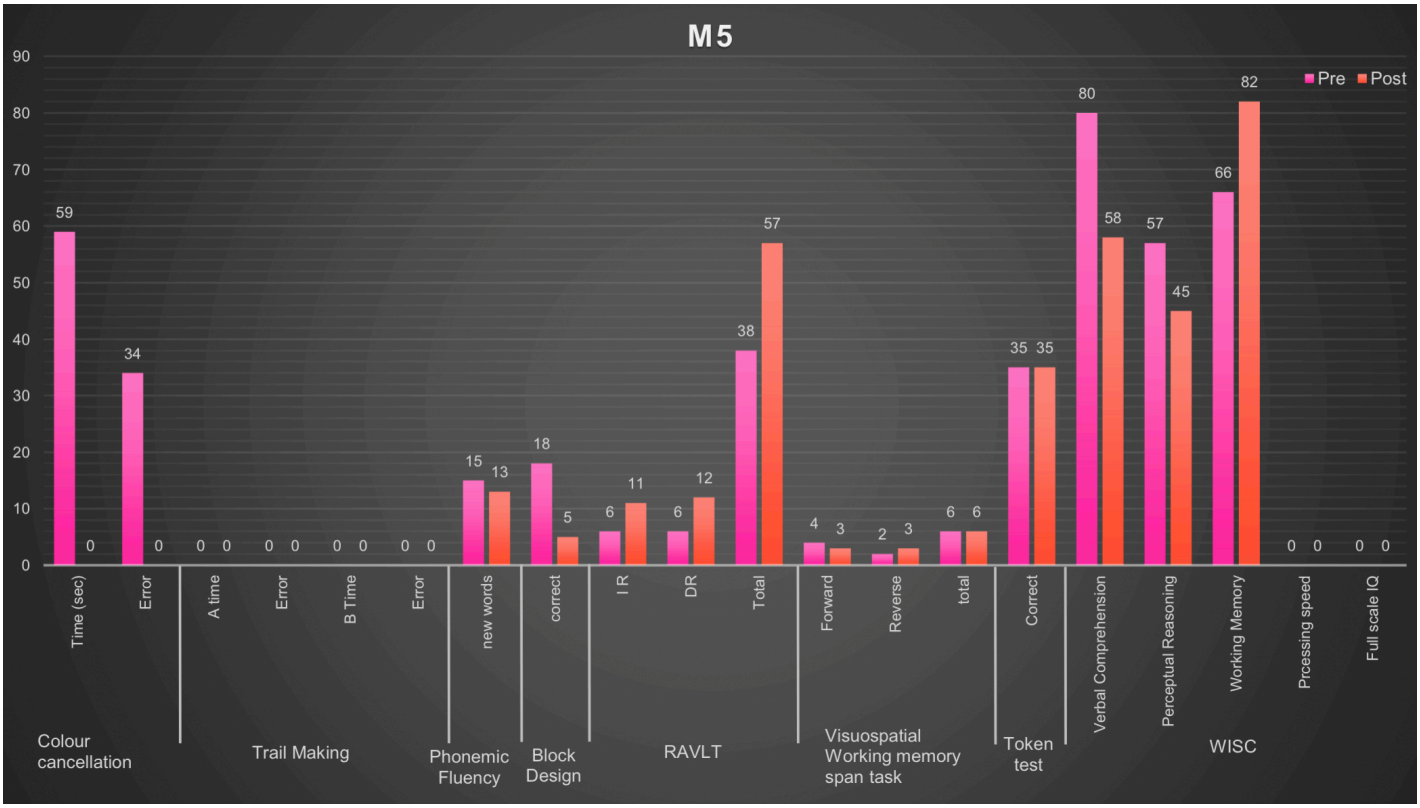
c. Working memory remained unaffected.

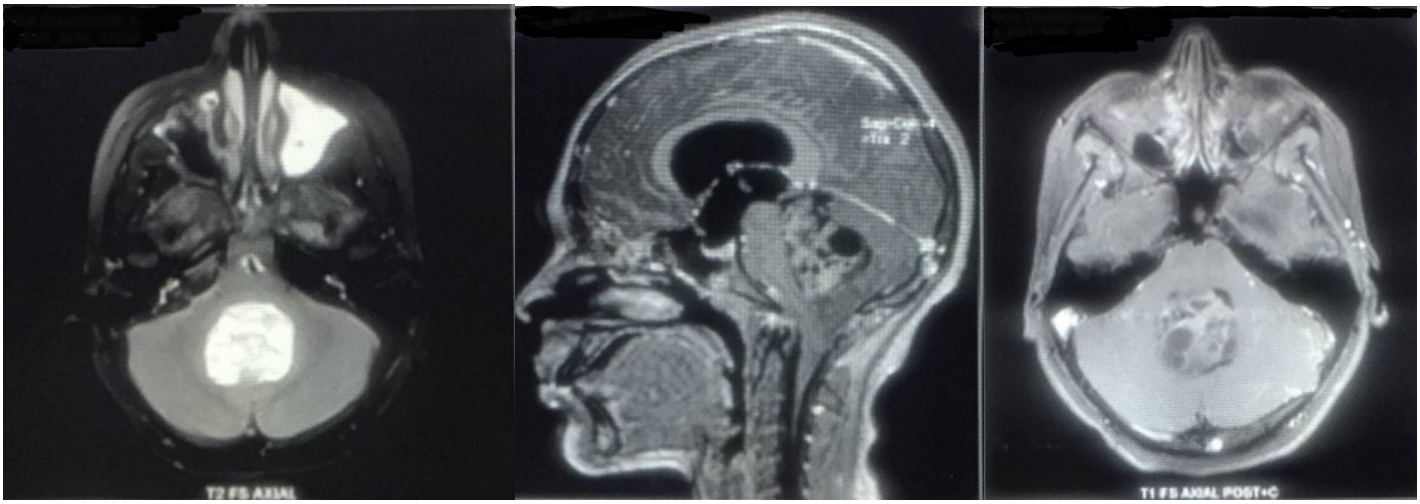
d. Processing speed and Full scale IQ could not be performed because she had difficulty holding onto the pencil.

Pre- Deficient scores indicate difficulty in sustained attention and verbal working memory. Verbal learning &memory found to be intact. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores

Post- No deficient scores.Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.

2. M5: 14 year old female patient, school going, diagnosed with 4th ventricular ependymoma who grade





2. EVD was inserted intraoperatively and CSF opening pressure was high. EVD internalised on D7. There was evidence of brainstem infiltration at floor of the 4th ventricle. Patient developed CMS postoperatively and had gradual recovery of speech. Gross total decompression achieved via telovelotonsillar approach.

B. Attention:

   A. Colour cancellation (Sustained attention) : could not be done post surgery as she could not perceive colours and small digits. Patient also was exhausted easily.

   B. Trail making test: (Focussed attention) could not be performed because could not be done post surgery as she could not perceive colours and small digits

Midline Neuropsychological scores-5-1

	Attention					
	Colour Cancellation		Trail Making			
	Time (sec)	Error	A time	Error	B Time	Error
Pre	59	34	-	-	-	-
Post	-	-	-	-	-	-

B. Executive function

Midline Neuropsychological scores-7

Executive functions		
Phonemic Fluency	Block Design	
new words	correct	P
15	18	
13	5	5

a. a. Phonemic fluency (Verbal fluency) - showed an decrease in number of new word formation by 2.

b. Design fluency (Planning) assessed with blocks showed a decrease in number of designs made from 18 to 5.

C. Memory

Midline Neuropsychological scores-1-6

RAVLT						VSWMS			
I R	P	DR	P	Total	P	Forward	Reverse	total	P
6	-	6	5	38	5	4	2	6	10
11	-	12	50	57	90	3	3	6	10

a. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall: score increased in post operative period by 5.

Delayed recall increased by 6 and percentile score rose to 50th position.

b. Visuospatial Working memory span task (VSWMS) performed.

It showed fall in forward test by 1 and increase in reverse test by 1 with no overall change in Percentile score.

D. Token test score (Verbal comprehension) increased by a score of 1.

Midline Neuropsychological scores-3-2

Comprehension	
Token	
Correct	P
35	95
35	95

F. WISC-V

Midline Neuropsychological scores-2-2

WISC									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Prcessing speed	P	Full scale IQ	P
80	9	57	0.2	66	1	-	-	-	-
58	0.3	45	<0.1	82	12	-	-	-	-

a. Verbal comprehension detoriated from 80 to 58 by 22 points and a percentile fall to 0.3 percentile group.

b. Perceptual reasoning decreased by 12 points and a fall to <0.1 percentile group.

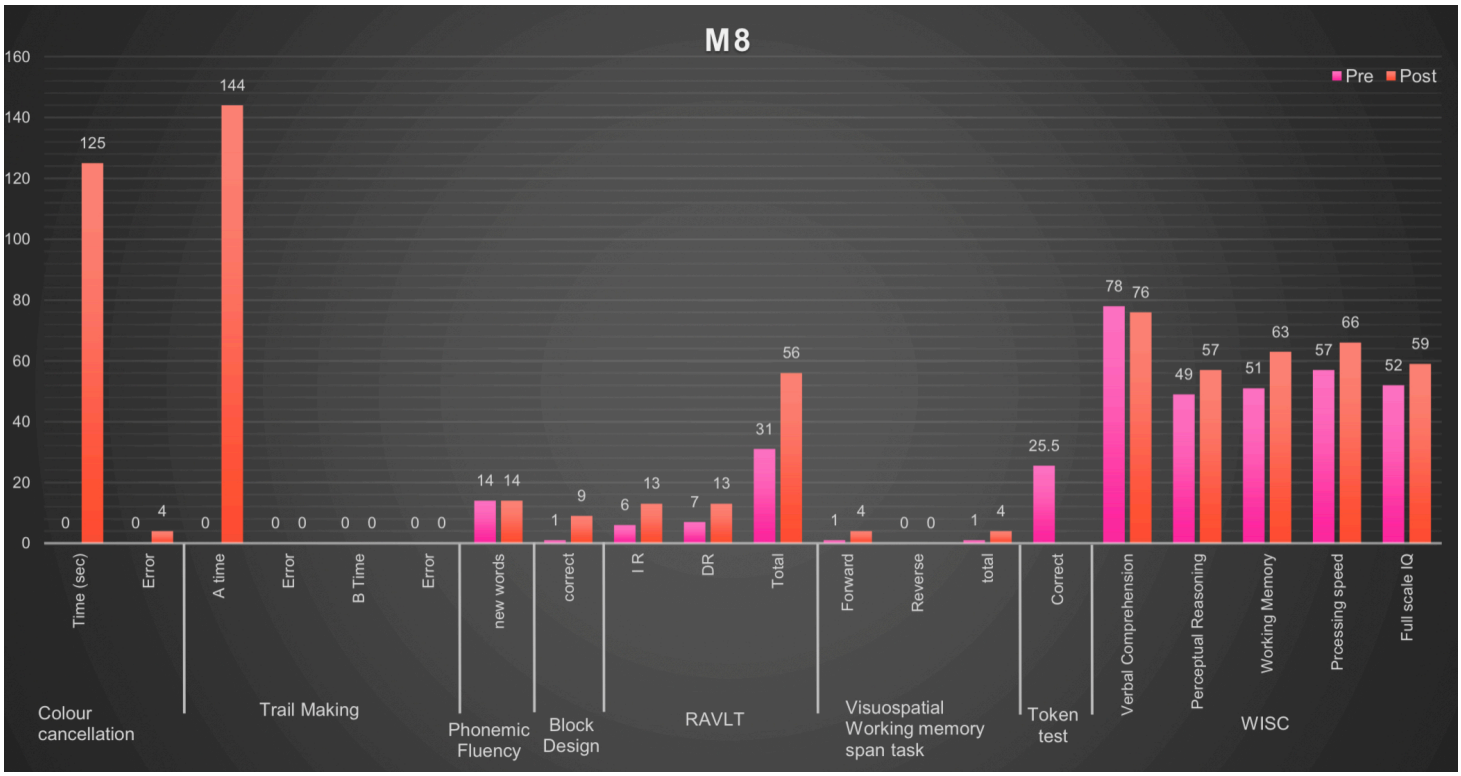
c. Working memory increased in score by 16 points with rise to 12th percentile group.

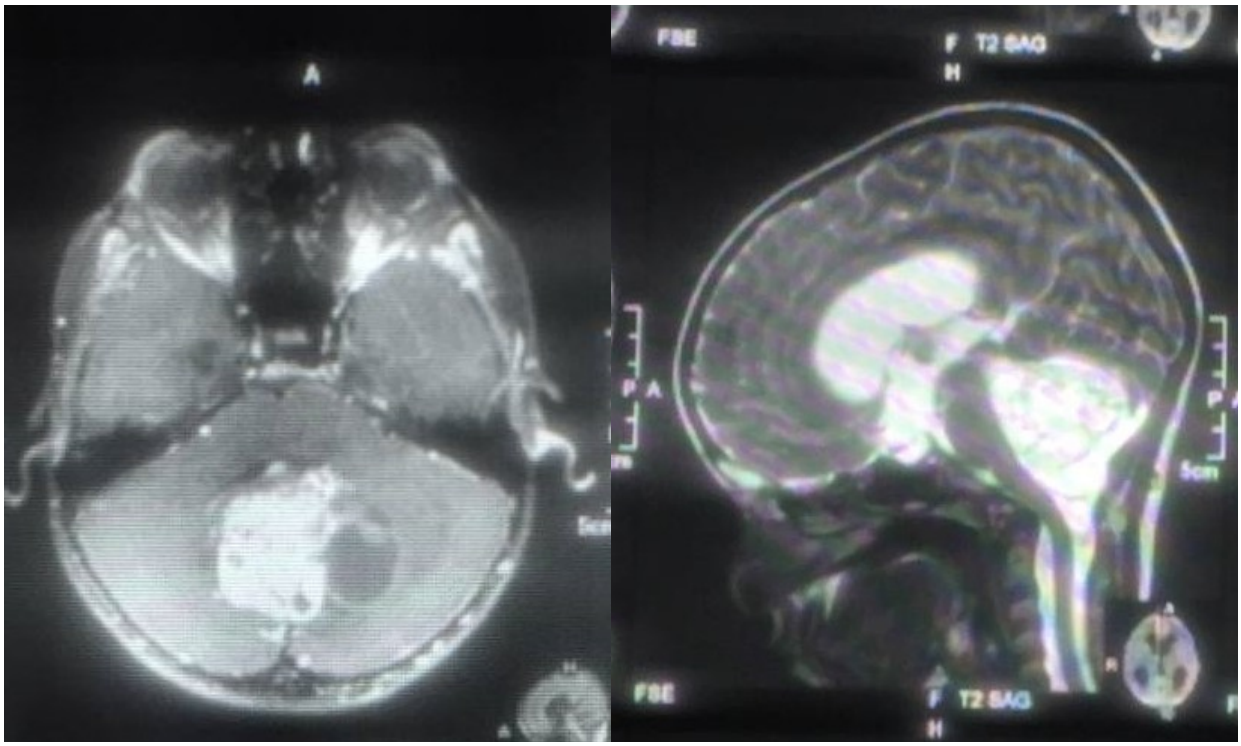
d. Processing speed and Full scale IQ could not be performed because could not be done as she could not perceive colours and small digits. Patient also was exhausted easily.

Pre op impression- Deficient scores indicate difficulty in visuo-spatial working memory, verbal working memory and Verbal learning &memory. Deficient scores indicate difficulty in visuo-spatial working memory,

Post op impression- Deficient scores indicate difficulty in visuo-spatial working memory and block design. Deficient scores indicate difficulty in visuo-spatial working memory,

3. M8: 9 year old male patient, school going, diagnosed with 4th ventricular Pilocytic astrocytoma. Gross total decompression achieved via telovelotonsillar approach.





A. Attention:

C. Colour cancellation (Sustained attention) : Reduced from 180 to 125 i.e by 55 points and error reduced by 2 in the postoperative period.

Midline Neuropsychological scores-5-2

	Attention					
	Colour Cancellation		Trail Making			
	Time (sec)	Error	A time	Error	B Time	Error
Pre	180	6	-	-	-	-
Post	125	4	144	0	-	-

D. Trail making test: (Focussed attention) could not be performed because child can't count beyond ten.

B. Executive function

Midline Neuropsychological scores-8

Executive functions		
Phonemic Fluency	Block Design	
new words	correct	P
14	1	5
14	9	25

a. Phonemic fluency (Verbal fluency) showed an no change pre and post operative period.

b. Design fluency (Planning) assessed with blocks showed an increase in number of designs made from 1 to 9. This reflected to a rise to 25th percentile group.

C. Memory

a. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal leaning)

Immediate recall: score increased in post operative period by 7.

Delayed recall remained increased by 7 and percentile score rose to 90th percentile group.

b. Visuospatial Working memory span task (VSWMS) *It showed fall in forward test by 3 and no change in reverse test.*

Midline Neuropsychological scores-1-3

RAVLT						VSWMS			
I R	P	DR	P	Total	P	Forward	Reverse	total	P
6	-	7	5	31	5	1	0	1	5
13	-	13	90	56	90	4	0	4	

D. Token test score (verbal comprehension) could not be done post operatively because child started crying due to exhaustion.

Midline Neuropsychological scores-3-3

Comprehension	
Token	
Correct	P
25.5	10

F. The Weshcler Adult intelligence score-4

Midline Neuropsychological scores-2-3

WISC									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Prcessing speed	P	Full scale IQ	P
78	7	49	<0.1	51	0.1	57	0.2	52	0.1
76	5	57	0.2	63	1	66	1	59	0.3

a. Verbal comprehension reduced by 2 points and a percentile fall to 5.

b. Perceptual reasoning increased by 8 points and a percentile score of 0.2 group in post op period

c. Working memory increased by 8 points. Patient remained in the 1st percentile group.

d. Processing speed increased by 9 points and a percentile score was 1

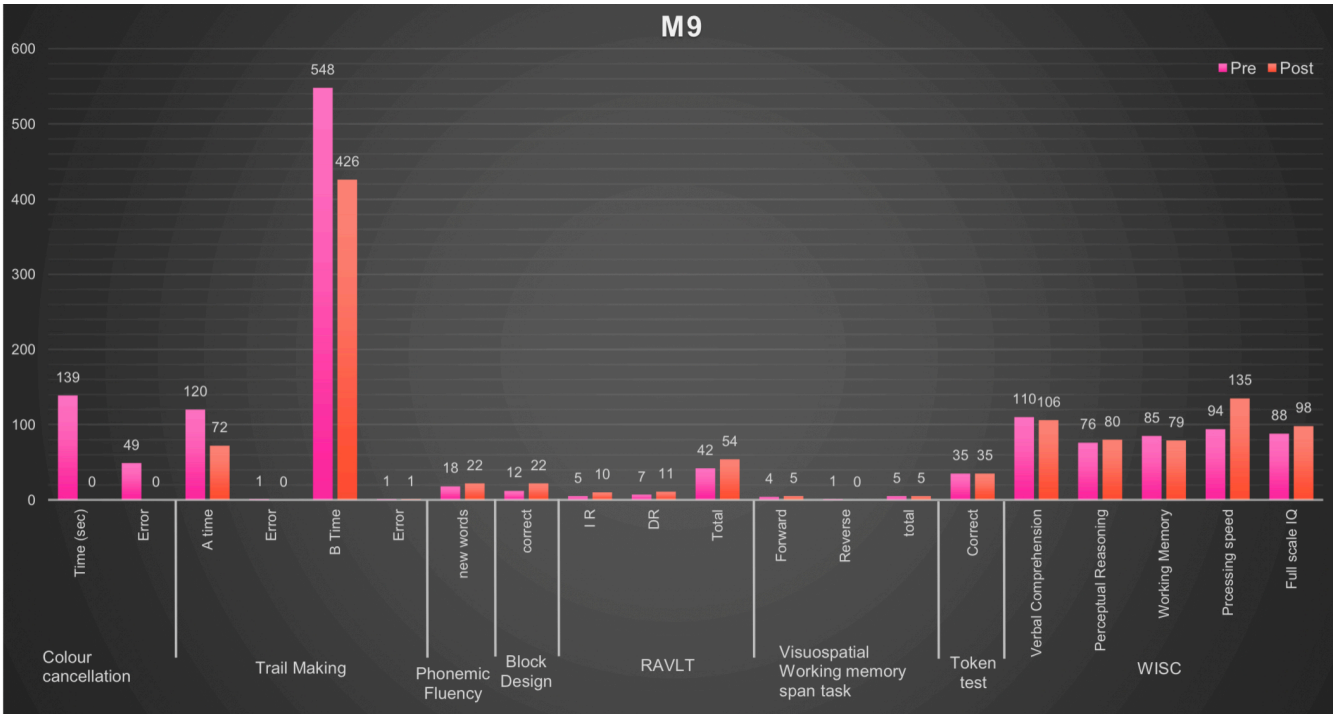
e. Full scale IQ increased postoperatively by 7, and a percentile group 0.3.

Pre comments: Test results indicate low working memory, perceptual reasoning and sustained attention. However verbal comprehension ability is intact.

IQ score of 88 indicating Low average Intelligence level.

Post comments -Deficient scores indicate difficulty in focused attention and visuo-spatial working memory.Normal range of performance in all the other tests without any significant deviation from the normative percentile scores. IQ score of 98 indicate average level of intelligence.

4. M9: 8 year old male patient, school going, diagnosed with fourth ventricular Medulloblastoma. Gross



total decompression achieved via telovelotonsillar approach.A. Aa A. Attention:

E. Colour cancellation (Sustained attention) : Reduced from 139 to 103 i.e by 36 points in the post

Midline Neuropsychological scores-5-3

	Attention					
	Colour Cancellation		Trail Making			
	Time (sec)	Error	A time	Error	B Time	Error
Pre	139	49	120	1	548	1
Post	103	51	72	0	426	1

operative period with an increase in error by 2 points.

F. Trail making test: (Focussed attention) Time to connect the numbers has gone down by 48s and with a zero error rate in the post operative period. Time to draw line between numbers and coloured circles in an alternate manner has gone down by 122s and and no change in error rate.

B. Executive function

a. Phonemic fluency - (Verbal fluency) showed an increase in number of new word formation from 18 to 22 I.e by 4.

b. Design fluency (Planning) assessed with blocks showed an increase in number of designs made from 18 to 22. This reflected to a rise to 90th percentile group.

C. Memory

a. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Midline Neuropsychological scores-9

Executive functions		
Phonemic Fluency	Block Design	
new words	correct	P
18	12	75
22	22	90

Immediate recall: score increased in post operative period by 5.

Midline Neuropsychological scores-1-4

RAVLT						VSWMS			
I R	P	DR	P	Total	P	Forward	Reverse	total	P
5	-	7	10	42	50	4	1	5	25
10	-	11	75	54	90	5	0	5	25

Delayed recall increased by 4 and percentile score increased to the 75th percentile group. .

b. Visuospatial Working memory span task (VSWMS): *It showed increase in forward test by 1 and decrease in reverse test by 1 with no overall change in Percentile score.*

D. Token test score (Verbal comprehension) remained unchanged

WISC-V

a. Verbal comprehension detoriated from 110 to 106 and percentile fall to 66th percentile. group.

Midline Neuropsychological scores-3-4

Comprehension	
Token	
Correct	P
35	95
35	95

b. Perceptual reasoning increased by 4 points and a rise tp percentile group 9.

c. Working memory decreased in score by 6 points with fall to 8th percentile group.

d. Processing speed went up to 135 from 99, i.e rise by 41 and rise to the 99th percentile group postoperatively.

e. Full scale IQ increased by 10 points going up to 45th percentile.

Pre comments: Deficit scores indicate difficulty in Attention, Verbal working memory, Visuo-constructive ability and Visual Memory. Normal performance in all the other tests in Nimhans Battery without any significant deviation from the normative percentile scores.

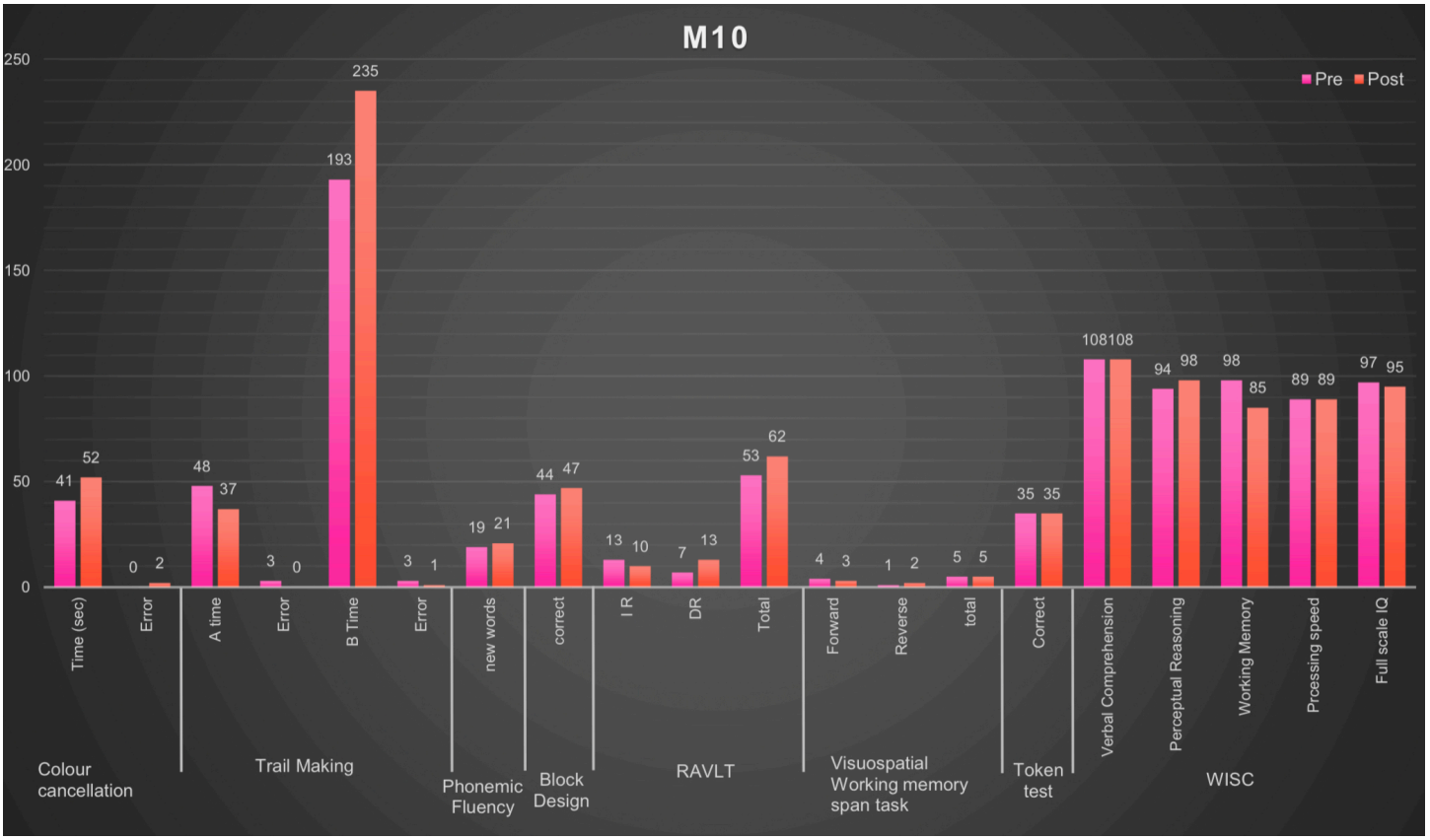
Midline Neuropsychological scores-2-4

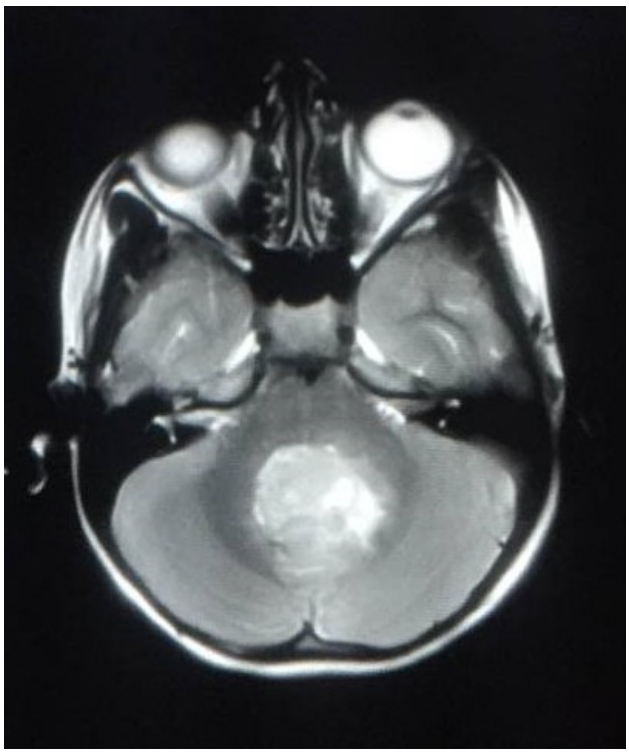
WISC									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Prcessing speed	P	Full scale IQ	P
110	75	76	5	85	16	94	34	88	21
106	66	80	9	79	8	135	99	98	45

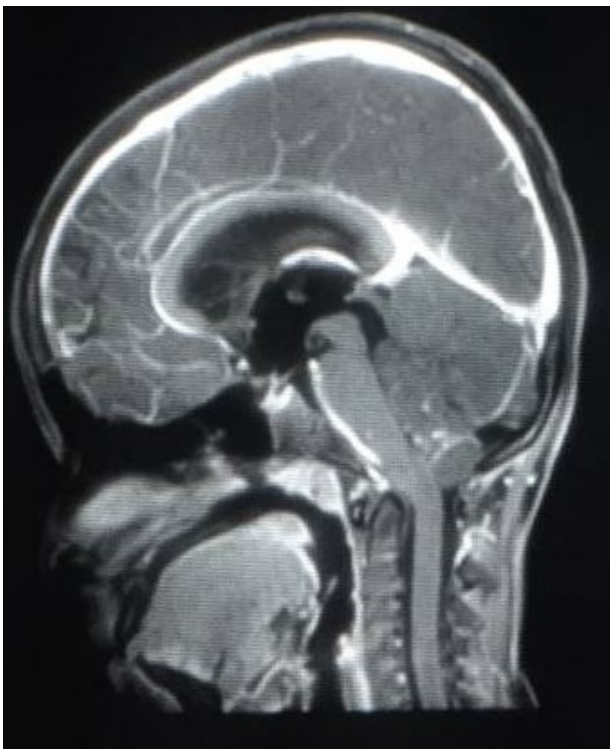
IQ score of 60 indicating Extremely Low Intelligence level.

Post comments: **Post** -Deficient scores indicate difficulty in focused attention and visuo-spatial working memory.Normal range of performance in all the other tests without any significant deviation from the normative percentile scores. IQ score of 98 indicate average level of intelligence.

5. M10: 10 year old female patient, school going, diagnosed with Cerebellar vermian medulloblastoma. EVD was inserted intraoperatively and opening pressure was moderate. EVD internalised on POD 6. Tumor was infiltrating left Middle cerebellar peduncle. Gross total decompression achieved via telovelotonsillar approach.







Midline Neuropsychological scores-5-4

	Attention					
	Colour Cancellation		Trail Making			
	Time (sec)	Error	A time	Error	B Time	Error
Pre	41	0	48	3	193	3
Post	52	2	37	0	235	1

A. Attention: a. Colour cancellation (Sustained attention): increased by 11 in the postoperative period.
b. Trail making test: (focused attention) could not be performed because

B. Executive function

Midline Neuropsychological scores-11

Executive functions		
Phonemic Fluency	Block Design	
new words	correct	P
19	44	95
21	47	95

a. Phonemic fluency - (Verbal fluency) showed an increase in number of new word formation by 3.

b. Design fluency (planning) assessed with blocks showed an increase in number of designs made from 44 to 47 i.e by 3.

C. Memory

Midline Neuropsychological scores-1-5

RAVLT						VSWMS			
I R	P	DR	P	Total	P	Forward	Reverse	total	P
13	-	7	5	53	90	4	1	5	10
10	-	13	75	62	95	3	2	5	10

a. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall: score decreased in post operative period by 3.

Delayed recall increased by 6 and percentile score rose to 75th position.

b. Visuospatial Working memory span task (VSWMS) performed.

It showed fall in forward test by 1 and increase in reverse test by 1 with no overall change Percentile score.

D. Token test score remained unchanged. (Verbal comprehension)

Midline Neuropsychological scores-3-5

Comprehension	
Token	
Correct	P
35	95
35	95

F. The Weshcler Adult intelligence score-4

a. Verbal comprehension remained unchanged after surgery with a 70th ercentile score

b. Perceptual reasoning increased by 4 points and a percentile score to 45th percentile group

c. Working memory reduced FP, 98 to 85 by 13 points and to 16th percentile group in the post operative period. .

d. Processing speed remained unaffected at the 23rd percentile post operatively.

e. Full scale IQ decreased postoperatively by 2, dropping to the. 37th percentile.

Midline Neuropsychological scores-2-5

WISC									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Prcessing speed	P	Full scale IQ	P
108	70	94	34	98	45	89	23	97	42
108	70	98	45	85	16	89	23	95	37

Pre- Deficient scores indicate difficulty in visuo-spatial working memory and verbal memory (delayed recall). other executive functions found to be intact. Normal range of performance in all the other tests

without any significant deviation from the normative percentile scores. IQ score of 97 indicate average level of intelligence.

Post- Deficient scores indicate difficulty in visuo-spatial working memory . Significant improvement noted in verbal memory compared to pre-op assessment. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores. IQ score of 95 indicate average level of intelligence.

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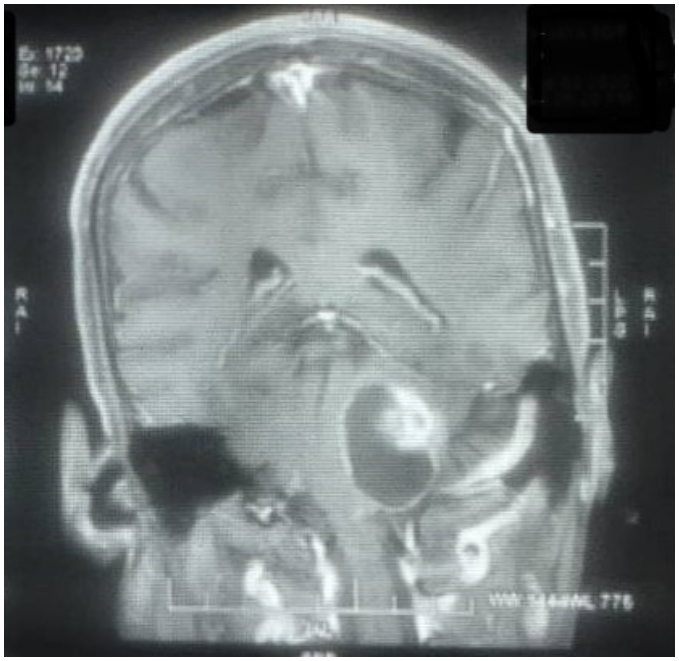
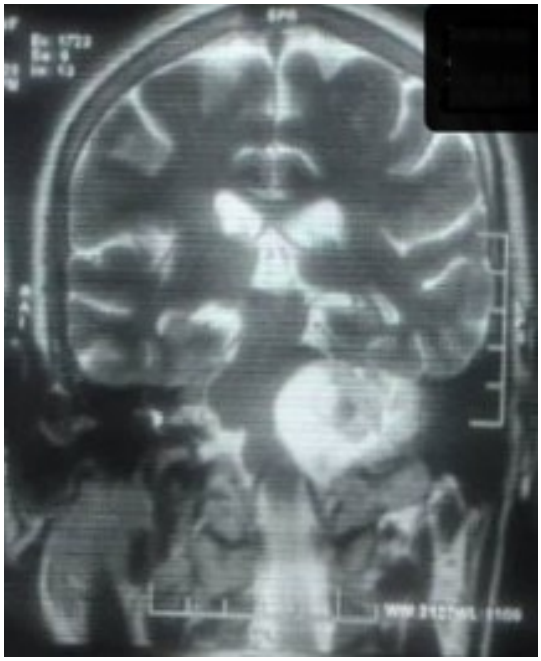
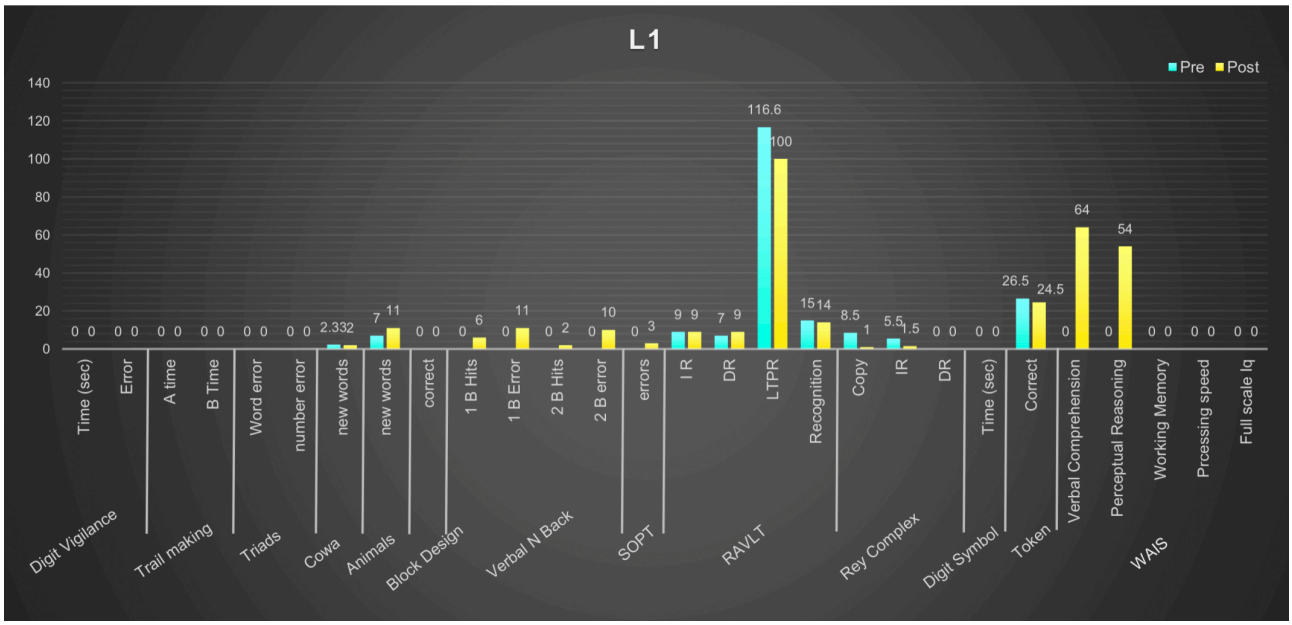
Lateral sub-occipital craniotomy cohort

Adults

1. L1: 59-year-old female patient, educated up to the tenth standard, diagnosed with left cerebellopontine angle vestibular schwannoma.







A. Attention:

	Attention		
	Digit Vigilance	Trail Making	Triads

	Attention											
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	-	-	-	-	-	-	-	-	-	-	-	-
Post	-	-	-	-	-	-	-	-	-	-	-	-

A. Digit vigilance, Trail making test and Triads test for assessing attention were not assessed due to lack of cooperation from the patient

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
2.33	30	7	30	-	
2	30	11	75	-	

a. COWAT (Verbal fluency) - showed an decrease in number of new word formation from 2.33 to 2 and had a corresponding percentile score of 30.

b. Animal name test (category fluency) showed an increase in the number of new-word formation by 4, accounting for an increase into the 75th percentile group.

c. Design fluency (Planning) was not assessed in view of patient's inability to understand the test

C. Memory

a. Verbal N back: (Verbal working memory)

Only the post-operative scores were available for this assessment tool. This was due to the fact that patient was not cooperative before surgery

b. Self-ordered point test: (Visual working memory): Similarly, only the post-operative test scores were available because of because of the above said reason

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall: score was the same in the pre op and post-operative period with no change in percentile rank.

Delayed recall improvement was seen by 2 and percentile rank remained the same for pre- and post-operative conditions, placing them in the 40th percentile group.

Long term percent retention fell from 116.6 to 100 with a fall from 90th to 80th percentile group.

Recognition: scores had decreased by a value of 1 causing the percentile score to change from 95 to 50.

d. Rey-Osterrieth Complex figure test (ROCF): (Visuoconstructive ability and visual memory)

Copy score had deteriorated from 8.5 to 1, with a percentile of 5.

Immediate recall score decreased from by 4 and a percentile of 5 after surgery.

Delayed recall score had only post-operative values because of as patient was not cooperative before surgery, was irritable.

Memory																							
Verbal N Back										SOPT		RAVLT								Rey Complex					
1 B Hits	P	1 B Error	P	2 B Hits	P	2 Beror	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
-	-	-	-	-	-	-	-	-	-	9	50	7	40	116.6	90	15	95	8.5	5	5.5	5	-	-
6	**40**	11	6	2	5	10	6	3	94	9	50	9	40	100	80	14	50	1	5	1.5	5	0	5

D. Speed (Mental speed)

Speed	
Digit Symbol	
Time (sec)	P
-	-
-	-

Test for Mental speed had not been assessed due to refractory error and patient did not wear corrective spectacles

E. Verbal comprehension

Comprehension	
Token	
Correct	P
26.5	
24.5	

Token test score decreased by a score of 2,

F. The Wechsler Adult Intelligence Scale – IV

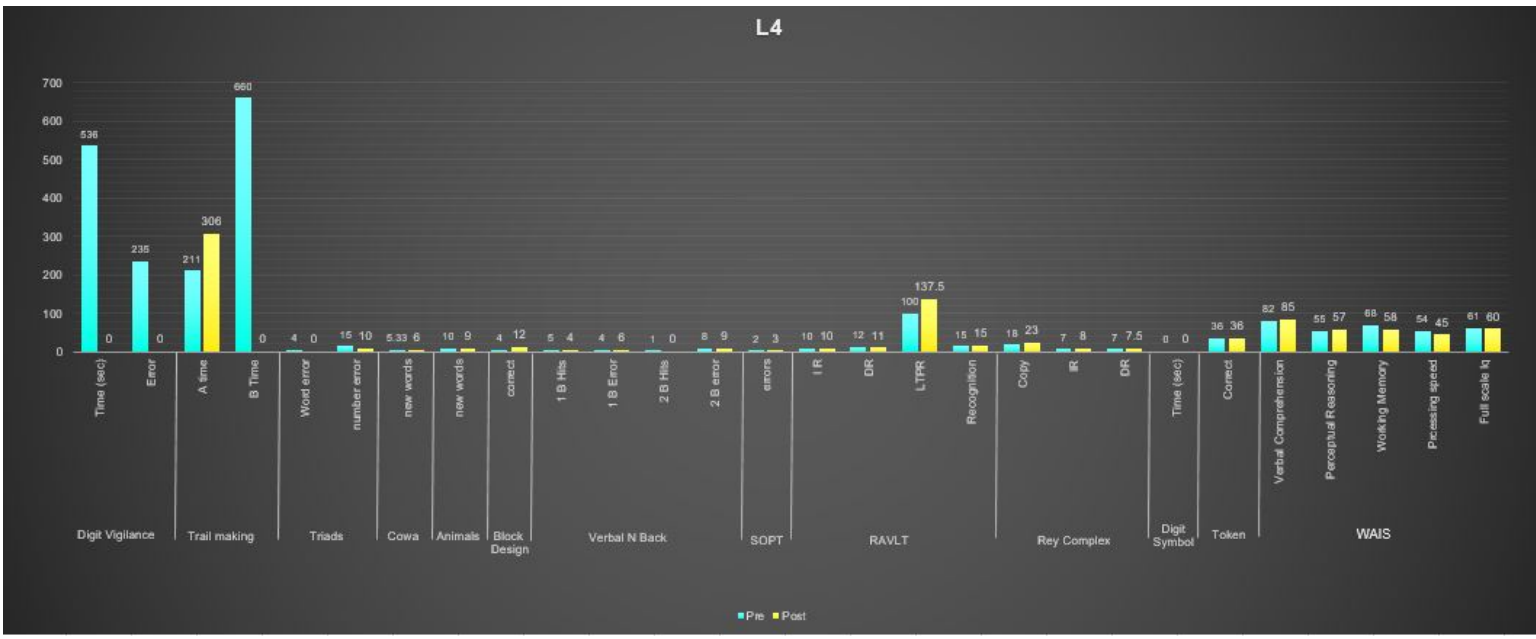
a. Verbal comprehension and perceptual reasoning had only post-operative scores available

c. Working memory, processing speed and Full-scale remained unassessed due to Lack of cooperation by the patient

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
-	-	-	-	-	-	-	-	-	-
64	1	54	0.1	-	-	-	-	-	-

Pre comments- Deficient scores indicate difficulty in sustained attention, divided attention, focused attention, verbal working memory, visuo-constructive ability and visual memory. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores. IQ score of 61 indicate extremely low level of intelligence.

Post comments: Defict scores indicate difficulty in Planning, Verbal fluency, Verbal Working memory, Visuo-constructive ability and visual memory. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.



2. L4: 52 year old Female patient, educated up to the tenth standard, diagnosed with Left Cerebellopontine Angle vestibular schwannoma. EVD was inserted intraoperatively and was under high pressure. It was subsequently removed on POD 2.

B. Attention:

	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	536	64	235	3	211	2	660	5	4	-	15	5
Post	-	-	-	-	306	**2**	-	-	0	-	10	**5**

Digit vigilance, Trail making test and Triads were not possible in post operative period in view of strain to the eyes.

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
5.33	30	10	25	4	
6	40	9	20	12	

a. COWAT (Verbal fluency) - showed an increase in number of new word formation from 5.33 to 6 and a corresponding percentile rank of 40.

b. Animal name test (Category fluency)showed increase in number of new word formation by 1 accounting for a decrease in percentile score to 20.

c. Design fluency (Planning)assessed with blocks showed an increase in number of designs made from 4 to 12

C. Memory

Memory																							
Verbal N Back								SOPT		RAVLT								Rey Complex					
1B Hits	P	1B Error	P	2B Hits	P	2B error	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
5	5	4	23	1	5	8	6	2	97	10	20	12	40	100	90	15	95	18	10	7	5	7	10
4	**5***	6	**11**	0	**5***	9	**3**	3	57	10	50	11	60	137.5	95	15	95	23	**15***	8	**10**	7.5	**10***

a. Verbal N back: (Verbal working memory)

1B hit score increased by a score of 1 causing a change in percentile score to 5. There was an increase in error in the post-operative period signifying a decrease in the score from 23rd percentile to 11.

2B hit score decrease to 0 causing a change in percentile score to fall below 5. The error increased by a score of 1 which corresponded to a percentile rank of 3.

b. Self-ordered point test (Visual working memory): The score did not improve after surgery, i.e., the error increased from 2 to 3 and the patient regressed from the 97th percentile to 57th.

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall: score was the same in the pre op and post-operative period with no change in percentile score.

Delayed recall had reduced by 1 and with a change in percentile rank from 40 to 60.

Long term percent retention fell from 100 to 137.5 with an increase in percentile by a score from the 90th to 95th percentile.

Recognition: scores remained unchanged in the pre and post op period.

d. Rey-Osterrieth Complex figure test (ROCF): Visuoconstructive ability and visual memory)

Copy score had changed between pre- and post-operative periods from 18 to 23 which corresponded to a percentile score of 15*.

Immediate recall score increased by a score of 1 and a percentile of 15 after surgery.

Delayed recall score increased 7 to 7.5 and a percentile of 10 after surgery.

D. Test for Mental speed remained unchanged in the pre and post operative period

Speed	
Digit Symbol	
Time (sec)	P
-	-
-	-

E. Token test (Verbal comprehension) score remained the same for both pre- and post-operative procedure

Comprehension	
Token	
Correct	P
36	
36	

F. The Weshcler Adult intelligence score-4

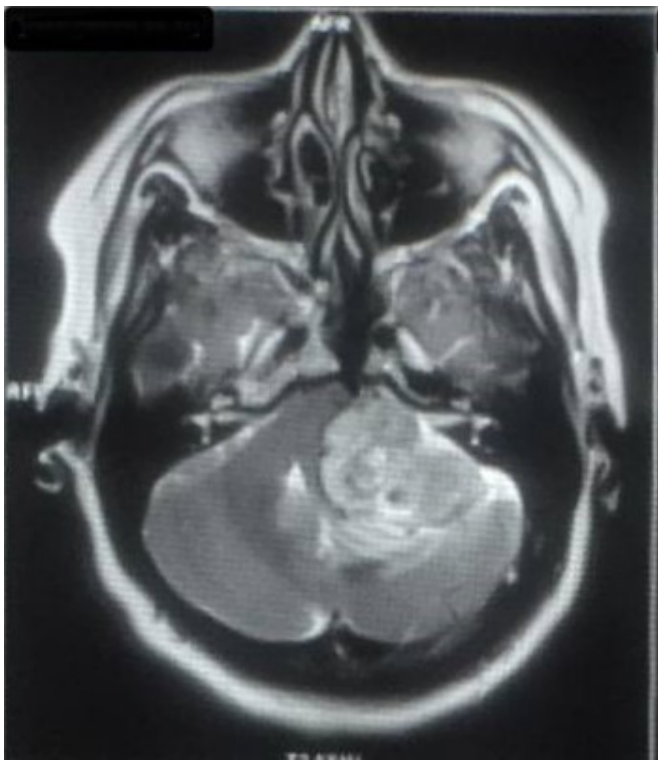
WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
82	12	55	0.1	68	2	54	0.1	61	0.5
85	16	57	0.2	58	0.3	45	<0.1	**60**	0.4

a. Verbal comprehension improved from by 3 points and a corresponded to the 16th percentile. b. Perceptual reasoning increased by 3 points and a percentile score of 0.2

c. Working memory reduced from 68 to 58 and a corresponding percentile dip from 2 to 0.3.

d. Processing speed also decreased by a value of 9 and a percentile rank of < 0.1.

e. Full scale IQ decreased postoperatively by 1, and a percentile of 0.4

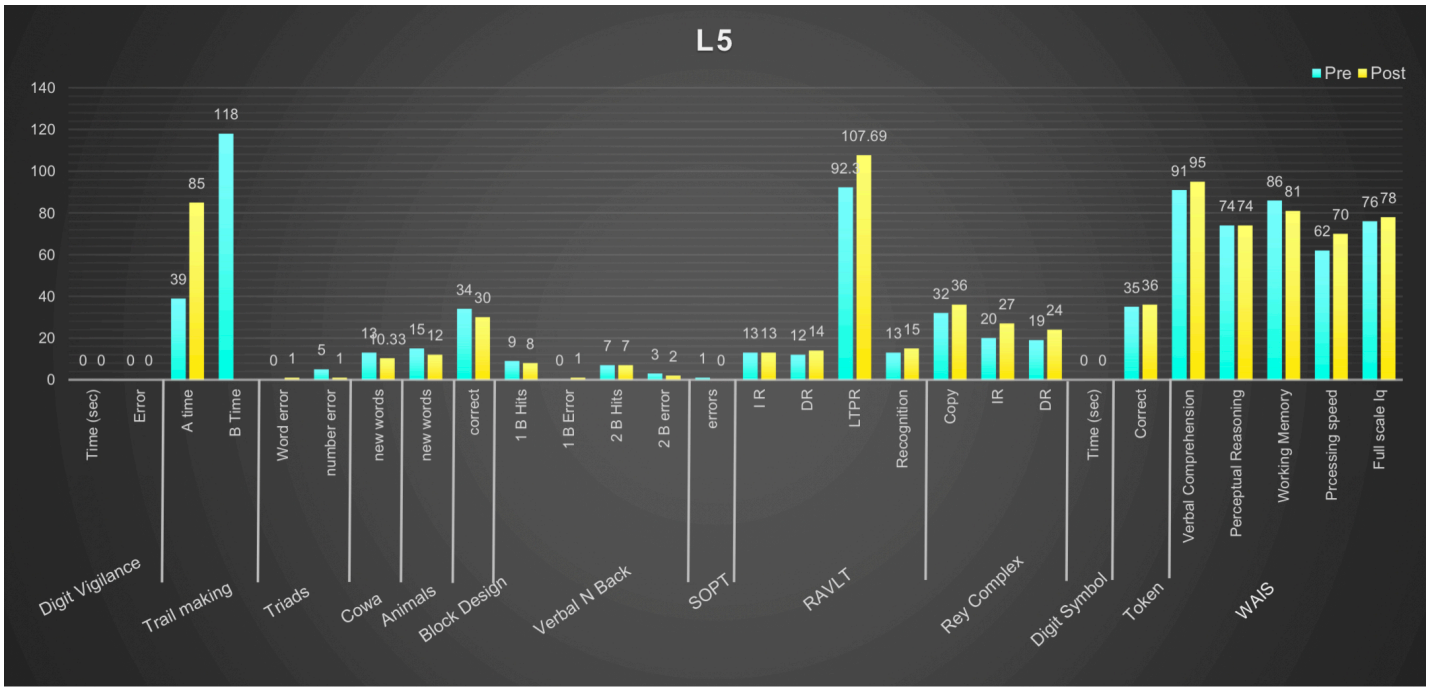


Pre- Deficient scores indicate difficulty in sustained attention, divided attention, focused attention, verbal working memory, visuo-constructive ability and visual memory. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores. IQ score of 61 indicate extremely low level of intelligence.

Post comments: Deficit scores indicate difficulty in Attention, Verbal working memory, Visuo-constructive ability and Visual Memory. Normal performance in all the other tests in Nimhans Battery without any significant deviation from the normative percentile scores.

IQ score of 60 indicating Extremely Low Intelligence level.

3. **L5**: 35-year-old male patient, who has completed graduation, diagnosed with left Cerebellopontine Angle vestibular schwannoma.



A. Attention

	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	-	-	-	-	39	94	118	62	0		5	
Post	-	-	-	-	85	35	-	-	1		1	

A. Digit vigilance:(Sustained attention) This assessment was not possible in view of refractory error and writing difficulty with right hand.

B. Trail making test: (Focussed attention and visual scanning) Time to connect the numbers has gone up by 63s and corresponding to percentile rank of 35 post-surgery. Time to draw line between numbers and coloured circles in an alternate manner pre-operation was 118, equivalent to the 62nd percentile. Post-operative was not completed due to exhaustion.

C. Triads (Divided attention) - The verbal triad test showed an increase in error by 1. The tactile number identification task showed a decrease in error by 4.

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
13	70	15	70	34	
10.33	40	12	30	30	

a. COWAT (Verbal fluency) - showed an decrease in number of new word formation from 13 to 10.33 and a percentile drop from 70th group to 40.

b. Animal name test (Category fluency) showed decrease in number of new word formation by 3 accounting for a drop in percentile to 30.

c. Design fluency (Planning) assessed with blocks showed an decrease in number of designs made from 34 to 30.

C. Memory

Memory																							
Verbal N Back								SOPT		RAVLT								Rey Complex					
1B Hits	P	1B Error	P	2B Hits	P	2B error	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
9	95	0	100	7	50	3	62	1	100	13	60	12	40	92.3	40	13	**10***	32	**5***	20	25	19	25
8	30	1	41	7	50	2	79	0	100	13	60	14	70	107.69	90	15	95	36	95	27	60	24	50

a. Verbal N back: (Verbal working memory)

1B hit score decreased by a score of 1 causing a change in percentile score by 65 with an error score of 1 in the post-operative period corresponding to 41st percentile group.

2B hit score remained the same for both pre-operative and post-operative condition and the error count decreased by a count of 1 with a percentile rank of 79.

b. Self-ordered point test:(Visual working memory) The score improved after surgery, i.e., the error reduced to 1 from 0 and the patient improved by a percentile score of 100. c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall: score was the same in the pre op and post-operative period with no change in percentile score.

Delayed recall improvement was seen by 2 and percentile score increased by 30.

Long term percent retention had a hike from 92.3 to 107.3 with an increase in percentile to the 90th group.

Recognition: scores remained increased from 13 to 15 corresponding to the 95th percentile group.

d. Rey-Osterrieth Complex figure test (ROCF): (Visio-constructive ability and visual memory)

Copy score increased to 36 corresponding to the 95th percentile group.

Immediate recall score increased by 7 and a percentile of 60 after surgery.

Delayed recall score increased by 5 and a corresponded to the 50th percentile group.

D. Speed

Test for Mental speed was not assessed because of exhaustion and writing difficulty.

Speed	
Digit Symbol	
Time (sec)	P
-	-
-	-

E. Token test score (Verbal comprehension) increased by a score of 1.

Comprehension	
Token	
Correct	P
35	
36	

F. The Wechsler Adult Intelligence Scale – IV

WAIS									

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
91	27	74	4	86	18	62	1	**76**	**5**
95	37	74	4	81	10	70	2	**78**	7

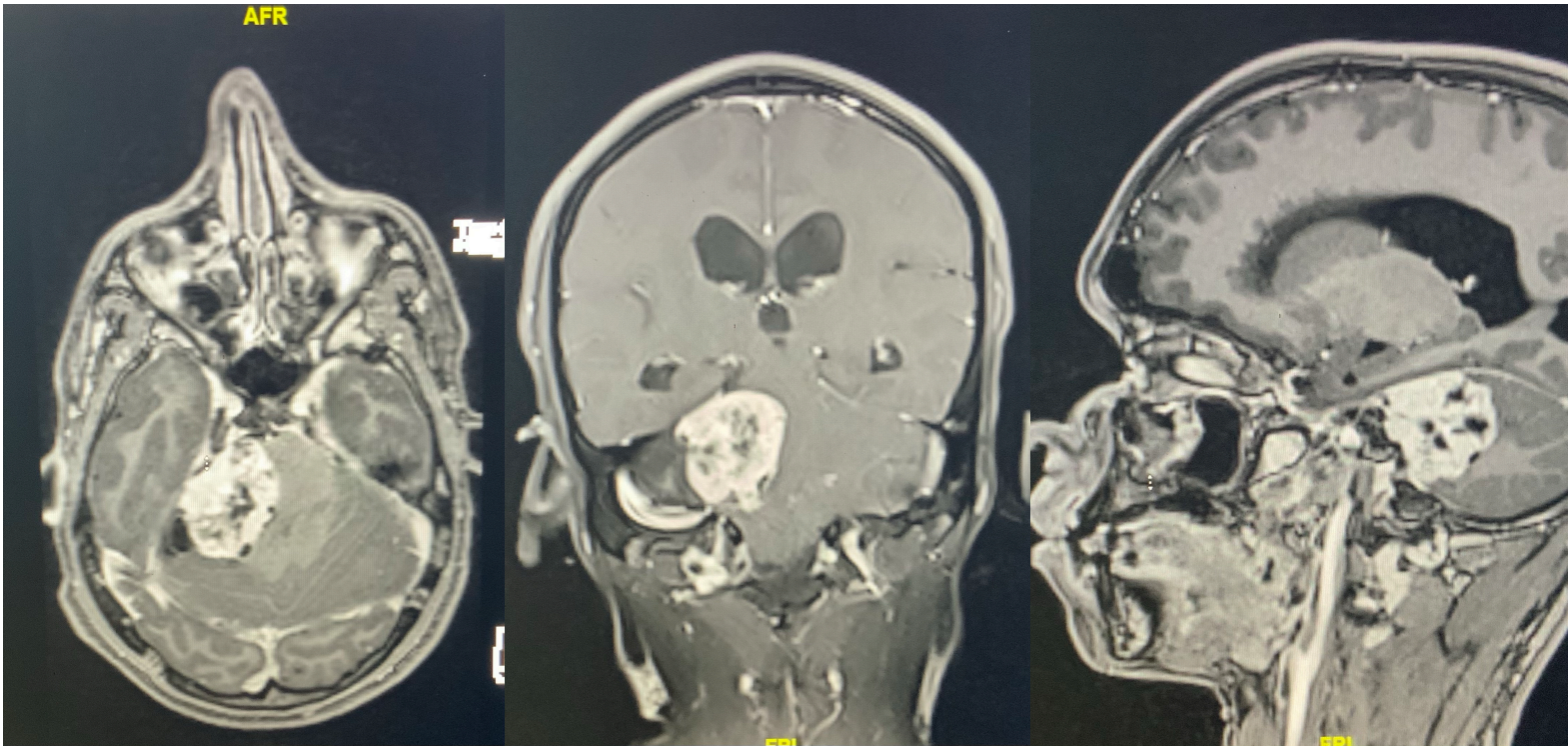
a. Verbal comprehension improved from by 4 points and a percentile jump from 27 to 37.

b. Perceptual reasoning remained the same between pre- and post-operative conditions.

c. Working memory decreased by a value of 5 reducing the percentile rank from 18 to 10.

d. Processing speed increased by 8 points and a percentile score of 2.

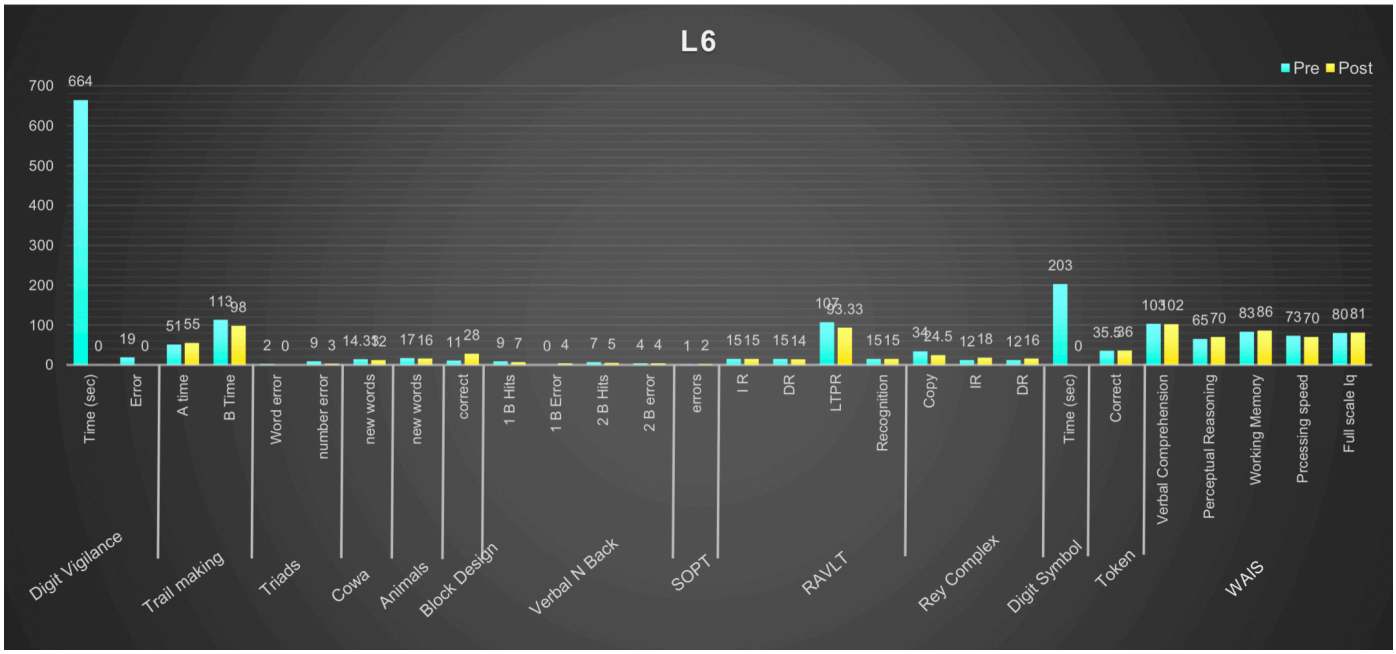
e. Full scale IQ increased postoperatively by 2,



Pre comments: Deficit scores indicating difficulty in Visuo-constructive ability and Recognition. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores. IQ score of 76 indicates Borderline Intelligence level.Post comments: No deficit scores. Normal range of performance in all the tests without any significant deviation from the normative percentile scores.

IQ score of 78 indicating Borderline Intelligence Level.

4. **L6**: 44-year-old female patient, enrolled in college, diagnosed with left Cerebellopontine Angle vestibular schwannoma.



A. Attention:

A. Digit vigilance (Sustained attention): The pre-operative score for this test was a time of 664s with a percentile rank of 3 and an error of 19. Due to eye strain in the post operative period the test could not be done.

B. Trail making test (Focussed attention and visual scanning): Time to connect the numbers has gone up by 5s and fallen by 13 percentile post surgery. Time to draw line between numbers and coloured circles in an alternate manner has come down by 20s and percentile rank increased to the 77th group in the post-operative period.

C. Triads (Divided attention)- The verbal triad test showed a decrease in error to 0. The tactile number identification task showed a decrease in error by a value of 6.

	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	664	3	19	6	51	71	113	55	2		9	
Post	-	-	-	-	55	58	98	77	0		3	

B. Executive function

Executive functions		
COWAT	Animals	Block Design

Executive functions					
new words	P	new words	P	correct	P
14.33	80	17	60	11	
12	60	16	50	28	

a. COWAT (Verbal fluency) - showed a decrease in number of new word formation from 14.33 to 12 and a percentile drop to 60.

b. Animal name test (Category fluency)showed decrease in number of new word formation by 1 accounting for a decrease in percentile by 10.

c. Design fluency (Planning) assessed with blocks showed an increase in number of designs made from 11 to 28.

C. Memory

Memory																							
Verbal N Back								SOPT		RAVLT								Rey Complex					
1B Hits	P	1B Error	P	2B Hits	P	2B error	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
9	95	0	100	7	25	4	39	1	100	15	95	15	95	107	95	15	95	34	15	12	5	12	10
7	10	4	7	5	10	4	39	2	82	15	95	14	60	93.33	50	15	95	24.5	5	18	20	16	15

a. Verbal N back: (Verbal working memory)

1B hit score decreased by a score of 2 causing a change in percentile score to10 with an increase in error the post-operative period to 4 with a percentile drop to 7.

2B hit score decreased by 2 causing the change in percentile score by 15 with error rate remaining the same value of 4, both pre- and post-operative condition.

b. Self-ordered point test: (Visual working memory) The score deteriorated post surgery, i.e., the error increased from 1 to 2 and the patient had a corresponding percentile score of 82. c. C. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal leaning)

Immediate recall: score was the same in the pre op and post-operative period with no change in percentile score.

Delayed recall improvement was seen by 1 and percentile score decreased by 35.

Long term percent retention fell from 107 to 93.33 with a fall in percentile by a score from 95th group to 50.

Recognition: scores remained unchanged in the pre and post op period.

d. Rey-Osterrieth Complex figure test (ROCF): (Visuo-constructive ability and visual memory)

Copy score reduced to a score of 24.5 during the post-operative periods with a corresponding percentile rank of 5.

Immediate recall score increased by 6 and to a percentile rank of 20 after surgery.

Delayed recall score increased by 4 and a percentile of 15 post surgery.

D. Speed

The time take for to test for Mental speed was 203, pre-surgery putting the patient in the 33rd percentile. Post operatively the test could not be done

Speed	
Digit Symbol	
Time (sec)	P
203	33
-	

E. Token test score (Verbal comprehension) increased by a score of 0.5.

Comprehension	
Token	
Correct	P
35.5	
36	

F. The Wechsler Adult Intelligence Scale – IV

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
103	58	65	1	83	13	73	4	80	9
102	55	70	2	86	18	70	2	81	10

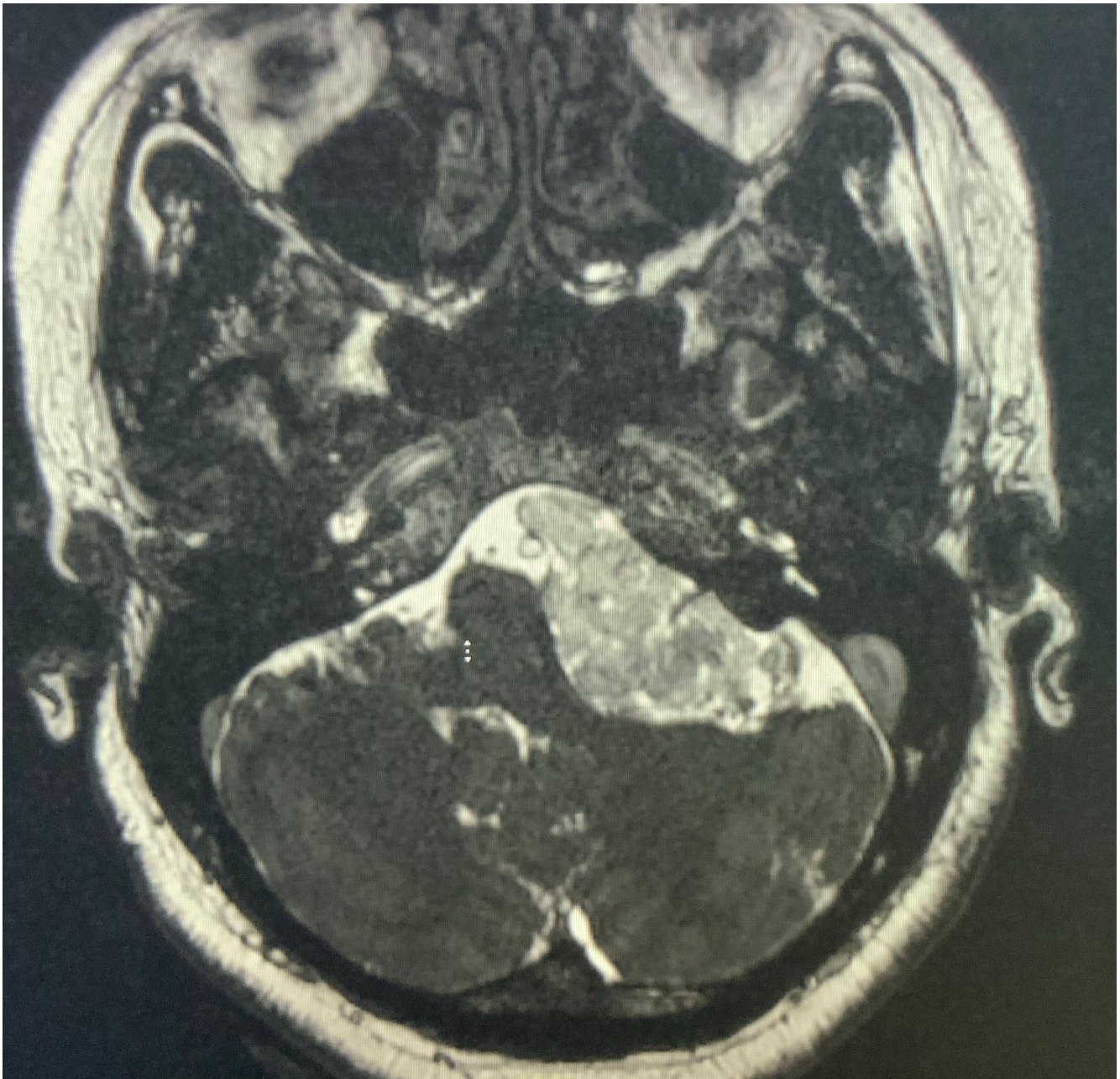
a. Verbal comprehension reduced by 1 point and a percentile drop of 55.

b. Perceptual reasoning increased by 5 points and a percentile score of 2

c. Working memory improved to 86 corresponding to a percentile score of 18.

d. Processing speed decreased by 3 points and a percentile score of 2.

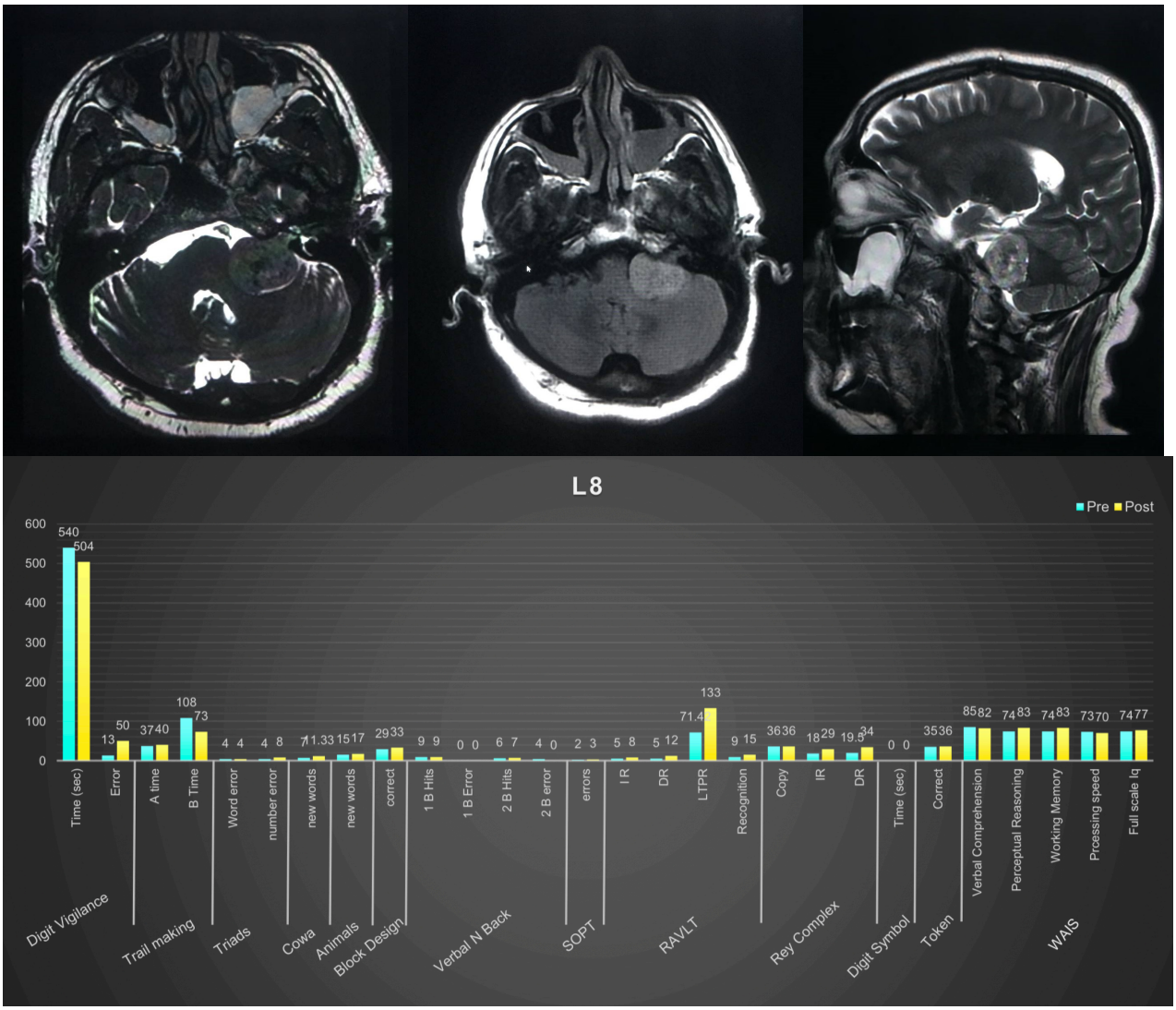
e. Full scale IQ increased postoperatively by 1, and a percentile of 10.



Pre Comments: Deficient scores in Digit Vigilance test, block design test, Triads test and Rey complex figure test indicates difficulty in sustained attention, divided attention, processing speed, visual memory and spatial visualization ability. However, Verbal learning and memory are found to be intact.
Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.
IQ score of 80 indicating Low Average intelligence level.

Post comments : Deficient scores indicate difficulty in verbal working memory, Visuo-constructive ability and visual memory. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.
IQ score of 81 indicate low average intelligence level.

5. ***L8***: 46-year-old male patient, educated up to the tenth standard, diagnosed with left Cerebellopontine Angle vestibular schwannoma.



B. Attention:

	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	540	42	13	31	37	94	108	91	4		4	
Post	504	50	50	6	40	94	73	100	4		8	

A. Digit vigilance: (Sustained attention) Time decreased by 36 seconds with a corresponding percentile of 50 post-surgery. The error rate has increased in the post op test from 13 to 50.

B. Trail making test: (focused attention and visual scanning) Time to connect the numbers has gone up by 3s with a percentile of 94 post surgery. Time to draw line between numbers and

coloured circles in an alternate manner reduced by 35s with a percentile score of 100 in the post-operative period.

C. Triads - (Divided attention) The verbal triad test score was the same in the pre-op and post-operative period. The tactile number identification task showed a increase in error by 4.

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
7	50	15	70	29	
11.33	80	17	85	33	

a. COWAT - (Verbal fluency) showed an increase in number of new word formation from 7 to 11.33 and a corresponding percentile score of 80.

b. Animal name test (Category fluency) showed increase in number of new word formation by 2 accounting for an increased percentile score of 85.

c. Design fluency (Planning) assessed with blocks showed an increase in number of designs made from 29 to 33.

C. Memory

a. Verbal N back: (Verbal working memory)

1B hit score remained the same in the pre-op and post-operative period with no change in percentile score.

2B hit score increased by 1 causing percentile score to be 60 with a fall in error to 0 which had a percentile score 86.

b. Self-ordered point test: (Visual working memory) The error score increased from 2 to 3 and the patients

Memory			
Verbal N Back	SOPT	RAVLT	Rey Complex

Memory																							
1 BHits	P	1 BError	P	2 BHits	P	2 Berror	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
9	95	0	100	6	40	4	59	2	94	5	5	5	5	71.42	10	9	5	36	95	18	30	19.5	40
9	95	0	100	7	60	0	86	3	59	8	15	12	50	133	95	15	95	36	95	29	85	34	95

percentile score dropped to 59.

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall: The score improved in post-operative period by a value of 3 with the corresponding percentile score as 15.

Delayed recall improvement was seen by 7 and percentile score was 50.

Long term percent retention increased from 71.42 to 133 with a rise in percentile score to 95.

Recognition: scores improved in the post op period to 15, with the percentile being 95.

d. Rey-Osterrieth Complex figure test (ROCF): (Visuo constructive ability and visual memory)

Copy score remained unchanged between pre- and post-operative periods.

Immediate recall score increased from 18 to 29 and a percentile score of 85 after surgery.

Delayed recall score increased from 19.5 to 34 and had a percentile score 95 after surgery.

D. Speed

Test for Mental speed remained unassessed due to exhaustion.

Speed	
Digit Symbol	
Time (sec)	P
-	-
-	-

E. Token test score increased by a score of 1. (Verbal comprehension)

Comprehension	
Token	
Correct	P
35	
36	

F. The Wechsler Adult Intelligence Scale – IV

a. Verbal comprehension decreased by 3 points and a pe

rcentile drop to 12. b. Perceptual reasoning increased by 9 points and a percentile score of 13.

c. Working memory improved to a score of 83, falling in the 13th percentile group.

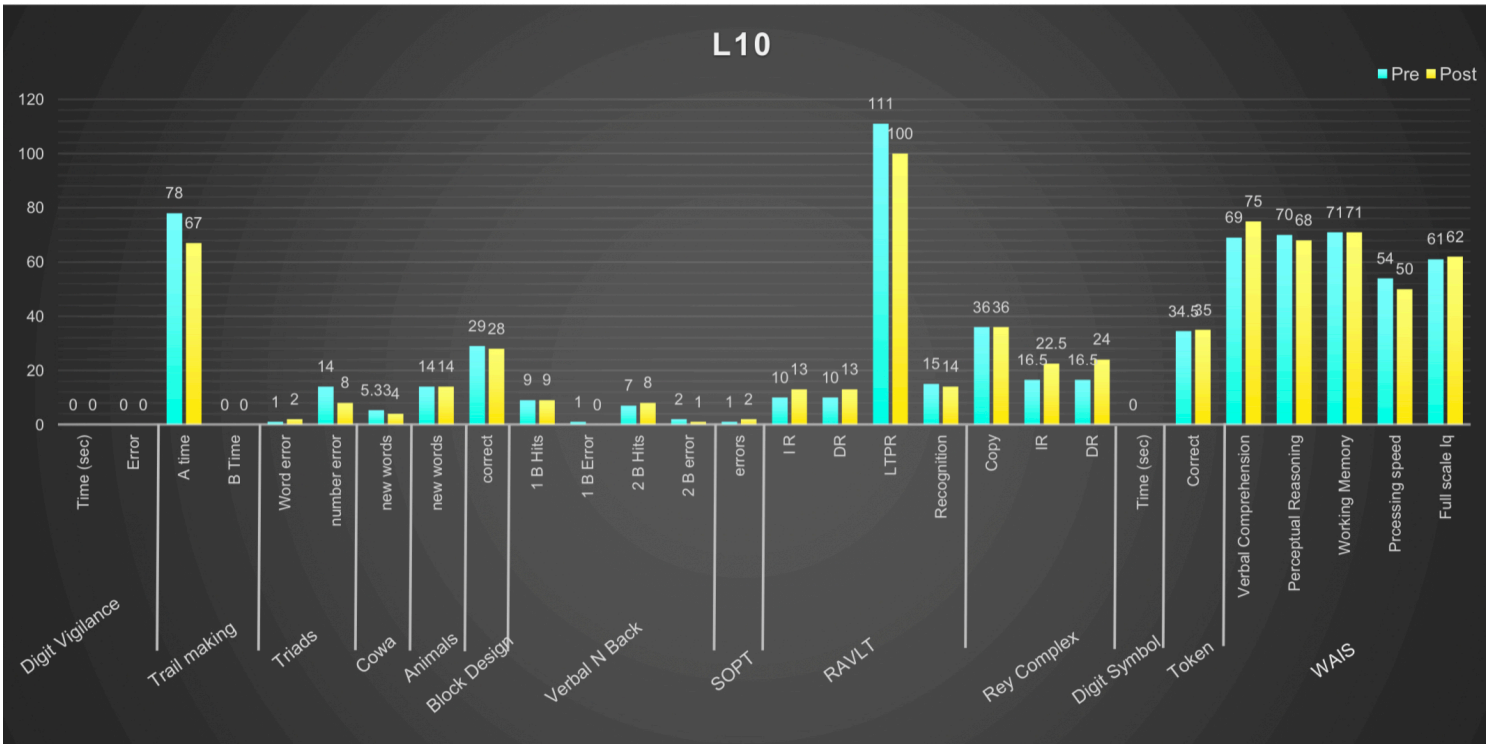
d. Processing speed decreased by 3 points and had a percentile score of 2

e. Full scale IQ increased postoperatively by 3, and a percentile of 6.

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
85	16	74	4	74	4	73	4	74	4
82	12	83	13	83	13	70	2	77	6

pre-Deficient scores indicate difficulty in verbal learning&memory. executive functions found to be intact. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.IQ score of 74 indicate borderline level of intelligence.
post-Deficient scores indicate difficulty in verbal learning&memory and focused attention.Normal range of performance in all the other tests without any significant deviation from the normative percentile scores. IQ score of 77 indicate borderline level of intelligence.

6. **L10**: 43-year-old female patient, educated up to 10th standard, diagnosed with right Cerebellopontine Angle vestibular schwannoma.



A. Attention:

A. Digit vigilance (Sustained attention): was not possible in view of difficulty reading as well as illiteracy.

B. Trail making test (Focussed attention and visual scanning): Time to connect the numbers has reduced by 11s and increased to a percentile rank of 72 post-surgery. Time to draw line was not possible due to inability to identify alphabets.

C. Triads (Divided attention)- The verbal triad test showed an increase in error by 1. The tactile number identification task showed a decrease in error from 14 to 8.

	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	-	-	-	-	78	50	-	-	1		14	5
Post	-	--	-	-	67	72	-	-	2		8	

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
5.33	30	14	70	29	
4	20	14	70	28	

a. COWAT (Verbal fluency)- showed an decrease in number of new word formation from 5.33 to 4 and a percentile rise drop to 20.

b. Animal name (Category fluency) showed no change in the score for the pre-surgery and post-surgery condition.

c. Design fluency (Planning) assessed with blocks showed an decrease in number of designs made from 29 to 28.

C. Memory

Memory																							
Verbal N Back								SOPT		RAVLT								Rey Complex					
1B Hits	P	1B Error	P	2B Hits	P	2B error	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
9	95	1	61	7	75	2	100	1	100	10	20	10	20	111	95	15	95	36	95	16.5	50	16.5	50
9	95	0	100	8	85	1	100	2	96	13	50	13	50	100	90	14	20	36	95	22.5	75	24	75

a. Verbal N back: (Verbal working memory)

1B hit had showed no change in the score for the pre-surgery and post-surgery condition. There was decrease for the error score to 0 which corresponded to a percentile rank of 100.

2B hit score increased by 1 causing the change in percentile score from 75 to 85 with a fall in error by 1 with the percentile rank remaining 100 for both pre- and post-operative conditions.

b. Self-ordered point test: (Visual working memory) The score slight decreased after surgery, i.e the error increase from 1 to 2 causing a percentile dip from 100 to 96.

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall: The score had increased from 10 to 13 with the percentile rank increasing to 50.

Delayed recall: Improvement was seen by 3 and percentile score increased by 30.

Long term percent retention fell from 111 to 100 with a fall in percentile by a score of 5.

Recognition: scores remained decreased by a value of 1, corresponding to a percentile score of 20.

d. Rey-Osterrieth Complex figure test (ROCF): (Visio-constructive ability and visual memory)

Copy score remained unchanged between pre and post-operative periods.

Immediate recall score increased from by 16.5 and a percentile of 22.5 after surgery.

Delayed recall score increased by 8.5 and a corresponding percentile of 75 after surgery.

D. Speed

Test for Mental speed remained was not assessed due to exhaution.

Speed	
Digit Symbol	
Time (sec)	P
-	-

E. Token test (Verbal comprehension) score increased by a score of 0.5.

Comprehension	
Token	
Correct	P
34.5	
35	

F. The Wechsler Adult Intelligence Scale – IV

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
69	2	70	2	71	3	54	0.1	61	0.5
75	5	68	2	71	3	50	<0.1	**62**	1

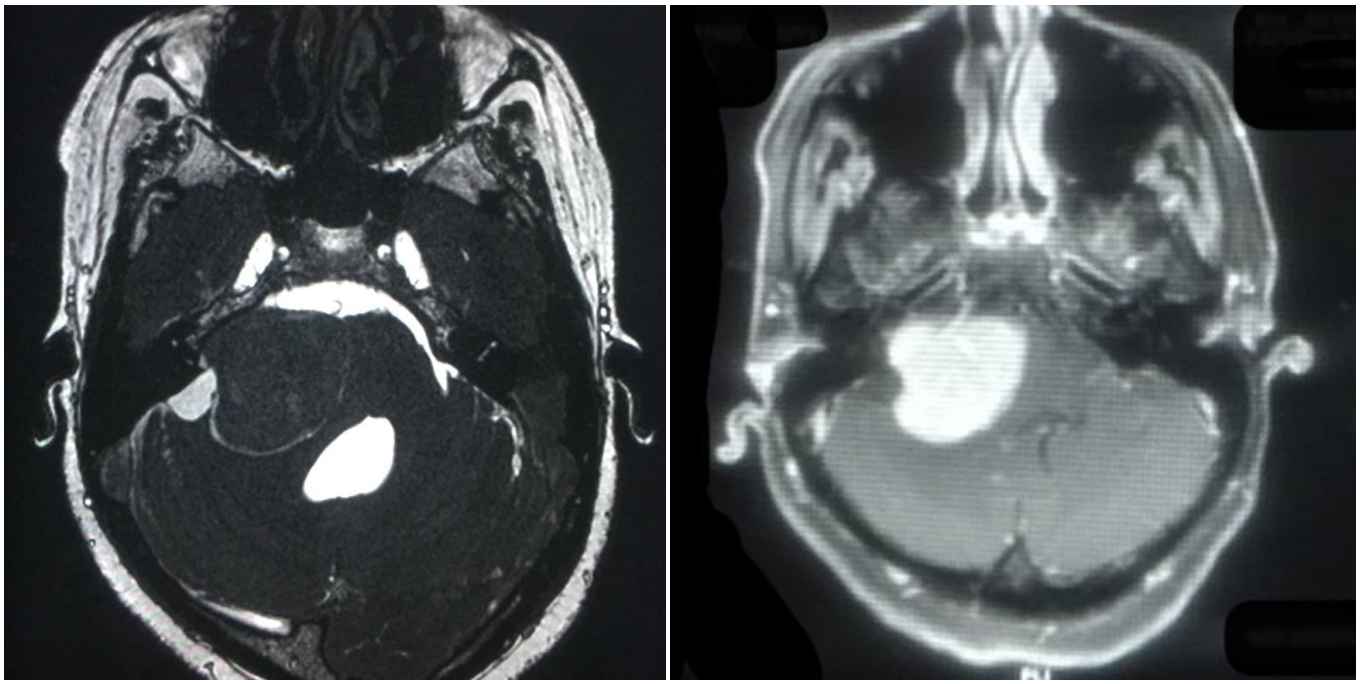
a. Verbal comprehension improved from by 6 points and a pe
rcentile jump of 3.

b. Perceptual reasoning reduced by 2 points and a percentile score of 2.

c. Working memory remained unaffected.

d. Processing speed decreased by 4 points and a percentile score of < 0.1.

e. Full scale IQ increased postoperatively to 62, and a percentile of 1.

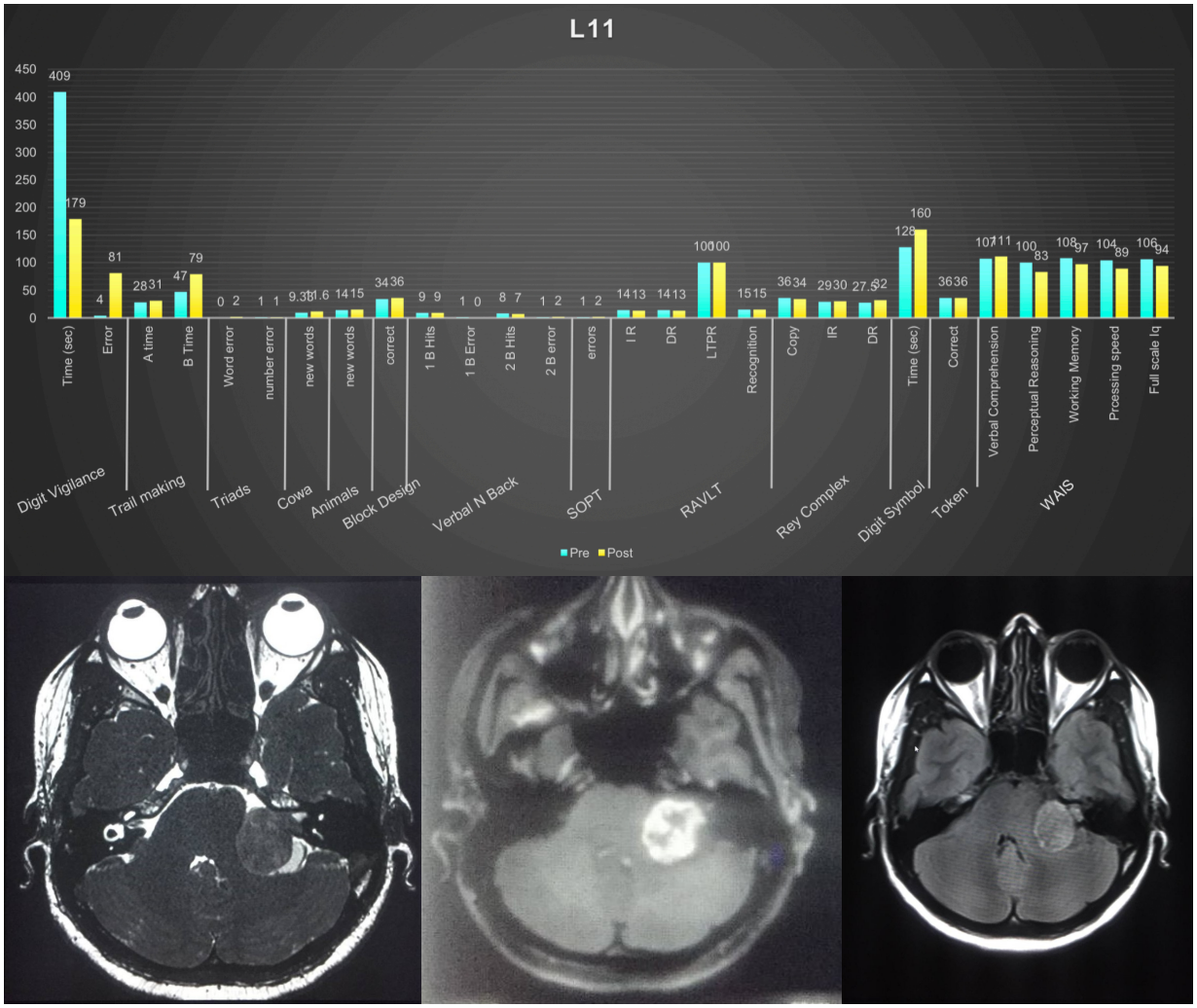


Pre Comments: Deficit score indicate difficulty in Divided attention. Normal range of performance in all the other tests in Nimhans Neuropsychological Battery without any significant deviation from the normative percentile scores. IQ score of 61 indicating extremely low intelligence level.

Post comments: No deficit scores. Normal range of performance in all the tests in Nimhans Neuropsychological Battery without any significant deviation from the normative percentile scores.

IQ score of 62 indicating Extremely Low Intelligence.

7. **L11**: 43-year-old female patient, educated up to the tenth standard, diagnosed with left Cerebellopontine Angle vestibular schwannoma.



B. Attention:

A. Digit vigilance: (Sustained attention) Time decreased by

	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	409	54	4	53	28	100	47	100	0		1	
Post	179	100	81	3*	31	100	79	100	2		1	

230 seconds with a 46 increase in percentile score post-surgery. The error rate had increased in the post op test from 4 to 81 with a drop in percentile score to 3.

B. Trail making test (Focussed attention and visual scanning): Time to connect the numbers has gone up by 3s with the percentile rank as 100. Time to draw line between numbers and coloured

circles in an alternate manner has gone up by 32s with a corresponding percentile rank of 100 in the post-operative period.

C. Triads (Divided attention) - The verbal triad test showed an increase in error by 2. The tactile number identification task remained the same pre- and post-surgery.

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
9.33	30	14	40	34	
11.6	50	15	40	36	

a. COWAT (Verbal fluency) - showed an increase in number of new word formation from 9.33 to 11.6 and an increase percentile rise 30 to 50.

b. Animal name test (Category fluency) showed increase in number of new word formation by 1 with a corresponding percentile rank of 40.

c. Design fluency (Planning) assessed with blocks showed an increase in number of designs made from 34 t0 36.

C. Memory

Memory																					
Verbal N Back								SOPT		RAVLT						Rey Complex					
1 B Hits	P	1 B Error	P	2 B Hits	P	2 Berror	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
9	95	1	29	8	75	1	94	1	100	14	75	14	60	100	90	15	95	36	95	29	70	27.5	70
9	95	0	100	7	25	2	71	2	82	13	50	13	60	100	90	15	95	34	15*	30	75	32	90

a. Verbal N back:(Verbal working memory)

1B hit score was the same in the pre-op and post-operative period with no change in percentile score and the error in the post-operative increased from 29 to 100 with a percentile drop to 7.
2B hit score decreased by 1 causing the change in percentile score to the 25th group with an increase in error by 1, corresponding to a percentile score of 71.

b. Self-ordered point test: (visual working memory): The score improved after surgery, i.e the error reduced to 1 from 2 and the patient improved by a percentile score of 48.

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)
Immediate recall: Here the score had a decline by a value of 1 with the percentile rank changing to 13.
Delayed recall also seen to have a decline by 1 and percentile score was 60.
Long term percent score was the same in the pre op and post-operative period with no change in percentile score.

d. Rey-Osterrieth Complex figure test (ROCF): (Visio-constructive ability and visual memory)
Copy score remained unchanged between pre- and post-operative periods.
Immediate recall score increased from by 9 and a percentile of 35 after surgery.
Delayed recall score increased by 7 and a percentile of 40 after surgery.
Recognition: The score remained unchanged for the pre- and post-operative conditions.

D. Speed
Test for Mental speed had increased by 32s in the post-operative period and caused a percentile dip to 67th group.

Speed	
Digit Symbol	
Time (sec)	P
128	100
160	67

E. Token test (Comprehension) score remained unchanged between pre- and post-operative periods

Comprehension	
Token	
Correct	P
36	
36	

F. The Wechsler Adult Intelligence Scale – IV

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
107	68	100	50	108	70	104	61	106	66
111	77	83	13	97	42	89	23	**94**	34

a. Verbal comprehension improved from by 4 points and a percentile jump from 68 to 77.

b. Perceptual reasoning reduced by 17 points having a percentile score of 13

c. Working memory reduced by a value 11, corresponding to a percentile score of 42.

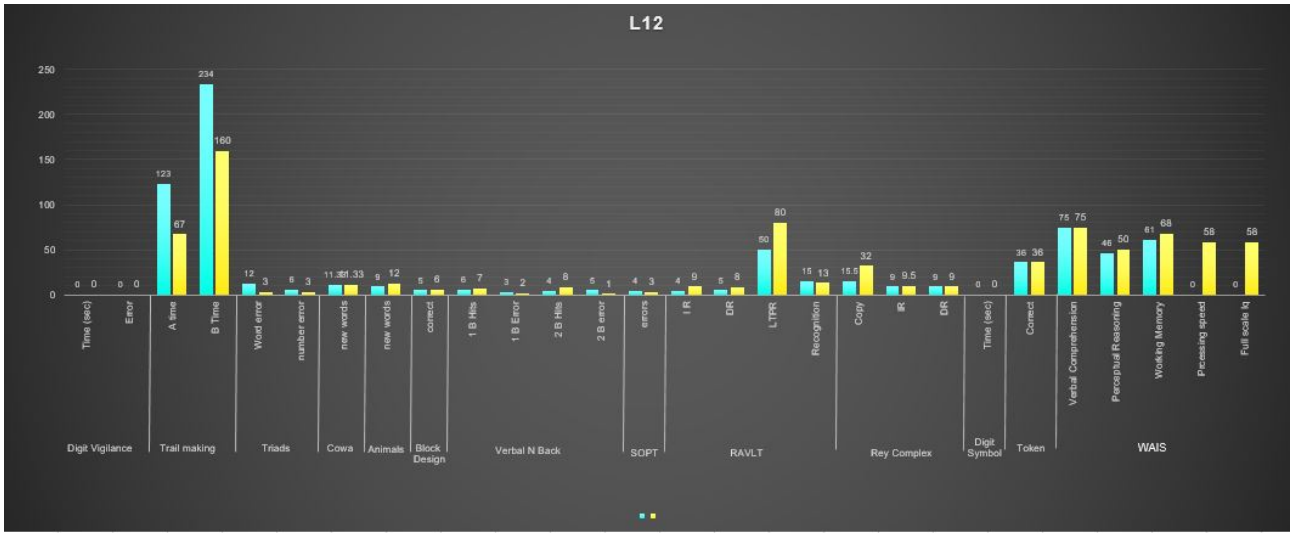
d. Processing speed decreased by 15 points and a percentile score changed from 61 to 23.

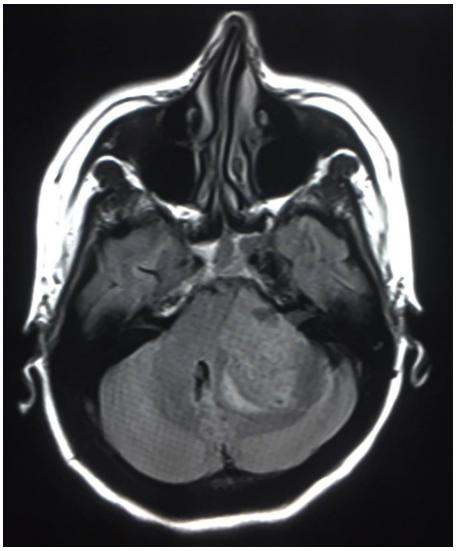
e. Full scale IQ increased postoperatively by 12, and a corresponding percentile of 32.

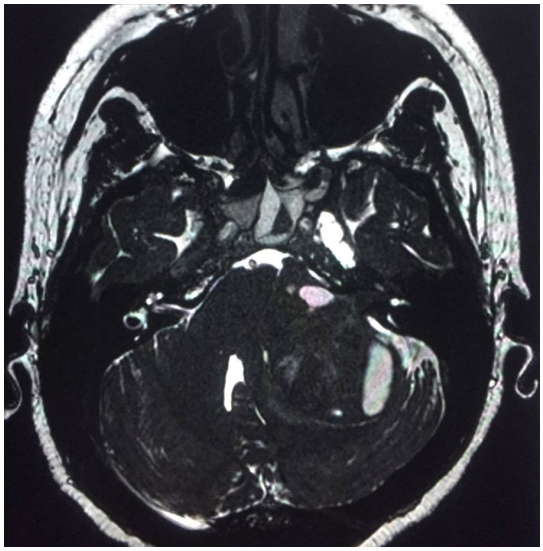
Pre- No deficit scores. Focused attention found to be intact. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.IQ score of 106 indicate average level of Intelligence.

Post- Deficit scores in sustained attention and Visuo-constructive ability. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.IQ score of 94 indicating Average level of Intelligence.

8. **L12**: 53-year-old female patient, educated up to her graduation, diagnosed with Left CP angle Vestibular schwanomma. Patient underwent VP shunting on POD 1 due to hydrocephalus and drop in sensorium.







A. Attention:
   A. Digit vigilance: This test was not assessed due to refractory error.
   B. Trail making test (Focussed attention and visual scanning): Time to connect the numbers had reduced by 56s with the percentile rank as 37. Time to draw line between numbers and coloured circles in an alternate manner had reduced by 74s with a corresponding percentile rank of 23 in the post-operative period.
   C. Triads (Divided attention)- The verbal triad test showed a decrease in error by 9. The tactile number identification task also reduced by a value of 3.

Attention		
Digit Vigilance	Trail Making	Triads

Attention											
Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
-	-	-	-	123	9	234	11	12		6	
-	-	-	-	67	37	160	23	3	-	3	-

B. Executive function

a. COWAT (Verbal fluency) - remained unchanged between pre- and post-operative periods

b. Animal name test (Category fluency) showed increase in number of new word formation by 3 with a corresponding percentile rank of 25.

c. Design fluency (Planning) assessed with blocks showed an increase in number of designs made by a value of 1.

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
11.33	40	9	10	5	
11.33	40	12	25	6	-

C. Memory

a. Verbal N back: (Verbal working memory)

1B hit score had increased by a score of 1 with a corresponding percentile rank of 20 and the 1B error score reduced by 1, having a percentile jump from 18 to 24.

2B hit score increased by 4 causing the change in percentile score to the 85th group with an decrease in error by 4, corresponding to a percentile score of 94.

b. Self-ordered point test: (visual working memory): The score improved after surgery, i.e the error reduced to 3 from 4 and the patient improved to a percentile score of 39.

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall: Here the score had a improvement in performance with a score of 9 having a percentile rank of 15.

Delayed recall also seen to improve by 3 and percentile score of 5.

Long term percent score improved in the post-operative period with a percentile score of 80.

Recognition: The score remained decreased by a value of 2 and had a percentile drop to 5.

d. Rey-Osterrieth Complex figure test (ROCF): (Visio-constructive ability and visual memory)

Copy score increased from 15.5 to 32 and a corresponding percentile score of 40.

Immediate recall score increased from 9 to 9.5 and had a percentile of 10 after surgery.

Delayed recall score remained unchanged for the pre- and post-operative conditions.

Memory																							
Verbal N Back								SOPT		RAVLT								Rey Complex					
1 B Hits	P	1 B Error	P	2 B Hits	P	2 B error	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
6	5	3	18	4	5	5	21	4	11	4	5	5	5	50	5	15	95	15.5	5	9	10	9	10
7	20	2	24	8	85	1	94	3	39	9	15	8	5	80	25	13	5	32	40	9.5	10	9	10

D. Speed

Test for Mental speed had not been evaluated due to Refractory error

Speed	
Digit Symbol	
Time (sec)	P
-	-
-	-

E. Token test score (Verbal comprehension) remained unchanged between pre- and post-operative periods

Comprehension	
Token	
Correct	P
36	-
36	-

F. The Wechsler Adult Intelligence Scale – IV

a. Verbal comprehension remained unchanged between pre- and post-operative periods

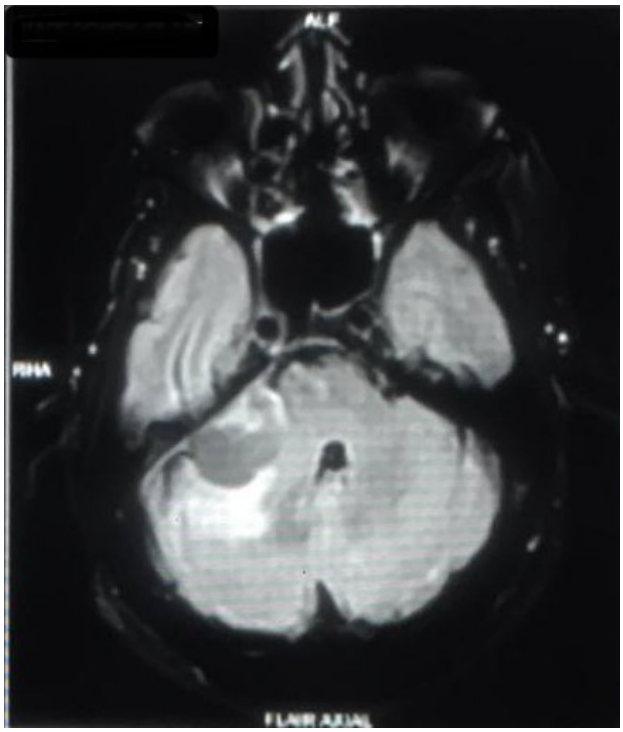
. b. Perceptual reasoning increased by 4 points having a percentile score of <0.1

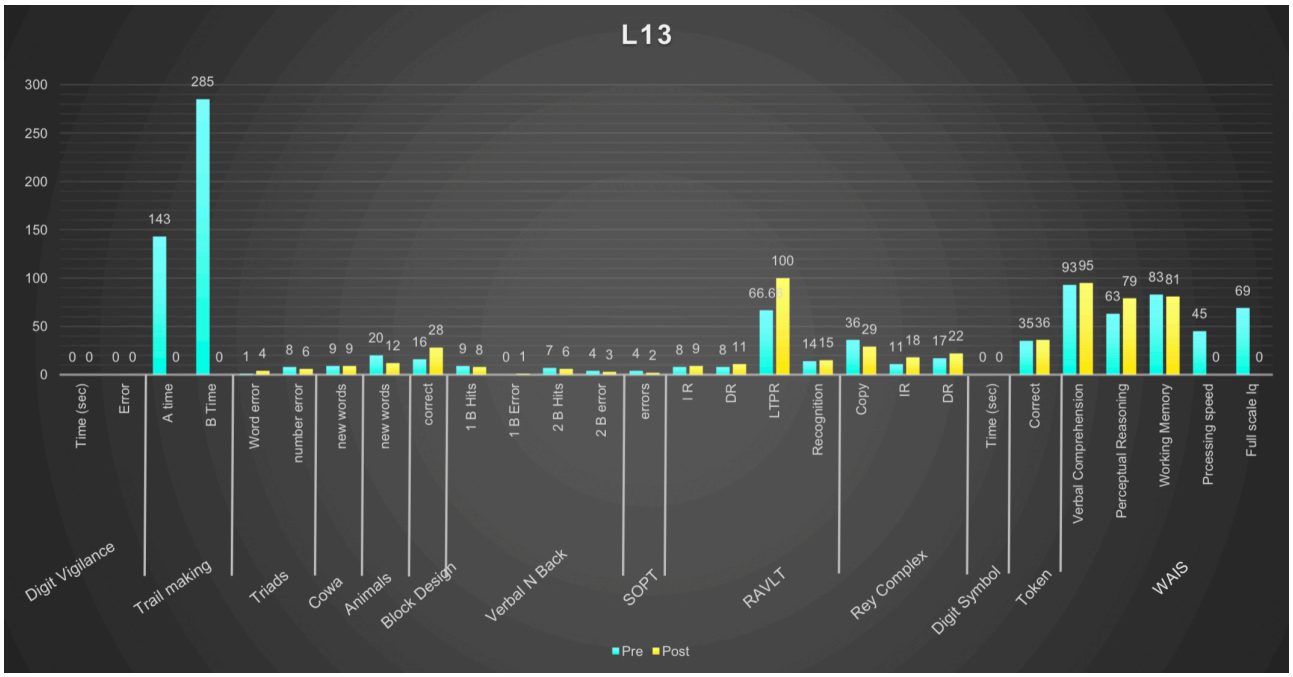
c. Working memory improved by a value 7, corresponding to a percentile score of 2.

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
75	5	46	<0.1	61	0.5	-	-	-	-
75	5	50	<0.1	68	2	58	0.3	58	0.3

d. Processing speed decreased and Full-scale IQ were not assessed pre-operatively due to the reason due to refractory error.

9. **L13**: 59-year-old male patient, educated up to the tenth standard, diagnosed with right Cerebellopontine Angle vestibular schwannoma.





B. Attention:

A. Digit vigilance:

	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	-	-	-	-	143	9	285	9	1		8	
Post	-	-	-	-	-	-	-	-	4		6	

This test was not assessed due to hearing difficulty and right eye visual deficit, both of which worsened following surgery.

B. Trail making test (Focussed attention and visual scanning): Time to connect the numbers was 143s pre-surgery and had a percentile score 9. Time to draw line between numbers and coloured circles in an alternate manner was 285s with a corresponding percentile score of 9.

C. Triads (divided attention)- The verbal triad test showed an increase in error by 3. The tactile number identification task showed a decrease in error by 2.

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
9	75	20	95	16	
9	75	12	60	28	

a. COWAT score (Verbal fluency) was the same in the pre-op and post-operative period with no change in percentile score.

b. Animal name test (Category fluency) showed decrease in number of new word formation from 20 to 12 accounting for an decrease in percentile to a score of 60.

c. Design fluency (Planning) assessed with blocks showed an increase in number of designs made from 16 to 28.

C. Memory

Memory			
Verbal N Back	SOPT	RAVLT	Rey Complex

Memory																							
1B Hits	P	1B Error	P	2B Hits	P	2B error	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
9	95	0	100	7	60	4	54	4	24	8	40	8	30	66.66	15	14	60	36	95	11	10	17	40
8	40	1	60	6	40	3	65	2	93	9	50	11	80	100	85	15	95	29	30	18	40	22	70

a. Verbal N back: (Verbal working memory)

1B hit score decreased by a score of 1 causing a change in percentile score from 95 to 40. There was an increase in error in the post-operative period by a value of 1, reducing the percentile to 60

2B hit score decreased by 1 causing the change in percentile score to 40, with a fall in error by 1, corresponding to a percentile rank of 65.

b. Self-ordered pointing test: (Visual working memory) The score improved after surgery, i.e the error reduced to 2 from 4 and the patient improved to a percentile group 93 .

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning).

Immediate recall: score had improved by a score of 1 with a corresponding percentile ranking of 50.

Delayed recall improvement was seen by a value of 3 and percentile score increased by 50.

Long term percent retention had risen from 66.66 to 100 with an increase in percentile to a score of 85.

Recognition: scores increased by a value of 1, with a corresponding percentile ranking of 95.

d. Rey-Osterrieth Complex figure test (ROCF): (Visuo-constructive ability and visual memory)

Copy score had changed between pre- and post-operative periods from 36 to 29 reducing the percentile rank to 30.

Immediate recall score increased from 11 to 18 and had a percentile score of 40 after surgery.

Delayed recall score increased by 5 and a percentile of 70 after surgery.

D. Speed

Test for Mental speed was not assessed due to vision and hearing difficulties

Speed	
Digit Symbol	
Time (sec)	P
-	-
-	-

E. Token test (verbal comprehension) score increased by a score of 1.

Comprehension	
Token	
Correct	P
35	
36	

F. The Weshcler Adult intelligence score-4

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
93	32	63	1	83	13	45	<0.1	69	2
95	37	79	8	81	10	-	-	-	-

a. Verbal comprehension improved by 2 points and a percentile jump to 37th group.

b. Perceptual reasoning increased by 16 points and had a percentile score of 8.

c. Working memory remained reduced by 2 points, corresponding to a percentile rank of 10.

d. Processing speed was scored as 45 pre-surgery, with the percentile <0.1

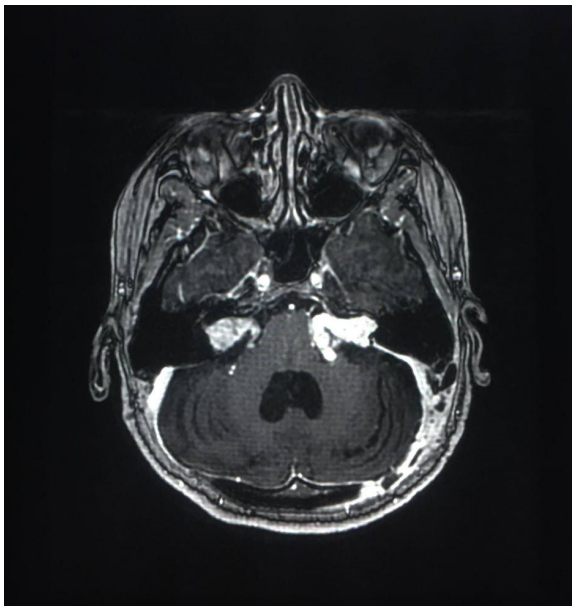
e. Full scale IQ was 69 pre-operatively and had a percentile of 2.

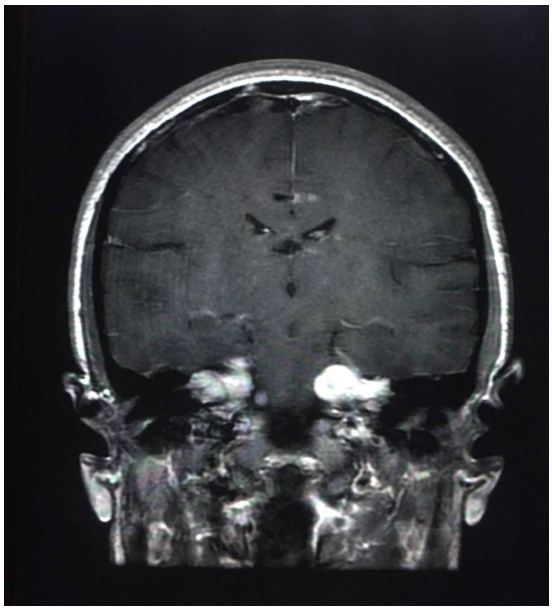
Processing speed and full scale IQ could not be assesses post operatively in view of hearing and visual difficulties.

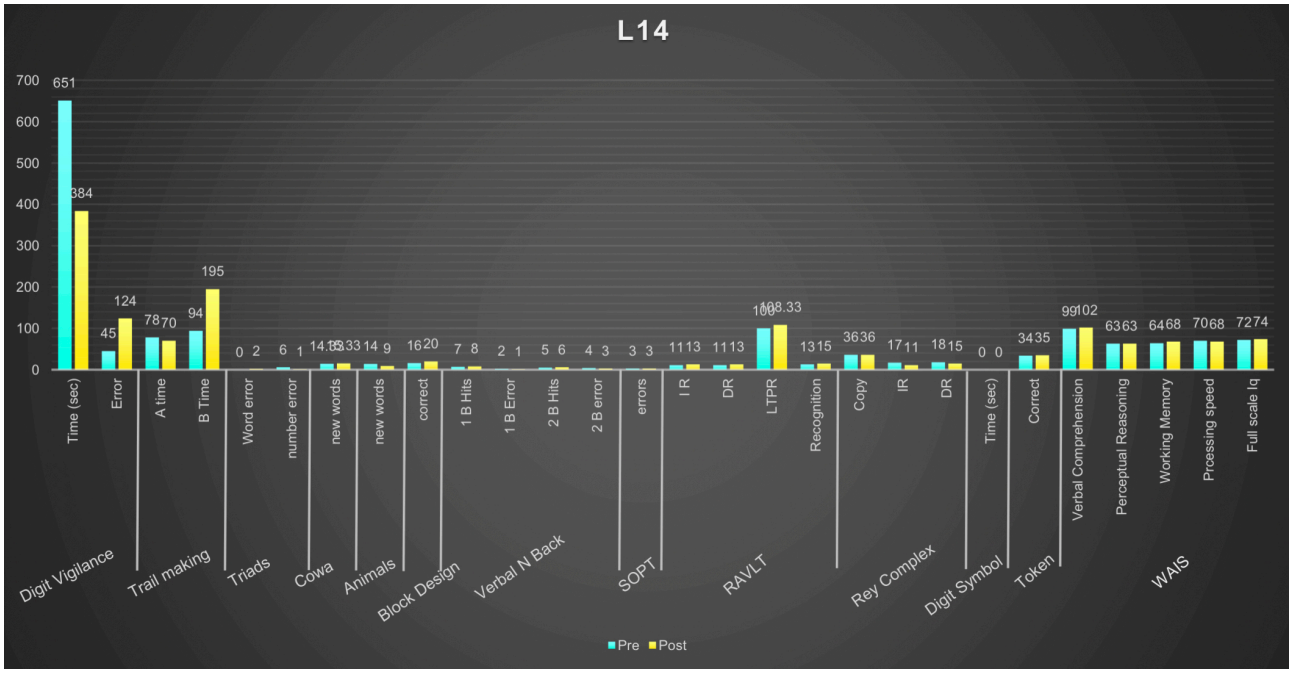
Pre- Deficient scores indicate difficulty in Verbal learning(Long-term retention rate),focused attention and visual memory. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores.IQ score of 69 indicate extremely low level of intelligence.

Post- no deficient scores. significant improvement in executive functions compared to the pre-op assessment.Normal range of performance in all the other tests without any significant deviation from the normative percentile scores

10. L14: 18-year-old female patient, educated up to the tenth standard, diagnosed with left Cerebellopontine Angle vestibular schwannoma.







C. Attention:

	Attention											
	Digit Vigilance				Trail Making				Triads			
	Time (sec)	Percentile	Error	P	A time	P	B Time	P	Word error	P	number error	P
Pre	651	23	45	**7***	78	39	94	90	0		6	
Post	384	100	124	4	70	48	195	36	2		1	

A. Digit vigilance (Sustained attention): Time decreased by 267 seconds with an increase in percentile ranking to 100 post-surgery. The error rate has increased post op test from 45 to 124.

B. Trail making test (focussed attention and visual scanning): Time to connect the numbers has gone down by 8s and had a corresponding percentile of 48 post-surgery. Time to draw line between numbers and coloured circles in an alternate manner has risen to 195s and had a percentile of 36 in the postoperative period.

C. Triads -(divided attention) The verbal triad test showed an increase in error by 2. The tactile number identification task showed a decrease in error by 5.

B. Executive function

Executive functions					
COWAT		Animals		Block Design	
new words	P	new words	P	correct	P
14.33	95	14	75	16	
15.33	95	9	20	20	

a. COWAT (Verbal fluency) - showed an increase in number of new word formation by a value of 1 and a percentile score of 95.

b. Animal name test (Category fluency): showed decrease in number of new word formation by 5 accounting for an decrease in percentile rank to 20.

c. Design fluency (Planning) assessed with blocks showed an increase in number of designs made from 16 to 20.

C. Memory

Memory																							
Verbal N Back								SOPT		RAVLT								Rey Complex					
1 B Hits	P	1 B Error	P	2 B Hits	P	2 B error	P	errors	P	IR	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P
7	30	2	**13***	5	30	4	27	3	50	11	30	11	30	100	80	13	**15***	36	95	17	30	18	40

Memory																								
8	30	1	33	6	15	3	50	3	50	13	60	13	60	108.33	90	15	95	36	95	11	10	15	25

a. Verbal N back: (Verbal working memory)

1B hit score increased by a score of 1 with the percentile score at 30 and had reduction in error in the post-operative period with percentile increasing from 13 to 33.

2B hit score increased by 1 causing the change in percentile score to 15. The error reduced by a count of 1, with a corresponding percentile of 50.

b. Self-ordered point test: (Visual working memory) The score remained the same pre- and post-operative conditions.

c. The Rey's Auditory verbal learning test (RAVLT): (Memory and verbal learning)

Immediate recall: score had increased from 11 to 13 in the post-surgical testing period with a corresponding percentile score of 60.

Delayed recall improvement was seen by 2 and percentile score increased to 60. Long term percent retention increased from 100 to 108.33 with a corresponding percentile score of 90.

Recognition: scores increased from 13 to 15 in the post-operative period with a percentile score of 95.

d. Rey-Osterrieth Complex figure test (ROCF): (Visuo-constructive ability and visual memory)

Copy score remained unchanged between pre- and post-operative periods.

Immediate recall score decreased by 6 and had a percentile of 10 after surgery.

Delayed recall score decreased by 3 and a percentile of 25 after surgery.

D. Speed

Test for Mental speed was not assessed due to exhaustion by the end of testing.

Speed	
Digit Symbol	
Time (sec)	P
--	--
-	-

E. Token test score (Verbal comprehension) increased by a score of 1.

The score for this test increased by a value of 1 in the post-operative period.

Comprehension	
Token	
Correct	P
34	
35	

F. The Wechsler Adult Intelligence Scale – IV

a. Verbal comprehension improved by 3 points and a percentile jump to 55.

b. Perceptual reasoning remained unchanged in the pre- and post-operative conditions.

c. Working memory increased by a value of 4 with a corresponding percentile of 2.

d. Processing speed decreased by 2 points and had a percentile score of 2

e. Full scale IQ increased postoperatively by 2, and had a percentile score of 4.

WAIS									
Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Processing speed	P	Full scale Iq	P
99	47	63	1	64	1	70	2	**72**	3
102	55	63	1	68	2	68	2	74	4

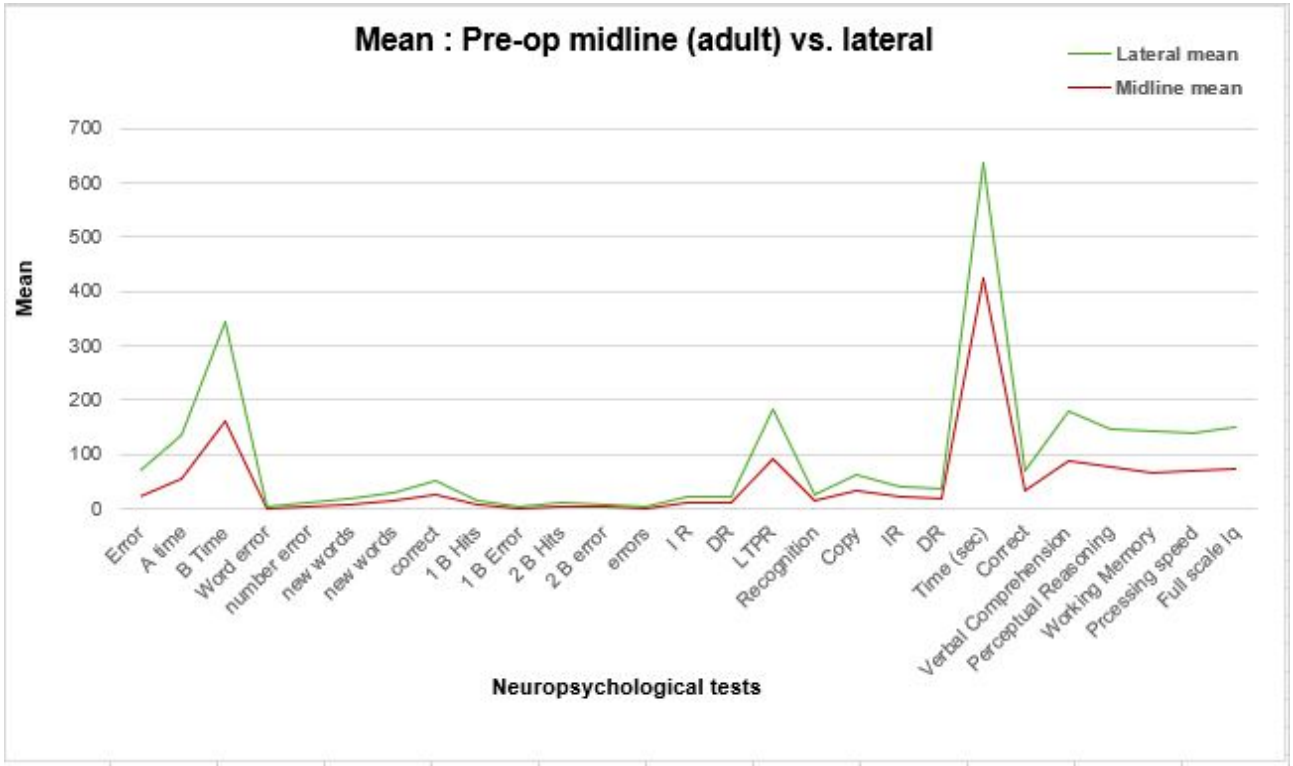
Pre comments: Deficit scores indicate difficulty in Attention and Verbal Recognition. Normal range of performance in all the other tests without any significant deviation from the normative percentile scores. IQ score of 72 indicating Borderline intelligence level.

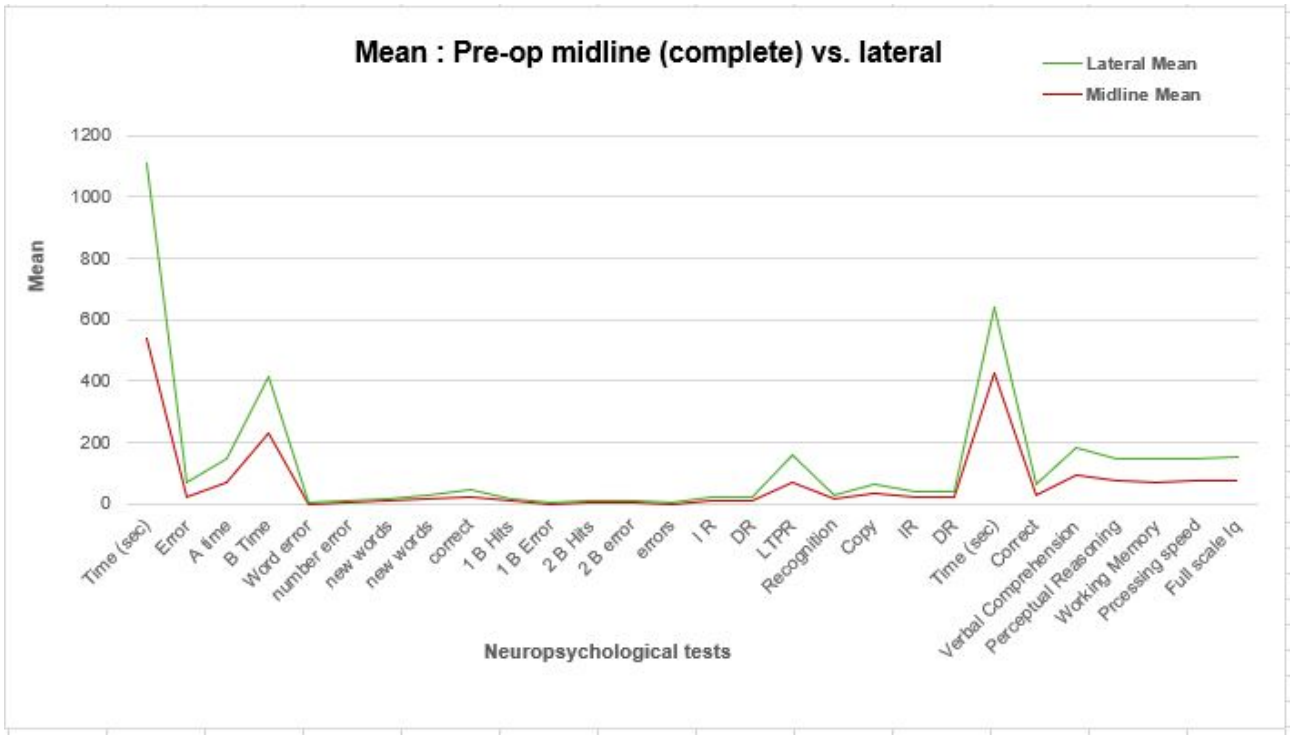
:

Group analysis

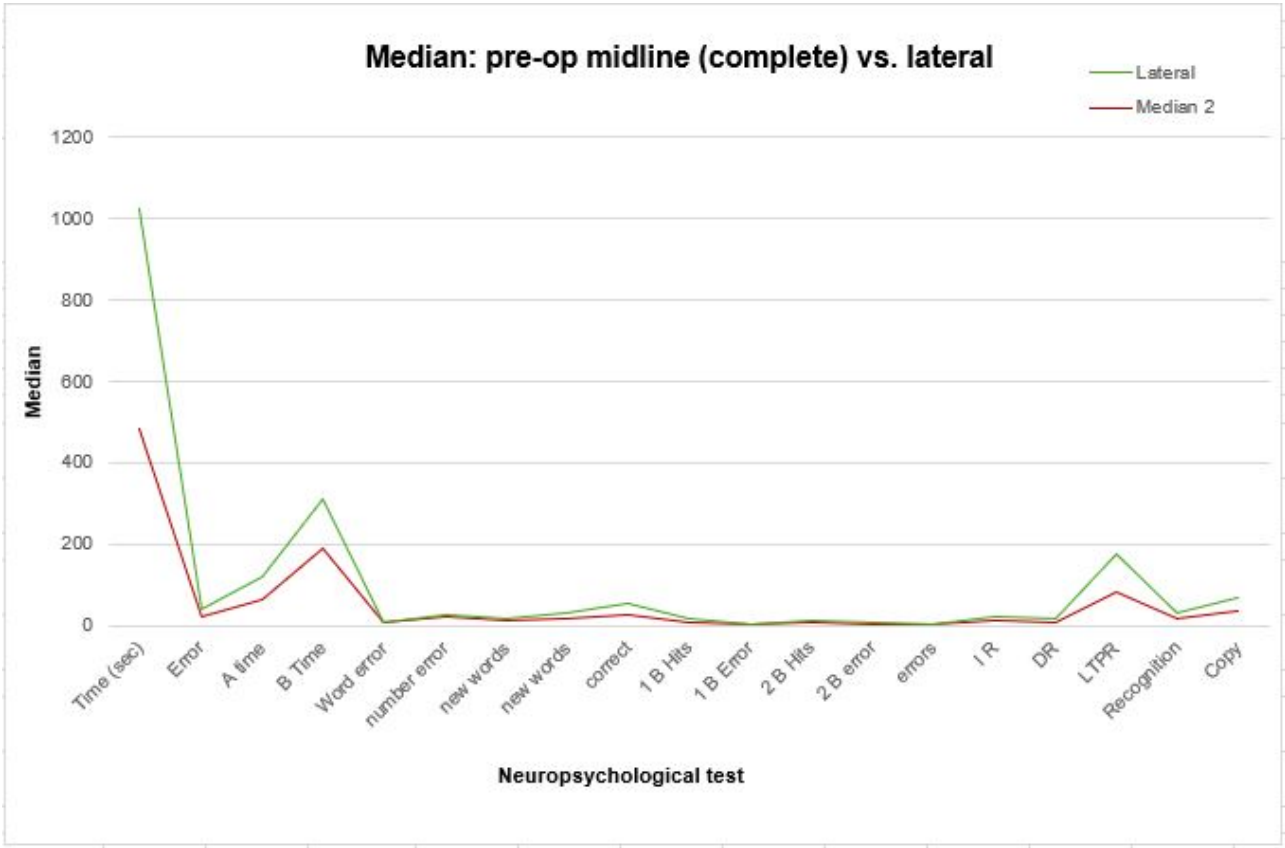
Adults and children differ in some of the neuropsychological tests they undergo. Hence, at evaluation the mean scores for each neuropsychological cases was calculated just for adults and then another mean was calculated adding those tests that were common to adults and children.

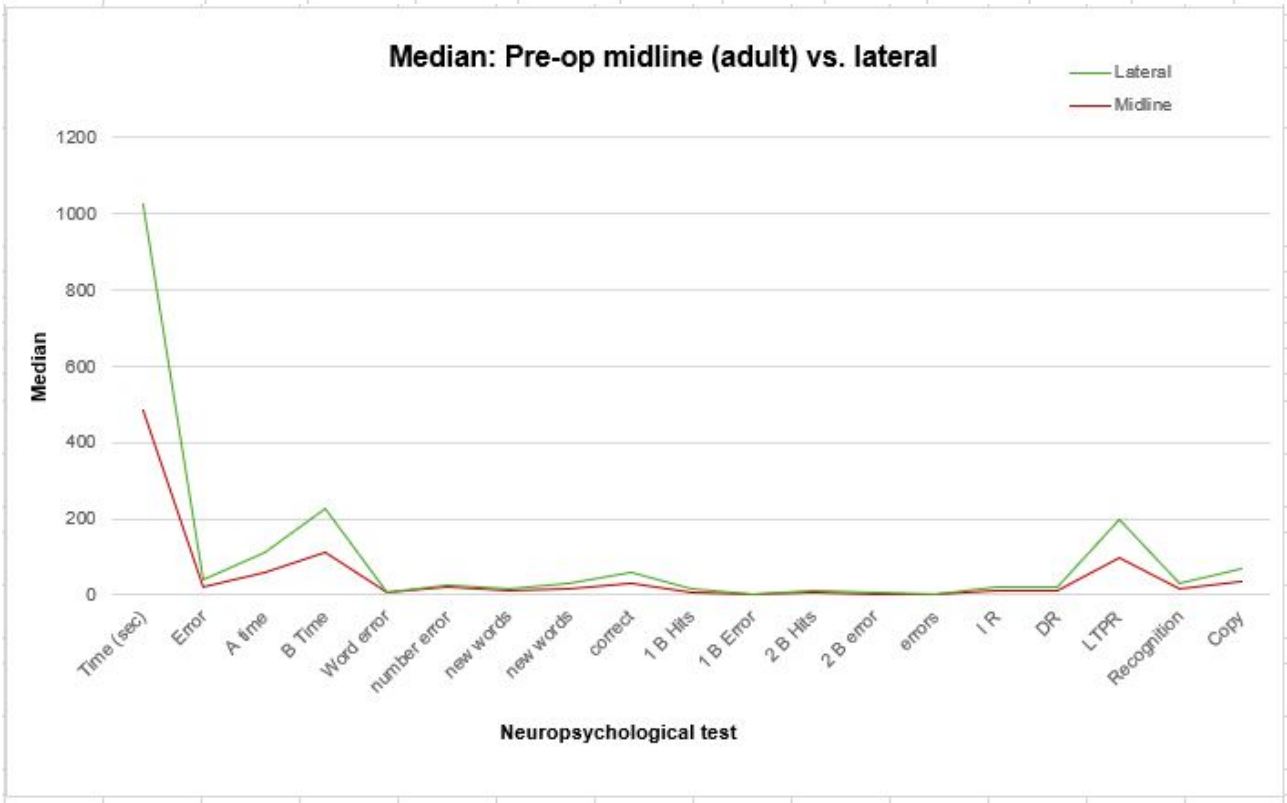
The mean pre op value for each neuropsychogical test was calculated in the pre op group, which also included patients who underwent surgery at our institute but were not available for post operative neuropsychological evaluation. The mean pre op scores were then charted as a line graph between the midline and lateral group. The graph in figures below shows us that the lateral group in general fared better in almost all neuropsychological parameters tested in the pre operative period. This may indicate that some degree of blunting of the different parameters may already be there due to the midline posterior fossa pathology itself.
Similarly, at evaluation the median values for each neuropsychological cases was calculated just for adults and then another median was calculated adding those tests that were common to adults and children.

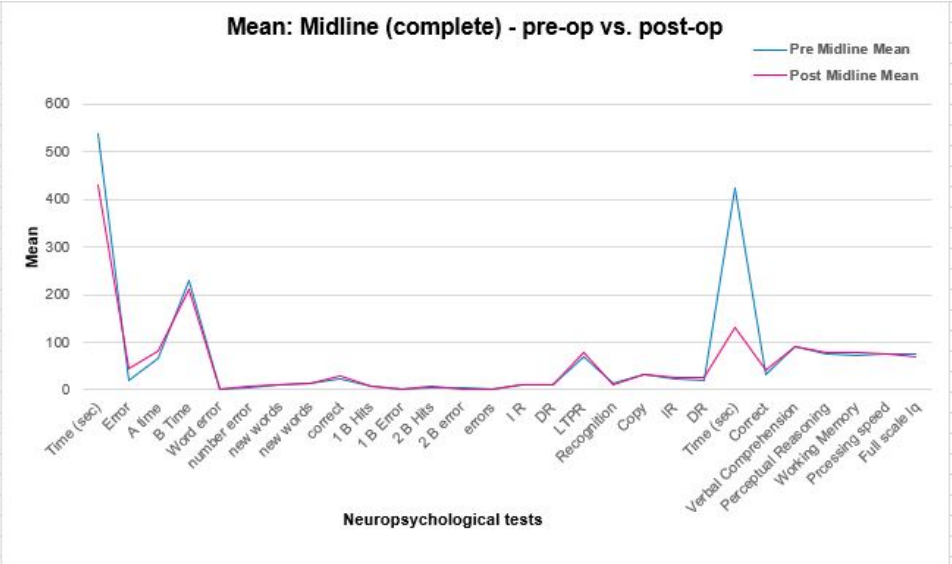


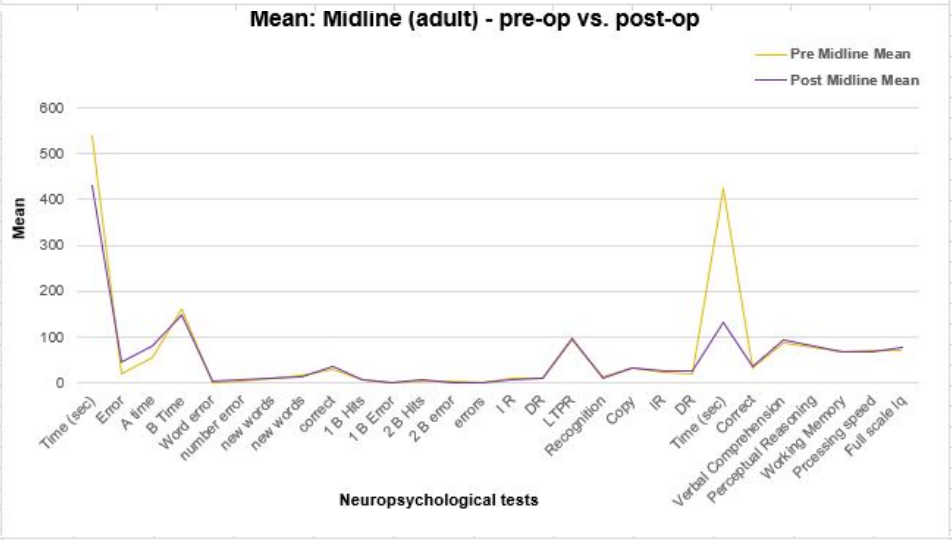


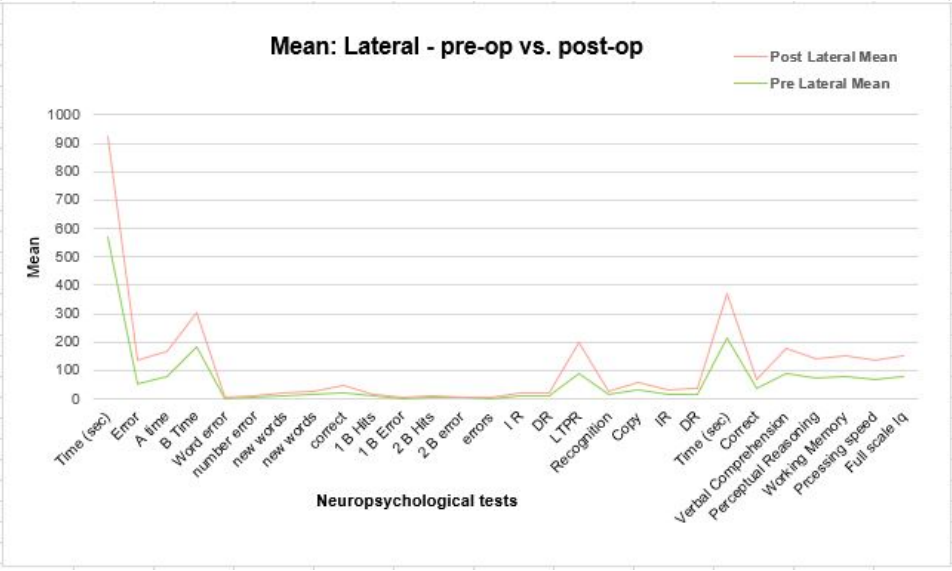
The median pre op value for each neuropsychogical test was calculated in the pre op group, which also included patients who underwent surgery at our institute but were not available for post operative neuropsychological evaluation. The median pre op scores were then charted as a line graph between the midline and lateral group. The graph in following figure shows us that the lateral group in general fared better in almost all neuropsychological parameters tested in the pre operative period. This again may indicate that some degree of blunting of the different parameters may already be there due to the midline posterior fossa



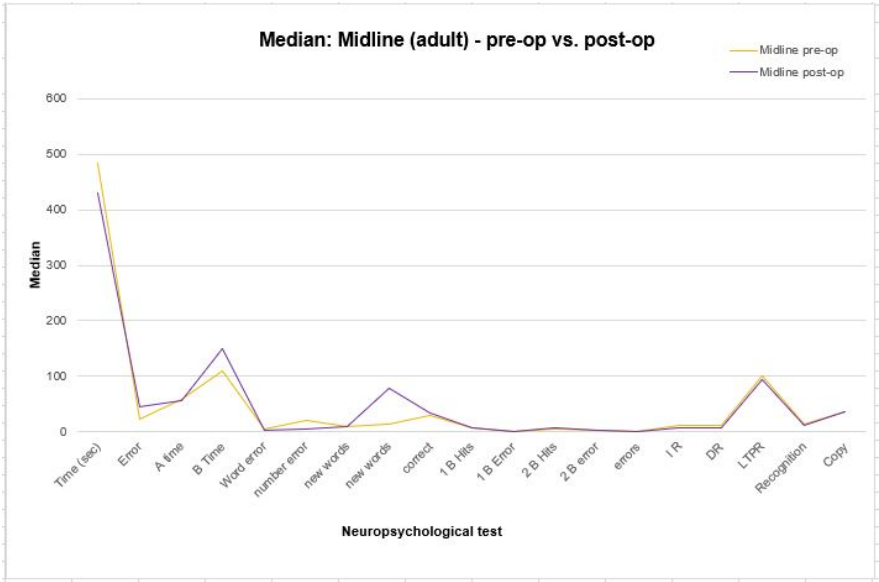


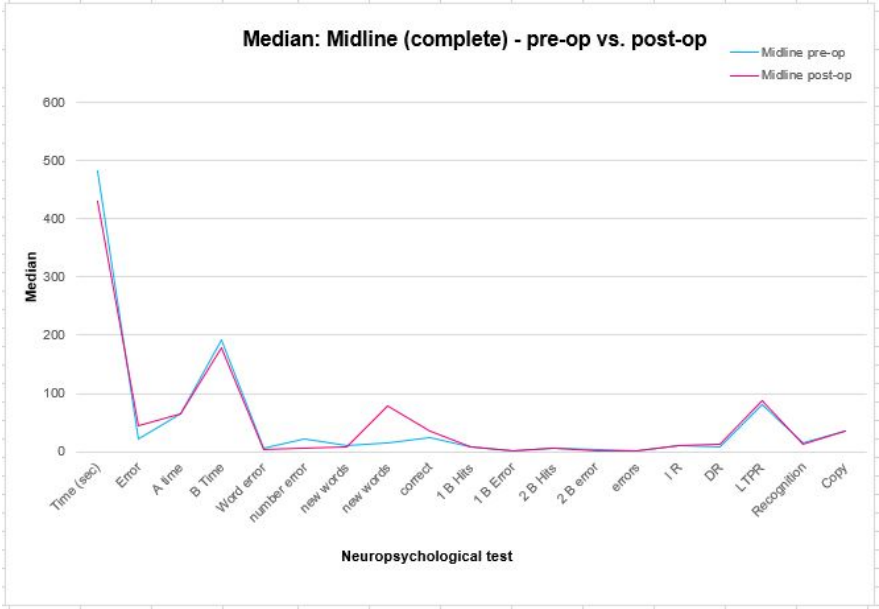


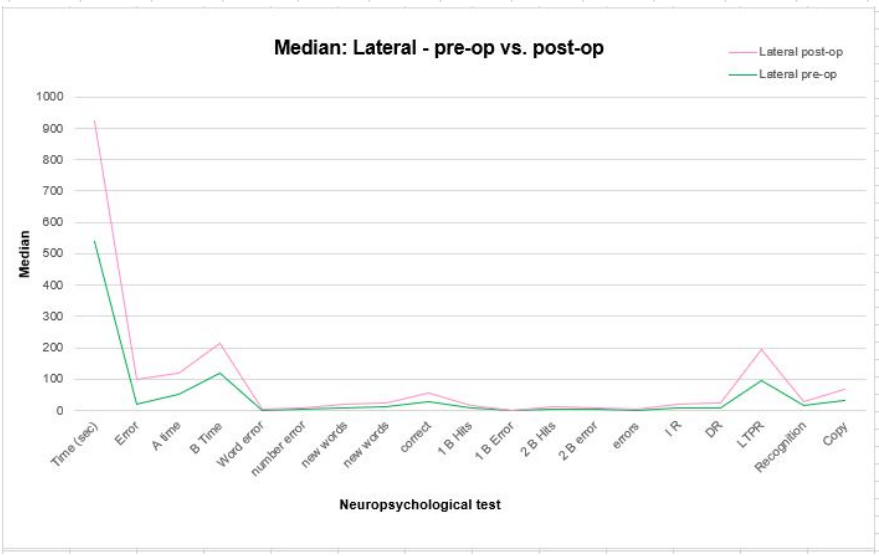




The mean pre op value for each neuropsychogical test was calculated in the pre op group, which also included patients who underwent surgery at our institute but were not available for post operative neuropsychological evaluation. The mean score for each test was also calculated in the post operative period. The mean pre op value for each test was plotted against the mean post operative value for that corresponding test. These mean pre and post op scores were then charted as a line graph between the midline and lateral group. The graph in these left hand figures visually represents the trend of change in neuropsychological parameters.

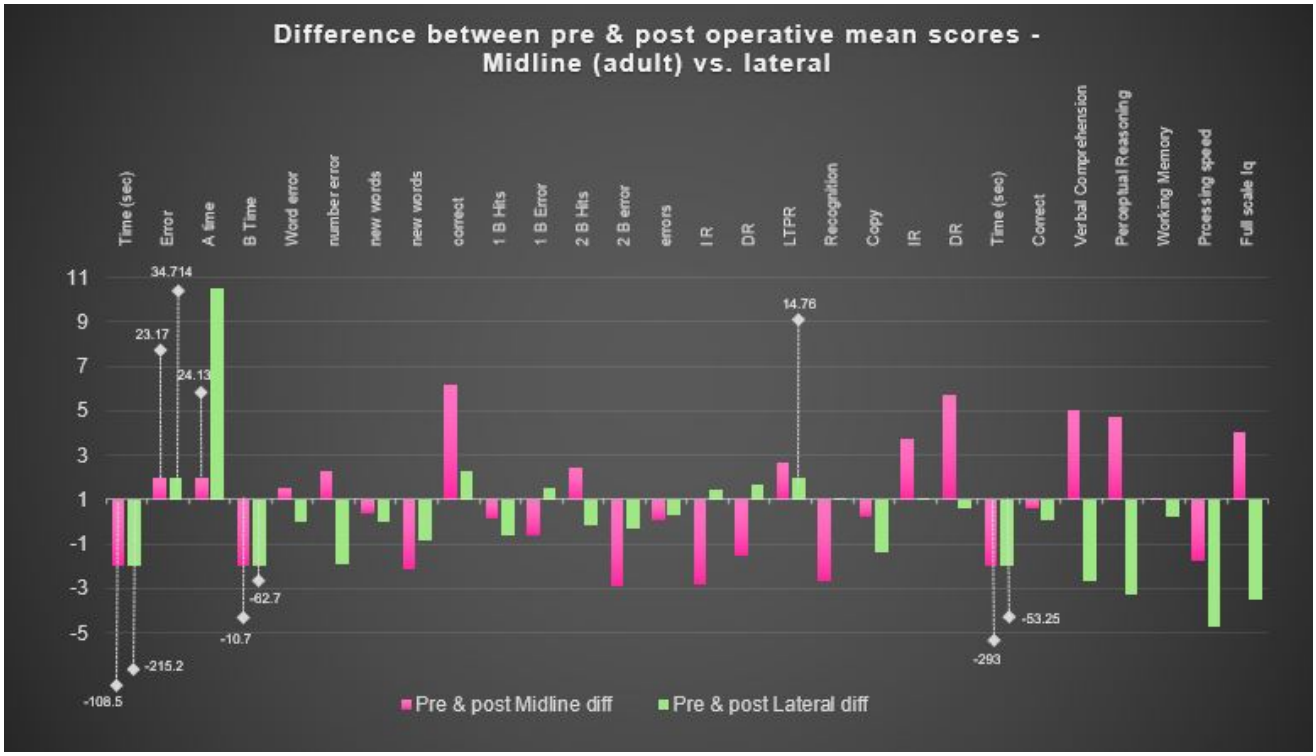


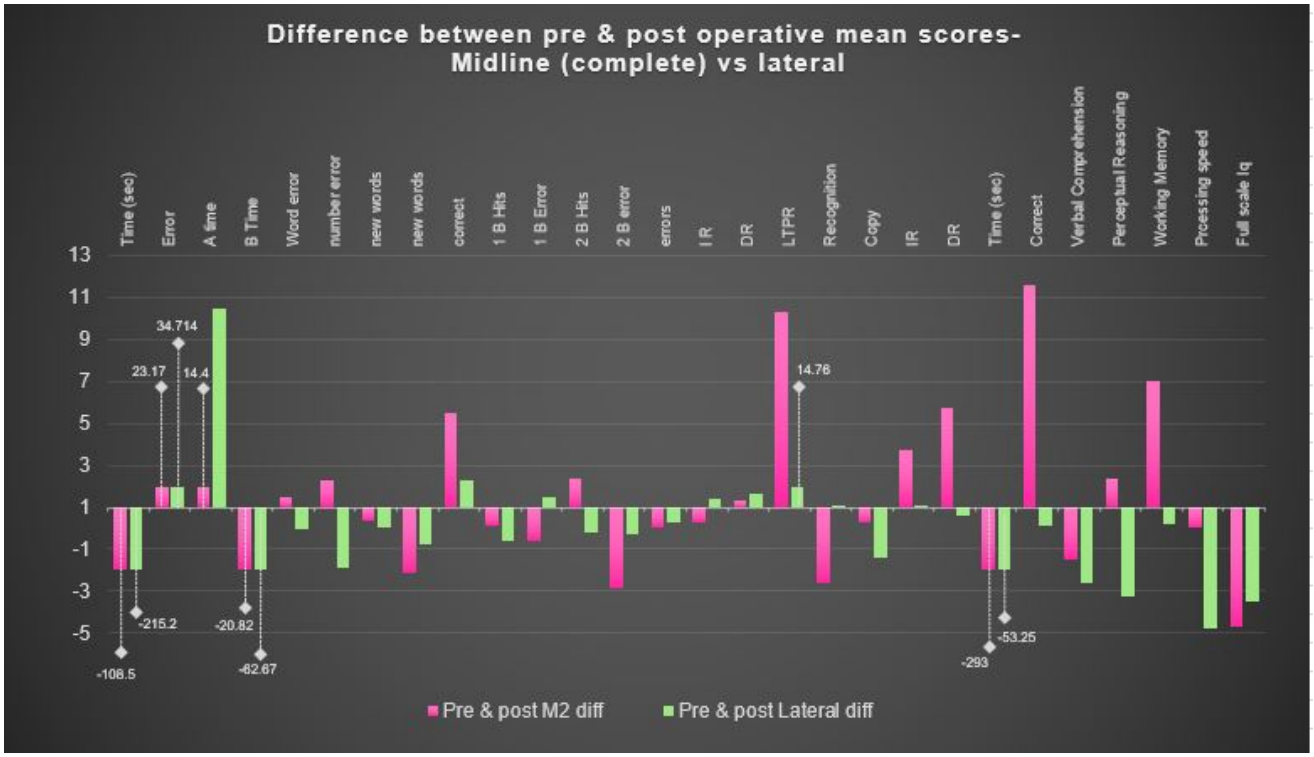




The median pre op value for each neuropsychogical test was calculated in the pre op group, which also included patients who underwent surgery at our institute but were not available for post operative neuropsychological evaluation. The median score for each test was also calculated in the post operative period. The median pre op value for each test was plotted against the median post operative value for that corresponding test. These median pre and post op scores were then charted as a line graph between the midline and lateral group. The graph in left handed Figures visually represents the trend of change in neuropsychological parameters.

Mean Values


Difference between pre & post operative mean scores - Midline (adult) vs. lateral
Time (sec)
Error
A time
B Time
Word error
number error
new words
new words
correct
1 B Hits
1 B Error
2 B Hits
2 B error
errors
I R
DR
LTPR
Recognition
Copy
IR
DR
Time (sec)
Correct
Verbal Comprehension
Perceptual Reasoning
Working Memory
Processing speed
Full scale Iq
11
9
7
5
3
1
-1
-3
-5
34.714
23.17
24.13
14.76
-62.7
-10.7
-215.2
-108.5
-293
-53.25
Pre & post Midline diff
Pre & post Lateral diff


Difference between pre & post operative mean scores- Midline (complete) vs lateral
Time (sec)
Error
A time
B Time
Word error
number error
new words
new words
correct
1 B Hits
1 B Error
2 B Hits
2 B error
errors
I R
DR
LTPR
Recognition
Copy
IR
DR
Time (sec)
Correct
Verbal Comprehension
Perceptual Reasoning
Working Memory
Processing speed
Full scale Iq
13
11
9
7
5
3
1
-1
-3
-5
34.714
23.17
14.4
14.76
-215.2
-20.82
-108.5
-62.67
-293
-53.25
Pre & post M2 diff
Pre & post Lateral diff

The mean value for all the subjects was calculated for a neuropsychological test, in the pre operative and post operative period. The mean post operative value was subtracted from the mean pre operative value for that particular neuropsychological test to get the difference between the average pre and post operative scores.
This average difference was positive, if for that test, the post operative mean value was higher than the pre operative mean value. It was negative if for that test the post operative mean value was lower than the pre operative mean value.

1. Attention: Midline:
    1. Digit vigilance average time was reduced in the post operative period by an average 108.5 words with an increase in the error rate by 23.17 errors per test.

        For the pre-op mean, the Digit vigilance was grouped into the 56th percentile and the post-operative mean value of the group was in the 90th percentile.
    2. A time has worsened (14.4 sec) further and B time improved by (20.82 sec) in the post operative period with a mild increase in the error rate. This signifies an decrease in attention scores.

        In trails test, A time score of the group fell into the 67th percentile and the post-operative mean value dropped them into a percentile of 35. For the Trail B time, the pre-op mean value had them in the 15th percentile group (<1SD) with the post-operative mean value falling into the 18th percentile category.

The improvement of the score post-surgery is a clear indicator on the cognitive abilities being restored due to rectification of their clinical conditions.

- For the Trail making test (complete), the difference between the pre-operative (mdn =54) and post-operative (mdn=64) had improved only for a few patients for Trail A. The Mann-Whitney test indicated that this was not a statistically significant difference and had a p= 0.22 (U=20, z= -1.207). For Trail B as well, the pre-op (mdn=190) and post-op (mdn=178.5) was not significant at p=0.127 (U= 23, Z= 0.896)

    3. Triad test showed an increase in number (2.3) and word error (1.5) in post operative period.

- The Digit vigilance test could not be analysed for significances due to lack of adequate tests scores in the cohort group.
- The triads test could not be calculated due to lack of test scores.
- The colour cancellation test used to assess the children did not have a significant pre-op (mdn=124) and post-op (mdn= 83.5) score difference having a p-value of 0.4 (U= 8, Z= 0.83).

2. Lateral:
    1. Digit vigilance average time was reduced in the post operative period by an average 215.29 words with an increase in the error rate by 34.714 errors per test. was a drastic drop in the time for doing the task as a whole group post-surgery.

        Digit vigilance average time in the pre-operative period had a mean value that corresponded to a percentile of 39th set and the pre-operative increase corresponded to the 89th percentile group.

    2. A time has worsened (10.505 sec) further and B time improved (62.67 sec) in the post operative period with a mild increase in the error rate. This signifies an decrease in attention scores. This signifies that as in general the sustained attention showed a lack of improvement and higher scores in trail B indicates a

	Digit Vigilance				Trail Making				Triads	
	Time (sec)	Percentile	Error	Percentile	A time	Percentile	B Time	Percentile	Word error	number error
Pre M Mean1	538		21.33333		55.66666		160.2		1	4.2
Pre M Mean 2	538	56	21.33333	11	67.11111	50	230.625	15	1	4.2
Post M Mean 1	429.5		44.5		79.8		149.5		2.5	6.5
Post M Mean 2	429.5	90	44.5	3	81.5	35	209.8333	18	2.5	6.5
Pre and post M1 diff	-108.5		23.17		24.13		-10.7		1.5	2.3
Pre and post M2 diff	-108.5		23.17		14.4		-20.82		1.5	2.3
Pre L Mean	570.8571	39	50.28571	3	79.61538	44	183.6666	30	2	6.461538
Post L Mean	355.6666	89	85	3	90.125	30	121	83	2	4.555555
Pre and post L diff	-215.29		34.714		10.505		-62.67		0	-1.9

general improvement in the functioning of the central executive memory.

For Trail A test, the mean value put the group in the 44th percentile set and post-operatively they declined to a percentile group of 30. The Trail B part of the test had a pre-operative mean value placing them in the 30th percentile, with a significant increase post-operatively putting them in the 83rd percentile group.

-

- For the Trail making test, the difference between the pre-operative (mdn =64.5) and post-operative (mdn=67) had improved almost all patients for Trail A. The Mann-Whitney test indicated that this was not a statistically significant difference and had a p= 0.86 (U=26, z= -0.17). For Trail B could not be analysed due to lack of adequate tests scores in the group.

-

3. Triad test showed a reduction in number error (1.9) and word error average remained unchanged in post operative period.

- The triads test as well, the pre-op (mdn=1) and post-op (mdn=2) was not a significant at p= 0.59 (U= 26.5, Z= 0.525).
- The Digit vigilance test could not be analysed due to lack of adequate tests scores in the cohort group.

-

2. Executive functions:

1. Midline

1. COWAT test: showed a marginal increase in the mean number of new word formation (0.388). This difference indicated an improvement in the patient group's ability in the post-operative condition.

The number of words generated on the COWAT had a pre-op mean value falling into the 70th percentile category and the post-operative score showed a slight increase placing them into the 75th category.

- For the COWAT, the pre-op (mdn = 9.33) and post-op (8.83) did not have a difference that was significant enough. It had a p-value of 1 with U= 17.5 and Z= 0.

2. Animal naming test: There was a marginal fall in the average number of new animals that could be named postoperatively (-2.143).

In the Animals name test the pre-surgical mean value was at the 70th percentile and post-operatively there was a dip in the score value putting them into the 45th percentile category.

- In the animals test, the difference between the pre-operative (mdn=15) and post-operative (12.5) group was not statistically significant with p= 0.262 (U= 10.5, Z= 1.12)

3. Block Design test: too showed an increase in the post operative block designing ability (5.5) which indicates a progression in their test performance post-surgery.

2. Lateral

1. COWAT test: showed a marginal increase in the mean number of new word formation (0.009). This difference indicated a slight improvement in the patient group's ability in the post-operative condition.

For the COWAT, the pre-op (mdn = 9) and post-op (10.33) did not have a difference that was significant enough. It had a p-value of 0.96 with U= 39.5 and Z= 0.044.

	Cowa		Animals		Block Design
	new words	Percentile	new words	Percentile	correct
Pre M Mean1	9.3771428571428		15.142857142857		28
Pre M Mean 2	9.3771428571428	70	15.142857142857	70	23.5
Post M Mean 1	9.765		13		34.2
Post M Mean 2	9.765	75	13	45	29
Pre and post M1 diff	0.388		-2.143		6.2
Pre and post M2 diff	0.388		-2.143		5.5
Pre L Mean	9.2828571428571	60	13.5	50	22.307692307692
Post L Mean	9.292	60	12.7	50	24.555555555555
Pre and post L diff	0.009		-0.8		2.25

For the COWAT the group had a mean value that placed them into the 60th percentile set and

post-operatively they were still in the 60th percentile group.

2. Animal naming test: There was a marginal fall in the average number of new animals that could be named postoperatively (-0.8). The requirement of multiple cognitive skills such as an organized verbal recall and retrieval, self-monitoring of cognition and inhibition of responses in addition to effective executive functions makes it difficult which could be related to a drop in the performance

- In the animals test, the difference between the pre-operative (mdn=14) and post-operative (12) group was not statistically significant with p= 0.477 (U= 32, Z= 0.7)

- In the Animals name test the pre-surgical mean value corresponded to the 50th percentile and post-surgical percentile for the group remained the same at 50.

3. Block Design test: too showed an increase in the post operative block designing ability. (2.25) which indicates a progression in their test performance post-surgery.

- For Block design, as a complete group, the pre-operative (mdn =26) and post-operative (mdn= 34.5) did not have a difference significant enough after using the Mann- Whitney test (p= 0.76, U= 55.5 and Z= 0.29)

So except for ability to name animals, there was an improvement in the executive function postoperatively.

3. Memory:

1. Midline

1. Verbal N back test: 1 b hit (+0.143) with a reduction in error (-0.571) and 2 b hit scores showed a marginal increase in average number of hits (+2.4) and a fall in error rate (-2.857).

In the Verbal-n-back test the pre-op mean values for the whole group was at the 20th percentile and the post-op mean value had increased putting them into the 25th category. The verbal 2 back pre op mean value jumped from 15 in the pre op period (<1SD) to 40 in the post operative period.

In the Verbal-n-back, the difference between the pre-op (mdn= 8) and post-op (mdn= 8) for the 1 B hit scores were not statistically significant with p= 0.76 (U= 16, Z= 0.29). Similarly, for the 2B hit scores as well, their pre-op (mdn= 5) and post-op (mdn= 7) was not significant after using the Mann- Whitney test (p= 0.2, U= 9.5, Z= 1.28).

2. Self ordered pointing test: error increased in the post op period (+0.07). In the SOPT, the pre-surgical group (mdn= 2) and the post-surgical group (mdn=1) did not have a statistically significant difference (p=0.92, U= 12.5, Z= 0.104).

- For the children's group, the pre-op (mdn= 18) and the post-op (mdn=21) group did not have a statistically significant difference post the Mann-Whitney test analysis (p= 0.92, U= 12.5 and Z= 0

- The self-ordered pointing test in pre-surgical condition placed them into the 77th percentile category and the post-operative had them fall into the 77th percentile group.

3. RAVLT: The rey's auditory verbal learning test focuses on assessing an individual's capacity for verbal learning and memory.

a. Immediate recall: increased by 0.308
b. Delayed recall: increased by 1.29
c. LTPR increased post op by 10.35
d. Recognition score reduced (-2.643)

	Verbal N Back						SOPT		RAVLT								Rey Complex					
	1 B Hits	Percentile	1 B Error	2 B Hits		2 B error	errors	Percentile	I R		DR		LTPR		Recognition		Copy		IR		DR	
Pre M Mean 1	7.85		1.57	5		4.85	1.33		11.2		11		92.9		14.1		32.7		23		20.6	
Pre M Mean 2	7.85	20	1.57	5	15	4.85	1.33	77	9.69	5	9.61	10	68.4	7	14.1	20	32.7	20	23	45	20.6	40
Post M Mean 1	8		1	7.4		2	1.4		8.5		9.5		95.5		11.5		33		26.7		26.4	
Post M Mean 2	8	25	1	7.4	40	2	1.4	77	10	10	10.9	15	78.8	13	11.5	5	33	22	26.7	70	26.4	50
Pre and post M1 diff	0.14		-0.5	2.4		-2.8	0.07		-2.7		-1.5		2.64		-2.6		0.25		3.7		5.73	
Pre and post M2 diff	0.14		-0.5	2.4		-2.8	0.07		0.30		1.29		10.3		-2.6		0.25		3.7		5.73	
Pre L Mean	8.07	30	1.07	5.76	3	3.76	2	39	9.78	25	10.1	25	91.2	49	13.5	15	30.1	7	16.4	15	17.7	30
Post L Mean	7.5	15	2.6	5.6	3	3.5	2.3	39	11.2	30	11.8	40	105.	78	14.6	30	28.7	5	17.4	25	18.3	30
Pre and post L diff	-0.5		1.52	-0.1		-0.2	0.3		1.41		1.66		14.7		1.06		-1.4		1.03		0.6	

The rey's auditory verbal learning, the midline group had a mean value which corresponded to the 5th percentile group for immediate recall <1.5SD), for delayed recall the mean value corresponded to the 10th percentile (<1SD), the LTPR mean value placed them into a percentile group of 7 (<1.5 SD) and the recognition put them into the 20th percentile category in the pre-operative evaluation. For the post-operative assessment, the immediate recall had the mean value that placed them at the 10th percentile (<1 SD), the delayed recall value corresponded to the 15th percentile <1SD) , the LTPR was at the 13th percentile category (<1SD) and recognition mean value put them into the 5th percentile group. (<1.5 SD)

- The RAVLT for the complete midline group was statistically analysed using the Mann-Whitney test. The immediate recall test between the pre-op (mdn= 11) and post-op (mdn= 10) did not have any significant difference (p= 0.66, U= 53.5, Z= 0.42). For delayed recall as well, the pre-op (mdn= 10) and post-op (mdn= 12) scores did not have any significant difference (p= 0.53, U= 50.5 and Z= 0.62). Similarly for the recognition task, the pre-op (mdn= 15) and post-op (mdn= 13) score did not have a significant difference with p=0.29, U= 11 and Z= 1.04. Finally, the LTPR value between the pre-op (mdn= 100) and post-op (mdn= 94.99) difference was also not statistically significant enough (p= 0.93, U= 17 and Z= 0.08).

RAVLT test scores were better for children during the post-operative condition (mdn = 42) than in the pre-operative condition (mdn = 57).
A Mann-Whitney test indicated that this difference was a statistically significant difference of U=0.5, z= -2.4, *p*=<0.015

4. Rey Complex
   a. Copy score increased by 0.25
   b. Immediate recall increased by 3.7
   c. Delayed recall increased by 5.73

Given that this test is sensitive to cognitive functions pertaining to visual memory and visuospatial constructional ability, it can be said that the improvement in scores is suggestive of an improvement in such functions post the surgical procedure.

In Rey complex, the copy test the pre-operative condition corresponded to a percentile score of 20 and the post-operative value for the same had an increased percentile score to the 22nd group. In the pre-operative condition, the immediate recall mean value placed them into the 45th percentile category and the post-operative mean value had an increase into the 70th percentile set. Finally for the delayed recall, the pre-op mean value corresponded to the 40th percentile group and the post-operative mean value increased placing them into the 50th percentile set.

- In the Rey complex test, the difference between the pre-surgical (mdn= 36) and post-surgical (mdn= 36) scores were not significant enough with a p-value of 0.57 (U=14, Z= 0.56) for the copy test. The immediate recall task, also, did not have a significant difference between the pre-op (mdn= 23) and post-op (mdn= 32) scores with p= 0.68 (U= 15, Z= 0.4). Finally, the delayed recall task also did not show any significant difference after using the Mann-Whitney test (p= 0.87, U= 16.5, Z= 0.16).

2. Lateral

1. Verbal N back test: 1 b hit reduced (-0.58) with an increase in error by(1.52) and 2 b hit scores showed a marginal decrease in average number of hits (-0.17) and a fall in error rate (-0.27) . Given these scores, it can be suggested that there was deterioration group wise post-surgically for verbal working memory.

- In the Verbal-n-back, the difference between the pre-op (mdn= 9) and post-op (mdn= 8) for the 1 B hit scores were not statistically significant with p= 0.25 (U= 23.5, Z= 1.15). Similarly, for the 2B hit scores as well, their pre-op (mdn= 7) and post-op (mdn= 6) was not significant after using the Mann- Whitney test (p= 0.59, U= 30, Z= 0.5).
- In the Verbal-n-back test the difference, for 1 B hits the pre-op mean corresponded to a percentile of 30 and post-operative mean placed them in the 15th percentile (<1SD). For 2B hit, the pre-operative and post-operative mean value placed the group into the 3rd percentile group (<2SD).

2. Self ordered pointing test: error increased in the post op period (+ 0.3) indicating an improvement in their verbal working memory and visual working memory.

- In the SOPT, the pre-surgical group (mdn= 1.5) and the post-surgical group (mdn=2) did not have a statistically significant difference (p=0.36, U= 26, Z= 0.914).
- The self-ordered pointing test, the pre-surgical assessment put the group into 39th percentile set and even post-operatively the percentile value stayed the same.

3. RAVLT:
   a. Immediate recall: increased by 1.41
   b. Delayed recall: increased by 1.66
   c. LTPR increased post op by 14.76
   d. Recognition score increase by (1.06)

Indicating an improvement in their verbal working memory and visual working memory.

- The RAVLT for the complete midline group was statistically analysed using the Mann-Whitney test. The immediate recall test between the pre-op (mdn= 10) and post-op (mdn= 13) did not have any significant difference (p= 0.72 U= 36, Z= 0.35). For delayed recall as well, the pre-op (mdn= 11) and post-op (mdn= 13) scores did not have any significant difference (p= 0.25, U= 27 and Z= 1.14). The LTPR value between the pre-op (mdn= 100) and post-op (mdn=100) difference was also not statistically significant enough (p= 0.28, U= 28 and Z= 1.05). Finally for the recognition task, the pre-op (mdn= 15) and post-op (mdn= 15) score did not have a significant difference with p=0.3, 29, U= 28.5 and Z= 1.01.
- The rey's auditory verbal learning, the lateral group had a mean value which corresponded to the 25th percentile group for immediate recall, for delayed recall the mean value corresponded to the 25th percentile, the LTPR mean value placed them into a percentile group of 49 and the recognition put them into the 15th percentile (<1SD) category in the pre-operative evaluation. For the post-operative assessment, the immediate recall had the mean value that placed them at the 30th percentile, the delayed recall value corresponded to the 40th percentile, the LTPR was at the 78th percentile category and recognition mean value put them into the 30th percentile group.

4. Rey Complex
   a. Copy score decreased by -1.4
   b. Immediate recall increased by 1.03
   c. Delayed recall increased by 0.6

There was a drop in performance for the copy task but an improvement for the memory parameter post-surgery.

- In the Rey complex test, the difference between the pre-surgical (mdn= 36) and post-surgical (mdn= 34) scores were not significant enough with a p-value of 0.68 (U=35.5, Z= 0.39) for the copy test. The immediate recall task, also, did not have a significant difference between the pre-op (mdn= 16.5) and post-op (mdn= 18) scores with p= 0.37 (U= 30, Z= 0.88). Finally, the delayed recall task also did not show any significant

difference after using the Mann-Whitney test (preop mdn= 17.5, post-op mdn= 22, p= 0.59, U= 30, Z= 0.59).

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- In Rey complex, the copy test the pre-operative condition corresponded to a percentile score of 7 and the post-operative value for the same had a decreased percentile score to the 5th group. In the pre-operative condition, the immediate recall mean value placed them into the 15th percentile category and the post-operative mean value had anv increase into the 25th percentile set. Finally for the delayed recall, the pre-op mean value corresponded to the 30th percentile group and the post-operative mean value also corresponded to 30th percentile set.

4. Speed

	Speed		Comprehension	
	Digit Symbol		Token	
	Time (sec)	Percentile	Correct	Mean population value
Pre M Mean1	424		34.0833333333333	
Pre M Mean 2	424	13	31.0909090909091	24.17
Post M Mean 1	131		34.7	
Post M Mean 2	131	100	42.7222222222222	24.17
Pre and post M1 diff	-293		0.62	
Pre and post M2 diff	-293		11.63	
Pre L Mean	213.25	60	34.5357142857143	39.34
Post L Mean	160	89	34.65	39.34
Pre and post L diff	-53.25		0.11	

1. Midline- There was a decrease in speed in the post operative period. (-293)
This indicates that there was a spike in the performance post-operatively as there was a reduction in the time taken as a whole group. From this it can be inferred that there was an improvement in the cognitive functions related to visuomotor coordination. sustained attention and response speed post the procedure.

The digit symbol substitution had a mean value corresponding to the 13th percentile group (<1SD) and the post-operative score increased putting them in the 100th percentile.

2. Lateral- There was a decrease in speed in the post operative period (-53.25). It can be inferred that there was an improvement in the cognitive functions related to visuomotor coordination, sustained attention and response speed post the procedure.
The digit symbol substitution had a mean value that corresponded to percentile score of 60 and the post-operative value had an increased value placing them into the 89th percentile group

5. Comprehension
1. Midline- There was an increase in comprehension (11.63) suggesting a development in the cognitive function post-operatively.

- For the token test, the whole group difference was analysed. Using the Mann-Whitney test it was understood that there was no significant difference between the pre-op (mdn= 35) and post-op (mdn= 35) scores with p=0.79 (U= 57.5, Z= 0.16).

2. Lateral- There was a marginal increase in comprehension (0.11) suggesting a progress in the cognitive function post-operatively.

- For the token test, the whole group difference was analysed. Using the Mann-Whitney test it was understood that there was no significant difference between the pre-op (mdn= 35) and post-op (mdn= 36) scores (p= 0.15, U= 24, Z= 1.41).

6. Intelligence:

1. Midline
    1. Verbal comprehension- scores decreased in the post operative period (unlike token test) (-1.45)
    2. Perceptual reasoning increased in the post op period (2.38)
    3. Working memory increased in the post operative period (7.05)
    4. Processing speed increased in the post op period (0.03)
    5. Full scale IQ test saw a fall in scores in post operative period by an average of 4.69 (-4.69)

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- For the WAIS intelligence test, the results were as follows –

1. Verbal comprehension had no significant difference between the pre-op (mdn= 95) and post-op (mdn= 98) scores with p = 0.79 (U=56, Z= 0.2).
2. Perceptual reasoning did not show any significant difference between the pre-op (mdn= 76) and post-op (mdn= 81.5) scores with p = 0.97 (U=59.5, Z= 0.03).
3. The pre-op (mdn= 71) and the post-op (mdn=71) score difference for working memory did not have a difference that was statistically significant enough (p= 79, U= 56, Z=0.26).

	Verbal Comprehension		Perceptual Reasoning		Working Memory		Prcessing speed		Full scale Iq	
Pre M Mean1	**87.16666**		76.5		66.5		70		72.5	
Pre M Mean 2	**91.75**	29.5	76.91666	6	72.75	4	75.11111	5	75.4	5
Post M Mean 1	**92.2**		81.2		67.6		68.25		76.5	
Post M Mean 2	**90.3**	29.5	79.3	8	79.8	8	75.14285	5	70.71428	3
Pre and post M1 diff	**5.04**		4.7		1.1		-1.75		4	
Pre and post M2 diff	**-1.45**		2.38		7.05		0.03		-4.69	
Pre L Mean	**91.23076**	27	71.38461	2	76.76923	6	69.75	2	76.5	6
Post L Mean	**88.6**	19	68.1	2	77	6	65	1	73	4
Pre and post L diff	**-2.63**		-3.28		0.23		-4.75		-3.5	

4. For processing speed as well, the pre-surgical (mdn= 73) and the post-surgical (mdn= 75) score difference was also not significant enough after using the Mann-Whitney test (p= 0.83, U= 29.5 and Z = 0.21).

5. Finally, the Full-scale IQ also did not show any significant difference between the two groups (Pre-op mdn= 78, Post-op mdn= 81, U= 39, Z= 0.08, p= 0.92).

In the intelligence test the percentile for 5 components were as follows-

- In the verbal comprehension task, the pre-operative percentile score was 29.5 and for the post-operative condition the mean of the whole group dropped to a percentile rank of 29.5
- For perceptual reasoning, the pre-operative percentile score was 6 (<1.5SD) and the post-operative value also remained in the 6th percentile. (<1.5SD)

- The working memory task had a group in the 2nd percentile for the pre-surgical testing and in the 4th percentile for the post-surgical phase. (<1.5SD)
- Processing speed had a pre-op percentile of 4 (<1.5SD) and a score of 5 in the post-operative condition (<1.5SD)
- Finally, the full-scale IQ had a mean value corresponding to the 5th percentile set (<1.5SD)in the pre-operative condition and a percentile rank of 3 (<2SD) in the post-operative testing phase.

2. Lateral
    1. Verbal comprehension- scores decreased in the post operative period (unlike token test) (-2.63)
    2. Perceptual reasoning decreased in the post op period (-3.28)
    3. Working memory increased in the post operative period (0.23)
    4. Processing speed decreased in the post op period (-4.75)
    5. Full scale IQ test saw a fall in scores in post operative period by an average of 4.69 (-4.69)

- For the WAIS intelligence test, the results were as follows –

1. Verbal comprehension had no significant difference between the pre-op (mdn= 92) and post-op (mdn= 95) scores with p = 0.96 (U=35, Z= 0.04).
2. Perceptual reasoning did not show any significant difference between the pre-op (mdn= 67.5) and post-op (mdn= 70) scores with p = 0.84 (U=33.5, Z= 0.19).
3. The pre-op (mdn= 78.5) and the post-op (mdn=81) score difference for working memory did not have a difference that was statistically significant enough (p= 0.91, U= 30.5, Z=0.1).
4. For processing speed as well, the pre-surgical (mdn= 66) and the post-surgical (mdn= 70) score difference was also not significant enough after using the Mann-Whitney test (p= 0.86, U= 26, and Z = 0.17).
5. Finally, the Full-scale IQ also did not show any significant difference between the two groups (Pre-op mdn= 73, post-op mdn= 77, U= 23.5, Z= 0.46, p= 0.64).

In the intelligence test the percentile for 5 components were as follows-

- In the verbal comprehension task, the pre-operative percentile score was 27 and for the post-operative condition the mean of the whole group dropped to the 19th percentile rank.
- For perceptual reasoning, the pre-operative percentile score was only 2 (<2SD) and the post-operative score remained the same in the 2nd percentile.(<2SD)
- The working memory task had a group in the 6th percentile (<1.5SD) for the pre-surgical testing and in the 6th percentile <1.5SD) for the post-surgical phase.
- Processing speed had a pre-op percentile of 2 (<2SD) and a drop into the 1st percentile set (<2SD), as a group, in the post-operative condition
- Finally, the full-scale IQ had a mean value corresponding to the 6th percentile (<1.5SD) set in the pre-operative condition and a percentile rank of 4 (<1.5SD) in the post-operative testing phase.

Difference in mean pre operative score vs mean post operative score-1

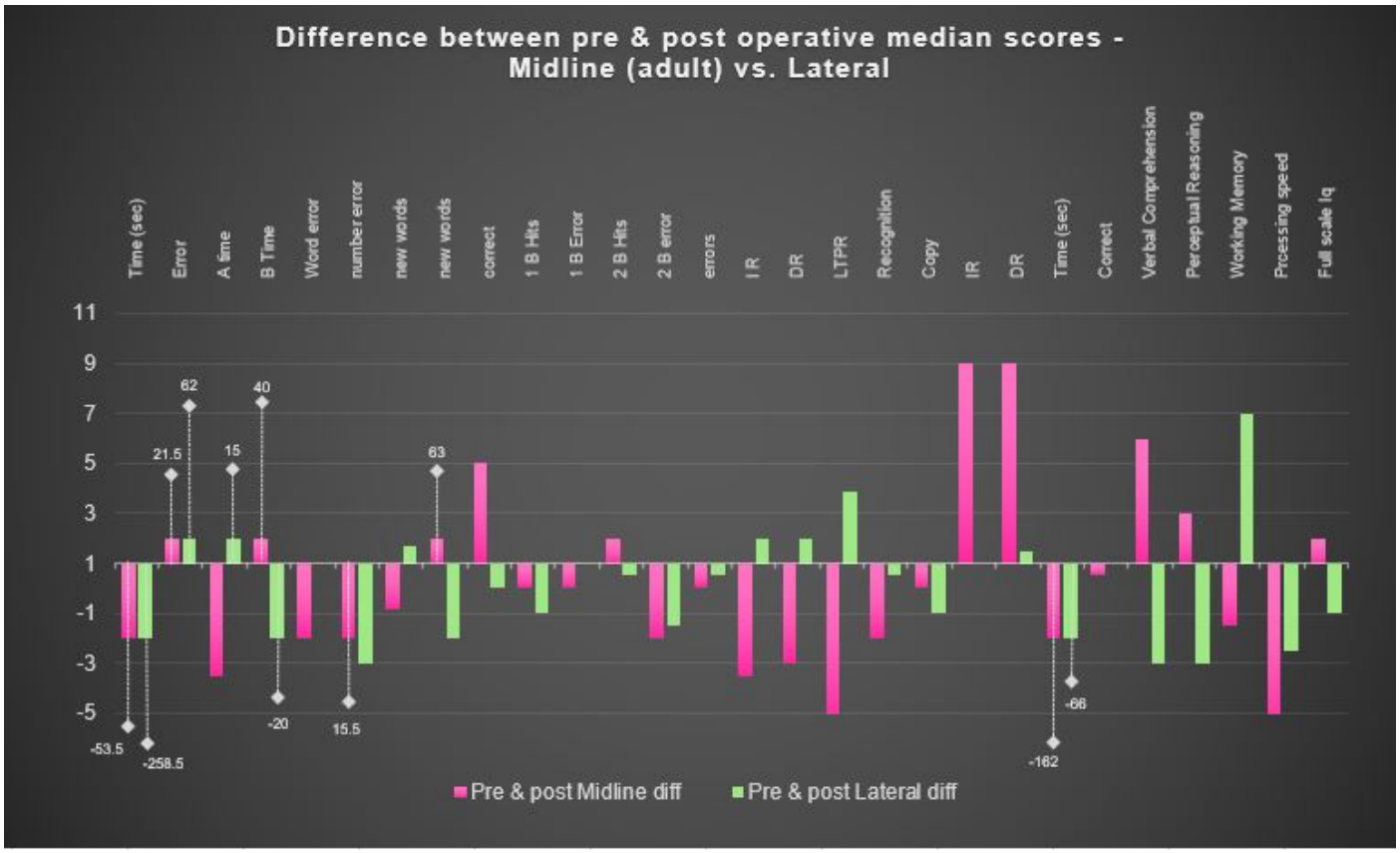
Parameter	Test	Midline	Lateral	
	Digit vigilance	-108.5	-215.29	Improvement
	Tail making A	14.4	10.505	Worsening
	Trail making B	-20.82	-62.67	Improvement
	Triads word error	1.5	0	Worsening, no chang
Attention	Triads number error d	2.3	-1.9	Worsening , improver
	Cowat	0.388	0.009	Improvement
	Animals	-2.143	-0.8	Worsening
Executive function	Block design	5.5	2.25	Improvement
	1 back	0.14	-0.58	Improvement, worser
	2 back	2.4	-0.1	Improvement, worser
	SOPT	2	0.3	Worsening
	IR	0.3	1.41	Improvement
	DR	1.29	1.66	Improvement
	LTPR	10.3	14.7	Improvement
	Reys	5.73	17.7	Improvement
Memory	Recognition	-2.6	1.06	Worsening, improvem
Speed	Digit symbol	-293	-53.25	Improvement
Token test	Verbal comprehensio	11.63	0.11	Improvement
	Verbal comprehensio	-1.45	-2.63	Worsening
	Perceptual reasoning	2.38	-3.28	improvement, worser
	Working memory	7.05	0.23	Improvement
	Processing speed	0.03	-4.75	Improvement / worse
Intelligence	Full scale IQ	-4.69	-3.5	Worsening

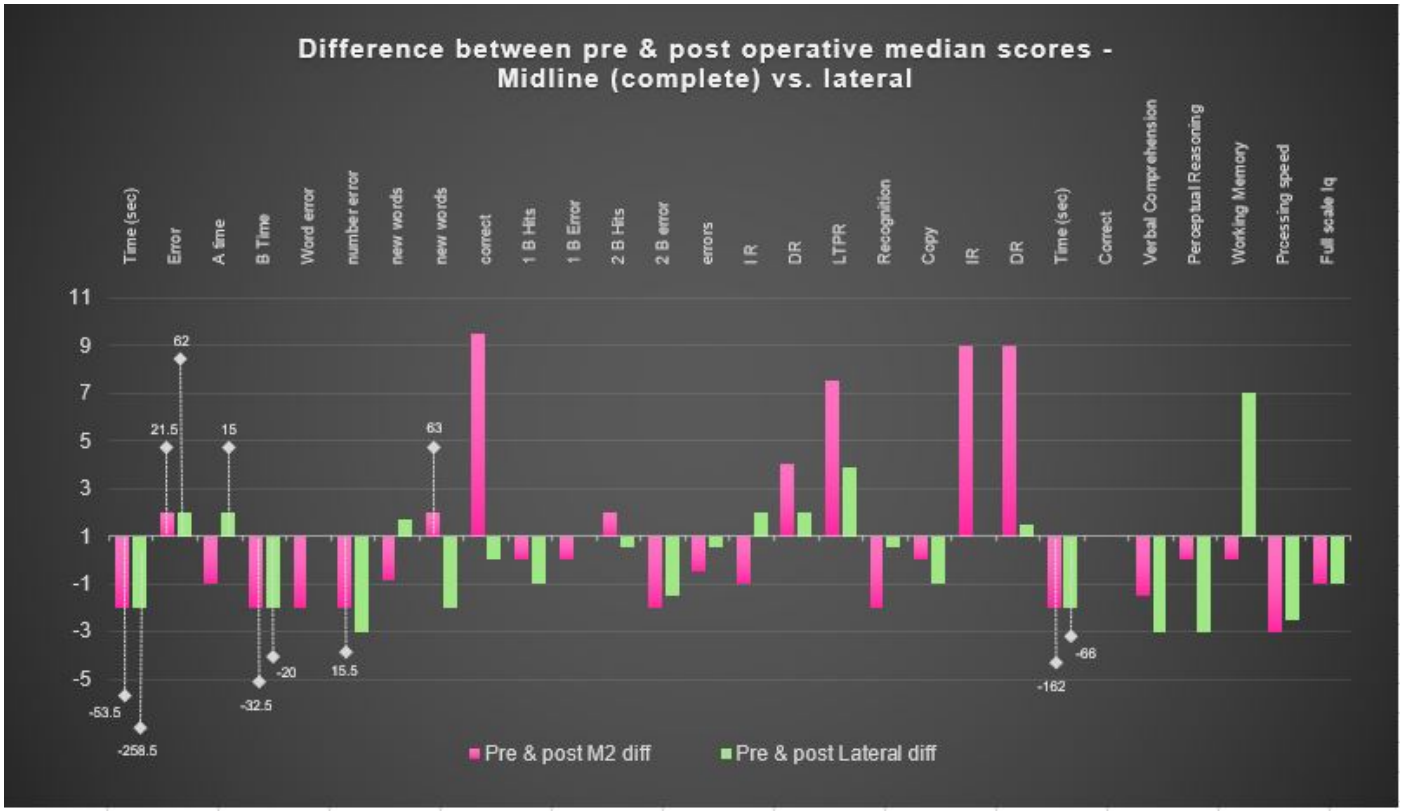
Percentile Jumps

Parameter	Test	Midline percentile jumps		Midline comment	Lateral percentile jumps	Lateral comment
Attention	Digit vigilance	56 —> 90		-	39 —> 89	-
	Tail making A	50 —> 35		-	44 —>30	-
	Trail making B	15 —> 18		< 1 SD	30 —>83	-
Executive function	Cowat	70 —> 75		-	60 —> 60	-
	Animals	70 —>45		-	50 —> 50	-
Memory	1 back	20 —>25		-	30 —>15	<1 SD in post op
	2 back	15 —> 40		People op <1SD	3 —> 3	<2 SD
	SOPT	77 —>77		-	39 —> 39	-
	IR	5 —> 10		<1 SD	25 —>30	-
	DR	10 —> 15		<1 SD	25 —> 40	-
	LTPR	7 —>13		<1.5SD —> <1SD	49 —>78	-
	Recognition	20 —>5		<1.5 SD post op	15 —> 30	<1SD pre op
	Reys	40 —>50		-	30 —>30	-
Speed	Digit symbol	13 —>100		<1 SD —>100th percentile	60 —> 89	-
Intelligence	Verbal comprehension	29.5 —> 29.5		-	27 —>19	-
	Perceptual reasoning	6 —> 8		<1.5SD	2 —>2	<2SD
	Working memory	4 —> 8		<1.5 SD	6 —> 6	<1.5SD
	Processing speed	5 —>5		<1.5 SD	2 —>1	<2SD
	Full scale IQ	5 —> 3		<1.5 SD —> <2SD	6 —> 4	<1.5 SD

The median value for all the subjects was calculated for a neuropsychological test, in the pre operative and post operative period. The median post operative value was subtracted from the median pre operative value for that particular neuropsychological test to get the difference between the median pre and post operative scores.

This average difference was positive, if for that test, the post operative median value was higher than the pre operative median value. It was negative if for that test the post operative median value was lower than the pre operative median value.





Attention-1

	Digit Vigilance		Trail Making		Triads	
	Time (sec)	Error	A time	B Time	Word error	number error
Pre M Median 1	483	23	59.5	110	5	21
Pre M Median 2	483	23	65	191.5	5	21
Post M Median 1	429.5	44.5	56	150	3	5.5
Post M Median 2	429.5	44.5	64	159	3	5.5
Diff Median M1	-53.5	21.5	-3.5	40	-2	-15.5
Diff Median M2	-53.5	21.5	-1	-32.5	-2	-15.5
Pre L Median	540	19	52	118	1	6
Post L Median	281.5	81	67	98	2	3
Diff Median L	-258.5	62	15	-20	1	-3

Executive functions-1

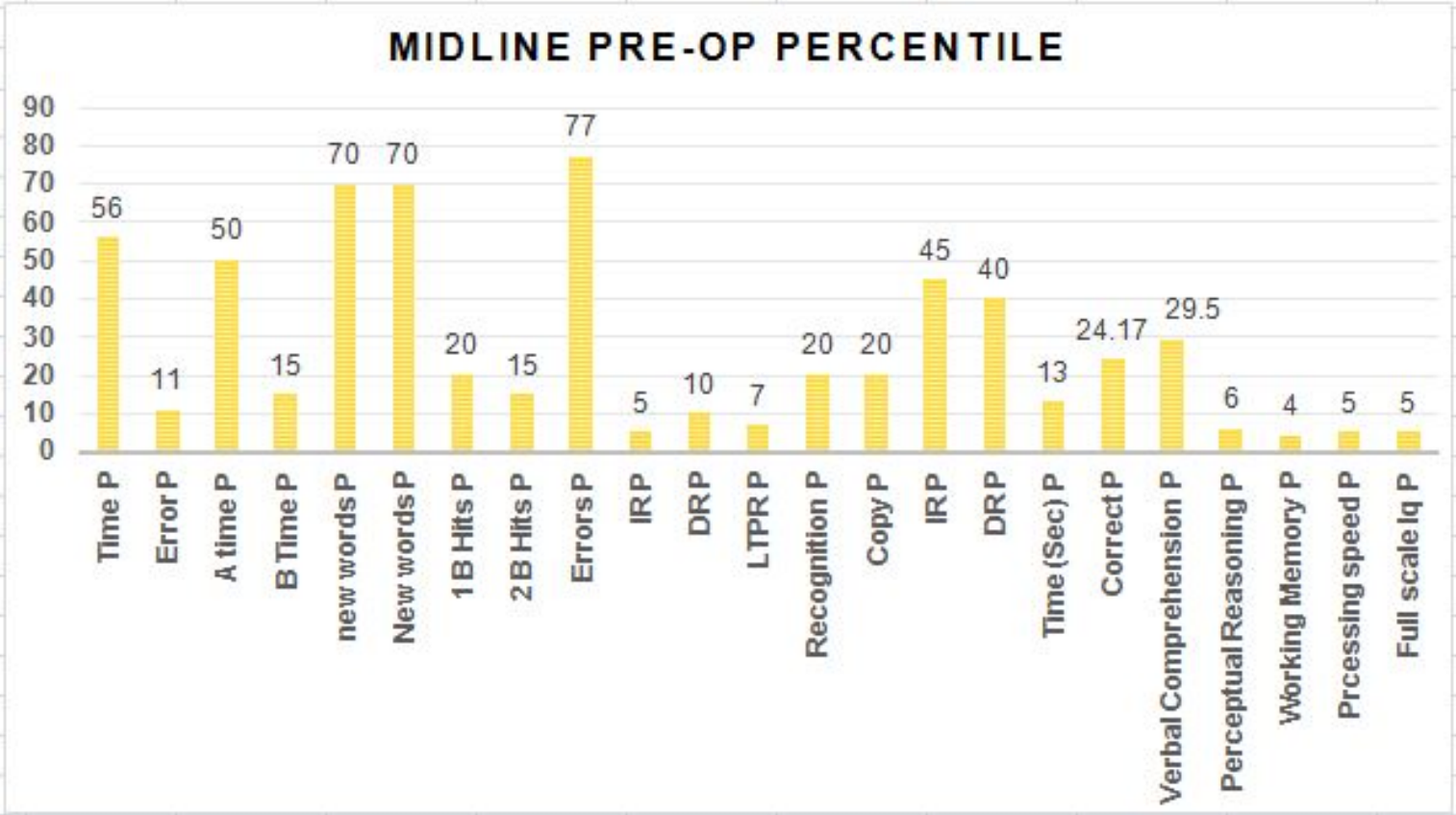
	Cowa	Animals	Block Design
	new words	new words	correct
Pre M Median 1	9.66	15	30
Pre M Median 2	9.66	15	25
Post M Median 1	8.83	78	35
Post M Median 2	8.83	78	34.5
Diff Median M1	-0.83	63	5
Diff Median M2	-0.83	63	9.5
Pre L Median	9.165	14	28
Post L Median	10.83	12	28
Diff Median L	1.665	-2	0

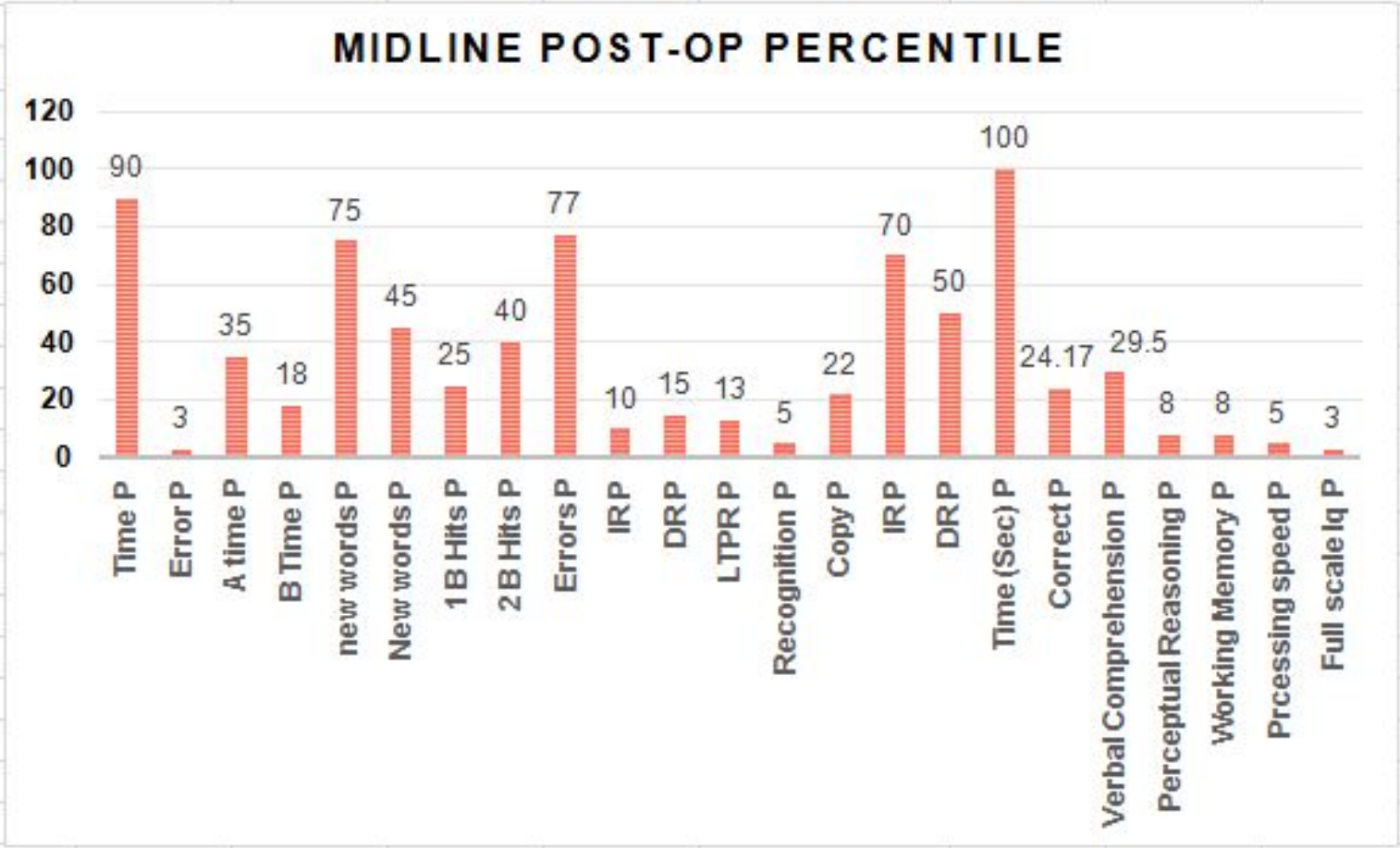
Memory-1

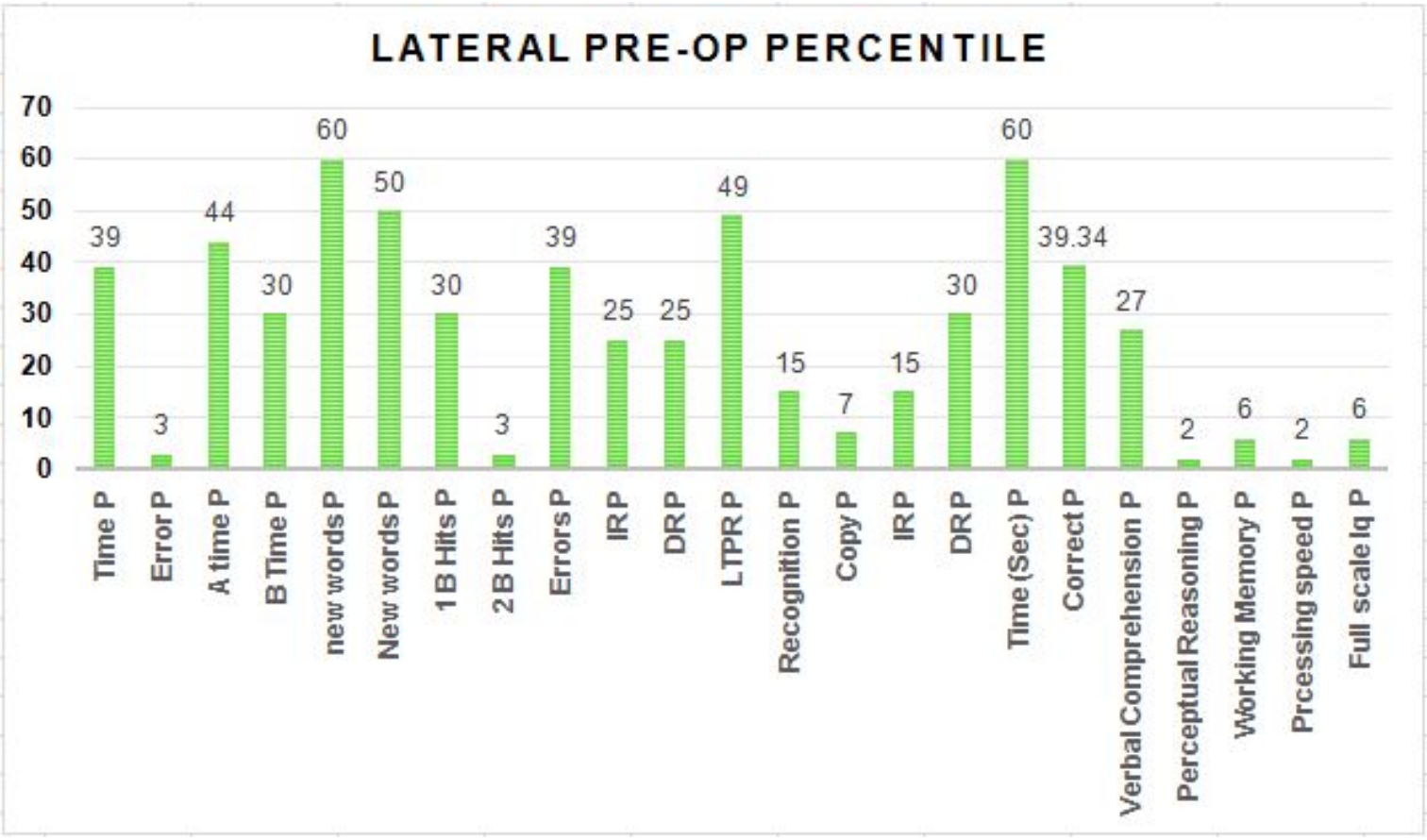
	Verbal N Back				SOPT	RAVLT				Rey Complex		
	1 B Hits	1 B Error	2 B Hits	2 B error	errors	I R	DR	LTPR	Recognition	Copy	IR	DR
Pre M Median 1	8	1	5	4	1	11	11	100	15	36	23	23
Pre M Median 2	8	1	5	4	1.5	11	8	80	15	36	23	23
Post M Median 1	8	1	7	2	1	7.5	8	94.44	13	36	32	32
Post M Median 2	8	1	7	2	1	10	12	87.5	13	36	32	32
Diff Median M1	0	0	2	-2	0	-3.5	-3	-5.56	-2	0	9	9
Diff Median M2	0	0	2	-2	-0.5	-1	4	7.5	-2	0	9	9
Pre L Median	9	0	6	4	2	9.5	10	96.15	14.5	34	17	17.5
Post L Median	8	1	6.5	2.5	2.5	11.5	12	100	15	33	18	19
Diff Median L	-1	1	0.5	-1.5	0.5	2	2	3.85	0.5	-1	1	1.5

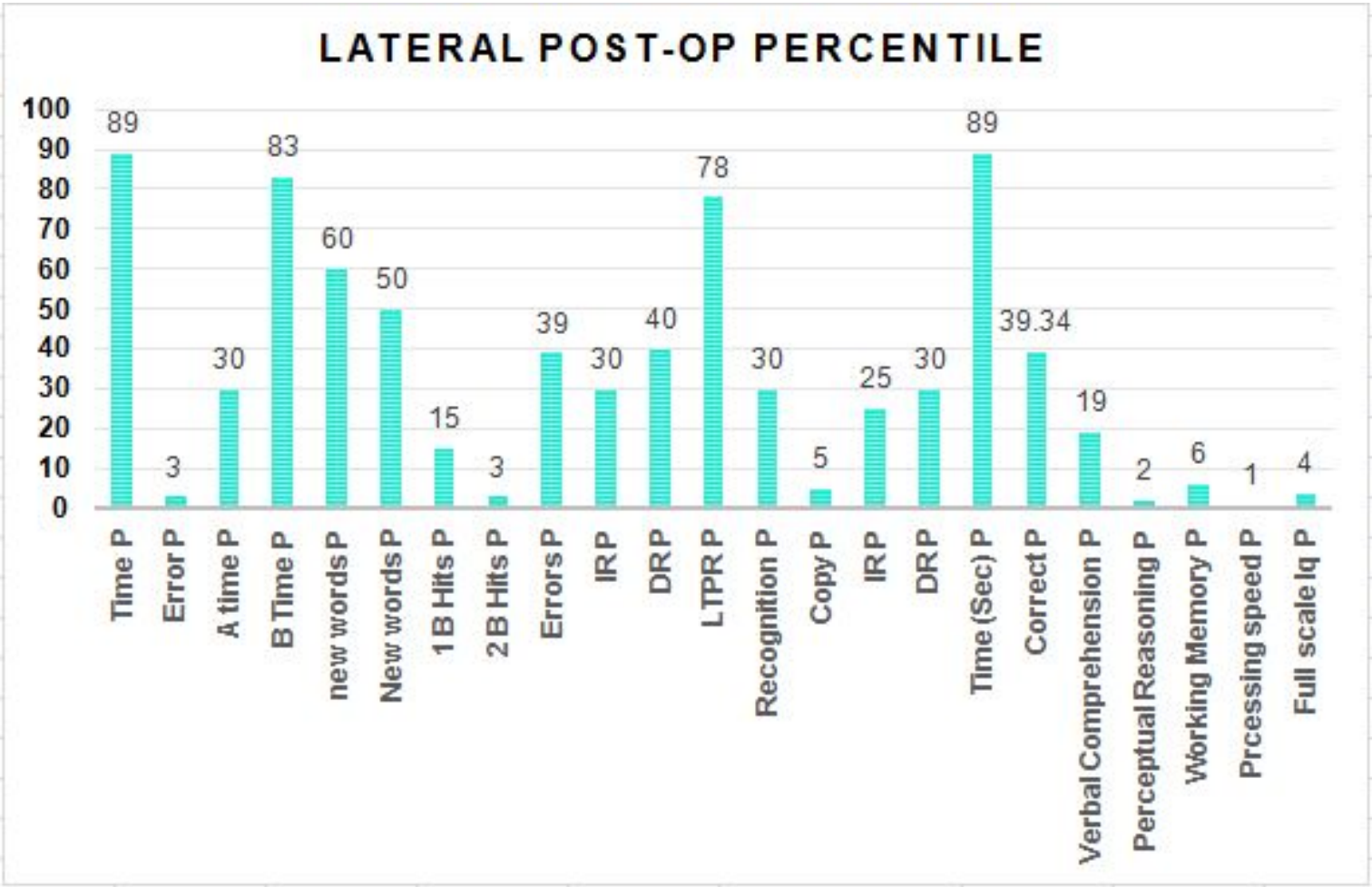
	Speed	Comprehension
	Digit Symbol	Token
	Time (sec)	Correct
Pre M Median 1	424	35.5
Pre M Median 2	424	35
Post M Median 1	262	36
Post M Median 2	262	36
Diff Median M1	-162	0.5
Diff Median M2	-162	1
Pre L Median	226	35
Post L Median	160	36
Diff Median L	-66	1

Intelligence					
	Verbal Comprehension	Perceptual Reasoning	Working Memory	Prcessing speed	Full scale Iq
Pre M Median 1	91	80	69.5	68	77
Pre M Median 2	92.5	81	71	78	78
Post M Median 1	97	83	68	62	79
Post M Median 2	91	81	71	75	77
Diff Median M1	6	3	-1.5	-6	2
Diff Median M2	-1.5	0	0	-3	-1
Pre L Median	93	72	74	71.5	75
Post L Median	90	69	81	69	74
Diff Median L	-3	-3	7	-2.5	-1

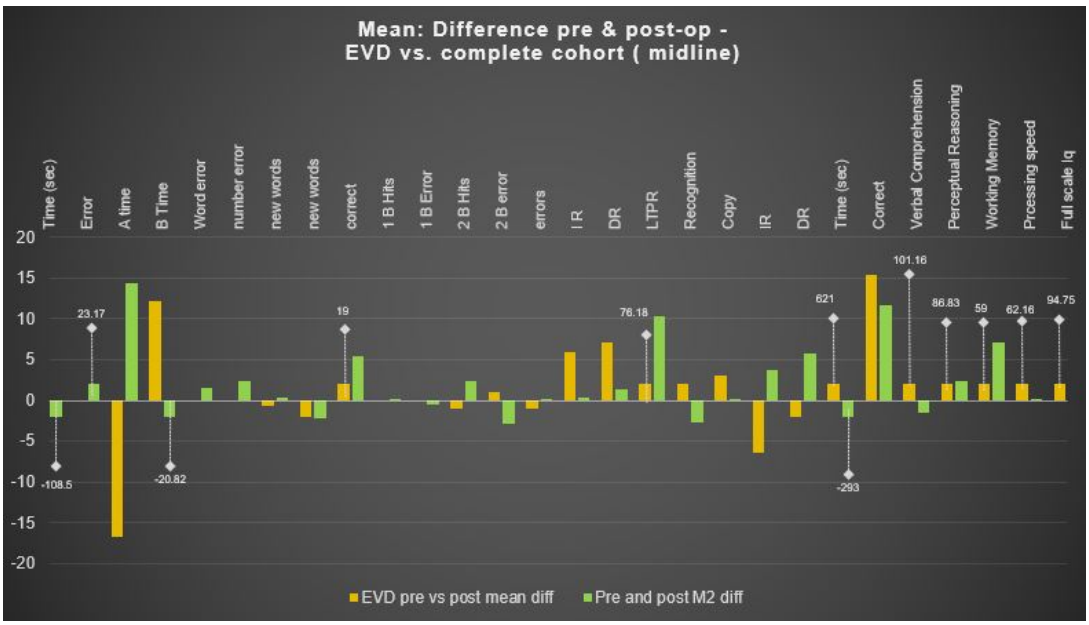

MIDLINE PRE-OP PERCENTILE
90
80
70
60
50
40
30
20
10
0
56
11
50
15
70
70
20
15
77
5
10
7
20
20
45
40
13
24.17
29.5
6
4
5
5
Time P
Error P
A time P
B Time P
new words P
New words P
1B Hits P
2B Hits P
Errors P
IR P
DR P
LTPR P
Recognition P
Copy P
IR P
DR P
Time (Sec) P
Correct P
Verbal Comprehension P
Perceptual Reasoning P
Working Memory P
Prcessing speed P
Full scale Iq P

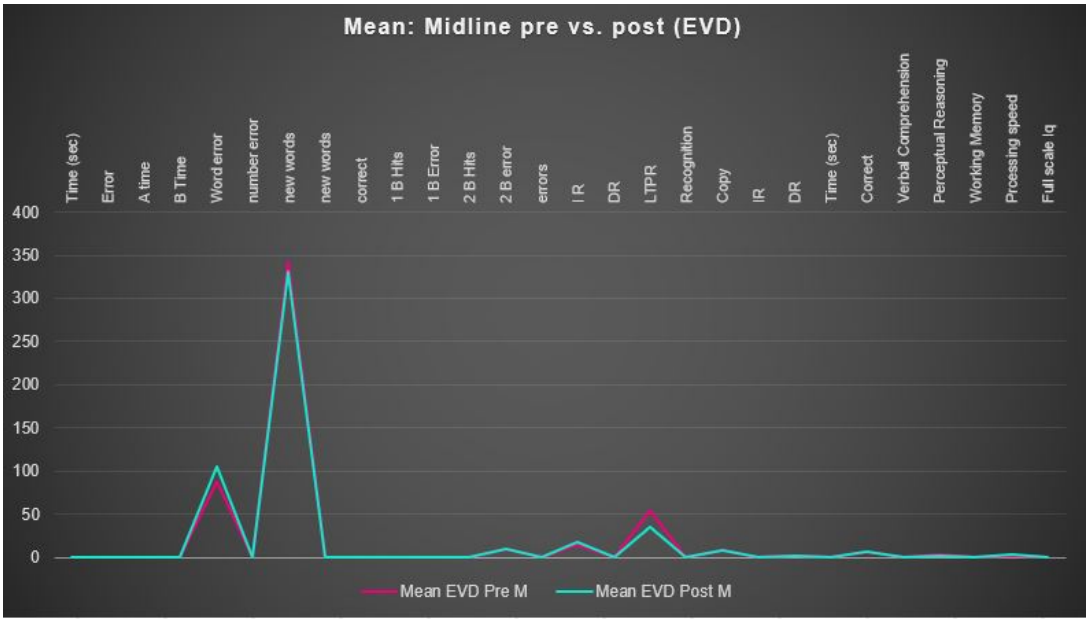

MIDLINE POST-OP PERCENTILE
120
100
80
60
40
20
0
90
3
35
18
75
45
25
40
77
10
15
13
5
22
70
50
100
24.17
29.5
8
8
5
3
Time P
Error P
A time P
B Time P
new words P
New words P
1B Hits P
2B Hits P
Errors P
IR P
DR P
LTPR P
Recognition P
Copy P
IR P
DR P
Time (Sec) P
Correct P
Verbal Comprehension P
Perceptual Reasoning P
Working Memory P
Prcessing speed P
Full scale Iq P

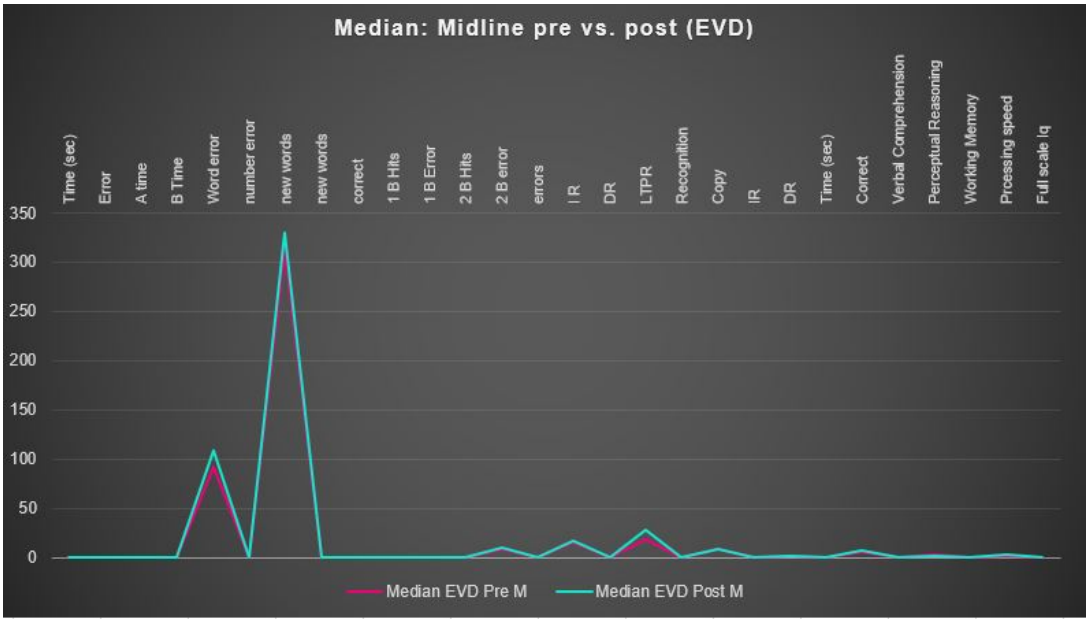

LATERAL PRE-OP PERCENTILE
70
60
50
40
30
20
10
0
39
3
44
30
60
50
30
3
39
25
25
49
15
7
15
30
60
39.34
27
2
6
2
6
Time P
Error P
A time P
B Time P
new words P
New words P
1 B Hits P
2 B Hits P
Errors P
IR P
DR P
LTPR P
Recognition P
Copy P
IR P
DR P
Time (Sec) P
Correct P
Verbal Comprehension P
Perceptual Reasoning P
Working Memory P
Prcessing speed P
Full scale Iq P


LATERAL POST-OP PERCENTILE
100
90
80
70
60
50
40
30
20
10
0
89
3
30
83
60
50
15
3
39
30
40
78
30
5
25
30
89
39.34
19
2
6
1
4
Time P
Error P
A time P
B Time P
new words P
New words P
1 B Hits P
2 B Hits P
Errors P
IR P
DR P
LTPR P
Recognition P
Copy P
IR P
DR P
Time (Sec) P
Correct P
Verbal Comprehension P
Perceptual Reasoning P
Working Memory P
Prcessing speed P
Full scale Iq P

EVD


Mean: Difference pre & post-op -
EVD vs. complete cohort (midline)
Time (sec)
Error
A time
B Time
Word error
number error
new words
new words
correct
1 B Hits
1 B Error
2 B Hits
2 B error
errors
I R
DR
LTPR
Recognition
Copy
IR
DR
Time (sec)
Correct
Verbal Comprehension
Perceptual Reasoning
Working Memory
Processing speed
Full scale Iq
20
15
10
5
0
-5
-10
-15
-20
23.17
-108.5
-20.82
19
76.18
621
-293
101.16
86.83
59
62.16
94.75
EVD pre vs post mean diff
Pre and post M2 diff


Mean: Midline pre vs. post (EVD)
Time (sec)
Error
A time
B Time
Word error
number error
new words
new words
correct
1 B Hits
1 B Error
2 B Hits
2 B error
errors
I R
DR
LTPR
Recognition
Copy
IR
DR
Time (sec)
Correct
Verbal Comprehension
Perceptual Reasoning
Working Memory
Processing speed
Full scale Iq
400
350
300
250
200
150
100
50
0
Mean EVD Pre M
Mean EVD Post M


Median: Midline pre vs. post (EVD)
Time (sec)
Error
A time
B Time
Word error
number error
new words
new words
correct
1 B Hits
1 B Error
2 B Hits
2 B error
errors
I R
DR
LTPR
Recognition
Copy
IR
DR
Time (sec)
Correct
Verbal Comprehension
Perceptual Reasoning
Working Memory
Processing speed
Full scale Iq
350
300
250
200
150
100
50
0
Median EVD Pre M
Median EVD Post M

The mean pre operative and postoperative score for each neuropshychological test was calculated for patients with EVD [M1,M4, M7,M8, M 9, M10] inserted intraoperatively.

The difference between mean pre and post operative scores in patients who had an EVD inserted was compared to the mean difference in score between pre and post operative period for the whole midline cohort, to look for effects of pre operative hydrocephalus on the neuropsychological outcome.

1. Attention:

Attention-2

	Digit Vigilance		Trail Making		Triads	
	Time (sec)	Error	A time	B Time	Word error	number error
Pre M Mean 2	538	21.333333333	67.111111111	230.625	1	4.2
Post M Mean 2	429.5	44.5	81.5	209.83333333	2.5	6.5
Pre and post M2 diff	-108.5	23.17	14.4	-20.82	1.5	2.3
EVD M Pre			88	342.75		
EVD M post			104.75	330.5		
Diff			16.75	-12.25		

1. A time has worsened (16.75 s) in EVD group (vs 14.4s in the whole midline cohort) faring marginally worse.
2. B time improved by (-12.25 s) in the EVD Group (vs -20.82 in the whole midline cohort) faring marginally worse than the in the whole midline cohort.

2. Executive functions:

1. COWAT test: EVD group showed a marginal increase in the mean number of new word formation (0.66) vs (0.388 in the complete midline cohort) faring marginally better. .

	Cowa	Animals	Block Design
	new words	new words	correct
Pre M Mean 2	9.37714285714286	15.1428571428571	23.5
Post M Mean 2	9.765	13	29
Pre and post M2 diff	0.388	-2.143	5.5
EVD M Pre	9	15	54
EVD M Post	9.66	17	35
EVD Diff	0.66	2	-19

2. Animal naming test: There was an increase in the average number of new animals that could be named postoperatively (2) in the EVD Group (vs -2.143 in the complete midline cohort) indicating an improvement. .

3. Block Design test: too showed a deterioration in the post operative block designing ability (-19) in the EVD Group (vs +5.5 in the complete midline cohort) indicating a fall.

.

3. Memory:

1. Verbal N back test: 1 b hit showed no difference in the EVD group (0) (vs 0.143 in midline cohort)

2 b hit scores showed a marginal increase in average number of hits (+1) in EVD group (vs 2.4 in complete midline cohort).

2. Self ordered pointing test: error increased in the post op period (+1) (vs +0.07 in complete midline cohort)

3. RAVLT:

a. Immediate recall: decreased by -6 in the EVD group (vs 0.308 in the complete midline cohort).

	Verbal N Back				SOPT	RAVLT				Rey Complex		
	1 B Hits	1 B Error	2 B Hits	2 B error	errors	I R	DR	LTPR	Recognition	Copy	IR	DR
Pre M Mean 2	7.85714	1.57142	5	4.85714	1.33333	9.69230	9.61538	68.4869	14.143	32.75	23	20.67
Post M Mean 2	8	1	7.4	2	1.4	10	10.9090	78.8418	11.5	33	26.7	26.4
Pre and post M2 diff	0.143	-0.571	2.4	-2.857	0.07	0.308	1.29	10.35	-2.643	0.25	3.7	5.73
EVD M pre	8	1	6	3	2	16.8333	19	140	15	36	17.5	21
EVD M Post	8	1	7	2	3	10.8333	11.8333	63.8133	13	33	24	23
Pre and post L diff	0	0	1	-1	1	-6	-7.17	-76.19	-2	-3	6.5	2

b. Delayed recall: decreased (-7.17) in the EVD group (vs +1.29 in the complete midline cohort)

c. LTPR decreased (-76.29) in the EVD group (vs +10.35 in complete midline cohort)

d. Recognition score reduced (-2) in EVD group (vs -2.643 in complete midline cohort)

4. Rey Complex

a. Copy score decreased (-3) in EVD group (vs +0.25 in complete midline cohort)

b. Immediate recall increased (6.5) in EVD group (vs +3.7 in complete midline cohort)

c. Delayed recall increased (2) in EVD group (vs +5.73 in complete midline cohort)

RAVLT test scores were better for children during the post-operative condition (mdn = 42) than in the pre-operative condition (mdn = 57).

A Mann-Whitney test indicated that this difference was a statistically significant difference of U=0.5, z= -2.4, p=<0.015

4. Comprehension: There was a decrease in comprehension in the EVD group (-15.35) (vs +34.6 in complete midline cohort)

	Comprehension
	Token
	Correct
Pre M Mean 2	31.0909090909091
Post M Mean 2	42.7222222222222
Pre and post M2 diff	11.63
EVD M Pre	64.75
EVD M Post	49.4
EVD Diff	-15.35

5. Intelligence:

1. Verbal comprehension- scores remained unchanged in EVD group(vs -1.45 in complete midline cohort)

2. Perceptual reasoning remained unchanged in EVD group (vs 2.38 in complete midline cohort)

3. Working memory increased (+1) in the EVD group (vs +7.05 in complete midline cohort)

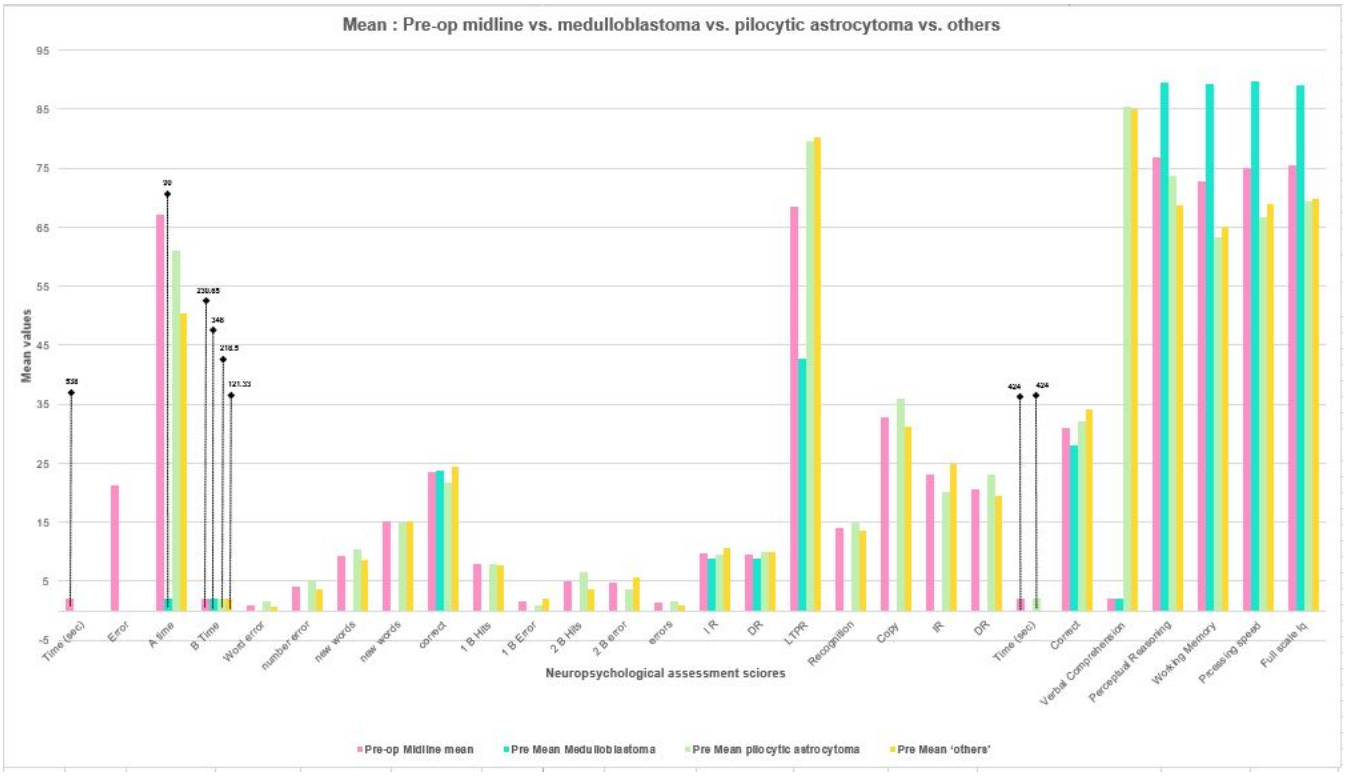
4. Processing speed decreased (-1) in the EVD group (vs +0.03 in complete midline cohort)

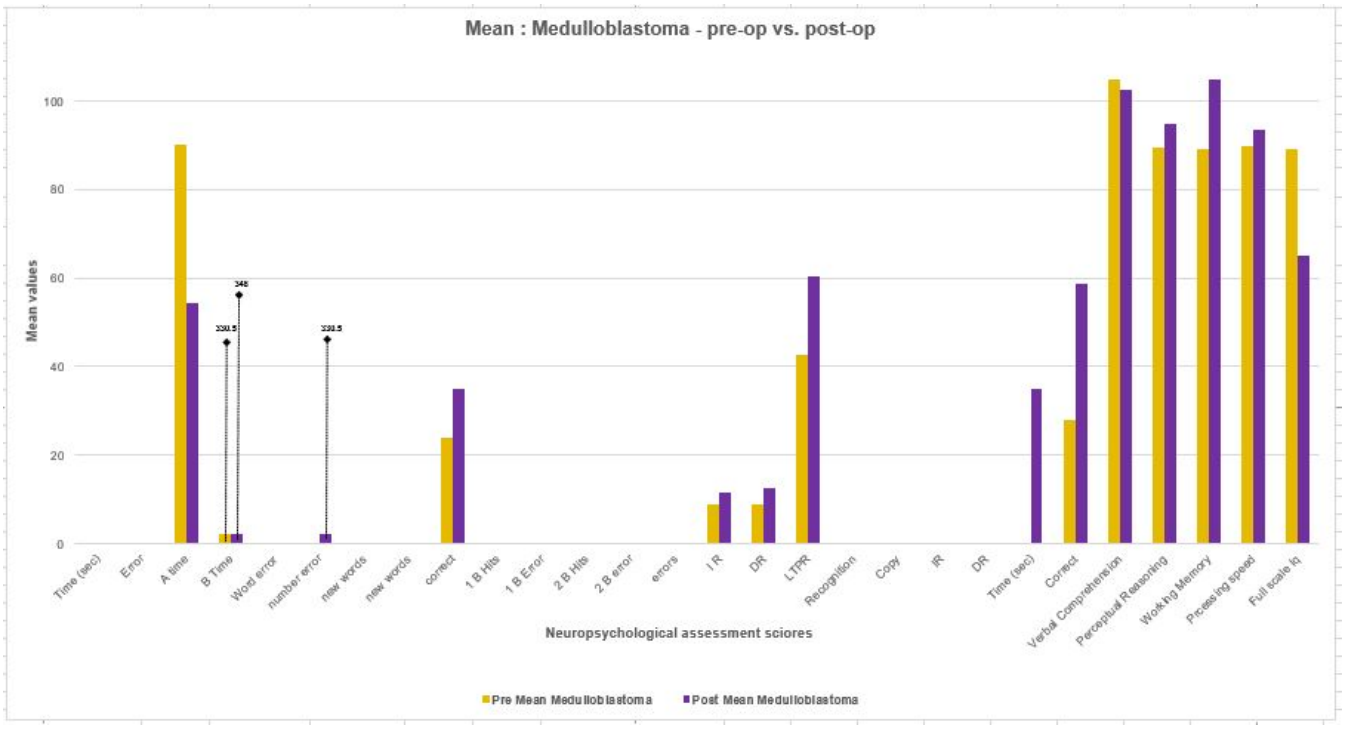
5. Full scale IQ test saw an increase in scores in EVD group (+1) (vs -4.69 in complete midline cohort).

Intelligence-1

	Verbal Comprehension	Perceptual Reasoning	Working Memory	Prcessing speed	Full scale Iq
Pre M Mean 2	91.75	76.916666666666	72.75	75.111111111111	75.4
Post M Mean 2	90.3	79.3	79.8	75.142857142857	70.714285714285
Pre and post M2 diff	-1.45	2.38	7.05	0.03	-4.69
EVD M Pre	8	1	6	3	2
EVD M post	8	1	7	2	3
EVD diff	0	0	1	-1	1

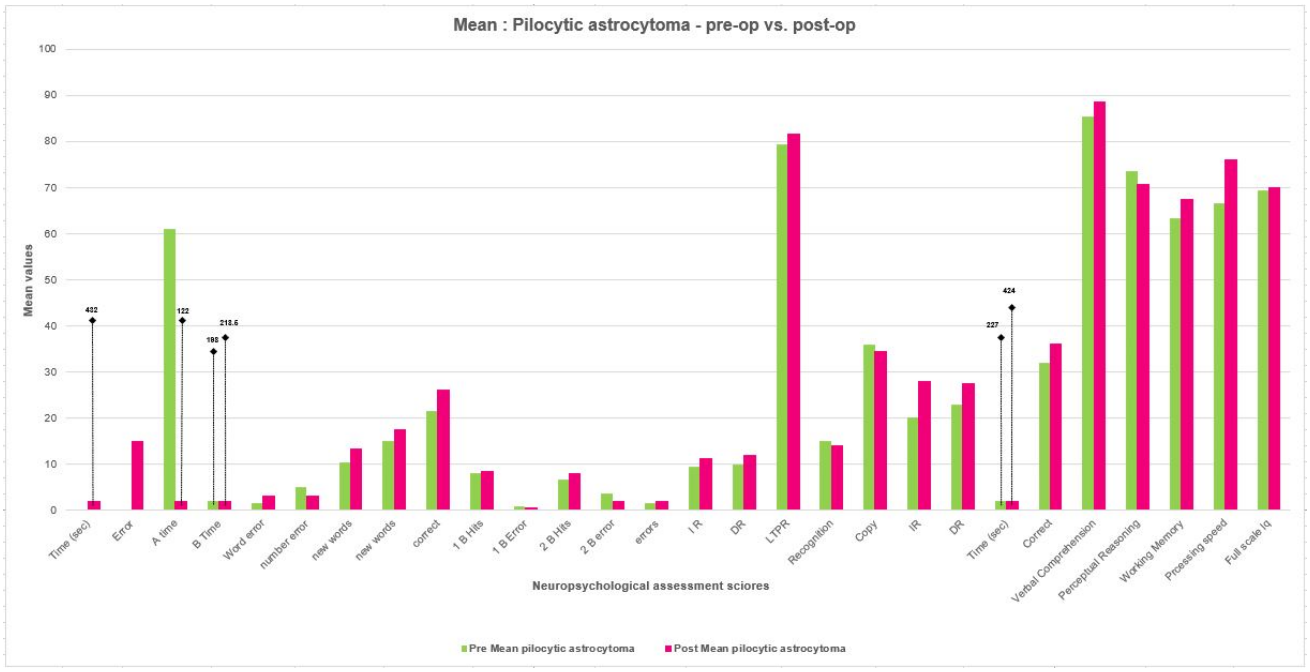
Histopathology report

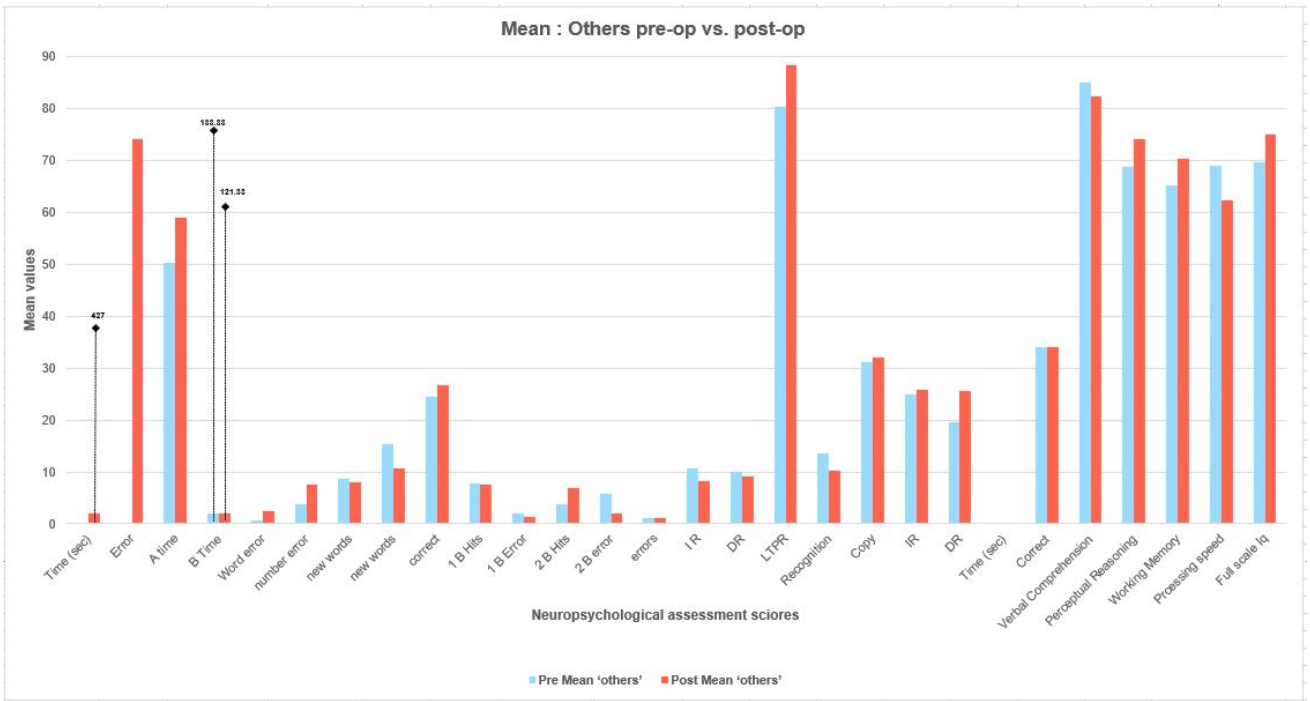


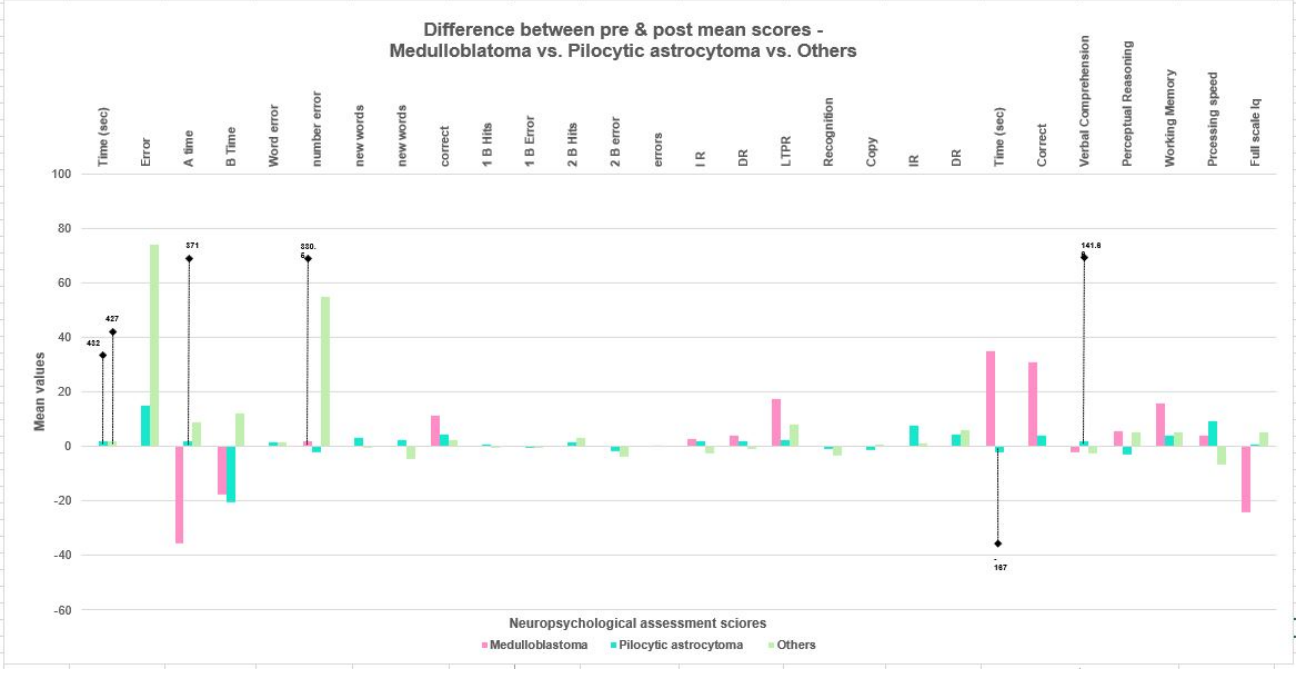


4 patients had tumor histology Medulloblastoma (M1,M7,M9,M10),

4 patients had pilocytic astrocytoma (M2,M4,M8,M12) and remaining 5 patients (M3,M5,M6,M11,M13) had different histology each. The mean value of neuropsychological score for these 3 groups i.e Medulloblastoma, Pilocytic astrocytoma and 'others' was determined in the pre and


Mean : Pilocytic astrocytoma - pre-op vs. post-op
Mean values
Neuropsychological assessment sciores
Time (sec)
Error
A time
B Time
Word error
number error
new words
new words
correct
1 B Hits
1 B Error
2 B Hits
2 B error
errors
I R
DR
LTPR
Recognition
Copy
IR
DR
Time (sec)
Correct
Verbal Comprehension
Perceptual Reasoning
Working Memory
Processing speed
Full scale Iq
Pre Mean pilocytic astrocytoma
Post Mean pilocytic astrocytoma


Mean : Others pre-op vs. post-op
Mean values
Neuropsychological assessment sciores
Pre Mean 'others'
Post Mean 'others'


Difference between pre & post mean scores -
Medulloblatoma vs. Pilocytic astrocytoma vs. Others
Mean values
Neuropsychological assessment sciores
Medulloblastoma
Pilocytic astrocytoma
Others

post operative period. Pre operative value of the three categories was plotted against each other's and the complete midline cohort.

The pre operative values was plotted against the post operative period values. The difference in mean post and pre op value was plotted between the 3 groups.

1. Attention:

1. Digit Vigilance :

Medulloblastoma-Digit vigilance could not be assessed due to insufficient data.

Pilocytic astrocytoma: pre operative mean could not be calculated in view of insufficient data, Post operative Digit vigilance time was 432 seconds with an average 15 errors per test.

Others: pre operative mean could not be calculated in view of insufficient data, Post operative Digit vigilance time was 427 seconds with 74 errors per test (Only one single person).

2.Trail making

Medulloblastoma- A time has improved from 90s to average 54.5 s showing an improvement by 35 s. B time also showed an improvement from 348 s to 330.5 s, 17.5 s faster after surgery.

Pilocytic astrocytoma: A time has worsened with an average 61s to 122 s after surgery, I.e by 61s. B time improved drastically from 218.5 to 198 by a difference of 20.5 seconds

Others: This cohort showed an A time average worsening by 8.66 seconds after surgery, I.e from 50.33 to 59 s. B time worsened by 12 s from 133.33 s to 121.33 s.

3. Triads

Medulloblastoma- Could not be evaluated due to insufficient data.

Pilocytic astrocytoma- Triad test showed an decrease in number (-2) and increase in word error (1.5) in post operative period

	Digit Vigilance		Trail Making		Triads	
	Time (sec)	Error	A time	B Time	Word error	number error
Pre M Mean 2	538	21.3333333333	67.1111111111	230.625	1	4.2
Post M Mean 2	429.5	44.5	81.5	209.833333333	2.5	6.5
Pre and post M2 diff	-108.5	23.17	14.4	-20.82	1.5	2.3
Pre Mean Medulloblastoma			90	348		
Pre Mean pilocytic astrocytoma			61	218.5	1.5	5
Pre Mean 'others'			50.3333333333	121.333333333	0.66666666666	3.66666666666
Mean MB post			54.5	330.5		
Mean PA post	432	15	122	198	3	3
Mean 'others'post	427	74	59	133.333333333	2.33333333333	7.66666666666
Mean MB pre post diff	0	0	-35.5	-17.5	0	0
Mean PA pre post diff	432	15	61	-20.5	1.5	-2
Mean 'others' pre post diff	427	74	8.66666666666	12	1.66666666666	4

Others: Triad test showed an increase in number (4) and word error (1.67) in post operative period

2. Executive functions

1. COWAT test:

Executive function-1

	Cowa	Animals	Block Design
	new words	new words	correct
Pre M Mean 2	9.37714285714286	15.1428571428571	23.5
Post M Mean 2	9.765	13	29
Pre and post M2 diff	0.388	-2.143	5.5
Pre Mean Medulloblastoma			23.75
Pre Mean pilocytic astrocytoma	10.33	15	21.6666666666667
Pre Mean 'others'	8.6625	15.25	24.4
Mean MB post			35
Mean PA post	13.33	17.5	26
Mean 'others'post	7.9825	10.75	26.75
Mean MB post	0	0	11.25
Mean PA post	3	2.5	4.3333333333333
Mean 'others'post	-0.68	-4.5	2.35

Medulloblastoma: Could ot be evaluated due to insufficient data.

Pilocytic astrocytoma: showed a marginal increase in the mean number of new word formation (3). This difference indicated an improvement in the patient group's ability in the post-operative condition

Others: showed a reduction in no of new word formation (-0.68)

2. Animal naming test:

Medulloblastoma: could not be evaluated due to insufficient data.

Pilocytic astrocytoma: There was a marginal increase in the average number of new animals that could be named postoperatively (2.5).

Others: There was a fall in the post operative period in avg no of new word formation (-2.5)

3. Block Design test:

Medulloblastoma: showed an increase in the post operative block designing ability (11.25) which indicates a progression in their test performance post-surgery.

Pilocytic astrocytoma: showed an increase in the post operative block designing ability (4.33) which indicates a progression in their test performance post-surgery.

Others showed an increase in the post operative block designing ability (2.35) which indicates a progression in their test performance post-surgery.

3. Memory:

1. Verbal N Back test

Medulloblastoma:could not be analysed due to insufficient data

Pilocytic astrocytoma: 1 b hit increased (+0.5) with a reduction in error (-0.5) and 2 b hit scores showed a marginal increase in average number of hits (+1.33) and a fall in error rate (-1.67)

Others: 1 b hit (-.0833) with a reduction in error (-0.67) and 2 b hit scores showed a marginal increase in average number of hits (+3.25) and a fall in error rate (-3.75)

2. SOPT

Medulloblastoma: could not be analysed in view of insufficient data

Pilocytic astrocytoma showed an increase in error by 0.3333 score

Others showed no change in error pre and post op

3. RAVLT

a. Immediate recall:

MB: increased by 2.92

PA:increased by 1.83

Others:reduced by 2.4 (-2.4)

b. Delayed recall:

MB increased by 3.92

PA increased by 2

Others reduced by 0.8 (-0.8)

c. LTPR

MB: increased post op by 17.58

PA: increased by 2.13

Others increased by 8.01

d. Recognition score

MB could not be analysed in view of insufficient data

PA recognition score reduced by 1 (-1)

Others recognition reduced by 3.25 (-3.25)

	Verbal N Back				SOPT	RAVLT				Rey Complex		
	1 B Hits	1 B Error	2 B Hits	2 B error	errors	I R	DR	LTPR	Recognition	Copy	IR	DR
Pre M Mean 2	7.85714	1.57142	5	4.85714	1.33333	9.69230	9.61538	68.4869	14.143	32.75	23	20.67
Post M Mean 2	8	1	7.4	2	1.4	10	10.9090	78.8418	11.5	33	26.7	26.4
Pre and post M2 diff	0.143	-0.571	2.4	-2.857	0.07	0.308	1.29	10.35	-2.643	0.25	3.7	5.73
Pre Mean Medulloblastoma						8.75	8.75	42.75				
Pre Mean pilocytic astrocytoma	8	1	6.66666	3.66666	1.66666	9.5	10	79.5	15	36	20.25	23
Pre Mean ‘others’	7.75	2	3.75	5.75	1	10.6	10	80.266	13.5	31.125	24.8333	19.5
Mean MB post						11.6666	12.6666	60.3333				
Mean PA post	8.5	0.5	8	2	2	11.3333	12	81.6266	14	34.5	28	27.5
Mean ‘others’post	7.66666	1.33333	7	2	1	8.2	9.2	88.276	10.25	32	25.8333	25.6666
Mean MB post	0	0	0	0	0	2.91666	3.91666	17.5833	0	0	0	0
Mean PA post	0.5	-0.5	1.33333	-1.6666	0.33333	1.83333	2	2.12666	-1	-1.5	7.75	4.5
Mean ‘others’post	-0.0833	-0.6666	3.25	-3.75	0	-2.4	-0.8	8.01	-3.25	0.875	1	6.16666

4. Rey Complex
    a. Copy score
        MB could not be analysed in view of insufficient data
        PA reduced by 1.5 (-1.5)
        Others increased by 0.875
    b. Immediate recall
        MB could not be analysed in view of insufficient data
        PA increased by 7.75
        Others increased by 1
    c. Delayed recall
        MB could not be analysed in view of insufficient data
        PA could not be 4.5
        Others increased 6.167

4. Intelligence

1. Verbal comprehension-
    MB scores decreased in the post operative period (-2.33)
    PA Score increased by 3.33 in the post op period
    Others decreased by 2.75 (-2.75) in the post op period
2. Perceptual reasoning
    MB increased in the post op period (5.55)
    PA score reduced by 3 (-3)
    Others score increased by 5.2
3. Working memory
    MB increased in the post op period (15.75)
    PA score increased by 4
    Others score increased by 5.05
4. Processing speed
    MB increased in the post op period (3.83)
    PA score increased by 9.33
    Others score decreased by 6.67 (-6.67)
5. Full scale IQ test
    MB decreased in the post op period (-24)
    PA score increased by 0.67
    Others score increased by 5.25

-

Intelligence-2

	Verbal Comprehension	Perceptual Reasoning	Working Memory	Prcessing speed	Full scale Iq
Pre M Mean 2	91.75	76.916666666667	72.75	75.111111111111	75.4
Post M Mean 2	90.3	79.3	79.8	75.142857142857	70.714285714285
Pre and post M2 diff	-1.45	2.38	7.05	0.03	-4.69
Pre Mean Medulloblastoma	105	89.5	89.25	89.666666666667	89
Pre Mean pilocytic astrocytoma	85.333333333333	73.666666666667	63.333333333333	66.666666666667	69.333333333333
Pre Mean 'others'	85	68.8	65.2	69	69.75
Mean MB post	102.66666666667	95	105	93.5	65
Mean PA post	88.666666666667	70.666666666667	67.333333333333	76	70
Mean 'others'post	82.25	74	70.25	62.333333333333	75
Mean MB post	-2.333333333333	5.5	15.75	3.8333333333333	-24
Mean PA post	3.3333333333334	-3	4	9.3333333333333	0.6666666666667
Mean 'others'post	-2.75	5.2	5.05	-6.666666666667	5.25

5. Mental speed

MB Digit symbol time could not be assessed in the pre op period. In the post op period it was 35.

PA Digit symbol time reduced from 424 s to 227 s signifying a 197 s reduction (-197)

Others could not be analysed due to insufficient data

6. Comprehension:

MB- There was an increase in comprehension score by 30.67

PA- There was an increase in the score by 3.875

Others- no difference in score pre and post op

	Speed	Comprehension
	Digit Symbol	Token
	Time (sec)	Correct
Pre M Mean 2	424	31.0909090909091
Post M Mean 2	131	42.7222222222222
Pre and post M2 diff	-293	11.63
Pre Mean Medulloblastoma		28
Pre Mean pilocytic astrocytoma	424	32.125
Pre Mean 'others'		34.125
Mean MB post	35	58.6666666666667
Mean PA post	227	36
Mean 'others'post		34.125
Mean MB post	35	30.6666666666667
Mean PA post	-197	3.875
Mean 'others'post	0	0

2 patients had brainstem infiltration (M5,M7), both these patients had EVD inserted which was later internalised.

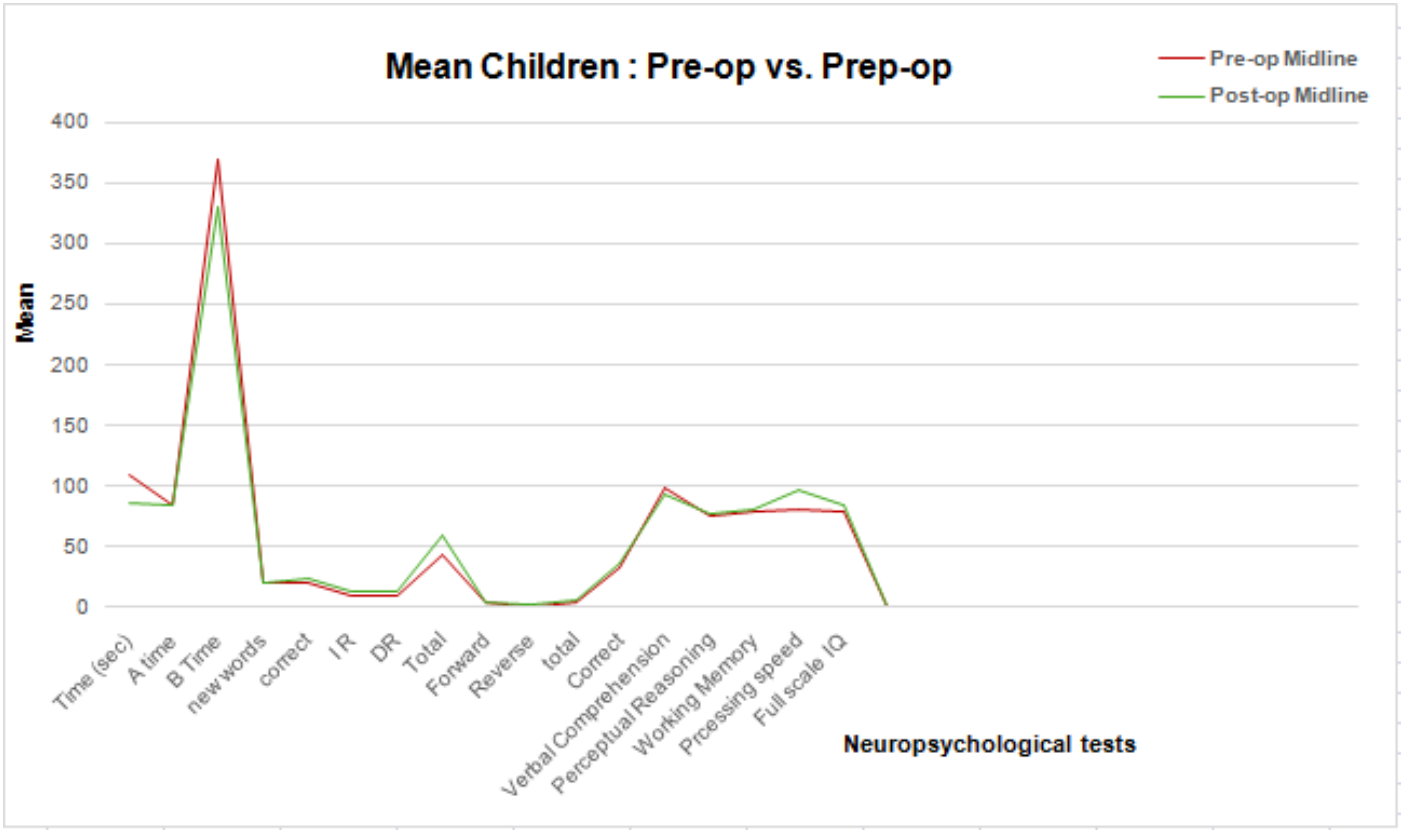
Both of these patients developed CMS in the post operative period.

M5 HPR was Grade 2 ependymoma, M7 HPR was medulloblastoma but post operative re radiotherapy neuropsychological evaluation was not possible,

Children

3 of the 5 children were diagnosed with medulloblastoma

The child with grade 2 ependymoma as a diagnosis developed an subsequently recovered from CMS. M7 a child with a 4th ventricular medulloblastoma also developed CMS but could not undergo post operative neuropsychological evaluation before scheduled radiation therapy. Both the children had an intra operative EVD placed which was subsequently internalised and both patients had evidence of brainstem invasion in pre op MRI and during surgery.



Attention

Attention-4

	Attention					
	Colour Cancellation		Trail Making			
	Time (sec)	Error	A time	Error	B Time	Error
Mean Pre	108.6	18.2	84	2	370.5	2
Mean post	86	14.25	84.3333333333	0	330.5	1
Diff pre and post	-22.6	-3.95	0.33333333333	-2	-40	-1

Colour cancellation score in pre op period was 108.6 and 86 in the post op period with an improvement of 22.6 seconds after surgery. The error rate also reduced by 3.95

Trail making showed A time almost unchanged and B time improvement by 40 seconds (-40) with a reduction in error by 1 (-1)

Executive function

Executive function

Phonemic fluency decreased by 1.4 mean new words per test (-1.4).

Block design capability increased by 3 points and the children improved from the 50th to 60th percentile group post surgery.

Executive function-2

	Executive functions	
	Phonemic Fluency	Block Design
	new words	correct
Mean Pre	20.6	20.2
Mean post	19.2	23.8
Diff pre and post	-1.4	3.6

Memory:

Memory-3

	Memory									
	RAVLT						VSWMS			
	I R	P	DR	P	Total	P	Forward	Reverse	total	P
Mean Pre	8.8	< 5	8.2	5	43.6	26	3.25	1	4.25	<5
Mean post	11.8	10	12.6	65	58.8	92	3.75	1.25	5	5
Diff pre and post	3		4.4		15.2		0.5		0.75	

RAVLT

IR - the mean value increased by 3 from 8.8 in the pre op period and 11.8 in the post op period. The percentile score for immediate recall was < 5 (<1.5SD) percentile in the pre op period to 10th percentile (<1SD) in the post op period.

DR- the mean value increased by 4.4 from 8.3 in the pre operative period which was the 5th percentile group (<1.5SD) and rise to 12.6 points in the post op period resulting in the 65th percentile position.

Total score- the mean value in the pre operative period increased from 43.6 to 58.8 i.e by 15.2 points. The mean score percentile rose from 26th to 92nd percentile with surgery

VSWMS:

mean forward score increased by 0.5 and backward score increased by a mean of 1.25. Total score increased by 0.75 points . The scores were poor and less than 5th percentile in the pre and post op.period. (<1SD)

Verbal comprehension score showed improvement from mean 33.1 representing the 50th percentile to 35 after surgery representing the 95th percentile, showing a difference of 1.9 correct score.

Verbal comprehension

	Comprehension	
	Token	
	Correct	P
Mean Pre	33.1	50
Mean post	35	95
Diff pre and post	1.9	

Intelligence (WISC)

Verbal comprehension decreased by a mean 4 words from 97.6 in the pre op period to 93.6 in the post operative period. I.e from 45th percentile in pre op to 34th percentile in the post op period.

Perceptual reasoning increased by a mean of 2.8 i.e from 74.8 to 77.6 points. I.e from 5th to 7th percentile. <1.5 SD both pre and post op

Working memory increased by a modest 1.8 from 79 to 80.8 i.e from 8th to 11th percentile <1 SD both pre and post op

Processing speed increased by 16.67 from 80 in the pre op period to 96.67 in the post op period. ie from 9th to 42nd percentile. <1SD in the re op period

Full scale IQ score increased from 79 to 84 by 5 points after surgery. Ie from 8th to 14th percentile. <1 SD in the pre

Intelligence-3

	WISC									
	Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Prcessing speed	P	Full scale IQ	P
Mean Pre	97.6	45	74.8	5	79	8	80	9	79	8
Mean post	93.6	34	77.6	7	80.8	11	96.66666	42	84	14
Diff pre and post	-4	-	2.8		1.8	-	16.66666	21.93333	5	

Parameter	Test	Midline	
Attention	Color cancellation	-22.6	Improvement
	Tail making A	0.33	Mild worsening
	Trail making B	-40	Improvement
Executive function	Phonemic fluency	-1.4	Mild worsening
	Block design	3.6	Improvement
Memory	IR	3	Improvement
	DR	4.4	Improvement
	Total	15.2	Improvement
	VSWMS	0.75	Improvement
Token test	Verbal comprehension	1.9	Improvement
Intelligence	Verbal comprehension	-4	Worsening
	Perceptual reasoning	2.8	improvement
	Working memory	1.8	Improvement
	Processing speed	16.67	Improvement
	Full scale IQ	5	Improvement

Percentile Jumps-2

Parameter	Test	Midline percentile jumps	Midline comment
Memory	IR	<5 —> 10	<1.5 SD- <1 SD
	DR	5–>7	<1.5 SD - < 1 SD
	Total	26 —> 92	
	VSWMS	<5 —> 5	<1.5 SD
Verbal comprehension	Token test	50 —> 95	
Intelligence	Verbal comprehension	45 —> 34	-
	Perceptual reasoning	5 —> 7	<1.5SD
	Working memory	8 —> 11	< 1 SD
	Processing speed	9 —> 42	< 1 SD pre op
	Full scale IQ	8 —> 14	< 1D

Discussion

With time, more and more patients with posterior fossa lesions survive into adulthood. The 5 year survival of medulloblastoma , ependymoma and pilocytic astrocytoma cases are 60%, 60-80%, 90% respectively (4)

In medulloblastoma and grade 3 ependymoma, following surgical decompression / debulking, RT is usually given to reduce the rate of recurrence. RT to the midline structures has been shown to cause blunting of neuropsychological parameters (3,4,98). Children who undergo surgery for pilocytic astrocytomas of the posterior fossa also showed poor performance in neuropsychological evaluation although they don't usually undergo radiation therapy. Hanslik et al noticed that all tumor types, even those who didn't undergo radiation showed cognitive deficits . This motivated us to look for effects of posterior fossa surgery on neuropsychology scores during pre op period. Considering posterior fossa surgery also includes RSSO group, we decided to use the lateral approach cohort to investigate if they too have any effect on the neuropsychological performance of an individual.

We looked for attention, executive function, Memory and Intelligence mainly and also ran tests on mental speed and verbal comprehension. Though the sample size was small, we ran a Mann Whitney U test between samples to look for any statistical significance between the different parameters.

Midline cases:

Many studies have shown that medulloblastoma survivors tend to have the lowest scores in various neuropsychological domains. (5,6,7,99))

Attention:

Digit vigilance test is extremely sensitive to subtle changes and is focused on measuring cognitive functions pertaining to rapid visual tracking and accurately selecting target stimuli. For the pre-op mean, the Digit vigilance was grouped into the 56th percentile and the post-operative mean value of the group was in the 90th percentile. This signifies an improvement.

In colour trails test, Trail A has been identified as a good indicator of focused attention, and here a general trend in the group was to have an the increase in time which is worsening in performance. Trail B of this test has been related more to an individual's visual ability and motor functioning. The improvement of the score post-surgery is an indicator of a tendency for the cognitive abilities towards correction due to rectification of their pathological condition. In colour trails test, A time score of the group fell into the 67th percentile and the post-operative mean value dropped them into a percentile of 35 signifying a deterioration with surgery. For the Trail B time, the pre-op mean value had them in the 15th percentile group with the post-operative mean value falling into the 18th percentile category signifying an insignificant increase.

Triad test showed an increase in number error (2.3) and word error (1.5) in post-operative period. Due to the requirement of overlapping attention resources for the skillful execution of the task, the patients normally find the task slightly difficult. As shown in the graph, the increase in number error is an indication of the inability to parallelly divide attention to multiple tasks in the post-operative conditions.

Executive function

The number of words generated on the COWA test, which measure phonemic fluency, had a difference of 0.388. This difference indicated an improvement in the patient group's ability in the post-operative condition.

In the Animals name test, the average value for generating words had decreased to -2.143. This test requires multiple cognitive skills such as an organized verbal recall and retrieval, self-monitoring of cognition and inhibition of responses in addition to effective executive functions (G1).

In the block design test, there was a difference of 5.5 between the pre-operative and post-operative mean values which indicates a progression in their test performance post-surgery. The block design test is a fairly accurate measure of visuospatial ability

Ronning et al and Vaquero et al (6,7) reported that there was a statistically significant difference in executive function scores between MB and PA survivors. They also showed that there is a significant difference between the midline tumor cohort with the general population.

Di Rocco et al (106) also noticed pre operative deficits in patients with midline tumors.

Memory :

The Verbal-N-back test predominantly focuses on assessing verbal working memory, these values suggested that post-surgery, there was an improvement in the group for the same.

The self-ordered pointing test had an increase in performance by 0.07 for the whole group. From this it can be proposed that there was an improvement in the functioning with regard to verbal working memory and visual working memory.

The rey's auditory verbal learning test focuses on assessing an individual's capacity for verbal learning and memory. In the midline group, the difference in the mean values between pre-op and post-op period demonstrated a positive trend for all three parameters except recognition indicating an improvement in their memory. A deterioration in the recognition score could be an indicator of a lack of proper functioning of the declarative memory, of which recognition is a part of.

Rey complex test is sensitive to cognitive functions pertaining to visual memory and visuospatial constructional ability, it can be said that the improvement in scores is suggestive of an improvement in such functions post the surgical procedure.

Ronning et al and Roncadin et al (5,6) reported MB survivors fared worse than pilocytic astrocytoma on evaluating for visual memory. And that the midline posterior fossa tumors in general fared worse than the general population. The data was found to be statistically significant for memory tests by Roncadin et al.(5)

Maddrey et al, edelstein et al and mulhem et al (98, 100,101) found statistically significant difference in memory between normal population and MB survivors. Edelstein found 3/52 below 1 SD for IR but 24/51 of MB survivors below 2 SD for DR.

Arsen et al in 2004 reported for attention and executive function 26% of PA survivors , those who did'n't receive radiation to be below the -2 Z score (as opposed to an expected 2.3%). In 2009 after long term follow up many of the changes returned to normal. (102, 103)

Intelligence:

The Wechsler Adult Intelligence Scale-IV has 5 sub-categories for scoring, from these scores it can be noted that working memory had the most improvement from all 5 modalities and the full-scale IQ had the largest rate in deterioration post-surgery.

Ronacadin et al and Vaquero et al (5,7) showed in comparison for IQ there was a statistically significant difference between Medulloblastomas and pilocytic astrocytomas. Quintero-Gallegos et al (99) showed the mean IQ score to be 93 in pilocytic astrocytomas and 82 in medulloblastomas. In our study, the mean IQ score for MB group was 89 in the pre operative period and 65 in the post operative period and this showed a massive 24 point drop after surgery. Pilocytic astrocytoma cases had a mean pre op IQ score of 69.33 and 70 postoperatively. The pre operative IQ in the other studies in general showed medulloblastoma patients fared worse in the pre operative than post operative period.

*Mental speed:*The digit symbol substitution had a spike in the performance post-operatively as there was a reduction in the time taken as a whole group. From this it can be inferred that there was an improvement in the cognitive functions related to visuomotor coordination. sustained attention and response speed post the procedure.

Verbal comprehension: For the token test the mean value had increased post-operatively suggesting a development in the cognitive function post-operatively.

Note: Most of the tests were not significant statistically as p value was not less than <0.05.

RAVLT test scores were better for children during the post-operative condition (mdn = 42) than in the pre-operative condition (mdn = 57).

A Mann-Whitney test indicated that this difference was a statistically significant difference of U=0.5, z= -2.4, p=<0.015

It is clear that surgery has an impact on neuropsychological outcomes in both midline and lateral groups. The magnitude of change of score in a particular test varies between midline and lateral groups.

Midline group showed improvement after surgery in Digit vigilance , trail making B, COWAT, block design, Reys, N Back, immediate and delayed recall, Long term percent retention,

Mental speed and verbal comprehension , Perceptual reasoning, working memory and processing speed.

Midline group showed a deterioration after surgery in trail making B Triads, animal naming, SOPT, recognition and full scale IQ.

Pre operative midline cohort scores were very low for the WAIS test with a 1.5 SD lower score than the mean for population calculated for age and sex. This is significantly low. For attention trail making B score was <1 SD below the population mean. Memory parameters like 2 back test, Immediate recall, Delayed recall were less than 1 SD in the pre operative period, however the recognition and long term percent retention scores were less than 1.5 SD below age and gender adjusted population mean scores. Digit symbol test for mental speed was slow in the pre operative period being 1 SD below the population gender and age adjusted mean. However there was a significant increase in this parameter in the post operative period.

In the midline group Executive function was not very affected in the pre operative period. All the remaining domains had scores below 1 SD below the age and gender adjusted population means.

Lateral cohort

Meskal et al (107) demonstrated patients with infratentorial meningiomas to have neurocognitive deficits. Extraaxial tumors in the posterior fossa show neurocognitive domains as intraaxial tumors, however the domains affected may differ. We conducted the same range of neuropsychological tests on patients undergoing RSSO Craniotomy to look for impact of tumors as well as surgery on cognitive outcomes.

Goebel et al (108) reported 69% patients in their cohort of 54 CPA tumors were found deficient in at least one of the administered Neuropsychological test.

Attention

Digit vigilance average time was reduced in the post-operative period.There was a drastic drop in the time for doing the task as a whole group post-surgery.

A time has worsened further and B time improve in the post-operative period with a mild increase in the error rate. This signifies that sustained attention showed a lack of improvement

and higher scores in trail B indicates a general improvement in the functioning of the central executive memory.

Triad test showed a reduction in number error and word error average remained unchanged in post-operative period.

Goebel et al (108) noted that memory was impaired when it involved executive or attentional resources like free recall of information. 13-19 % tasks independant of Visuo motor functioning was impaired whereas 40-45% of patients were found to have deficient scores in tests needing Visuo motor coordination .

Executive Function :

For the COWAT there was a difference which indicated a slight improvement in the patient group's ability in the post-operative condition.

In the Animals name test, the average value for generating words decreased after surgery. The requirement of multiple cognitive skills such as an organized verbal recall and retrieval, self-monitoring of cognition and inhibition of responses in addition to effective executive functions makes it difficult which could be related to a drop in the performance.

There was a difference of 2.25 between the pre-operative and post-operative mean values in the block design test which indicates a progression in their test performance post-surgery.

Memory:

In the Verbal-n-back test the difference between pre- and post-op mean values decreased for 1B hits and the 1B error had increased. For 2B hits also there was a decrease in score and 2B error had increased. Given these scores, it can be suggested that there was deterioration group wise post-surgically for verbal working memory.

The self-ordered pointing test had an increase in performance indicating an improvement in their verbal working memory and visual working memory.

The rey's auditory verbal learning test focuses on assessing an individual's capacity for verbal learning and memory. In the midline group, the difference in the mean values between pre-op and post-op demonstrated a positive trend for all four variables indicating an improvement in their memory as a whole.

Goebel et al (108) demonstrated preservation of language and Visuo perceptive abilities in their cohort of patients with CP angle tumors

Rey complex had an increase in mean scores for the post-operative conditions. The was a drop in performance for the copy task but an improvement for the memory parameter post-surgery.

Intelligence

The Wechsler Adult Intelligence Scale-IV has 5 sub-categories for scoring which showed deterioration post surgery

Speed: The digit symbol substitution demonstrated an improvement in the cognitive functions related to visuomotor coordination, sustained attention and response speed post the procedure.

Verbal comprehension: The token test the had an increase of score post-operatively suggesting a progress in the cognitive function post-operatively.
All of the tests were not significant statistically as p value was not less than <0.05.

Lateral group showed improvement after surgery in Digit vigilance , trail making B, COWAT, block design, Reys, immediate and delayed recall, Long term percent retention, Recognition, Mental speed and verbal comprehension,working memory.
Lateral group showed a deterioration after surgery in trail making B Triads, animal naming, SOPT, N back, perceptual reasoning, processing speed and full scale IQ.

Therefore in both the midline and lateral groups surgical removal of the space occupying lesion tended to cause an improvement in neuro-cognitive score in general. Although statistical significance cannot be proven in view of a small sample size, the trend is a very encouraging one for future research.

Pre operative lateral cohort scores were also very low in WAIS scores. Perceptual reasoning and processing speed were less than 2 SD below the age and gender corrected population

mean. Memory parameters like 1 back and recognition were lower than 1 SD and 2 back was lower than 2 SD below the age and gender adjusted population mean.

In the lateral group, Memory and intelligence was primarily affected sparing attention, executive function, mental speed and comprehension.

Histpathology

Ronning et al and Vaquero et al (6,7) reported that there was a statistically significant difference in attention scores between MB and PA survivors. They also showed that there is a significant difference between the midline tumor cohort with the general population.

Medulloblastoma- A time has improved from 90s to average 54.5 s showing an improvement by 35 s. B time also showed an improvement from 348 s to 330.5 s, 17.5 s faster after surgery.

Pilocytic astrocytoma: A time has worsened with an average 61s to 122 s after surgery, I.e by 61s. B time improved drastically from 218.5 to 198 by a difference of 20.5 seconds. Both A and B times were 76 pre op and 81 post op & 230 pre op and 209 post op in the complete midline cohort.

Maddrey (100) et al reported 92% of the MB survivors to score below 2 standard deviations below the mean where as Mulhern et al (98) reported the attention and executive function to score in the 20th percentiles.

D Rocco et al (106) reported presence of hydrocephalus to be a statistically significant predictor of post operative neuropsychological decline.

Children

Younger age and WBRT were considered statistically significant predictors of neurocognitive decline in children with brain tumors (104). Lafayette cousin et al (105) reported younger age and craniospinal irradiation led to statistically significant decline in almost all the neuropsychological parameters. Di Rocco et al (106) showed children with IQ had statistically significant improvement in IQ after suregery due to removal of tumor. In our study, we saw a trend towards post operative decline in patients with MB in IQ scores.

In children, midline cohort most tests were impaired in the pre operative period and showed improvement with surgery (Except fr verbal fluency and trail A test which showed mild worsening after surgery. Pre operative percentile scores were possible to be calculated only for a limited number of cases. Memory assessment showed that Immediate recall, delayed recall and VSWMS total score were less than 1.5 SD of the age and gender adjusted population mean. Intelligence scores too were impaired severely in pre operative period with working memory, processing speed and full scale IQ less than 1 SD and perceptual reasoning less than 1.5 SD than age and gender adjusted population mean on WISC scale. There was a significant improvement in the RAVLT total score after surgery. Other scores improved after surgery to a lesser extent like token test for verbal comprehension and processing speed for intelligence. 3 of the 5 cases amongst children were medulloblastoma.

Di Rocco et al (106) did not see an association with surgery and cognitive decline. They concluded many of the cognitive factors which were documented had to have been present preoperatively and surgery in fact improved a lot of these factors.

Cerebellar Mutism Syndrome- 2 patients had brainstem infiltration (M5,M7), both these patients had EVD inserted intra operatively which was later internalised. Both of these patients developed CMS in the post operative period. M5 HPR was Grade 2 ependymoma, M7 HPR was medulloblastoma but post operative neuropsychological evaluation was not possible before the scheduled radiation therapy. Both the children had neuro-behavioral changes like whining and inconsolable high pitched cry, apathy, Motor symptoms like reduced spontaneous initiation of movements, nystagmus and hypotonia. M5 even developed right upper limb weakness. Both the children developed complete mutism. Both the children recovered over the course of 3 months.

Future Implications

This study can be by expanded in 2 directions. Recruit more patients at our institution to increase the sample size and there by power of the study. With the leads gained thus far, a hypothesis can be drawn about the affected neuronal circuits which can then be objectively proven with relevant imaging studies making it multidisciplinary in nature. A few of the possible imaging modalities that could possibly be included are diffusion tensor imaging and fiber tractography and diffusion kurtosis imaging which is an extension of DTI to study the various white fibre tracts that may be involved as implicated by Mulhern et al (98). Using fMRI techniques and specific ROI's implicated in the sample population by utilizing Voxel-based morphometry can also offer valuable information particularly if tests can be conducted during fMRI. This can be studied in the pre-operative and post-operative period for mid-line and lateral cohort and help us understand how the different parameters are affected in these lesions. .

Conclusion

Posterior fossa tumors have an impact on the neuropsychological outlook of patients.
Many patients score low in the pre operative period. Surgery can have a beneficial effect on the scores provided the white fibre tracts are not disturbed. Both midline and lateral posterior fossa tumors blunt neuropsychological scores albeit different components.

Presence of brainstem infiltration, hydrocephalus and a younger age at outcome are factors that predict worse neuropsychological outcomes.

Limitations of the study

Fatigue was frequently an impediment in being able to complete the neuropsychological evaluation, especially amongst the midline post operative cohort. The entire battery of tests would take about 90 to 120 minutes to run. Therefore, the duration of the tests was a significant factor in assessment completion.

The small sample size necessitated a descriptive approach and statistical tests frequently did not amount to significance.

The short duration of follow up was necessary in order to avoid adjuvant treatment from being confounding factors for the higher grade tumors. Long term follow up to evaluate for further changes is justified but beyond was the duration of our prospective study.

The subjects were a heterogenous group as far as age and sex was concerned.

The handedness of the patients could have given further information regarding dominant lobe function abnormalities.

The tumor size and extent was not standardised and variations in these parameters were not accounted for in correlation to outcome of neuropsychological tests.

Speech, behaviour and emotional assessment was not possible at the time of testing subjects. This would have added to the ecological validity of different study subjects and given us a better idea about quality of life and independance of activity.

Reference:

1. Nejat F, Khashab M, Rutka J (2008) Initial management of childhood brain tumors: neurosurgical considerations. J Child Neurol 23:1136–1148

2. Pollack I (1999) Pediatric brain tumors. Semin Surg Oncol 16:7390

3. Palmer S, Leigh L (2009) Survivors of pediatric posterior fossa tumors: cognitive outcome, intervention, and risk-based care. Eur J Oncol Nurs 13:171–178

4. Emily Hanzlik et. Al (2015) A systematic review of neuropsychological outcomes following posterior fossa tumor surgery in children. Childs Nerv Syst (2015) 31:1869–1875

5. Roncadin C, Dennis M, Greenberg M, Spiegler B (2008) Adverse medical events associated with childhood cerebellar astrocytomas and medulloblastomas: natural history and relation to very longterm neurobehavioral outcome. Childs Nerv Syst 24:995–1002

6. Ronning C, Sundet K, Due-Tonnessen B, et al. (2005) Persistent cognitive dysfunction secondary to cerebellar injury in patients treated for posterior fossa tumors in childhood. Pediatr Neurosurg 41:15–21

7. Vaquero E, Gomez C, Quintero-Gallego E, etal. (2008)Differential prefrontal-like deficit in children after cerebellar astrocytoma and medulloblastoma tumor. Behav Brain Funct 4:18–32

8. Von Hoff K, Kieffer V, Habrand J, et al. (2008) Impairment of intellectual functions after surgery and posterior fossa irradiation in children with ependymoma is related to age and neurologic complications. BMC Cancer 8:15–23

9. Schmahmann J, Caplan D (2006) Cognition, emotion and the cerebellum. Brain 129:288–292

10. Steinlin M (2007) The cerebellum in cognitive processes: supporting studies in children. Cerebellum 6:237–241

11. Rickert CH, Paulus W. Epidemiology of central nervous system tumors in childhood and adolescence based on the new WHO classification. Childs Nerv Syst. 2001;17(9):503–11.

12. Gudrunardottir T, Sehested A, Juhler M, Schmiegelow K. Cerebellar mutism: review of the literature. Childs Nerv Syst. 2011;27(3):355–63.

13. Van CF, Van de Laar A, Plets C, Goffin J, Casaer P. Transient cerebellar mutism after posterior fossa surgery in children. Neurosurgery. 1995;37(5):894–8.

14. Pollack IF, Polinko P, Albright AL, Towbin R, Fitz C. Mutism and pseudobulbar symptoms after resection of posterior fossa tumors in children: incidence and pathophysiology. Neurosurgery. 1995;37(5):885–93.

15. Kotil K, Eras M, Akcetin M, Bilge T. Cerebellar mutism following posterior fossa tumor resection in children. Turk Neurosurg. 2008;18(1):89–94.

16. Robertson PL, Muraszko KM, Holmes EJ, Sposto R, Packer RJ, Gajjar A, et al. Incidence and severity of postoperative cerebellar mutism syndrome in children with medulloblastoma: a prospective study by the Children's Oncology group. J Neurosurg. 2006;105(6 Suppl):444–51.

17. Wells EM, Khademian ZP, Walsh KS, Vezina G, Sposto R, Keating RF, et al. Postoperative cerebellar mutism syndrome following treatment of medulloblastoma: neuroradiographic features and origin. J Neurosurg Pediatr. 2010;5(4):329–34.

18. Catsman-Berrevoets CE, Aarsen FK. The spectrum of neurobehavioural deficits in the posterior fossa syndrome in children after cerebellar tumour surgery. Cortex. 2010;46(7):933–46.

19. van Baarsen KM, Grotenhuis JA. The anatomical substrate of cerebellar mutism. Med Hypotheses. 2014;82(6):774–80.

20. Doxey D, Bruce D, Sklar F, Swift D, Shapiro K. Posterior fossa syndrome: identifiable risk factors and irreversible complications. Pediatr Neurosurg. 1999;31(3):131–6.
21. Korah MP, Esiashvili N, Mazewski CM, Hudgins RJ, Tighiouart M, Janss AJ, et al. Incidence, risks, and sequelae of posterior fossa syndrome in pediatric medulloblastoma. Int J Radiat Oncol Biol Phys. 2010;77(1):106–12.
22. Catsman-Berrevoets CE, Van Dongen HR, Mulder PG, Geuze D, Paquier PF, Lequin MH. Tumour type and size are high risk factors for the syndrome of "cerebellar" mutism and subsequent dysarthria. J Neurol Neurosurg Psychiatry. 1999;67(6):755–7.
23. Reed-Berendt R, Phillips B, Picton S, Chumas P, Warren D, Livingston JH, et al. Cause and outcome of cerebellar mutism: evidence from a systematic review. Childs Nerv Syst. 2014;30(3):375–85.
24. Law N, Greenberg M, Bouffet E, Taylor MD, Laughlin S, Strother D, et al. Clinical and neuroanatomical predictors of cerebellar mutism syndrome. Neuro-Oncology. 2012;14(10):1294–303.
25. McMillan HJ, Keene DL, Matzinger MA, Vassilyadi M, Nzau M, Ventureyra EC. Brainstem compression: a predictor of postoperative cerebellar mutism. Childs Nerv Syst. 2009;25(6):677–81.
26. Di RC, Chieffo D, Frassanito P, Caldarelli M, Massimi L, Tamburrini G. Heralding cerebellar mutism: evidence for pre-surgical language impairment as primary risk factor in posterior fossa surgery. Cerebellum. 2011;10(3):551–62.
27. Kupeli S, Yalcin B, Bilginer B, Akalan N, Haksal P, Buyukpamukcu M. Posterior fossa syndrome after posterior fossa surgery in children with brain tumors. Pediatr Blood Cancer. 2011;56(2):206–10.
28. Wells EM, Walsh KS, Khademian ZP, Keating RF, Packer RJ. The cerebellar mutism syndrome and its relation to cerebellar cognitive function and the cerebellar cognitive affective disorder. Dev Disabil Res Rev. 2008;14(3):221–8
29. Gelabert-Gonzalez M, Fernandez-Villa J. Mutism after posterior fossa surgery. Review of the literature. Clin Neurol Neurosurg. 2001;103(2):111–4.
30. Pollack IF. Posterior fossa syndrome. Int Rev Neurobiol. 1997;41:411–32.

31. Bodranghien F, Bastian A, Casali C et al. (2016). Consensus paper: revisiting the symptoms and signs of cerebellar syndrome. Cerebellum 15: 369–391.
32. Morris EB,Phillips NS,LaninghamFHetal.(2009).Proximal dentatothalamocortical tract involvement in posterior fossa syndrome. Brain 132: 3087–3095.
33. Schmahmann JD, Sherman JC (1998). The cerebellar cognitive affective syndrome. Brain 121: 561–579.
34. Patay Z (2015). Postoperative posterior fossa syndrome: unraveling the etiology and underlying pathophysiology by using magnetic resonance imaging. Childs Nerv Syst 31: 1853–1858.
35. Sagiuchi T, Ishii K, Aoki Y et al. (2001). Bilateral crossed cerebello-cerebral diaschisis and mutism after surgery for cerebellar medulloblastoma. Ann Nucl Med 15: 157–160.

36. Catsman-Berrevoets CE, Aarsen FK (2010). The spectrum of neurobehavioural deficits in the posterior fossa syndrome in children after cerebellar tumour surgery. Cortex 46: 933–946.
37. Miller NG, Reddick WE, Kocak M et al. (2010). Cerebellocerebral diaschisis is the likely mechanism of postsurgical posterior fossa syndrome in pediatric patients with midline cerebellar tumors. AJNR Am J Neuroradiol 31: 288–294.
38. Akil H, Statham PFX, Götz M, Bramley P, Whittle IR: Adult cerebellar mutism and cognitive-affective syndrome caused by cystic hemangioblastoma. Acta Neurochir (Wien) 148:597–598, 2006
39. Fujisawa H, Yonaha H, Okumoto K, Uehara T, Ie T, Nagata Y, et al: Mutism after evacuation of acute subdural hematoma of the posterior fossa. Childs Nerv Syst 21:234–236, 2005

40. Al-Anazi A, Hassounah M, Sheikh B, Barayan S: Cerebellar mutism caused by arteriovenous malformation of the vermis. Br J Neurosurg 15:47–50, 2001

41. Sinha AK, Rajender Y, Dinakar I. Transient cerebellar mutism after evacuation of a spontaneous vermian haematoma. Childs Nerv Syst 1998;14:460-2.

42. Riva D, Giorgi C. The cerebellum contributes to higher functions during development. Evidence from a series of children surgically treated for posterior fossa tumours. Brain 2000;123:1051-61.

43. Bhatoe HS. Mutism, oropharyngeal apraxia and dysarthria after posterior fossa tumour excision. Br J Neurosurg. 1997;11:341-3

44. Levisohn L, Cronin-Golomb A, Schmahmann JD. Neuropsychological consequences of cerebellar tumour resection in children: cerebellar cognitive affective syndrome in a paediatric population. Brain 2000;123:1041–50.

45. Steinlin M, Schimid M, Landau K, Boltshauser E. Follow-up in children with Joubert syndrome. Neuropediatrics 1997;28:204-11.

46. Cornish K, Kogan C, Turk J, Manly T, James N, Mills A, et al. The emerging fragile X permutation phenotype: evidence from the domain of social cognition. Brain Cogn 2005;57:53–60.

47. Eckert MA, Leonard CM, Richards TL, Aylward EH, Thomson J, Berninger VW. Anatomical correlates of dyslexia: frontal and cerebellar findings. Brain 2003;126:482–94.

48. Giedd JN, Blumenthal J, Molloy E, Castellanos FX. Brain imaging of attention deficit/hyperactivity disorder. Ann N Y Acad Sci 2001;931:33–49.

49. Nicolson R, Fawcett AJ, Dean P. Dyslexia, development and the cerebellum. Trends Neurosci 2001;24:515–6.

50. Pinter JD, Eliez S, Schmitt JE, Capone GT, Reiss AL. Neuroanatomy of Down's syndrome: a high-resolution MRI study. Am J Psychiatry 2001;158:1659–65.

51. Stoodley CJ, Fawcett AJ, Nicolson RI, Stein JF. Balancing and pointing tasks in dyslexic and control adults. Dyslexia 2006;12:276–88.

52. Le TH, Pardo JV, Hu X. 4T-fMRI study of nonspatial shifting of selective attention: cerebellar and parietal contributions. J Neurophysiology 1998;79:1535–48

53. Allen G, Buxton RB, Wong EC, Courchesne E. Attentional activation of the cerebellum independent of motor involvement. Science 1997;275:1940–3.

54. Ersahin Y,MutluerS,CagliSetal.(1996).Cerebellarmutism: report of seven cases and review of the literature. Neurosurgery 38: 60–65; discussion 66.

55. GermanoA,BaldariS,CarusoGetal.(1998).Reversiblecerebral perfusion alterations in children with transient mutism after posterior fossa surgery. ChildsNervSyst14:114–119.

56. Avula S, KumarR,PizerBetal.(2015a).Diffusion abnormalities on intraoperative magnetic resonance imaging as an early predictor for the risk of posterior fossa syndrome. Neuro-Oncology 17: 614–622.

57. CORIENE CATSMAN-BERREVOETS AND ZOLTAN PATAY. Cerebellar mutism syndrome. M. Manto and T.A.G.M. Huisman (ed). Handbook of Clinical Neurology, Vol. 155 (3rd series) The Cerebellum: Disorders and Treatment, 3rd ed. : Elsevier; 2018. pp. 273-288.

58. Bailey H, Buchanan DN, Bucy P (1939). Intracranial tumors of infancy and childhood, University of Chicago Press, Chicago, IL.

59. Fraioli A, Guidetti B (1975). Effects of stereotactic lesions of the dentate nucleus of the cerebellum in man. Appl Neurophysiol 38: 81–90.

60. Rekate HL, Grubb RL, Aram DM et al. (1985). Muteness of cerebellar origin. Arch Neurol 42: 697–698.

61. Riva D, Pantaleoni C, Milani N et al. (1989). Impairment of neuropsychological functions in children with medulloblastomas and astrocytomas in the posterior fossa. Childs Nerv Syst 5: 107–110.

62. Gudrunardottir T, Lannering B, Remke M et al. (2014). Treatment developments and the unfolding of the quality of life discussion in childhood medulloblastoma: a review. Childs Nerv Syst 30: 979–990.

63. Gudrunardottir T, Morgan AT, Lux AL et al. (2016). Consensus paper on post-operative pediatric cerebellar mutism syndrome: the Iceland Delphi results. Childs Nerv Syst 32: 1195–1203.
64. Gudrunardottir T, Sehested A, Juhler M et al. (2011a). Cerebellar mutism: definitions, classification and grading of symptoms. Childs Nerv Syst 27: 1361–1363.
65. Chen DY, Aristizabal P, Crawford JR (2015). Preoperative presentation of a variant of cerebellar mutism syndrome in a young boy with juvenile pilocytic astrocytoma. Pediatr Neurol 53: 266–267.
66. Morgan AT, Liegeois F, Liederkerke C et al. (2011). Role of cerebellum in fine speech control in childhood: persistent dysarthria after surgical treatment for posterior fossa tumour. Brain Lang 117: 69–76.
67. VanMourikM,Catsman-BerrevoetsCE,vandongenHRetal. (1997). Complex orofacial movements and the disappearance of cerebellar mutism: report of five cases. Dev Med Child Neurol 39: 686–690.
68. De Smet HJ, Marien P (2012). Posterior fossa syndrome in an adult patient following surgical evacuation of an intracerebellar haematoma. Cerebellum 11: 587–592.
69. Moretti R, Bava A, Torre P et al. (2002). Reading errors in patients with cerebellar vermis lesions. J Neurol 249: 461–468.
70. Robertson PL, Muraszko KM, Holmes EJ et al. (2006). Incidence and severity of postoperative cerebellar mutism syndrome in children with medulloblastoma: a prospective study by the Children's Oncology Group. J Neurosurg 105: 444–451.
71. Palmer SL, Hassall T, Evankovich K et al. (2010). Neurocognitive outcome 12 months following cerebellar mutism syndrome in pediatric patients with medulloblastoma. Neuro-Oncology 12: 1311–1317.
72. SchreiberJE,GurneyJG,PalmerSLetal.(2014).Examination of risk factors for intellectual and academic outcomes following treatment for pediatric medulloblastoma. NeuroOncology 16: 1129–1136.

73. Miller, E. (1992). Some basic principles of neuropsychological assessment. In *A handbook of neuropsychological assessment* (pp. 7–20). Lawrence Erlbaum Associates, Inc.

74. Lan, T. (2005, June 27). *Neuropsychological Assessment of Attention and Executive Functioning*. The Raz Lab. http://razlab.org/raz/neuropsychological-assessment-of-attention-and-executive-functionning/

75. Alexander, M., S., D. (2000). *Executive functions and the frontal lobes: A conceptual view | SpringerLink*. *63*, 289–298. https://doi.org/10.1007/s004269900007

76. Burgess, P. W., & Stuss, D. T. (2017). Fifty Years of Prefrontal Cortex Research: Impact on Assessment. *Journal of the International Neuropsychological Society*, *23*(9–10), 755–767. https://doi.org/10.1017/S1355617717000704

77. Benton, A. L., Hamsher, K., Rey, G. L., & Sivan, A. B. (1994). *Multilingual Aphasia Examination* (3rd ed.). Iowa City, IA: AJA Associates.

78. Kemenoff, L. A., Miller, B. L., & Kramer, J. H. (2002). Frontal Lobe. In V. S. Ramachandran (Ed.), *Encyclopedia of the Human Brain* (pp. 317–325). Academic Press. https://doi.org/10.1016/B0-12-227210-2/00148-5

79. Lezak, P. of N. P. and N. M. D., Lezak, M. D., Howieson, A. P. of N. and P. D. B., Howieson, D. B., Loring, P. of N. D. W., Loring, D. W., & Fischer, J. S. (2004). *Neuropsychological Assessment*. Oxford University Press.

80. Quaranta, D., Piccininni, C., Caprara, A., Malandrino, A., Gainotti, G., & Marra, C. (2019). Semantic Relations in a Categorical Verbal Fluency Test: An Exploratory Investigation in Mild Cognitive Impairment. *Frontiers in Psychology*, *10*. https://doi.org/10.3389/fpsyg.2019.02797

81. Hutt, M.L. (1932). The Kohs Block-designs test: a revision for clinical practice. *Journal of Applied Psychology, 16*, 298-307

82. Schlösser, R., Hutchinson, M., Joseffer, S., Rusinek, H., Saarimaki, A., Stevenson, J., Dewey, S. L., & Brodie, J. D. (1998). Functional magnetic resonance imaging of human brain activity in a verbal fluency task. *Journal of Neurology, Neurosurgery, and Psychiatry*, *64*(4), 492–498. https://doi.org/10.1136/jnnp.64.4.492

83. Smith, E. E., & Jonides, J. (1997). Working Memory: A View from Neuroimaging. *Cognitive Psychology*, *33*(1), 5–42. https://doi.org/10.1006/cogp.1997.0658

84. Petrides, M., & Milner, B. (1982). Deficits on subject-ordered tasks after frontal-and temporal-lobe lesions in man. *Neuropsychologia*, *20*(3), 249-262.

85. Ross, T. P., Hanouskova, E., Giarla, K., Calhoun, E., & Tucker, M. (2007). The reliability and validity of the self-ordered pointing task. *Archives of Clinical Neuropsychology*, *22*(4), 449–458. https://doi.org/10.1016/j.acn.2007.01.023

86. Strauss, E., Strauss, P. of P. E., Sherman, N. and A. A. P. D. of P. and C. N. E. M. S., Sherman, E. M. S., Spreen, O., & Spreen, B. P. of P. O. (2006). *A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary*. Oxford University Press.

87. Elger, C. E., Grunwald, T., Lehnertz, K., Kutas, M., Helmstaedter, C., Brockhaus, A., Van Roost, D., & Heinze, H. J. (1997). Human temporal lobe potentials in verbal learning and memory processes. *Neuropsychologia*, *35*(5), 657–667. https://doi.org/10.1016/s0028-3932(96)00110-8

88. Rey, A. (1941). L'examen psychologique dans les cas d'encéphalopathie traumatique.(Les problems.). *Archives de psychologie*.

89. Osterrieth, P. A. (1944). Le test de copie d'une figure complexe; contribution a l'etude de la perception et de la memoire. *Archives de psychologie*.

90. Milner, B. (1971). INTERHEMISPHERIC DIFFERENCES IN THE LOCALIZATION OF PSYCHOLOGICAL PROCESSES IN MAN. *British Medical Bulletin*, *27*(3), 272–277. https://doi.org/10.1093/oxfordjournals.bmb.a070866

91. Jaeger, J. (2018). Digit Symbol Substitution Test. *Journal of Clinical Psychopharmacology*, *38*(5), 513–519. https://doi.org/10.1097/JCP.0000000000000941

92. De Renzi, E., & Faglioni, P. (1978). *Normative Data and Screening Power of a Shortened Version of the Token Test. Cortex, 14(1), 41–49.* doi:10.1016/s0010-9452(78)80006-9

93. Struiksma, M. E., & Postma, A. (2017). Chapter 6 - Tell Me Where to Go: On the Language of Space. In A. Postma & I. J. M. van der Ham (Eds.), *Neuropsychology of Space* (pp. 197–230). Academic Press. https://doi.org/10.1016/B978-0-12-801638-1.00006-9

94. Kaufman, A., & Lichtenberger, E. (1990). Assessing Adolescent and Adult Intelligence.

95. Kaplan, R.M. & Saccuzzo, D.P. (2009) Psychological Testing Principles, Applications, and Issues. (7th ed.). Belmont, CA.: Wadsworth

96. Hartman, D. E. (2009). Wechsler Adult Intelligence Scale IV (WAIS IV): Return of the Gold Standard. *Applied Neuropsychology*, *16*(1), 85–87. https://doi.org/10.1080/09084280802644466

97. Kaufman, A., & Lichtenberger, E. (1990). Assessing Adolescent and Adult Intelligence.

98. Mulhern R,Palmer S, Reddick W, et al. (2001) Risks of young age for selected neurocognitive deficits in medulloblastoma are associated with white matter loss. J Clin Oncol 19:472–479

99. Quintero-Gallego E, Gomez C, Casares E, et al. (2006) Declarative and procedural learning in children and adolescents with posterior fossa tumours. Behav Brain Funct 2:9–17

100. Maddrey A, Bergeron J, Lombardo E, et al. (2005) Neuropsychological performance and quality of life of 10 year survivors of childhood medulloblastoma. J Neuro-Oncol 72:245253

101. Edelstein K, Spiegler B, Fung S, et al. (2011) Early aging in adult survivors of childhood medulloblastoma: long-term neurocognitive, functional, and physical outcomes. NeuroOncology 13:536–545

102. Aarsen F, Paquier P, Arts W, et al. (2009) Cognitive deficits and predictors 3 years after diagnosis of a pilocytic astrocytoma in childhood. J Clin Oncol 27:3526–3532

103. Aarsen F, vanDongenH, Paquier P etal.(2004) Long-term sequelae in children after cerebellar astrocytoma surgery. Neurology 62: 1311–1316

104. Olsson I, Perrin S, Lundgren J, et al. (2014) Long-term cognitive sequelae after pediatric brain tumor related to medical risk factors, age and sex. Pediatr Neurol 51:515–521

105. Lafay-Cousin L, Bouffet E, Hawkins C, et al. (2009) Impact of radiation avoidance on survival and neurocognitive outcome in infant medulloblastoma. Curr Oncol 16:21–28

106. DiRocco C, Chieffo D, Pettorini B, et al. (2010) Preoperative and postoperative neurological, neuropsychological and behavioral impairment in children with posterior cranial fossa astrocytomas and medulloblastomas: the role of the tumor and the impact of the surgical treatment. Childs Nerv Syst 26:1173–1188

107. Meskal I, Gehring K, van der Linden SD et al (2015) Cognitive improvement in meningioma patients after surgery: clinical relevance of computerized testing. J Neurooncol 121:617–625.

108. Goebel, S., & Mehdorn, H. M. (2018). A missing piece? Neuropsychiatric functioning in untreated patients with tumors within the cerebellopontine angle. Journal of Neuro-Oncology, 140(1), 145–153.

Sree Chitra Tirunal Institute for Medical Sciences & Technology

Proforma

Neuropsychological Impact of posterior fossa lesion- A prospective study of a cohort of patients operated for posterior fossa lesions.

General Instructions

Please fill in all the questions

Write Yes / No/NA wherever applicable

If the response is not known please write UK

If additional info is available please elaborate

Please use separate proforma for each admission

If admission is for a post operative complication please go to section E after completing the general information

Intra operative illustrations will be appreciated

Annexure I

Code no:
Age
Sex
Duration of symptoms:
Symptoms: Raised ICP/ Motor/sensory/Visual/ cognitive/seizures/hormonal imbalance/others.
Neurological Deficits.
Days of post op stay.
Days of intensive care.
Deficits
GOS on discharge.
VA/VF
hormonal status
Neuropyschological assessment pre op:
Language-
Speech -
Memory-Ray visual learning test-

Intelligence weschlers adult/pediatric intelligence score-
Attention -Trail A Test-

Pre operativeRadiology: MRI / CT.
Diagnosis
Size of lesion
Location
Extent
Hydrocephalus

Edema (grade)
Relation to vessels,third ventricle

Operative findings:
Approaches
- Telo-Velo tonsillar
- Trans-vermian
- Cerebellar cortisectomy
- Supracerebellar infratentorial

Veins-
Sinus-
Coronal suture
Plane with surrounding / good/ poor/ very poor/ arterial injury
Brain Retraction
- Brain fullness present or not
- Single or dual retractor
- Structure retractor
  - Tonsil
  - vermis
  - cerebellar cortex
- Direction of retraction

Extent of lesionectomy.
Use of hemostats – descriptive.
External ventricular drainage
- days
- volume
- microscopy
- Is EVD introduced prior to opening posterior fossa
- brain fullness
- Post op hydrocephalus

Extent of bone removal- brain fullness (at opening, during mid surgery, at closure)
- Replaced?

Dural Closure
- Primary
- Lax duroplasty
- Onlay graft
- No closure attempted

Intra operative complications

Pathological diagnosis:

Post op radiology:
Infarcts- arterial - descriptive.
Hydrocephalus
Tumour removal- total/ near total (90%)/ Partial (70%)/ Less than 50%.
Venous infarcts/ haematoma – size, extend.
Odema.

Serial Number	Age	Sex	Diagnosis	Date of admission	Date of surgery	Presentation	Examination	Comorbidity	Procedure	Intar op complications	Post op CT	Complications	Date of discharge	Final HPR	Readmission	Follow up issues	Any other issues
M1	10 years	F	4th ventricular medulloblastoma	11/10/20	14/10/20	Headache vomiting and abdominal pain	B/l papilledema	No	MLSO craniotomy and NTT (Telovelar approach)	EVD insitu at beginning of surgery; Poor plane with vermis, brainstem not infiltrated. ; Left PICA infiltrated by the tumor	Operative site edema, pneumocephalus	Hyponatremia in post op period, EVD pressure high, repeated headache	22/10/21	Medulloblastoma who gr 4 classical	No	Finished RT, receiving CT	No
M2	23 years	M	Superior vermian pilocytic astrocytoma	11/11/20	19/11/20	Headache and gait unsteadiness 10 months	Left Cerebellar signs +	Nil	MLSO craniectomy and GTD	Transcortical,	N		24/11/20	Pilocytic astrocytoma	Nio	Mild leak initially and re- sutured	No
M3	54 years	F	Right Cerebellar Mets in an occ r breast Ca	23/11/20	27/11/20	Headache vomiting and gait unsteadiness since 1.5 months	Left cerebellar signs and gait usteadiness, left> right cerebellar signs	HTN	MSSO craniectomy and STD	Residuals left behind Hard tumor sitting on the right transverse sinus left behind. Durgen only closure for dura	N	No	1/12/20	Metastatic adenocarcinoma	No	Breakthrough seizure after tapering Levipil after 6 months, awaiting RT	No
M4	51 years	M	4th ventricular exophytic brain stem glioma	28/11/20	1/12/20	Giddiness 3 months, loss of appetite 2 months, altered taste sensation , weight loss, gait imbalance	Right LR palsy, Left gaze evoked nystagmus, left deviation of angle of muth	Dyslipidemia	MLSO craniotomy + C1 arch excision + NTE , telovelotonsillar aproach	Poor plane with brainstem, EVD kept in situ , EVD removed on POD2,	N	Right LMN facial palsy, right LR palsy, right INO	6/12/20	Pilocytic astrocytoma, WHO grade 1	No	Mild residual Right LR paresis	No
M5	14 years	F	4th ventricular ependymoma who grade 2 with HCP	8/12/20	11/12/20	Headache since 6 months, blurring of vision bilaterally,	VA FC- RE 3 ft and LE 2 ft, bilateral papilledema, poor gag and cough reflex, swaying in all directions.	Nil	MLSO craniotomy and total excision	EVD on POD 1 and converted to VP shunt on POD 7	N	Developed Cerebellar mutism, gait ataxia, right upper limb weakness	29/12/20	Ependymoma WHO gr 2	No	CMS persistent , vision FC inconsistent with difficulty fixing gaze.	No
M6	46 years	F	Pontine and dorsal midline cavernous Angioma with adjacent venous Angioma	9/12/20	21/12/20	Headache since 11 years, progressive weakness in the left upper and lower limb since 2016, progressive gait unsteadiness and currently wheel chair bound, Diplopia and nystagmus	Right LR palsy, down beat nystagmus, cerebellum signs and severe gait ataxia,	Hypothyroid	MLSO craniotomy and C1 arch excision, telovellotonsillar approach, GTD achieved	Nil	N	same as pre op- No significant changes. WOund leak with pneumocephalus with pseudomeningocoele, Resutured, Needed VP shunting in Feb 2021.	9/12/20	Cavernous hemangioma	Yes, 1/2/21 , for right keen's point MPVP shunt	No	No
M7	6 years	F	4th ventricular medulloblastoma with hydrocephalus	15/12/20	21/12/20	Headache, vomiting, gait unsteadiness	Left lateral Rectus palsy, dorsum reduced in all 4 limbs, b/l cerebellar signs, severe gai ataxia	No	MLSO and GTD telovelar approach	Poor planes with brainstem, EVD inserted, csf under moderate pressure, intra op developed bronchospasm after EVD insertion and was turned to supine n tube changed n repositioned. Lax duroplasty, bone flap replaced.	N	Cms developed.right upper limb paucity.	4/1/21	Medulloblastoma classic who grade 4.	No	Right cerebellar tremors, otherwise recovered fully from CMS, finished RT/ CT	No
M8	8 years	M	4th ventricular Pilocytic astrocytoma with hydrocephalus with NF1	22/12/20	24/12/20	Headache and vomiting 6 months	Multiple cafe au lait spots, b/l ceebellar signs +	NF1	MLSO Craniotomy And GTD (TVT aproach)	EVD inserted, removed on POD4	N	Nil	30/12/20	Pilocytic astrocytoma	No	No	No
M9	8 years	M	Forth ventricular medulloblastoma with HCP	1/2/21	4/2/21	Headache 4 weeks, vomiting, gait disturbance 2 weeks, speech disturbance 2 weeks,	B/l cerebellar signs	No	MLSO Craniotomy and GTD TVT approach	EVD inserted, removed on POD4, infiltrating left MCP and left foramen of luschka	N	No	9/2/21	Medulloblastoma non WNT, non SHH group	No	Completed RT CT	No
M10	10 years	F	Cerebellar vermian medulloblastoma with Hydrocephalus	4/2/22	10/2/21	Headache and vomiting since 6 months, loss of appetite and vomiting	B/l papilledema, uvula deviated to the left, left sided cerebellar signs +, left sided swaying gait	Nil	MLSO craniotomy and GTD TVT approach, right FP MPVP shunt 14/2/21	EVD inserted,	N	Meningitis	22/2/21	Medulloblastoma non WNT, non SHH group	No	Sent for RT?CT	No
M11	24 years	F	Pontine cavernoma	9/2/21	23/2/21	Diplopia 1.5years, Weakness of right upper and lower limb since 1.5 years, right facial deviation, right facial numbness,	Left LR Palsy, reduced facial sensation by 20% on the right side V1,2,3 , palatial myoclonus , power 4/5 right side, sensation reduced by 20% in the right side of body		MLSO craniotomy and GTE TVT approach	Nill	N	Nil	26/02/21	Inconclusive	No	No	No
M12	33 years	F	Left cerebellar PA	22/2/21	18/3/21	Headache for 2 years, associated with vomiting , visual blurring during headache, photophobia during headache, loss of balance and gait disturbance	Webers lateralised to the right, Mild lower limb weakness, left cerebellar signs and slow gait.	Nil	MLSO craniotomy and GTD	Nil	N	At admission was Hyponatremic,	22/3/21	PA	25/3/21: Drowsiness, altered sensorium, low GCS, fever spikes, on Mechanical ventillator transferred from another hospital, on 24/3/21 acute diarrheal disease, ? Meningitis/SSI, Pneumonia and pleural effusion , DVT etc	Died on 29/5/21	No
M12																	
M13	21 years	M	Left inferior cerebellar hemispheric AVM SM Grade 4	15/03/21	26/03/21	Sudden onset headache 15/5/20, multiple episodes of vomiting,	Normal	Ni	MLSO craniotomy and complete excision	IOR, controlled	N	Nil	26/03/21	AVM	No	No	No
L1	59 years	F	Left CP angle lesion	15/10/20	16/10/20	Headache with left sided hearing loss, gait unsteadiness	Left corneal absent, subtile left facial, Weber lateralised to right, left gag absent, Left cerebellar signs, wide based gait, Romberg +, tandem gait not possible	HTN and hypothyroid	Left RSSO craniotomy and NTT with anatomical and electro physiological 7th nerve preservation	Left sigmoid sinus injury, Tumor in IAM left behind	N	No	19/10/21	Schwanomma	No	No	
L2	63 years	M	Left CP angle lesion	21/10/20	27/10/20	HA since 10 years, increased since 3 years, Gait unsteadiness since 3 years, Patient complaints of decreased hearing in the left ear since 2 years	10% reduction in V1V2 left side, Weber's lateralised to the right ,	HTN and DM2	Left RSSO craniotomy and total excision	5th nerve stretched out and thin	N	Left facial nerve palsy HB grade 3, POD 3 patient developed anisocoria and was reintubated and electively ventilated for 2 days as CT showed operative cavity hematoma, Left eye keratopathy +	6/11/2020	Schwanomma	No	Left eye chemists and pain, advised tarsorhaphy	No
L3	43 years	M	Right CP angle lesion	27/10/20	30/10/2020	Right sided hearing loss since 4-5 months	Weber lateralised to left	Nil	Right RSSO craniotomy and GTE	Right 5th nerve stretched and thinned out	N	Right Facial HB 3	2/11/20	Schwanomma	No	Pseudomeningocoele at operated site	No
L4	52 years	F	L cp angle	25/11/20	3/12/20	Headache, gait unsteadiness, reduced hearing in the left ear	Webers lateralised to right , Left sided cerebellar signs`	HTN	Left RSSO craniotomy and GTE	EVD inserted Intra op, 5,7,8 preserved anatomically		Left HB 5 and left reduced sensation in V1 , left eye tarsorrhaphy		Schwannoma			
L5	35 years	M	Right CP angle lesion	24/11/20	27/11/20	Headache dizziness and gait unsteadiness since 1 year, generalised tremors since 5 years, Visual blurring since 5-6 months and occasion diplopia	B/l Papilledema, Bruns Nystagmus, Weber lateralised t the right, Uvua deviated t the right, Swaying f gait to the right		Right RSSO craniotomy and GTD with IAM drilling	Anatomically and electrophysiological ly preserved. Poor plane with the brainstem	N	Right LMN facial with EYE closure adequate	2/12/20	Schwanomma	No	Right CN7 HB 2 palsy	Reduced vision in the right eye FC 3ft
L6	44 years	F	Left CP angle epidermoid	21/11/20	27/11/20	Giddiness, left sided hearing loss, tinnitus, regurgitation of food both solids and liquids occasionally with coughing while eating.	Webers lateralised to the right. Gag poor but cough good,	HTN	Left RSSO Craniotomy and GTE	A small bit of the lesion attached to the labyrinthine artery left behind	N	Nil	30/11/20	Epidermoid	No	No	No
L7	59 years	F	Left premeatal petrous meningioma	30/11/20	7/12/20	Headache, gait unsteadiness, shock like sensation of the left side of the face,	Touch sensation reduced 75% in left V1, Weber lateralised to the right,Left cerebellum signs+. Tandem gait not possible, Romberg negative	DM2	Left RSSO craniotomy and GTE	Sudden cerebellar bulge, hence cerebellum partially sucked out. Major bleed from one of the perforator of PICA	N`	Patient could not be readily weaned off ventilator and hence tracheostomy done, poor gag post op and swallowing test done thrice reported high risk of aspiration. Hence discharged with RT.	30/12/20	Transitional meningioma WHO gr 1	No	Speech improved gradually, Dysphagia for solid and liquids improved gradually, left eye permanent tarsorrhaphy	Independent for ADL
L8	46 years	M	Left Vestibular schwanomma	2/12/20	10/12/20	Tinnitus 2 years , reduced hearing 2 years, numbness and paraesthesia of the left side of face 6 months	Left LMN facial paresis, Weber's lateralised to the right.	DM2 and HTN	Left RMSO craniotomy and NTE with facial nerve preserved.	Nil	N	Left Upper limb distal weakness which improved over 4 days.	14/12/20	Shwanomma	No	No	No
L9	44 years	F	Right CP angle Epidermoid	2/12/20	9/12/20	Headache since 4 years, hearing loss, giddiness 6 months	Reduced V2 sensation, Weber lateralised to the right,	Bronchial asthma	Right RMSO craniotomy and total excision	Nil	N	Nil	14/12/20	EPIDERMOID CYST	No	No	No
L10	43 years	F	Right CP angle vestibular schwanomma	23/01/21	2/2/21	Headache 6 years, decreased hearing in the right ear, gait unsteadiness since 1 year	Gaze evoked nystagmus, Weber's lateralised to left side	Depression	Right RSSO and GTE , 7th nerve anatomically and electrophysiological ly preserved.	Nil	N	NIL	2/2/21	Schwanomma	No	No	CT showed mild Hydrocephalus at 6 weeks. No f/u after
L11	34 years	F	Left CP angle schwanomma	25/01/21	5/2/21	Reduced hearing since 3 years, reduced sensation over left side of face	Reduced sensation in the V1,2,3 regions on left side, Weber lateralised to the right, Left cerebellar signs, Gait unsteadiness	Nil	Left RSSO craniotomy and NTD facial nerve preserved anatomically and electrophysiological ly	Poor plane with brainstem	N	Left facial palsy	8/2/21	Schwanomma	No	No	No
L12	53 years	F	Left Cp angle vestibular schwanomma	09/02/21	24/02/21	Headache since 1 year, Left sided hearing loss since 1 year, giddiness and gait unsteadiness since 4 months	B/l papilledema, left facial palsy HB grade 2, Weber's lateralised to the right,	Nil	Left RSSO Craniotomy and STD with 7th nerve reserved anatomically and Electrophysiological ly, right FP MPVP shunt on POD1	Poor planes with 7th nerve	N	Aspiration pneumonia	8/3/21	Schwanomma	No	No	No
L13	59 years	F	Right CP angle cystic vestibular schwanomma	11/1/21	18/1/21	Reduced hearing in the right ear since past 8 months, Tinnitus, Deviation of angle of mouth to left side 2 months	V1 reduced by 20% on the right side, Right facial palsy HB grade 2, Weber lateralised to the left, b/l cerebellar signs (R>L),	DM2	Right RSSO craniotomy and GTR , 7th anatomically preserved	Nil	N	Right facial nerve Hb grade 4	18/01/21	Schwanomma	No	NO	No
L14	18 years	F	Left Vestibular schwanomma	12/02/21	23/02/21	Previously operated on the right side for VS. Known case of NF2. B/l hearing loss, 2 weeks h/o gait unsteadiness, imaging shows increase in the size of the lesion	Weber's lateralised to the left,	NF2	Left RSSO craniotomy and radical excision with anatomical and physiological preservation of 7th nerve	Nil	N	Right shoulder abduction 3/5	27/02/21	Schwanomma	No	Nil	No

						Memory																Speed		Comprehension		WAIS											
						SOPT		RAVLT								Rey Complex								Digit Symbol		Token													
Serial No.	Age	Gender	Education	Diagnosis		rs	P	I R	P	DR	P	LTPR	P	Recognition	P	Copy	P	IR	P	DR	P	Time (sec)	P	Correct	P	Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Prcessing speed	P	Full scale Iq	P
M2	23	Male	School	cerebellar lesion	Pre	2	47	15	95	14	75	107	85	15	95	36	95	23	50	25	50	227	64	35		83	13	86	18	71	3	78	7	**78**	7
					Post	1	95	15	95	15	95	100	80	15	95	36	95	32	85	32	90	227	64	36		91	27	83	13	71	3	86	18	**81**	10
M3		female	School	cerebellar lesion	Pre	3	39	11	60	10	50	83.33	50	10	5	34	60	0	5	5	5	-	-	-		87	19	63	1	74	4	58	0.3	67	1
					Post	2	97	9	30	8	25	88.88	50	13	20	24	20	7.5	**5**	7	**10**	-	-	29.5		71	3	57	0.2	64	1	50	<0.1	**57**	0.2
M4	51	Male		4th ventricle lesion	Pre	2	93	9	50	11	80	100	85	15	95	36	95	17.5	40	21	70	621	3	36		95	37	86	18	68	2	65	1	78	7
					Post	3	69	6	**10**	8	30	88.88	60	13	30	33	60	24	80	23	80	-	-	36		99	47	72	3	68	2	-	-	-	-
					Pre			12	30	13	50	100	90	15	95	18.5	**5**	5.5	**5**	4	**5**			29.5		56	0.2	48	<0.1	47	<0.1			46	<0.1
M6	46	female	School	Pontine cavernoma	Pre	-	-	5	5	7	5	87.5	40	0	5	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
					Post	0	100	13	70	13	60	100	80	15	95	36	95	36	95	36	95	-	-	36		97	42	74	4	71	3	68	2	76	5
M11	24	Male	School		Pre	0	100	11	30	13	60	108	90	15	95	36	95	36	95	36	95	-	-	36		97	42	86	18	64	1	62	1	77	6
					Post	1	100	8	5	8	5	80	10	15	95	-	-	-	-	-	-	-	-	32		-	-	-	-	-	-	-	-	-	-
M12		female			Pre																														
					Post	0	100	11	30	8	5	80	15	14	20	36	95	33	90	33	95	-	-	36		105	63	102	55	68	2	81	10	90	25
M13	21	Male	School	(L) Cerebellar AVM	Pre	1	75	5	5	6	5	100	5	13	15	36	95	34	95	34	95	-	-	36		103	58	108	70	71	3	75	5	91	27
					Post	-	-	9	50	7	40	116.6	90	15	**95**	8.5	5	5.5	5	-	-	-	-	26.5		-	-	-	-	-	-	-	-	-	-
L1	59	female		(L) CP angle lesion	Pre	3	94	9	50	9	60	100	80	14	**50**	1	5	1.5	5	0	5	-	-	24.5		64	1	54	0.1	-	-	-	-	-	-
					Post	1	98	8	40	9	40	90	60	11	**10**	34	80	17	30	14	15			33		107	68	79	8	81	10	68	2	**83**	13
L2	63	Male	School	(L) CP angle lesion	Pre	3	59	8	10	9	20	81.81	15	12	10	34	40	22.5	50	23.5	50	273	28	35	-	75	5	81	10	71	3	73	4	71	3
					Post																														
L3		male			Pre	2	97	10	20	12	40	100	90	15	95	18	10	7	5	7	10	-	-	36		82	12	55	0.1	68	2	54	0.1	61	0.5
					Post	3	57	10	50	11	60	137.5	95	15	95	23	**15**	8	**10**	7.5	**10**	-	-	36		85	16	57	0.2	58	0.3	45	<0.1	**60**	0.4
L4	55	female		C P angle lesion	Pre	1	100	13	60	12	40	92.3	40	13	**10**	32	**5**	20	25	19	25	-	-	35		91	27	74	4	86	18	62	1	**76**	**5**
					Post	0	100	13	60	14	70	107.69	90	15	95	36	95	27	60	24	50	-	-	36		95	37	74	4	81	10	70	2	**78**	7
L5	35	Male	college	C P angle lesion	Pre	1	100	15	95	15	95	107	95	15	95	34	15	12	5	12	10	203	-	35.5		103	58	65	1	83	13	73	4	80	9
					Post	2	82	15	95	14	60	93.33	50	15	95	24.5	5	18	20	16	15	-		36		102	55	70	2	86	18	70	2	81	10
L6	44	female	college	C P angle lesion	Pre	1	97	14	70	15	95	107.14	85	15	95	36	95	20	50	19	50	-	-	36		105	63	72	3	74	4	86	18	83	13
					Post																														
L7	59	female	college		Pre	2	94	5	5	5	5	71.42	10	9	5	36	95	18	30	19.5	40	-	-	35		85	16	74	4	74	4	73	4	74	4
					Post	3	59	8	15	12	50	133	95	15	95	36	95	29	85	34	95	-	-	36		82	12	83	13	83	13	70	2	77	6
L8	46	Male	School	(L) CP angle lesion	Pre	2	96	8	5	10	20	83.33	25	14	20	36	95	29	95	30	95	249	63	36		95	37	86	18	74	4	75	5	82	12
					Post																														
L9		female		CP angle Epidermoid	Pre	1	100	10	20	10	20	111	95	15	95	36	95	16.5	50	16.5	50	-	-	34.5		69	2	70	2	71	3	54	0.1	61	0.5
					Post	2	96	13	50	13	50	100	90	14	20	36	95	22.5	75	24	75			35		75	5	68	2	71	3	50	<0.1	**62**	1
L10	43	female	School		Pre	1	100	14	75	14	60	100	90	15	95	36	95	29	70	27.5	70	128	100	36		107	68	100	50	108	70	104	61	106	66
					Post	2	82	13	50	13	60	100	90	15	95	34	15	30	75	32	90	160	67	36		111	77	83	13	97	42	89	23	**94**	34
L11	34	female	College	(L) CP angle lesion	Pre	4	11	4	5	5	5	50	5	15	95	15.5	5	9	10	9	10	-	-	36	-	75	5	46	<0.1	61	0.5	-	-	-	-
					Post	3	39	9	15	8	5	80	25	13	5	32	40	9.5	10	9	10	-	-	36	-	75	5	50	<0.1	68	2	58	0.3	58	0.3
L12	53	female	College		Pre	4	24	8	40	8	30	66.66	15	14	60	36	95	11	10	17	40	-	-	35		93	32	63	1	83	13	45	<0.1	69	2
					Post	2	93	9	50	11	80	100	85	15	95	29	30	18	40	22	70	-	-	36		95	37	79	8	81	10	-	-	-	-
L13	59	Male	School	(R) CP angle lesion	Pre	3	50	11	30	11	30	100	80	13	**15**	36	95	17	30	18	40	--	--	34		99	47	63	1	64	1	70	2	**72**	3
					Post	3	50	13	60	13	60	108.33	90	15	95	36	95	11	10	15	25	-	-	35		102	55	63	1	68	2	68	2	74	4
L14	17	female	School		Pre																														
					Post																														

						Attention												Executive functions						Verbal N Back							
						Digit Vigilance				Trail Making				Triads				Cowa		Animals		Block Design									
Serial No.	Age	Gender	Education	Diagnosis		Time (sec)	P	Error	P	A time	P	B Time	P	Word error	P	number error	P	new words	P	new words	P	correct	P	1 B Hits	P	1 B Error	P	2 B Hits	P	2 B error	P
M2	23	Male	School	cerebellar lesion	Pre	400	91	33	**6**	34	94	110	79	1		4		9.66	75	15	70	29		8	40	1	45	5	20	6	26
					Post	432	88	15	19	56	62	198	18	3		3		17	95	18	95	34		9	95	0	100	9	95	2	97
M3		female	School	cerebellar lesion	Pre	-	-	-	-	65	71	190	39	1		5		10.66	90	19	95	24		8	70	2	54	8	90	2	86
					Post	-	-	-	-	88	49	159	56	4		14	5	7.33	50	13	75	16		7	30	2	54	8	90	1	94
M4	51	Male		4th ventricle lesion	Pre	-	-	-	-	82	54	327	5	-	-	-	-	9	75	15	85	35		8	40	1	60	6	40	3	65
					Post	-	-	-	-	166	**7**	-	-	-	-	-	-	9.66	80	17	95	35		8	40	1	73	7	60	2	86
M6	46	female	School	Pontine cavernoma	Pre	-	-	-	-	-	-	-	-	-	-	-	-	3	10	15	85	3		6	20	5	11	2	10	8	25
					Post	-	-	-	-	-	-	-	-	-				2	5	7	5	-		-	-	-	-	-	-	-	-
M11	24	Male	School		Pre	731	19	8	41	54	68	109	79	0		1		12.66	95	14	60	31		9	95	0	100	0	5*	9	10
					Post	-	-	-	-	51	74	141	50	0		1		14.6	95	11	25	43		9	95	0	100	6	30	3	48
M12		female			Pre	-	-	-	-	67	32	-	-	**2**	-	6	-	12.33	60	15	40	-	-	8	20	1	29	9	95	2	71
					Post																										
M13	21	Male	School	(L) Cerebellar AVM	Pre	483	78	23	9	32	97	65	97	1		5		8.33	60	13	50	46		8	40	1	45	5	20	4	32
					Post	427	88	74	3	38	88	100	85	3		8	15	8	60	12	30	43		7	15	2	23	7	50	2	97
L1	59	female		(L) CP angle lesion	Pre	-	-	-	-	-	-	-	-	-	-	-	-	2.33	30	7	30	-		-	-	-	-	-	-	-	-
					Post	-	-	-	-	-	-	-	-	-	-	-	-	2	30	11	75	-		6	**40**	11	6	2	5	10	6
L2	63	Male	School	(L) CP angle lesion	Pre	668	41	8	29	107	28	196	40	1		7		6.66	60	11	50	28		6	**5**	3	19	6	40	3	65
					Post																										
L3		male			Pre	528	44	28	11	38	100	144	51	0	-	3	-	8.33	50	12	40	32	-	9	95	0	100	6	40	4	59
					Post																										
L4	55	female		C P angle lesion	Pre	536	64	235	3	211	2	660	5	4		15	5	5.33	30	10	25	4		5	5	4	23	1	5	8	6
					Post	-	-	-	-	306	**2**	-	-	0		10	**5**	6	40	9	20	12		4	**5**	6	**11**	0	**5**	9	**3**
L5	35	Male	college	C P angle lesion	Pre	-	-	-	-	39	94	118	62	0		5		13	70	15	70	34		9	95	0	100	7	50	3	62
					Post	-	-	-	-	85	35			1		1		10.33	40	12	30	30		8	30	1	41	7	50	2	79
L6	44	female	college	C P angle lesion	Pre	664	3	19	6	51	71	113	55	2		9		14.33	80	17	60	11		9	95	0	100	7	25	4	39
					Post	-	-	-	-	55	58	98	77	0		3		12	60	16	50	28		7	10	4	7	5	10	4	39
L7	59	female	college		Pre	-	-	-	-	50	60	118	49	1		4		11.33	40	16	70	19		9	95	0	100	7	50	2	76
					Post																										
L8	46	Male	School	(L) CP angle lesion	Pre	540	42	13	31	37	94	108	91	4		4		7	50	15	70	29		9	95	0	100	6	40	4	59
					Post	504	50	50	6	40	94	73	100	4		8		11.33	80	17	85	33		9	95	0	100	7	60	0	86
L9		female		CP angle Epidermoid	Pre	-	-	-	-	52	88	87	97	0		2		12.33	90	15	85	33		9	95	0	100	4	25	5	50
					Post																										
L10	43	female	School		Pre	-	-	-	-	78	50	-	-	1		14	5	5.33	30	14	70	29		9	95	1	61	7	75	2	100
					Post	-	-	-	-	67	72	-	-	2		8		4	20	14	70	28		9	95	0	100	8	85	1	100
L11	34	female	College	(L) CP angle lesion	Pre	409	54	4	53	28	100	47	100	0		1		9.33	30	14	40	34		9	95	1	29	8	75	1	94
					Post	179	100	81	3	31	100	79	100	2		1		11.6	50	15	40	36		9	95	0	100	7	25	2	71
L12	53	female	College		Pre	-	-	-	-	123	9	234	11	12		6		11.33	40	9	10	5		6	5	3	18	4	5	5	21
					Post	-	-	-	-	67	37	160	23	3	-	3	-	11.33	40	12	25	6	-	7	20	2	24	8	85	1	94
L13	59	Male	School	(R) CP angle lesion	Pre	-	-	-	-	143	9	285	9	1		8		9	75	20	95	16		9	95	0	100	7	60	4	54
					Post	-	-	-	-	-	-	-	-	4		6		9	75	12	60	28		8	40	1	60	6	40	3	65
L14	17	female	School		Pre	651	23	45	**7**	78	39	94	90	0		6		14.33	95	14	75	16		7	30	2	**13**	5	30	4	27
					Post	384	100	124	4	70	48	195	36	2		1		15.33	95	9	20	20		8	30	1	33	6	15	3	50

Sl.No	Age	Gender	Diagnosis		Attention						Executive functions											
					Colour Cancellation		Trail Making				Phonemic Fluency	Block Design		RAVLT						VSWMS			
					Time (sec)	Error	A time	Error	B Time	Error	new words	correct	P	I R	P	DR	P	Total	P	Forward	Reverse	total	P
M5	14	female	Grade 2 ependymoma	Pre	59	34	-	-	-	-	15	18		6	-	6	5	38	5	4	2	6	10
				Post	-	-	-	-	-	-	13	5	5	11	-	12	50	57	90	3	3	6	10
M1	10	female	Medulloblastoma	Pre	124	2	-	-	-	-	37	26	90	14	-	14	95	54	90	-	-	-	-
				Post	64	0	-	-	-	-	26	36	95	15	-	14	95	65	95	-	-	-	-
M8	9	Male	Pilocytic astrocytoma	Pre	180	6	-	-	-	-	14	1	5	6	-	7	5	31	5	1	0	1	5
				Post	125	4	144	0	-	-	14	9	25	13	-	13	90	56	90	4	0	4	5
M9	7	Male	Medulloblastoma	Pre	139	49	120	1	548	1	18	12	75	5	-	7	10	42	50	4	1	5	25
				Post	103	51	72	0	426	1	22	22	90	10	-	11	75	54	90	5	0	5	25
M10	10	female	Medulloblastoma	Pre	41	0	48	3	193	3	19	44	95	13	-	7	5	53	90	4	1	5	10
				Post	52	2	37	0	235	1	21	47	95	10	-	13	75	62	95	3	2	5	10
M7	6	female	Medulloblastoma	Pre	63	3	102	0	303	5	17	13	90	3	-	7	25	22	5	4	1	5	25
				Post											-								

Sl.No	Age	Gender	Diagnosis		Comprehension		WISC									
					Token											
					Correct	P	Verbal Comprehension	P	Perceptual Reasoning	P	Working Memory	P	Prcessing speed	P	Full scale Iq	P
M5	14	female	Grade 2 ependymoma	Pre	35	95	80	9	57	0.2	66	1	-	-	-	-
				Post	35	95	58	0.3	45	<0.1	82	12	-	-	-	-
M1	10	female	Medulloblastoma	Pre	35	95	112	79	98	45	95	37	-	-	-	-
				Post	35	95	120	91	108	70	95	37	-	-	-	-
M8	9	Male	Pilocytic astrocytoma	Pre	25.5	10	78	7	49	<0.1	51	0.1	57	0.2	52	0.1
				Post			76	5	57	0.2	63	1	66	1	59	0.3
M9	7	Male	Medulloblastoma	Pre	35	95	110	75	76	5	85	16	94	34	88	21
				Post	35	95	106	66	80	9	79	8	135	99	98	45
M10	10	female	Medulloblastoma	Pre	35	95	108	70	94	34	98	45	89	23	97	42
				Post	35	95	108	70	98	45	85	16	89	23	95	37
M7	6	female	Medulloblastoma	Pre	7	5	90	25	90	25	79	8	86	18	82	12
				Post												

श्री चित्रा तिरुनाल आयुर्विज्ञान और प्रौद्योगिकी संस्थान, त्रिवेंद्रम - 695 011, केरल, भारत
SREE CHITRA TIRUNAL INSTITUTE FOR MEDICAL SCIENCES AND TECHNOLOGY
TRIVANDRUM - 695 011, KERALA, INDIA
(एक राष्ट्रीय महत्व का संस्थान, विज्ञान एवं प्रौद्योगिकी विभाग, भारत सरकार)
(An Institution of National Importance, Department of Science and Technology, Government of India)
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Institutional Ethics Committee

(IEC Regn No. ECR/189/Inst/KL/2013/RR-16)

SCT/IEC/1553 /OCTOBER/ 2020 30.10.2020

Dr. Sanjay HM
Senior Resident
Department of Neurosurgery
SCTIMST, Thiruvananthapuram

Dear Dr. Sanjay,

The Institutional Ethics Committee reviewed and discussed your application to conduct the study entitled "**NEUROPSYCHOLOGICAL IMPACT OF POSTERIOR FOSSA LESION-A PROSPECTIVE STUDY OF A COHORT OF PATIENTS OPERATED FOR POSTERIOR FOSSA LESIONS** (IEC/1553)**"** on August 3- 21, 2020.

The following documents were reviewed:

Original submission

1. *IEC checklist* 2. *Proposal for the study* 3. *IEC application form* 4. *Forwarding letter from HOD (Dr.Mathew Abraham) dated 21/07/2020* 5. *Proforma* 6. *TAC-Clinical Studies approval without questions and responses to issues raised by TAC-Clinical Studies* 7. *Informed consent form in English*	8. *Assent form in English* 9. *Patient information sheet in English* 10. *Informed consent form in Malayalam* 11. *Assent form in Malayalam* 12. *Patient information sheet in Malayalam* 13. *CV of PI, Sanjay MM with Karnataka registration number* 14. *CV of Co-PI, Dr.Mathew Abraham with TCMC registration number* 15. *Covering letter from PI, Dr.Sanjay HM - undated*

Revised submission on 27/09/2020

1. *Revised IEC checklist* 2. *Revised Proposal for the study* 3. *Revised IEC application form* 4. *Forwarding letter from HOD (Dr.Mathew Abraham) dated 21/07/2020* 5. *Proforma* 6. *TAC-Clinical Studies approval without questions and responses to issues raised by TAC-Clinical Studies* 7. *Informed consent form in English*	8. *Assent form in English* 9. *Patient information sheet in English* 10. *Informed consent form in Malayalam* 11. *Assent form in Malayalam* 12. *Patient information sheet in Malayalam* 13. *CV of PI, Sanjay MM with Karnataka registration number* 14. *CV of Co-PI, Dr.Mathew Abraham with TCMC registration number* 15. *Covering letter from PI, Dr.Sanjay HM - undated*

The following members of the Students Sub-Committee of the Institutional Ethics Committee participated in the discussions held between August 3-21, 2020 at the offices and residences of the members

SL. No.	Member Name	Highest Degree	Gender	Scientific /Non Scientific	Affiliation with Institution(s)
1.	Dr. R V G Menon	M Tech, PhD	Male	Lay Person (Chairman)	No
2.	Dr. Harikrishnan S	MD, DM (Cardiology) DNB (Cardiology)	Male	Clinician	Yes
3.	Dr. Kala Kesavan. P	MBBS, MD	Female	Basic Medical Scientist	No
4.	Smt. Sathi Nair	MA (English Literature)	Female	Lay Person	No
5.	Dr. Rema M. N	MD	Female	Basic Medical Scientist	No
6.	Dr. Christina George	MD Psychiatry	Female	Clinician	No
7.	Dr. Mala Ramanathan	PhD	Female	Social Scientist (Member Secretary)	Yes

IEC Decision

The IEC approved the conduct of the study in the present form.

Remarks:
The Institutional Ethics Committee expects to be informed about the progress of the study, any SAE occurring in the course of the study, any changes in the protocol and patient information/informed consent and asks to be provided a copy of the final report.

There was no member of the study team who participated in voting / decision making process. The ethics committee is organized and operated according to the requirements of Good Clinical Practice and the requirements of the Indian Council of Medical Research (ICMR).

Sincerely,

Mala Ramanathan
Member Secretary, IEC

Plagiarism Checker X - Report

Originality Assessment

Overall Similarity: **1%**

Date: Aug 1, 2021

Statistics: 73 words Plagiarized / 6862 Total words

Remarks: Low similarity detected, check your supervisor if changes are required.