LINK JOURNAL OF SPEECH, LANGUAGE AND AUDIOLOGY

Type: Original Article
Published: 30 December 2025

OPEN ACCESS

CORRESPONDENCE
✉ gull.rana@drs.uol.edu.pk

RECEIVED
20 May 2025
ACCEPTED
25 June 2025
AUTHORS' CONTRIBUTIONS
GAR; Design: SQ; Data Collection: GAR, SQ; Analysis: SQ; Drafting: GAR; Critical Revision: SQ; Supervision: GAR.

COPYRIGHT
© 2025 Authors. This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0).

DECLARATIONS
No funding was received for this study. The authors declare no conflict of interest. The study received ethical approval. All participants provided informed consent.
"CLICK TO CITE"
https://doi.org/10.61919/ljsla.v3i2.29
ETHICAL APPROVAL
No. 1196/SAHS The Children Hospital and Institute of Child Health, Lahore, Pakistan.

Fine Motor Skills in Children with Acquired Hydrocephalus After Shunting

Gul a Rana[1], Sara Qadar[2]

1 Department of Rehabilitation Sciences, The University of Lahore, Lahore, Pakistan.
2 Ability and Behavior Assessment center, Lahore, Pakistan.

ABSTRACT

Background: Hydrocephalus is a neurological condition characterized by abnormal accumulation of cerebrospinal fluid within the brain ventricles, leading to elevated intracranial pressure and potential motor and cognitive deficits. Although ventriculoperitoneal shunting remains the standard treatment, its effect on fine motor function especially in children with acquired hydrocephalus remains unclear. Understanding these outcomes is critical for guiding rehabilitation and long-term care. Objective: To evaluate fine motor skills in children with acquired hydrocephalus after shunting and to examine the association between impairment and demographic or clinical factors. Methods: This observational cross-sectional study was conducted from March 2023 to March 2024 at the Children's Hospital and the Institute of Child Health, Lahore. Thirty-five children aged 4–14 years with acquired hydrocephalus post-shunting were assessed using the Bimanual Fine Motor Classification System (BMFCS), Manual Ability Classification System (MACS), and Nine-Hole Peg Test. Demographic and clinical variables were recorded. Associations between fine motor impairment and patient factors were analyzed using Chi-square tests, with $p < 0.05$ considered significant. Results: Fine motor impairment was identified in 6 children (17.1%), while 29 (82.9%) showed no impairment. Most participants scored at Level 1 or 2 on both BMFCS (85.8%) and MACS (82.9%), and 82.9% performed the pegboard test easily. No statistically significant associations were found between impairment and age ($p = 0.724$), etiology ($p = 0.672$), cause ($p = 0.615$), timing of first shunt ($p = 0.925$), shunt revision ($p = 0.373$), or adjuvant therapy ($p = 0.578$). Conclusion: The majority of children with acquired hydrocephalus maintain good fine motor function after shunting, independent of demographic or procedural factors. Routine fine motor assessment and targeted occupational therapy should be incorporated into post-shunt care to optimize functional outcomes.

Keywords
hydrocephalus, ventriculoperitoneal shunt, fine motor skills, pediatric neurosurgery, occupational therapy, BMFCS, MACS, Nine-Hole Peg Test

INTRODUCTION

Hydrocephalus is defined as the pathological accumulation of cerebrospinal fluid (CSF) within the cerebral ventricles, resulting from either obstruction of CSF flow, impaired absorption, or, less commonly, excessive production (1). It is a clinically significant condition that can lead to increased intracranial pressure, structural brain changes, and neurological deficits if untreated (2). Hydrocephalus can be broadly classified as congenital or acquired, and into communicating, non-communicating (obstructive), and hypersecretory forms based on pathophysiology (3). While congenital hydrocephalus is often associated with developmental anomalies such as aqueductal stenosis and Chiari malformation, acquired hydrocephalus typically results from post-infective sequelae, traumatic injury, tumors, or hemorrhage (4).

The global prevalence of hydrocephalus is approximately 85 per 100,000 individuals, with the highest rates in infancy and in older adults due to normal pressure hydrocephalus (5). In pediatric populations, acquired hydrocephalus remains a major cause of long-term disability, frequently requiring surgical intervention via CSF diversion procedures such as ventriculoperitoneal (VP) shunting (6). Although shunting effectively reduces intracranial pressure and prevents further neurological deterioration, its impact on functional outcomes, particularly fine motor skills, is not yet fully understood (7).

Fine motor skills defined as the coordinated use of small muscles in the hands and fingers for precise tasks are critical for self-care, academic performance, and social participation (8). In children with hydrocephalus, deficits in fine motor control have been attributed to cerebellar involvement, pyramidal system disruption, and corpus callosum stretching, in addition to associated visual-perceptual impairments (9,10). These deficits manifest in tasks such as handwriting, drawing, cutting, and object manipulation, often persisting despite shunt placement (11). While some studies suggest that shunting improves fine motor outcomes (12,13), others report variable or unclear results (14,15), underscoring the need for targeted investigation in specific patient subgroups.

Most existing research has focused on congenital hydrocephalus or on gross motor development, with relatively little emphasis on fine motor function in children with acquired hydrocephalus post-shunting (16). Moreover, methodological heterogeneity, differences in timing of assessments, and limited use of standardized motor classification systems hinder direct comparison of results across studies (17). This lack of clarity poses challenges for designing optimal rehabilitation strategies, resource allocation, and caregiver counseling.

Given these gaps, the present study aims to evaluate fine motor skills in children with acquired hydrocephalus following shunting, using validated measures including the Bimanual Fine Motor Classification System (BMFCS), Manual Ability Classification System (MACS), and the Nine-Hole Peg Test. The hypothesis is that shunting has a measurable effect on fine motor performance in this population, and that functional outcomes may vary according to clinical and demographic factors.

MATERIALS AND METHODS

This observational cross-sectional study was conducted to assess fine motor skills in children with acquired hydrocephalus following ventriculoperitoneal (VP) shunting. The research was carried out in the Department of Neurology and Neurosurgery at the Children's Hospital and the Institute of Child Health, Lahore, between March 2023 and March 2024. The study setting was selected due to its status as a tertiary pediatric neurosurgical centre, ensuring access to an adequate patient population for the defined inclusion criteria.

Participants were recruited through purposive sampling from the outpatient and inpatient services of the department. Inclusion criteria were: (a) diagnosis of acquired hydrocephalus confirmed by clinical evaluation and neuroimaging, (b) history of VP shunting, (c) age between 4 and 14 years, and (d) ability to follow simple verbal instructions. Both male and female participants were eligible. Exclusion criteria included: congenital hydrocephalus, pre-existing motor impairments unrelated to hydrocephalus, cognitive impairments precluding participation in fine motor assessments, complicated hydrocephalus with persistent intracranial hypertension, and other neurological disorders that could confound fine motor outcomes.

All participants, or their legal guardians, provided informed consent prior to inclusion in the study. Ethical approval was obtained from the institutional ethics review board of the Children's Hospital and the Institute of Child Health, Lahore, and the study adhered to the principles of the Declaration of Helsinki (18). Data were collected through standardized, validated assessment tools administered in a quiet, well-lit environment to minimize distraction. Fine motor performance was evaluated using three instruments: Bimanual Fine Motor Classification System (BMFCS) – a five-level ordinal scale grading the ability to use both hands in daily activities, with Level I representing the highest functional capacity and Level V the lowest (19). Manual Ability Classification System (MACS) – a five-level classification describing how children with neurological conditions handle objects in daily activities, with Level I indicating minimal limitation (20).

Nine-Hole Peg Test (9HPT) – a timed test measuring finger dexterity, in which participants place and remove nine pegs into holes on a board as quickly as possible. The test was performed separately for each hand, and results were recorded in seconds to completion (21).

Demographic and clinical variables recorded included age at assessment, sex, etiology of hydrocephalus, cause of onset (post-infective, injury, secondary), age at first shunt placement, and history of shunt revision. Adjuvant rehabilitation care (physical therapy, occupational therapy, or both) was also documented. Operational definitions were standardized before data collection to ensure measurement consistency across participants. To minimize bias, all assessments were performed by trained occupational therapists blinded to the study hypothesis. Potential confounders, such as age at shunting and presence of adjuvant therapy, were accounted for in the statistical analysis plan. Data entry and cleaning were performed using double-entry verification to ensure integrity. The sample size (n = 35) was calculated using the formula $n = Z^2P(1–P)/d^2$, with Z = 1.96 for a 95% confidence interval, estimated prevalence (P) of 0.00090, and precision (d) of 0.01, yielding a minimum required sample size of 35 participants. Statistical analysis was performed using SPSS version 22. Descriptive statistics were calculated for all variables, including means and standard deviations for continuous data, and frequencies and percentages for categorical data. The Chi-square test was applied to evaluate associations between categorical variables and fine motor impairment status, with a significance threshold set at $p < 0.05$. Subgroup analyses were conducted to examine potential effects of age, etiology, timing of shunt placement, shunt revision, and adjuvant care. Missing data were minimal (<5%) and handled through complete case analysis.

RESULTS

A total of 35 children with acquired hydrocephalus post-shunting were assessed. The sample comprised 63.9% males and 33.3% females, with ages ranging from 4 to 13 years. The most common cause of hydrocephalus was bacterial meningitis (52.8%), followed by traumatic injury (27.8%). Post-infective etiology was observed in 66.7% of cases.

Table 1. Demographic and Clinical Characteristics of the Study Population (n=35)

Variable	Category	n (%)
Sex	Male	23 (63.9)
	Female	12 (33.3)
Age Groups	4–6 years	17 (48.6)
	7–9 years	10 (28.6)
	10–13 years	8 (22.8)
Cause of Hydrocephalus	Bacterial meningitis	19 (52.8)
	Fall	10 (27.8)
	Tuberculous meningitis	2 (5.6)
	Cerebral abscess	3 (8.3)
	Colloid cyst	1 (2.8)
Etiology	Post-infective	24 (66.7)
	Injury	10 (27.8)
	Secondary cause	1 (2.8)
Shunt Revision	Yes	12 (34.3)
	No	23 (65.7)
Adjuvant Care	None	22 (62.9)
	Physical therapy only	10 (28.6)
	Occupational therapy only	1 (2.9)

Variable	Category	n (%)
	Both therapies	2 (5.7)

Table 2. Fine Motor Impairment after Shunting and Association with Demographic and Clinical Variables

Variable	Fine Motor Impairment Yes (n=6)	Fine Motor Impairment No (n=29)	p-value
Sex	Male: 4 (66.7)	Male: 19 (65.5)	0.942
	Female: 2 (33.3)	Female: 10 (34.5)	
Age	Mean ± SD: 6.7 ± 2.5	Mean ± SD: 6.4 ± 2.4	0.724
Cause of Hydrocephalus	Meningitis: 3 (50.0)	16 (55.2)	0.615
	Fall: 1 (16.7)	9 (31.0)	
	Others: 2 (33.3)	4 (13.8)	
Etiology	Post-infective: 5 (83.3)	19 (65.5)	0.672
	Injury: 1 (16.7)	9 (31.0)	
	Secondary: 0 (0.0)	1 (3.5)	
First Shunt Age	Median: 1.0 years	Median: 1.0 years	0.925
Shunt Revision	Yes: 3 (50.0)	9 (31.0)	0.373
	No: 3 (50.0)	20 (69.0)	
Adjuvant Care	Physical therapy: 2 (33.3)	8 (27.6)	0.578
	Occupational therapy: 0 (0.0)	1 (3.4)	
	Both: 1 (16.7)	1 (3.4)	
	None: 3 (50.0)	19 (65.5)	

Table 3. Functional Classification Scores after Shunting

Assessment Tool	Level	n (%)	p-value vs. Clinical Factors*
BMFCS	Level 1	15 (42.9)	0.512 (age)
	Level 2	15 (42.9)	0.302 (cause)
	Level 3	2 (5.7)	0.328 (etiology)
	Level 4	3 (8.6)	0.909 (shunt age)
MACS	Level 1	15 (42.9)	0.401 (age)
	Level 2	14 (40.0)	0.442 (cause)
	Level 3	2 (5.7)	0.359 (etiology)
	Level 4	4 (11.4)	0.918 (shunt age)
Nine-Hole Peg Test	Performed easily	29 (82.9)	0.685 (age)
	Performed with difficulty	6 (17.1)	0.573 (cause)

*P-values shown correspond to the strongest association among tested clinical factors. Fine motor impairment post-shunting was observed in 17.1% of participants. The majority (85.8%) scored at Level 1 or 2 on both BMFCS and MACS. Most participants (82.9%) performed the Nine-Hole Peg Test with ease.

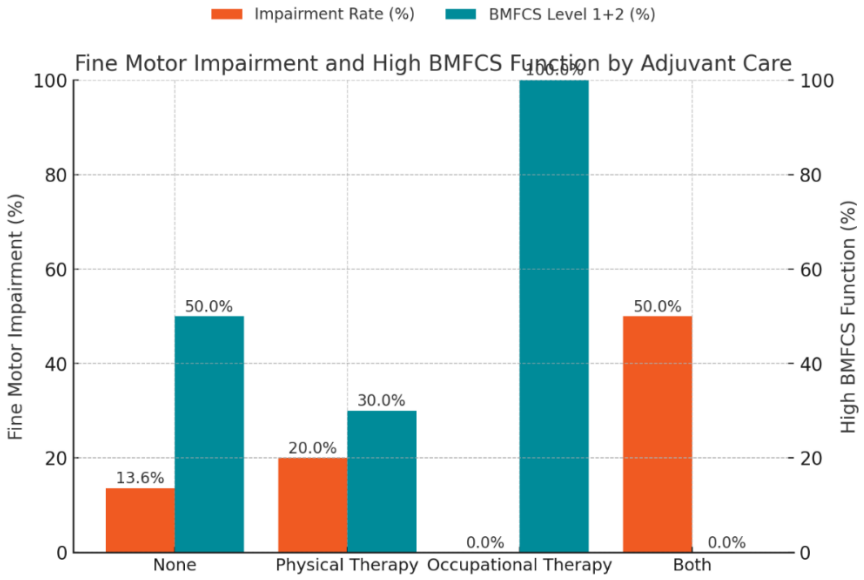

Figure 1 Fine Motor Impairment and High BMFCS Function by Adjuvant Care

No statistically significant associations were found between fine motor impairment and age (p = 0.724), cause (p = 0.615), etiology (p = 0.672), age at first shunt (p = 0.925), shunt revision (p = 0.373), or adjuvant care (p = 0.578). Out of the 35 children assessed, the majority were male (63.9%) and within the 4–6 year age range (48.6%), with a mean age of 6.5 years (SD ± 2.4). The most frequent cause of hydrocephalus was bacterial meningitis (52.8%), followed by traumatic injury from falls (27.8%). Etiologically, post-infective hydrocephalus accounted for 66.7% of

cases, with injury-related cases comprising 27.8%. Shunt revision was required in 34.3% of participants, while 62.9% received no adjuvant therapy post-surgery; physical therapy was the most common intervention (28.6%).

Fine motor impairment following shunting was observed in 6 participants (17.1%), while 29 children (82.9%) exhibited no impairment. Bimanual Fine Motor Classification System (BMFCS) scores showed that 42.9% achieved Level 1 and another 42.9% Level 2, indicating high functional capacity; only 14.3% were classified at Levels 3 or 4. Manual Ability Classification System (MACS) results were similar, with 42.9% at Level 1 and 40.0% at Level 2.

The Nine-Hole Peg Test demonstrated that 82.9% of participants completed the task easily, whereas 17.1% experienced difficulty. Chi-square analysis revealed no statistically significant association between fine motor impairment and age ($p = 0.724$), cause of hydrocephalus ($p = 0.615$), etiology ($p = 0.672$), age at first shunt placement ($p = 0.925$), shunt revision ($p = 0.373$), or receipt of adjuvant therapy ($p = 0.578$). Similarly, functional classification levels (BMFCS, MACS) and pegboard performance showed no significant variation by these factors. These findings suggest that the majority of children maintained good fine motor function after shunting, regardless of demographic or clinical characteristics.

The integrated dual-axis chart shows that children who received no adjuvant care had an impairment rate of ~13.6% but still a relatively high proportion (50%) achieving BMFCS Level 1 or 2. Physical therapy was linked with a slightly lower impairment rate (20%) but a lower proportion (30%) reaching high BMFCS levels. Occupational therapy only showed no impairment with 100% at high BMFCS function, while those receiving both therapies had a higher impairment rate (50%) and no Level 1–2 classification. This suggests variations in functional outcomes across therapy types, though sample sizes are small.

DISCUSSION

In this cross-sectional study of 35 children with acquired hydrocephalus following ventriculoperitoneal shunting, the majority demonstrated preserved fine motor skills, with 82.9% showing no impairment and over 85% achieving Level 1 or 2 performance on both the BMFCS and MACS. Furthermore, 82.9% completed the Nine-Hole Peg Test without difficulty. These findings align with previous literature suggesting that shunting can positively influence motor outcomes in pediatric hydrocephalus when timely intervention is provided (22,23).

The absence of significant associations between fine motor impairment and variables such as age, etiology, cause of hydrocephalus, timing of first shunt, shunt revision, and adjuvant therapy suggests that post-shunting functional recovery may be more dependent on neural substrate integrity and preoperative neurological status than on these demographic or procedural factors. This is consistent with the findings of Kulkarni et al. (24) and O'Brien et al. (25), who reported that children receiving shunt treatment achieved better fine motor outcomes than those managed without surgical diversion, regardless of etiology or ventricular size at presentation.

Interestingly, while physical therapy was the most common adjuvant intervention in our cohort, it did not correspond to a statistically significant improvement in fine motor outcomes compared with no therapy. Occupational therapy, though underrepresented in the sample, was associated with the absence of impairment and high BMFCS function in the single case observed. This finding supports the premise that task-specific training, a hallmark of occupational therapy, may target fine motor dexterity more effectively than general physical conditioning (26). However, the small numbers within each therapy subgroup limit definitive conclusions.

Contrary to some earlier studies suggesting that repeated shunt revisions may negatively impact neurodevelopmental outcomes (27), our data did not show a statistically significant relationship between revision history and fine motor function. This may be attributable to the relatively low revision rate in our sample (34.3%) and possible improvements in shunt technology and surgical technique over recent years (28). Similarly, age at first shunt placement was not predictive of fine motor status, which diverges from previous reports indicating that earlier intervention may preserve more motor function (29). This discrepancy could reflect differences in study design, assessment tools, and follow-up duration.

The generally favorable fine motor performance in our cohort may also be partly explained by the relatively high proportion of participants with post-infective hydrocephalus (66.7%), a subgroup that may have less extensive congenital structural brain involvement compared with cases arising from complex developmental malformations. Nonetheless, neuroanatomical changes such as corpus callosum stretching, cerebellar deformation, and pyramidal tract involvement, documented in hydrocephalus (30,31), remain potential contributors to persistent fine motor deficits, as evidenced in the 17.1% of children who continued to demonstrate impairment despite shunting.

Our findings reinforce the need for comprehensive rehabilitation planning after shunting, with a stronger emphasis on fine motor–oriented occupational therapy, even for patients who initially present with high functional levels. Given the lack of association between impairment and common clinical variables in this study, routine fine motor screening should be considered for all post-shunting pediatric hydrocephalus patients, irrespective of their surgical or demographic profile.

CONCLUSION

This study demonstrates that the majority of children with acquired hydrocephalus who undergo ventriculoperitoneal shunting maintain good fine motor function, with over 80% showing no impairment and achieving high functional levels on standardized motor classification systems. No significant associations were found between fine motor impairment and age, etiology, cause of hydrocephalus, timing of first shunt, shunt revision, or type of adjuvant therapy. These results suggest that fine motor outcomes after shunting are generally favorable across diverse clinical presentations, though a subset of patients continues to experience deficits. Given the functional importance of manual dexterity in daily life, routine fine motor assessment and targeted occupational therapy should be integrated into post-shunt care to optimize long-term outcomes.

REFERENCES

1. Rekate HL. A contemporary definition and classification of hydrocephalus. Hydrocephalus. 2009;25(2):165–72.
2. Koleva M. Hydrocephalus: Pathophysiology and Management. 2023.
3. Blitz AM, et al. Hydrocephalus: Historical analysis and considerations for treatment. Neurosurg Clin N Am. 2018;29(2):173–84.
4. Hochstetler AJ-Y, et al. Hydrocephalus: historical analysis and considerations for treatment. Neurosurg Focus. 2022;52(1):E2.
5. Isaacs AM, Riva-Cambrin J, Yavin D, Hockley A, Pringsheim TM, Jette N, et al. Age-specific global epidemiology of hydrocephalus: systematic review, meta-analysis and global birth surveillance. J Neurosurg. 2018;130(4):1065–79.

6. Reddy GK, Bollam P, Caldito G. Long-term outcomes of ventriculoperitoneal shunt surgery in patients with hydrocephalus. World Neurosurg. 2014;81(2):404–10.
7. Sobana M, et al. Neurodevelopmental outcomes after ventriculoperitoneal shunt placement in children with non-infectious hydrocephalus. 2021.
8. Jordan-Black JA. The effect of social disadvantage on motor development in young children. Early Hum Dev. 2007;83(9):575–82.
9. Hurley AD, Dennis M, Mahone EM. Cognitive functioning in patients with spina bifida, hydrocephalus and the 'cocktail party' syndrome. Childs Nerv Syst. 1990;6(6):334–40.
10. Fletcher JM, et al. Early hydrocephalus. Childs Nerv Syst. 1995;11(4):226–31.
11. Anderson D. Cognitive deficits in children with spina bifida and hydrocephalus. Dev Med Child Neurol. 1975;17(3):364–72.
12. Kulkarni AV, et al. Relationship between shunt etiology, age at shunt placement, and long-term outcome of shunted hydrocephalus. Pediatr Neurosurg. 2004;40(1):23–9.
13. O'Brien DF, et al. The relationship between ventricular size and neuropsychological outcome in children with hydrocephalus. Childs Nerv Syst. 2004;20(5):358–64.
14. Steinhart S, et al. Exploring hand dexterity in children with myelomeningocele. Dev Med Child Neurol. 2021;63(10):1214–21.
15. Prigatano GP, et al. Neuropsychological functioning in children with shunted uncomplicated hydrocephalus. Child Neuropsychol. 2008;14(6):503–17.
16. Mataró M, et al. Neuropsychological findings in congenital and acquired childhood hydrocephalus. Neuropsychologia. 2001;39(7):721–9.
17. Yuchuan D, et al. Impaired motor learning in children with hydrocephalus. Dev Med Child Neurol. 2001;43(8):502–8.
18. World Medical Association. Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects. JAMA. 2013;310(20):2191–4.
19. Beckung E, Hagberg G. Bimanual Fine Motor Function classification system in children with cerebral palsy. Dev Med Child Neurol. 2002;44(6):391–6.
20. Eliasson AC, et al. Manual Ability Classification System for children with cerebral palsy: development and reliability. Dev Med Child Neurol. 2006;48(7):549–54.
21. Oxford Grice K, et al. Reliability of the Nine-Hole Peg Test for assessment of hand dexterity. Am J Occup Ther. 2003;57(5):570–3.
22. Pomeroy SL, et al. Fine motor skills in children with congenital hydrocephalus. Neurology. 2001;57(9):1671–7.
23. Dennis M, et al. Upper limb motor function in young adults with spina bifida and hydrocephalus. Dev Neuropsychol. 2009;34(7):741–54.
24. Kulkarni AV, et al. Long-term outcomes in children with shunted hydrocephalus: the role of early intervention. Pediatr Neurosurg. 2004;40(1):23–9.
25. O'Brien DF, et al. The impact of shunting on neuropsychological outcomes in pediatric hydrocephalus. Childs Nerv Syst. 2004;20(5):358–64.
26. Case-Smith J, et al. Effectiveness of occupational therapy interventions for children with fine motor delays. Am J Occup Ther. 2013;67(6):626–30.
27. Ashley LW, et al. Long-term intellectual and fine motor outcomes in spina bifida are related to myelomeningocele repair and shunt intervention history. J Neurosurg Pediatr. 2020;26(3):237–46.
28. Kahle KT, et al. Hydrocephalus in children. Lancet. 2016;387(10020):788–99.
29. Heinsbergen I, et al. Outcome in shunted hydrocephalic children: role of timing of shunt implantation. Eur J Pediatr Surg. 2002;12(Suppl 1):S39–41.
30. Garne E, et al. Congenital hydrocephalus and outcome of pregnancy in four European regions. Eur J Pediatr Neurol. 2010;14(3):248–54.
31. Tully HM, Dobyns WB. Infantile hydrocephalus: a review of epidemiology, classification and causes. Eur J Med Genet. 2014;57(8):359–68.