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Impact of Standardized Measurement Versus Conventional Estimation of Keen's Point on Localization Accuracy, Surgical Complications, and Clinical Outcomes in Ventriculoperitoneal Shunt Surgery: A Prospective Comparative Study

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Abstract

Background:

Accurate localization of Keen's point is a critical step in ventriculoperitoneal (VP) shunt surgery, directly influencing ventricular catheter placement and subsequent shunt function. In many low- and middle-income countries, Keen's point is commonly identified using fingerbreadth estimation or surgeon experience rather than standardized cranial measurements. Variability in localization may contribute to catheter malposition, shunt dysfunction, and unfavorable clinical outcomes. This study aimed to compare standardized measurement-based localization of Keen's point with conventional estimation techniques in terms of localization accuracy, surgical complications, and clinical outcomes.

Methods:

This prospective comparative study included 140 patients undergoing VP shunt placement for hydrocephalus. Patients were divided into two groups according to the method used for localization of Keen's point. In the standardized measurement group, Keen's point was identified using predefined anatomical landmarks and measuring tape. In the conventional estimation group, localization was performed using fingerbreadth estimation and surgeon experience. Also demographic characteristics etiology of hydrocephalus, postoperative imaging findings, catheter tip location, complications and clinical outcomes were recorded and analyzed. Neurological status is assessed using the Glasgow Coma Scale (GCS).

Results:

The majority of patients were children, and congenital hydrocephalus was the most common etiology (49.3%). Overall clinical improvement was observed in 75.7% of patients. Satisfactory postoperative imaging was achieved in 74.3% of cases, while hydrocephalus resolved in 67.1%. The standardized measurement group demonstrated superior radiological outcomes, with a higher proportion of satisfactory postoperative CT scans (95.7% vs. 57.1%) and greater hydrocephalus resolution rates (78.6% vs. 55.7%) compared with the conventional estimation group. Postoperative GCS scores were also significantly higher in the standardized measurement group ($p = 0.02$).

Conclusion:

Standardized measurement-based localization of Keen's point was associated with improved catheter placement accuracy, better radiological outcomes, and superior neurological recovery compared with conventional estimation techniques. Adoption of standardized localization methods may represent a simple, reproducible, and cost-effective strategy to improve VP shunt outcomes, particularly in resource-limited settings.

Introduction

Hydrocephalus is common neurosurgical condition. It is characterized by abnormal accumulation of cerebrospinal fluid (CSF), within the ventricular system. It leads to ventricular dilatation. If left untreated progresses with neurological impairment. Ventriculoperitoneal (VP) shunt remains the most widely performed procedure for hydrocephalus management. It is effective method for long-term CSF diversion for various etiologies [1, 2]. Other surgical options for hydrocephalus management include endoscopic third ventriculostomy (ETV), ventriculoatrial shunts (VA), and ventriculopleural shunts (VPL). These alternative options are particularly in patients where VP shunting is unsuitable or has failed [9, 10].

Despite its widespread use, VP shunt surgery is associated with considerable complication rates, with reported shunt failure rates approaching 40–50% in paediatric patients and approximately 30% in adults during long-term follow-up [2, 3]. Among these complications, proximal catheter obstruction is reported as a leading cause of shunt failure, accounting for a substantial proportion of revision cases [3, 4]. Shunt infections remain a significant source of morbidity, with reported infection rates ranging from 5–15% and frequently necessitating revision surgery [2]. Accurate ventricular catheter placement is essential for effective shunt function and reduction of shunt-related complications, as freehand techniques have been associated with relatively high malposition rates ranging from 10% to 40% [4–6].

Traditionally, ventricular access is obtained using anatomical landmarks such as Keen’s point or Kocher’s point. While widely accepted, freehand techniques based on these landmarks may be associated with reduced catheter placement accuracy, particularly in patients with distorted ventricular anatomy. Variations in entry point and trajectory can increase the risk of catheter malposition, parenchymal injury, and subsequent shunt dysfunction [5–7].

Image-guided and neuronavigation-assisted techniques have been developed to enhance the accuracy of ventricular catheter placement. Compared with conventional freehand methods, these approaches have demonstrated improved catheter positioning and lower malposition rates, although their use remains limited in many resource-constrained settings due to cost and availability [6, 8]. Therefore, modifications of conventional freehand techniques, including alterations in burr hole positioning, have gained increasing attention as practical and cost-effective alternatives.

Standardized measurement-based localization of Keen's point offers a simple, inexpensive, and reproducible alternative that may improve the consistency of ventricular catheter placement without requiring specialized equipment. By utilizing predefined anatomical measurements and objective localization methods, variability associated with conventional estimation techniques may be reduced.

The present study was conducted to evaluate the impact of standardized measurement-based localization of Keen's point compared with conventional estimation techniques on localization accuracy, postoperative complications, and clinical outcomes in patients undergoing ventriculoperitoneal shunt surgery.

Methodology

This prospective comparative study was done at the Neurosurgery Department, MTI/Lady Reading Hospital, Peshawar, Pakistan, which spanned across a period of 1 year. The purpose of the study was to find the significance of standardized measurement-based localization of Keen's point in comparison with conventional estimation techniques on surgical precision, complications, and postoperative outcomes following ventriculoperitoneal shunt surgery.

A total of 140 patients fulfilled the inclusion criterion using non-probability consecutive sampling technique. Patients of either gender and any age who underwent Ventriculoperitoneal shunt for Hydrocephalus were included in the study. Patients who had done VP shunting previously, other cranial surgeries distorting anatomical landmarks, and patients with inadequate medical record or lack of follow-up were excluded from the final analysis.

Before surgery, each patient underwent comprehensive assessment including detailed neurologic examination and neuroimaging using computed tomography (CT) of the brain to confirm the diagnosis and find the cause of hydrocephalus if any.

Patients were allocated into two groups according to the localization technique used for identification of Keen's point:

Group A (Standardized Measurement Group): Keen's point was localized using predefined anatomical landmarks and direct measurement with a sterile measuring tape. The burr-hole site was marked according to standardized cranial measurements before skin incision.

Group B (Conventional Estimation Group): Keen's point was identified using conventional methods based on fingerbreadth estimation, visual assessment, and surgeon experience without formal cranial measurement.

All VP shunt procedures were performed under strict aseptic conditions by experienced neurosurgeons following standardized operative protocols. Ventricular catheter insertion was performed according to the assigned localization technique.

A standardized questionnaire was used to collect data. Data collected comprised of patient age, sex, clinical presentation, and Cause of hydrocephalus. Operative variables included side of shunt placement and technical details of catheter insertion.

Postoperatively, radiological confirmation of catheter placement accuracy was done by CT scan. Based om CT scan review, findings were categorized as satisfactory or unsatisfactory depending on location of ventricular catheter and whether the tip of ventricular catheter was located in frontal horn, body, atrium, occipital horn, or brain parenchyma.

Clinical assessment was done based on which patient were divided into improved, static, deteriorated, or death group at follow-up visits. Neurological function was determined both preoperatively and postoperatively by using the Glasgow Coma Scale (GCS). Additional outcomes recorded include

resolution of hydrocephalus on imaging and postoperative complications, including but not limited to catheter obstruction, infection, CSF leakage, catheter malposition, and shunt-related adverse events.

Statistical analysis was carried out using Statistical Package for Social Sciences (SPSS) version 26. Continuous variables, including Glasgow Coma Scale (GCS) scores, were mentioned as mean ± standard deviation, whereas categorical variables such as age, gender, shunt side, etiology of hydrocephalus, postoperative tip location and clinical outcome were presented as frequencies and percentages. Independent sample t-tests was applied to compare mean GCS scores before and after surgery. Chi-square test was utilized to find association between localization technique and categorical outcome variable including hydrocephalus resolution, complication rate, mortality and overall clinical outcome. Statistical significance was established at p-value ≤ 0.05.

Ethical approval

for the study was obtained from the Institutional Review Board of MTI/Lady Reading Hospital, Peshawar before commencement of data collection. Informed written consent was obtained from all patients or their legal guardian where applicable. Confidentiality of all patients was strictly maintained throughout the study, and all procedures were conducted in accordance with ethical principles.

Results

Table 1
Baseline Characteristics of the Study Population

Variable	Category	Frequency	Percent (%)
Age	1 to 10	62	44.3
	11–20	14	10.0
	21–30	6	4.3
	31–40	8	5.7
	41–50	5	3.6
	above 50	6	4.3
	7 to 12 months	29	20.7
	less than 6 months	10	7.1
Gender	Female	64	45.7
	Male	76	54.3
	Brain lesion	45	32.1
	Congenital	69	49.3
	NPH	1	0.7
	Post meningitis	15	10.7
	Post traumatic	8	5.7

A total of 140 patients were operated for Ventriculoperitoneal (VP) shunt placement. The main bulk of the study participants were children aged 1 to 10 years (44.3%) and infants aged 7 to 12 months (20.7%). While the rest of the patients were in the 11–20 years (10%), 21–30 years (4.3%), 31–40 years (5.7%), 41–50 years (3.6%), and above 50 years (4.3%) age groups, with 6.4% under 6 months, respectively. There was a slight predominance of male patients 54.3% in comparison with female patients which accounted for 45.7% of cases. By far the most common cause of hydrocephalus (HCP) was congenital conditions (49.3%), followed by space occupying lesion of brain (32.1%), post-meningitis (10.7%), post-traumatic (5.7%), and normal-pressure hydrocephalus (0.7%) respectively.

Table 2
Distribution of Causes, Outcomes, and Postoperative Variables

Variable	Category	Frequency (n)	Percent (%)
	Brain lesion	45	32.1%
	Congenital	69	49.3%
	NPH	1	0.7%
	Post meningitis	15	10.7%
	Post traumatic	8	5.7%
Side of Shunt	Left	10	7.1%
	Right	130	92.9%
Outcome and Complication	Incomplete drainage	3	2.1%
	Lower end extraperitoneal	1	0.7%
	Lower end obstruction	5	3.6%
	Lower end obstruction, lower end extraperitoneal	1	0.7%
	NIL	95	67.8%
	NIL, upper end in brain parenchyma	1	0.7%
	Upper end CSF leakage	1	0.7%
	Upper end exposed	1	0.7%
	Upper end exposed, upper end or lower end SSI	1	0.7%
	Upper end in brain parenchyma	4	2.9%
	Upper end in brain parenchyma, basal ganglia injury, incomplete drainage	1	0.7%
	Upper end obstruction	10	7.1%
	Upper end obstruction, incomplete drainage	2	1.4%
	Upper end obstruction, upper end exposed, incomplete drainage	1	0.7%
	Upper end obstruction, upper end in brain parenchyma	2	1.4%
	Upper end obstruction, upper end in brain parenchyma, basal ganglia injury	1	0.7%
	Upper end or lower end SSI	3	2.1%

	Upper end or lower end SSI, incomplete drainage	1	0.7%
	Upper end retracted back from ventricle, lower end obstruction, incomplete drainage	1	0.7%
Follow Up Outcome	Death	4	2.9%
	Deteriorated	9	6.4%
	Improved	106	75.7%
	Static	21	15.0%
Post OP Imaging	Not satisfactory	33	23.6%
	Satisfactory	104	74.3%
Post OP HCP	Persistent	46	32.9%
	Resolved	94	67.1%
Post OP Tip Location	Atrium	11	7.9%
	Body	31	22.1%
	Frontal horn	66	47.1%
	Occipital horn	21	15.0%
	Parenchyma	10	7.1%

Results of the above variables highlits the following important points. Almost half of the patients had hydrocephalus due to congenital conditions (49.3%), this was followed by brain lesions causing hydrocephalus in (32.1%). Analysis of the postoperative variables shows that majority of patients had shunt placement on the right side (92.9%), with only a small percentage of patient had shunt placement on the left side (7.1%). Clinical follow-up demonstrated that, most of the patients (75.7%) showed clinical improvement, while 15% of patients had stable conditions postoperatively and only 6.4% experienced significant clinical deterioration. Regarding complications, 66.4% of patients had no postoperative complications, with fewer cases reporting incomplete drainage, upper end CSF leakage, and upper end obstruction. Postoperative imaging outcomes were largely satisfactory in 74.3% of patients, and the majority (67.1%) had resolved hydrocephalus, although 32.9% had persistent issues. The post-operative tip location was most frequently positioned in the frontal horn (47.1%), followed by the body (22.1%) and occipital horn (15%).

Fig: Distribution of Post-Operative Outcomes by measuring vs estimation of keen point

The comparison of post-operative outcomes based on the position of the burr hole (standardized measuring vs. conventional estimation) reveals distinct differences in patient recovery. In the standardized measuring group postoperative CT scan findings were most satisfactory with 95.7% (67 cases) being satisfactory and only 4.3% (3 cases) labelled as not satisfactory based on already

established criterion, whereas in the conventional estimation group, there was a lower satisfactory percentage of 57.1% (40 cases) and a higher percentage of unsatisfactory imaging at 42.9% (30 cases). Similarly, hydrocephalus (HCP) resolution was achieved in 78.6% (55 cases) postoperatively on imaging in the standardized measuring group compared to 55.7% (39 cases) in the conventional estimation group. Conversely persistence of HCP was present in 21.4% (15 cases) of patients in the standardized measuring group versus 44.3% (31 cases) in the conventional estimation group on postoperative imaging.

Table 3
Comparison of Pre- and Post-Operative GCS Scores between standardized measuring group and conventional estimation group

Group	Category	Mean (SD)	Mean Difference	95% CI for Mean Difference	p-value
Pre OP GCS	standardized measuring group	14.33 (2.06)	0.17	-0.39 to 0.73	0.55
	conventional estimation group	14.16 (1.18)			
Post OP GCS	standardized measuring group	14.59 (1.65)	0.70	0.11 to 1.29	0.02
	conventional estimation group	13.88 (1.87)			

The Pre-operative GCS scores of the standardized measuring group and conventional estimation group showed no statistically significant difference between the two groups (mean difference 0.17, 95% CI -0.39 to 0.73, p = 0.55). The mean GCS score of the standardized measuring group on preoperative assessment was 14.33 (SD 2.06), while the conventional estimation group had a mean preoperative GCS of 14.16 (SD 1.18). In contrast, GCS scores on postoperative assessment showed a statistically significant mean difference of (mean difference 0.70, 95% CI 0.11 to 1.29, p = 0.02). The standardized measuring group reporting a mean score of 14.59 (SD 1.65) compared to 13.88 (SD 1.87) in the conventional estimation group on postoperative clinical assessment.

Discussion

This study highlights the significance of (standard measurement vs. conventional estimation) on outcomes following ventriculoperitoneal (VP) shunt placement in patients with hydrocephalus. Our results demonstrate that standard measurement significantly influences postoperative recovery, radiological outcomes, and neurological status.

The study population was predominantly paediatric, with 44.3% of patients in the 1–10-year age group. Congenital hydrocephalus was the most common underlying etiology, about 49.3%. These results consistent with previous reports demonstrating a substantial burden of congenital hydrocephalus among paediatric neurosurgical patients in low- and middle-income countries [11, 12]. The majority of

patients in this study demonstrated favorable postoperative outcomes with 75.7% showing clinical improvement and 67.1% demonstrating radiological resolution of hydrocephalus. Similar outcome trends have been reported in previous studies evaluating VP shunt surgery in uncomplicated hydrocephalus cases [13]. But a significant proportion (21.4%) had persistence of hydrocephalus, highlighting the ongoing challenge of shunt dependency and suboptimal CSF diversion.

One of the key findings of this study was the superior postoperative outcomes observed with the standard measurement. Patients undergoing standard measurement of burr hole point demonstrated higher rates of satisfactory postoperative imaging (95.7% vs. 57.1%) and hydrocephalus resolution (78.6% vs. 55.7%) compared with the conventional estimation group. Additionally, the standard measurement group demonstrated a higher proportion of unsatisfactory outcomes (42.9%), suggesting less optimal catheter positioning or CSF drainage dynamics. These findings can be attributed to improved alignment of the ventricular catheter with the frontal horn when using a higher entry point, which has been shown to enhance accuracy and reduce malposition rates [14]. Optimal ventricular catheter placement within the frontal horn is associated with improved shunt performance and reduced obstruction risk. Previous studies have identified catheter malposition as an important contributor to shunt dysfunction and early failure [15].

Postoperative tip location analysis further supports this observation, with the frontal horn being the most common and preferred location (47.1%). Accurate placement in the frontal horn is associated with improved shunt function and reduced obstruction rates.

Malposition into the parenchyma (7.1%) or other suboptimal locations may contribute to complications such as obstruction, hemorrhage, or inadequate drainage. Long-term studies have identified proximal catheter obstruction and suboptimal positioning as key contributors to shunt revision. The improved hydrocephalus resolution rates in the standardized measurement group likely reflect more effective CSF diversion due to optimal catheter placement.

In contrast, the conventional estimation group may be associated with increased variability in catheter trajectory, particularly in cases of distorted ventricular anatomy. Prior literature has shown that freehand ventricular catheter placement can result in malposition rates ranging from 20% to 40%, contributing to suboptimal outcomes. The higher proportion of unsatisfactory imaging and persistent hydrocephalus observed in the conventional estimation group in our study is consistent with these findings.

Complication rates in this study were relatively low, with 67.8% of patients experiencing no complications. Among those with complications, upper-end obstruction (7.1%) and infection (approximately 2–3%) were the most common. These findings are consistent with previous studies identifying shunt obstruction and infection as the leading causes of shunt failure and revision procedures [2, 16]. The low infection rate in our study may reflect improve perioperative protocols and surgical technique.

Importantly, the comparison of Glasgow Coma Scale (GCS) scores demonstrated no significant difference preoperatively between the two groups, indicating baseline comparability. However, postoperative GCS was significantly better in the standardized measurement group ($p = 0.02$), suggesting a true effect of surgical technique on neurological recovery. This reinforces the importance of optimal catheter trajectory and ventricular access in influencing functional outcomes.

From a clinical standpoint, burr hole positioning is a modifiable factor that can significantly influence VP shunt success. Given that shunt-related complications impose a substantial burden, adopting a technique that improves catheter accuracy without increasing operative complexity is advantageous.

However, this study has limitations. The single-center design and potential lack of randomization, may limit generalizability. Additionally, factors such as surgeon experience and ventricular anatomy were not controlled which may influence outcomes. More prospective studies are needed in the future to validate these findings and establish standardized recommendations.

Conclusion

Standardized measurement-based localization of Keen's point was associated with significantly improved radiological accuracy, higher rates of hydrocephalus resolution, and superior postoperative neurological outcomes compared with conventional estimation techniques. By reducing variability in burr-hole localization and improving ventricular catheter placement, standardized measurement offers a simple, reproducible, and cost-effective method for optimizing VP shunt surgery.

Given its ease of implementation and minimal resource requirements, this technique may be particularly beneficial in developing countries and resource-constrained neurosurgical settings. Catheter placement accuracy, reduce shunt-related complications, and enhance overall patient outcomes can be achieved by using standardized localization protocols. Further multicenter prospective studies are warranted to confirm these findings and support the development of standardized surgical guidelines.

Declarations

Author Contribution

all data collection

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Figures

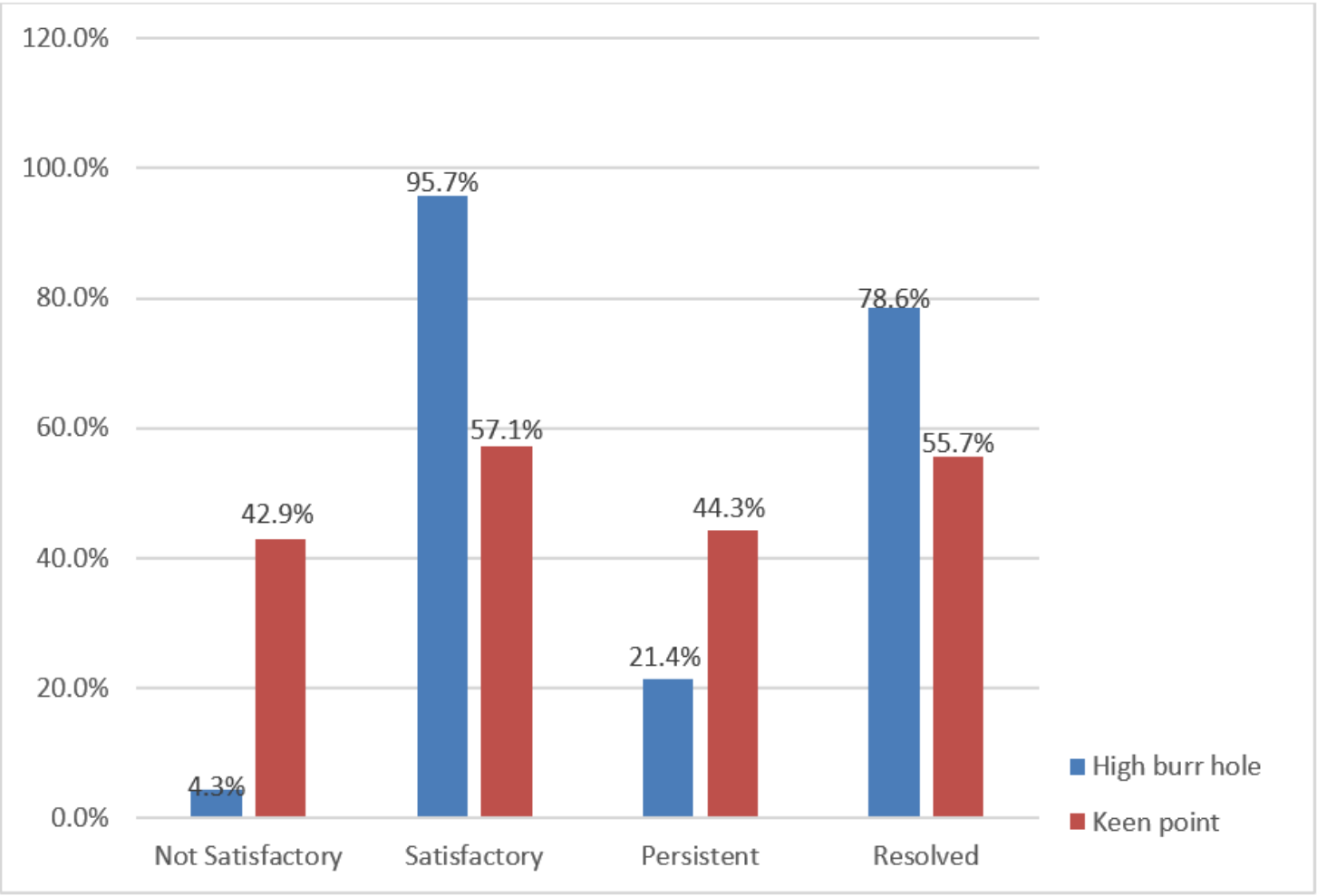


Figure 1

Distribution of Post-Operative Outcomes by measuring vs estimation of keen point