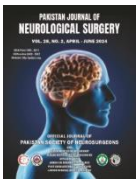

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Original Research

Patients Experiencing Cerebrospinal Fluid Leak After Undergoing Elective Posterior Fossa Surgery

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ABSTRACT

Objective: This descriptive case series anticipated to explore the occurrence and related factors of CSF leaks in patients undergoing elective posterior fossa surgery, highlighting on identifying possible risk factors and exploring treatment modalities.

Materials & Methods: Included 97 patients undergoing elective posterior cranial fossa surgery at Lady Reading Hospital, Peshawar, from July 2021 and January 2022. Thorough patient demographics, surgical indications, and outcomes were precisely documented and investigated.

Results: 70 patients experienced symptoms for one month or fewer, whereas 27 patients underwent symptoms for longer durations, emphasizing a predominant manifestation of short-term symptoms. 43 patients had a BMI of 27 Kg/m^2 or less, even though 54 patients had a BMI exceeding 27 Kg/m^2. With reference to patients with diabetes mellitus, 17 patients were diabetic, with the bulk, comprising 80 patients, being non-diabetic. 20 patients were hypertensive, while 77 patients were non-hypertensive. 46 patients were diagnosed with hydrocephalus, while 51 patients showed symptoms related to loss of consciousness. The study established that 15% of patients experienced CSF leaks postoperatively, with males including a greater proportion of affected individuals.

Conclusion: The results highlight the significance of comprehensive preoperative assessments and surgical techniques to minimize the risk of CSF leakage. Whereas conservative methods such as re-suturing the wound and CSF lumbar drainage were first employed, surgical repair became compulsory in some cases. This exploration offers a valuable understanding of the incidence and management of CSF leaks succeeding posterior fossa surgery, proposing guidance for healthcare professionals in elevating patient outcomes.

Keywords: Cerebrospinal fluid Leakage, Elective posterior fossa surgery, surgical techniques, Dural Repair, Outcome.

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INTRODUCTION

Cerebrospinal fluid (CSF) leakage is a well-recognized complication following cranial surgeries, largely in procedures relating to the posterior fossa. Irrespective of improvements in surgical techniques, CSF leaks remain a stance worth mentioning challenges, leading to probably severe complications such as meningitis and hydrocephalus. Posterior fossa surgery is a difficult and gentle procedure that involves the removal of tumors or other lesions in the posterior fossa of the brain. This kind of surgery risks a possibly dangerous complication known as a CSF leak, which happens when CSF leaks out of the dura mater, the outermost layer of the brain's protective covering.

A craniotomy is a surgical procedure that consists of making an opening in the skull to access the brain. During this process, the dura, the protective layer close to the brain, is opened to access the brain tissue. On the other hand, this opening can lead to CSF leakage, which can cause problems such as meningitis, brain abscess, or intracranial hypotension.

To avoid CSF leakage, it is common practice to re-approximate the dura at the end of the surgery[1]. Closing the edges of the dura or placing graft material between the dural defects can achieve this[2]. Nevertheless, even with these measures, CSF leakage remains a known risk of cranial surgery, particularly when a dural opening is involved.[3]

Studies have revealed that the frequency of CSF leaks differs depending on the kind of procedure. For example, Trans-sphenoidal procedures have a lower occurrence of CSF leaks, with rates as low as 4%. In comparison, posterior fossa procedures have a higher frequency of CSF leaks, with rates as high as 32%.[4]

Recognizing possible risk factors for this complication is vital to reduce the risk of CSF leakage. These may comprise patient factors such as age, sex, comorbidities, surgical factors such as the size and site of the Dural defect, the kind of closure technique used, and the surgeon's capability. Refining the dural closure method may also help lessen the associated morbidity and surgical burden.[5]

Despite developments in surgical techniques and adjuvant procedures for dural closure, postoperative CSF leaks are quite common, with a frequency rate of up to 17% in rear fossa cases.[6] This amount is six times higher in infratentorial procedures than in supratentorial methods.[7] The high occurrence of CSF leakage is due to the posterior fossa's difficult anatomy, making it challenging to attain a watertight closing of the dura mater.

A CSF leak can cause substantial morbidity and may even be fatal due to the potential risk of meningitis, a severe infection of the brain and spinal cord[8]. Patients affected by this complication necessitate rapid and specialized management, which can be expensive and is likely to be greater than 141% than those lacking a CSF leak.[9] Treatment choices include bed rest, hydration, and antibiotics to avoid infection. In severe cases, surgical intervention may be compulsory to repair the dura mater and stop the leak.

Neurosurgery experts are working diligently to reduce the occurrence rate of CSF leakage and discovering new ways to treat patients affected by this complication. Some techniques under investigation include using sealants, patches, and other resources to enhance Dural closure and avoid leakage of CSF. Addressing this matter can increase patient results and reduce the load on healthcare systems. Consequently, treating postoperative CSF leak after a posterior fossa surgery remains a multifaceted and challenging problem that necessitates ongoing research and novelty.

CSF leaks can occur after posterior fossa surgery, and it is essential to understand the available treatment options. Conservative measures are usually the first line of treatment, which may include re-suturing the wound and opting for CSF lumbar drainage if the CSF leakage does not stop. Concurrently with conventional

measures, CSF lumbar drainage can also be considered the first intervention in some cases.[10] However, if these measures fail, surgical repair is done.

It is worth noting that studies on the topic have conflicting results, and an agreement on the ideal treatment method must be recognized.[11] The described occurrence of CSF leaks after posterior fossa surgery is 17%, which highlights the prominence of accepting the available treatment options and taking proper measures to prevent and manage CSF leaks.[12]

Over the past five years, we have directed a wide-ranging investigation inside our local community to comprehend the frequency of CSF leaks after posterior fossa surgery. This study intended to provide appreciated insights into CSF leak prevalence in patients undergoing elective posterior cranial fossa surgery. Our study involved a thorough analysis of medical records, patient results, and consultations with medical professionals and experts in the field. We are assertive that our results offer the latest and most extensive data on the incidence rate of CSF leaks succeeding posterior fossa surgery among our residents. Regardless of limited studies in other areas, our research has permitted us to gain a deeper consideration of this issue and provide valued comprehension for medical professionals and patients.

MATERIALS & METHODS

Study Design & Setting

A Descriptive case series was the Neurosurgery department of the Lady Reading Hospital, Peshawar.

Study Duration

The study was conducted for 6 months from 30/7/2020 to 30/1/2021.

This descriptive case series was intended and conducted at Lady Reading Hospital, Peshawar starting from July 2021 till January 2022.

Sampling

Information was collected from 97 patients through a non-probability sampling method to attain the anticipated research objectives. The sample size was determined employing the World Health Organization (WHO) formula for sample size computation, predicated on 17% CSF leaks post posterior fossa surgery, at a 95% confidence level with a 7.5% margin of error.[12] This study served to enhance healthcare professionals' comprehension of the risks linked to this surgical procedure and enable them to implement appropriate preventive measures for CSF leaks.

Inclusion Criteria

Patients of any gender aged between 10 and 60 years, scheduled for elective surgery in the posterior cranial fossa, irrespective of the underlying medical condition, were qualified for participation. The diagnosis was established through a thorough examination of comprehensive brain images gained via Magnetic Resonance Imaging (MRI). Furthermore, participants were required to have a Glasgow Coma Scale (GCS) score of <12.

Exclusion Criteria

Exclusion criteria incorporated patients having lesions in the third ventricle floor or vicinity of the basilar artery, as these could impede surgical perforation. Additionally, patients detected with a third ventricular size lower than seven millimeters, as determined by computerized tomographic (CT) scans, were also left out to alleviate potential biases and confounding factors.

Ethical Approval

The research and ethics committee of the hospital provided official confirmation, supporting the

dependability and integrity of the study. Qualified patients planned for posterior fossa surgery were enlisted from the outpatient or emergency department and then admitted to the neurosurgery ward for further assessment. After allowing written consent, patients were provided with comprehensive information regarding the study's purposes and probable benefits. This simplified an informed decision-making procedure, making sure that patients were fully aware of the implications and could decide on the most suitable course of action aligned with their needs.

Patient Assessment

All patients undertook thorough physical and neurological assessments, together with routine diagnostic investigations to guarantee data accuracy. Preceding surgery, an experienced anaesthesiologist assessed all enrolled patients. Later surgical procedures were performed under general anesthesia by an experienced neurosurgeon having a minimum of five years of experience. Patients were attentively monitored postoperatively until the seventh day to determine the presence of CSF leaks, as per the predefined operational criteria.

Complete data collection involved various patient demographics such as age, gender, weight, height, body mass index (BMI), presence of diabetes mellitus, hypertension, baseline GCS score, indication for surgery, and duration of symptoms. Adherence to exclusion criteria was carefully maintained to lessen confounding variables and biases.

Data Analysis

Data analysis was methodically conducted using SPSS version 20. Quantitative variables, including age, weight, height, BMI, and symptom duration, were studied by calculating means besides standard deviations (SD) to simplify comprehensive data understanding. For categorical variables, such as gender, surgical indication, presence of diabetes mellitus, hypertension, and incidence of CSF leaks, frequencies and percentages were computed to separate evident patterns and trends. To define the statistical significance of the relationship between CSF leaks and various demographic as well as clinical parameters, p-values were calculated with the post-stratification chi-square test. This test was selected since it is effective for measuring associations between categorical variables in contingency tables.

Categorization of Data

Patients were grouped based on variables such as age (18-31 and 31-60), gender (male and female), duration of symptoms (<1 month and >1 month), BMI (<27 and >27 kg/m2), presence of diabetes mellitus (yes and no), presence of hypertension (yes and no), and indication for surgery (hydrocephalus and loss of conscious). The presence or absence of CSF leaks was recorded for each group.

Chi-Square Test

For each variable, a 2×2 contingency table was made to relate the presence and absence of CSF leaks within each category.

The chi-square test was applied to each contingency table to assess if the observed distribution of CSF leaks varied significantly from the expected distribution. A p-value < 0.05 was considered statistically significant, indicating a non-random association between the variables and the presence of CSF leaks.

The significance of outcomes was determined by comparing the calculated p-values compared to the threshold value (0.05). This procedure allowed for identifying whether any of the demographic or clinical parameters were significantly associated with the occurrence of CSF leaks.

RESULTS

Population Distribution

A total of 97 patients who underwent surgery were evaluated in associations of their demographic features, including age, gender, duration of symptoms, body mass index (BMI), presence of diabetes mellitus, hypertension, and indication for surgery. The age dispersal among these patients displayed variability, with 67 patients (69%) falling within the 18-20 years age bracket, while 30 patients (31%) were aged between 31 to 60 years. The mean age of the patients was 22 years, with a standard deviation (SD) of ±5.71 which is displayed in Table 01.

Findings

The investigation of these patients revealed noteworthy findings. Amongst the total cohort, 61 patients (63%) were male, while 36 patients (37%) were female, signifying a higher predisposition among males. Investigation of symptom duration specified that 70 patients (72%) experienced symptoms for one month or fewer, whereas 27 patients (28%) underwent symptoms for longer durations, emphasizing a predominant manifestation of short-term symptoms.

Associated Factors

Several factors as well as BMI, diabetes mellitus, hypertension status, and indication for surgery were reflected. 43 patients (44%) had a BMI of 27 Kg/m2 or less, even though 54 patients (56%) had a BMI exceeding 27 Kg/m2. With reference to patients with diabetes mellitus, 17 patients (18%) were diabetic, with the bulk, comprising 80 patients (82%), being non-diabetic. A study of hypertension status showed that 20 patients (21%) were hypertensive, while 77 patients (79%) were non-hypertensive. Besides, 46 patients (47%) were diagnosed with hydrocephalus, while 51 patients (53%) showed symptoms related to loss of consciousness as displayed in Table 02.

CSF Leak Analysis

The study methodically scrutinized the existence of CSF leaks among the patients. Outcomes revealed that 15% of the patients established CSF leaks, while the majority, constituting 85%, did not. Likewise, the relationship between CSF leaks and various parameters such as age, gender, symptom duration, BMI, diabetes mellitus, hypertension, and indication for surgery was explored using Table: 03. The study determined that no statistically significant association occurred between these variables and the presence of CSF leaks (p-value>0.05). These outcomes stress the need for further research to explain the underlying determinants of this condition.

Presentation of Results

Table 01 presents the male-to-female ratio within the study sample (n=97). The data reveals that the incidence among males is notably higher, with 61 males representing 63% of the total sample. In contrast, females account for 36 cases, constituting 37% of the sample. These findings underscore a significant disparity in the distribution between sexes, with a higher prevalence observed in the male subgroup. Overall, the sample size totals 97 individuals, illustrating the demographic breakdown and highlighting the male predominance in this particular study cohort. Our study produces a valuable understanding of the relationship between different variables, which means advising future research endeavors and clinical practices. To enhance transparency and concisely summarize the findings, results were presented in Tables 01 and 02.

Table 1: Frequency of CSF Leak (n=97).

CSF Leak	Frequency	Percentage
Yes	15	15%
No	82	85%
Overall	**97**	**100%**

Table 2: Relationship of Various Parameters with the Presence of CSF Leak.

Parameters	No CSF Leak	CSF Leak	P-Value
Duration of Symptoms			
<1 Month	59	11	0.912
>1month	23	04	
BMI			
<27	36	07	0.842
>27	46	08	
Diabetes Mellitus			
Yes	14	03	0.783
No	68	12	
Hypertension			
Yes	17	03	0.948
No	65	12	
Indication of Surgery			
Hydrocephalus	39	07	0.949
Los of Conscious	43	08	

DISCUSSION

When a craniotomy procedure is done, which involves opening the skull to access the brain, it is crucial to reattach the dura, which is the outermost layer of the brain, to avoid a leak of CSF.[1] There are two approaches to do this: suturing the edges of the dura or inserting a graft material to fill the gap. Performing cranial surgery that contains an opening of the dura may intensify the chances of CSF leakage. Severe complications may follow, which could include meningitis, brain abscess, and hydrocephalus. A research study has shown that the possibility of leakage differs from 4% in Trans-sphenoidal procedures, which include gaining access to the pituitary gland through the nose, to 32% in posterior fossa procedures.[4]

Recognizing the risk factors related to this complication is of paramount significance. This includes the size and position of the dural defect, the type of surgery done, and the patient's medical history. By improving our method for Dural closure, we can reduce the accompanying morbidity and surgical burden.[5] This can be comprised of employing specialized instruments, such as dural sealants and patches, to strengthen the closure and lessen the risk of leakage. By doing so, we can ensure the best possible postoperative results and uphold patient safety.

In our research on CSF leakage, we came across a study by Altaf et al,[12] that discovered the same problem. The study was led on 146 patients who undertook various surgical procedures, and it displayed that 25 cases of CSF leakage were noted, equal to 17% of all surgeries performed. Of these cases, 24 were incisional CSF leaks; the remaining existed were CSF otorrhea. Additionally, it revealed that 08 patients primarily received conservative treatment, which involved re-suturing of the wound. On the other hand, only 02 of these patients experienced the cessation of CSF leakage. CSF lumbar drainage was employed for the 06 patients with persistent leakage, which directed to an end of leakage. In the case of the remaining 14 patients, equal re-suturing of the wound and concomitant CSF lumbar drainage were used, resulting in the discontinuation of CSF leakage for all of them. Consequently, the study also established that 02 patients who experienced gross hydrocephalus on postoperative CT received effective treatment with a VP shunt. About the previous studies, our research specifies that re-suturing of the wound with instantaneous CSF lumbar drainage was substantially allied with the termination of CSF leakage ($p=0.003$) and the resolve of meningitis ($p= 0.014$).

This study offers significant information on how to manage CSF leakage. It underlines the requirement of re-stitching the wound even though simultaneously draining the CSF lumbar to stop the leakage. Likewise, the study's outcomes recommend that conservative treatment may not be effective in all cases, and more aggressive measures, such as CSF lumbar drainage, may perhaps be needed to achieve the desired result. In addition, this study emphasizes the prominence of timely diagnosis and treatment of CSF leakage to avoid complications such as meningitis and hydrocephalus. For that reason, the study's outcomes suggest that early intervention is key to avoiding severe complications accompanying CSF

leakage.

The study conducted by Hutter et al,[13] is a comprehensive analysis of 229 out of 241 patients who underwent surgical procedures. The research study outcomes showed that 13.5% of the patients had CSF leakage, mainly caused by self-limiting subgaleal collections. Conversely, merely 3.5% of the patients required invasive treatment, which is evidence of the efficacy of modern surgical techniques. The study has discovered that patients with diabetes mellitus, raised preoperative levels of C-reactive protein (CRP), and individuals who need a dural patch in the course of surgery are further susceptible to suffering from CSF leakage. This highlights the significance of bearing in mind the possible risk factors and making use of proper surgical techniques and materials to reduce the amount and severity of complications.

The control group and the study group were compared, and it was established that the study group had a lesser incidence of infection and CSF leakage. This specifies that using TachoSil, a surgical patch, can considerably decline the possibility of postoperative complications. The study likewise displayed that employing TachoSil, substantially reduced the chances of remaining in the intermediate care unit (IMCU) for one day or more. Moreover, the control group experienced postoperative epidural hematoma and empyema, while the study group did not. This highlights the necessity for modern surgical techniques and materials to lessen the complications.

In conclusion, the study shown by Hutter et al,[13] highlights the significance of employing suitable surgical techniques and materials to lower the incidence and severity of complications. TachoSil, a surgical patch, can considerably cut the risk of postoperative complications, and it is important to think through possible risk factors to ensure the best possible results for patients.

Kehler et al,[14] led a broad study to investigate CSF leak incidence in patients experiencing cranial surgeries. The study explored 545 cranial surgeries and established that 42 patients (7.7%) had CSF leaks at the period of hospital discharge. The study recognized several significant risk factors that upsurge the probability of CSF leaks in patients undergoing cranial surgeries. The research shows that surgery on the posterior fossa leads to the opening of pneumatized spaces. Likewise, patients lower than the age of 66, patients who underwent larger craniotomies or craniectomies, in addition to those with residual dura defects larger than 1 cm existed at a greater risk for CSF leaks. Furthermore, wound closure without using muscle sutures and continuous locked or unlocked sutures were correspondingly noteworthy risk factors for CSF leaks. These factors considerably amplified the probability of CSF leaks in patients.

On the other hand, the study established that certain factors, such as revision craniotomies, craniotomies for diverse pathologies, earlier radiotherapy and systemic chemotherapy, augmentation of dura sutures with several materials, and wound drains as well as short-term CSF drains, were non-significant-risk-aspects-for CSF leaks.[15-17]

CONCLUSION AND RECOMMENDATION

Our team's broad exploration and investigation of published studies have directed us to a definitive conclusion. Our findings tell that a considerable 15% of patients undergoing elective posterior fossa surgery experience CSF leaks, which can lead to severe health concerns if left untreated.

Surgeons can shrink the incidence of complications allied with cranial surgeries by recognizing and managing the risk factors causative of CSF leaks. Our study offers a valuable understanding of these aspects, giving helpful information to medical experts. The outcomes of this study can benefit surgeons to take suitable measures to avoid CSF leaks and increase patient outcomes.

As healthcare experts, we must ensure that patients are given top-quality care and get the

finest possible results. Our research sheds light on a significant matter earlier unnoticed, and our conclusions will help healthcare workers better recognize and be able to manage CSF leaks in patients undergoing elective posterior fossa surgery.

We urge healthcare providers to take note of our research and integrate it into their practice to increase the chances of improved patient outcomes. Initial recognition and correct management of CSF leaks can benefit in avoiding severe complications and augment the quality of care for patients enduring elective surgery in the posterior fossa.

Additional study will be inspired by our research on this crucial subject, which will at the end of the day result in improved patient results and a fall in the manifestation of CSF leaks.

LIMITATIONS

Despite the fact our study provides valuable comprehension into the prevalence and risk factors of CSF leaks among patients experiencing elective posterior fossa surgery, several limitations should be recognized. First of all, the relatively modest sample proportion of 97 patients from a single center possibly will constrain the generalizability of our results to broader patient populations and healthcare settings. In addition, our dependence on retrospective data assortment methods could bring together biases related to the extensiveness and precision of medical records. Besides, the short-term follow-up period restricted to the seventh postoperative day possibly will not capture all instances of CSF leaks, demanding longer-term monitoring for a comprehensive assessment. Additionally, even though we measured various patient demographics and surgical factors, other probable variables inducing CSF leaks were not widely discovered in this study. Addressing these restrictions in prospective research endeavors may give additional explanations due to the complex nature of CSF leaks and advise additional effective prevention and management strategies.

ETHICAL STATEMENT

We endorse that entirely participating patients provide informed consent aforementioned to their taking part in this study. Furthermore, this research has undergone comprehensive review and approval by the ethical team to maintain the utmost criteria of ethical conduct. All poised data will be preserved with maximum confidentiality and partakers maintain the right to withdraw from the study at any time without repercussion.

DISCLOSURE STATEMENT

This study received approval from the Department of Neurosurgery, Lady Reading Hospital, Peshawar, Institutional Review Board confirming adherence to ethical guidelines and participant welfare. Preceding their participation, all partakers provided informed consent, confirming their voluntary participation in the study. The researchers confirm that there are no conflicts of interest that could have inclined the conduct or reporting of this study, preserving its integrity and neutrality. To protect participant privacy, all recognizable data has been anonymized. The results obtained in this study are exclusively resulting from the data collected and evaluated, certifying transparency and accuracy in reporting.

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REFERENCES

1. Jito J, Nitta N, Nozaki K. Delayed cerebrospinal fluid leak after watertight dural closure with a polyethylene glycol hydrogel dural sealant in posterior fossa surgery: case report. Neurol Med Chir (Tokyo) 2014;54(8):634–9. Doi: 10.1055/s-0039-1679509
2. Kim YH, Han JH, Kim CY, Oh CW. Closed-suction drainage and cerebrospinal fluid leakage following microvascular decompression: a retrospective comparison study. J Korean Neurosurg Soc. 2013;54(2):112–7. Doi: 10.1055/s-0039-1679509
3. Mangus BD, Rivas A, Yoo MJ, Alvarez J, Wanna GB, Haynes DS, et al. Management of cerebrospinal fluid leaks after vestibular schwannoma surgery. Otol Neurotol. 2011;32(9):1525–9. Doi: 10.1097/MAO.0b013e31822a1d6e
4. Stoker MA, Forbes JA, Hanif R, Cooper C, Nian H, Konrad PE, Neimat JS. Decreased rate of CSF leakage associated with complete reconstruction of suboccipital cranial defects. J Neurol Surg B Skull Base. 2012;73(4):281–6. Doi: 10.1055/s-0032-1321500
5. Hutter G, von Felten S, Sailer MH, Schulz M, Mariani L. Risk factors for postoperative CSF leakage after elective craniotomy and the efficacy of fleece-bound tissue sealing against dural suturing alone: a randomized controlled trial. J Neurosurg. 2014;121:735–44. Doi: 10.3171/2014.5.JNS132238
6. Schiariti M, Acerbi F, Broggi M, Tringali G, Raggi A, Broggi G, et al. Two alternative dural sealing techniques in posterior fossa surgery: (Polylactide-co-glycolide) self-adhesive resorbable membrane versus polyethylene glycol hydrogel. Surg Neurol Int. 2014;5:171. Doi: 10.4103/2152-7806.144653
7. Walcott BP, Neal JB, Sheth SA, Kahle KT, Eskandar EN, Coumans JV, et al. The incidence of complications in elective cranial neurosurgery associated with dural closure material. J Neurosurg 2014;120:278-84. Doi: 10.3171/2013.10.JNS13221
8. Mehta K, Naples J, Eisen M. Cerebrospinal Fluid Rhinorrhea and a Lytic-Appearing Lesion of the Posterior Cranial Fossa. JAMA Otolaryngol 2018;144(2):173-4. Doi: 10.1001/jamaoto.2017.2440
9. Torres-Bayona S, Velasquez N, Nakassa A, Eguiliz A, Borghei-Razavi H, Wang E et al. Persistent cerebrospinal fluid leak following endoscopic endonasal surgery of the posterior fossa. J Neurol Surg 2019;80(S 01): A093. Doi:10.1055/s-0039-1679509
10. Butt B, Shiekh MM, Anwar H, Chudary MA, Butt RM. Six months analysis of posterior fossa surgery in neurosurgery unit-I, Punjab Institute of Neurosciences (PINS). Pak J Neurolog Surg 2018;22(1):7-16.
11. Wick CC, Killeen DE, Clark M, Kutz JW, Isaacson B. Posterior fossa spontaneous cerebrospinal fluid leaks. Otol Neurotol. 2017;38(1):66-72. Doi: 10.1097/MAO.0000000000001261
12. Altaf I, Vohra AH, Shams S. Management of Cerebrospinal Fluid Leak following Posterior Cranial Fossa Surgery. Pak J Med Sci. 2016 Nov-Dec;32(6):1439–43. Doi: 10.12669/pjms.326.9956
13. Hutter G, Felten SV. Risk factors for postoperative CSF leakage after elective craniotomy and the efficacy of fleece-bound tissue sealing against dural suturing alone: a randomized controlled trial. J Neuro Surgery. 2014;3:501-768. Doi: 10.3171/2014.6.JNS131917
14. Kehler U, Hirdes C, Weber C, Spuck S. CSF leaks after cranial surgery — a prospective multicenter analysis. Innovative Neurosurgery 2013;1(1):49–53. Doi:10.1515/ins-2012-0002
15. Sastry RA, Walek K, Leary OP, et al. Incidence, Characteristics, and Outcomes of Pseudomeningocele and Cerebrospinal Fluid Fistula after Posterior Fossa Surgery. World Neurosurg. 2022;164:e1094-e1102. Doi: 10.1016/j.wneu.2022.05.102
16. Hara T, Akutsu H, Tanaka S, Kino H, Miyamoto H, Ii R, et al. Risk Factors for Postoperative Cerebrospinal Fluid Leak after Graded Multilayer Cranial Base Repair with Suturing via the Endoscopic Endonasal Approach. Neurol Med Chir (Tokyo). 2023 Feb 15;63(2):48-57. Doi: 10.2176/jns-nmc.2022-0132. Epub 2022 Nov 25. PMID: 36436977; PMCID: PMC9995146.
17. Torres-Bayona S, Velasquez N, Nakassa A, et al. Risk Factors and Reconstruction Techniques for Persistent Cerebrospinal Fluid Leak in Patients Undergoing Endoscopic Endonasal Approach to the Posterior Fossa. J Neurol Surg B Skull Base. 2021;83(Suppl 2):e318-e323. Published 2021 May 17. Doi:10.1055/s-0041-1729904

Additional Information

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Human Subjects: Waiver of Consent was obtained from the ethical review board.
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AUTHORS CONTRIBUTION

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1.	Nafees Ahmad Khan	1. Study design and methodology.
2.	Riffat Ullah Khan	2. Paper writing.
3.	Mubbashir Ali Baig	3. Data collection and calculations.
4.	Usama Bin Zubair	4. Analysis of data and interpretation of results.
5.	Noman Shah	5. Literature review and referencing.
6.	Muhammad Osama	6. Editing and quality insurer.