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Extended Extradural Anterior Skull Base Approach for Management of Post-Traumatic Cerebrospinal Fluid Rhinorrhea

HANY EL NEMR, M.D.; AHMED M. DEABES, M.D. and MOHAMED S. OSMAN, M.D.

The Department of Neurosurgery, Faculty of Medicine, Benha University

Abstract

Background: Cerebrospinal fluid rhinorrhea is a serious and potentially fatal condition that still presents a major challenge in terms of its diagnosis and management.

It is estimated that meningitis develops in approximately 10%-25% of patients with this disorder, and 10% of them die as result. Approximately 80% of all cases of CSF rhinorrhea are caused by head injuries that are associated with cranial fractures.

Aim of Study: To evaluate the technique and perioperative management for cerebrospinal fluid (CSF) leak following anterior skull base fracture via extradural anterior skull base approach.

Patients and Methods: This study was executed at the Department of Neurosurgery of Benha University hospitals, Egypt from June 2024 to December 2024. This study included patients with post-traumatic CSF rhinorrhea following significant anterior skull base fractures treated surgically using an extended extradural anterior skull base approach. Analysis was done on the information from radiological and medical records, surgical methods, repair methods, perioperative care, surgical results, and postoperative monitoring. Patients were monitored for postoperative complications and the result of CSF leaks. Frequencies and percentages were used to display the data.

Results: Twenty-five patients were comprised in this study. The mean age of the patients was 41.5 years (range 30-53 years). The remaining 18 patients with chronic or recurring CSF rhinorrhea underwent repair surgery 2 to 3 weeks following the initial trauma, whereas seven patients underwent surgery within two weeks. The mean duration of the follow-up was six months. All of the patients experienced numerous fractures in the anterior skull base. The primary objective of the surgical procedure was to establish a watertight barrier around the dura. In 14 patients, the frontal peri-cranial flap was employed alone, whereas in 8 patients, it was joined with the temporalis muscle and/or its fascia. Free fascia Lata graft was used instead in the rest 3 patients. The patients were all discharged without any evidence of a CSF leak. Mortality was absent from this series. The most prevalent complication was bilateral anosmia. At the follow-up, 3 patients experienced recurrent CSF leaks, while 2 cases experienced postoperative infections.

Conclusion: Anterior prolonged intracranial extradural approach is frequently necessary for the aggressive treatment of traumatic CSF rhinorrhea with substantial anterior skull base fractures. Vascularized tissue flaps are effective grafts for the rebuilding of the anterior cranial base, either independently or in conjunction with the temporalis muscle and accompanying fascia. Additionally, sometimes the fascia Lata can be used as a free autologous graft. The method is often reserved for individuals who have sustained anterior skull base injuries and experience post-traumatic cerebrospinal fluid rhinorrhea.

Key Words: *Rhinorrhea – Anterior skull base – Post-traumatic – CSF leak – Extradural.*

Correspondence to: Dr. Hany El Nemr, The Department of Neurosurgery, Faculty of Medicine, Benha University

Introduction

CEREBROSPINAL fluid rhinorrhea is a significant and potentially lethal illness that continues to pose a significant barrier in terms of diagnosis and management **[1,2].**

Meningitis is suspected to manifest in around 10% to 25% of people with this ailment, and 10% of them succumb to the condition. Approximately 80% of all occurrences of CSF rhinorrhea are the result of head injuries that are linked to cranial fractures **[3,4].**

The estimated incidence of basilar skull fracture with no penetrating head trauma ranges from 7% to 15.8% of all skull fractures, with concomitant CSF leakage occurring in 10% and 30% of these patients **[5,6].**

Dura tears and resultant cerebrospinal fluid (CSF) leaks are frequent due to the dura's strong

attachment to the skull base. The leak can occur in any location where the dura mater is lacerated during injury and there is contact between the cerebral and nasal cavities [7,8].

It remains challenging to objectively analyse the research in relation to the best therapy of CSF leaking following craniomaxillofacial trauma, despite numerous advancements [9,10].

Furthermore, the success of nonsurgical treatment modalities, including bed rest and CSF diversion, has not been consistently analysed by any authors. Furthermore, the incidence and natural history of this disease entity, the necessity for antibiotics, and the surgical indications for and timing of intervention remain poorly understood [11].

Additionally, the complications and disparities associated with the leakage of CSF as a result of severe injury are multifaceted. We have undertaken a comprehensive analysis of the available literature and are now reviewing the diagnosis and management of CSF rhinorrhea in the context of traumatic anterior skull base injuries. Our objective is to identify areas in which additional study is required [12,13].

Objective:

The objective of this investigation is to assess the technique and perioperative therapy for CSF leak following an anterior skull base fracture using an extradural anterior skull base approach.

Patients and Methods

This study was executed at the Department of Neurosurgery of Benha University hospitals, Egypt from June 2024 to December 2024. The study focused on individuals presenting with post-traumatic cerebrospinal fluid (CSF) rhinorrhea secondary to significant anterior skull base fractures, managed surgically through an extended extradural anterior skull base approach. Comprehensive analysis included medical and radiological records, surgical procedures, repair strategies, perioperative care, outcomes, and follow-up data. Patients were closely monitored for postoperative complications and the resolution of CSF leakage. Data were summarized and reported in terms of frequencies and percentages.

Inclusion criteria:

1- Patients with extensive anterior skull base fracture.

2- Patients with CSF rhinorrhea.

Exclusion criteria:

• Patients with spontaneous CSF rhinorrhea.

Pre-operative assessment:

Complete neurological and general examinations were administered to all patients. Glasgow Coma Scale (GCS), age, blood pressure, blood glucose level, sex (male to female ratio), and present symptoms were all assessed.

Presenting symptoms like headache, bleeding per nose or disturbed conscious level were assessed.

Also occurrence of meningitis was assessed in early days after trauma and also in the following 4 weeks after trauma.

A straightforward test was conducted to ascertain the presence of CSF by visualizing a ring or halo indication on a piece of gauze in the case of a nasal leak.

The clinical and radiological records of the patients included in the review were examined, including their clinical status and admission results, initial imaging data, fracture features and associated cerebral abnormalities, surgical procedures, and treatment outcomes.

Neuro-radiological assessment:

Upon admission, all patients included in the study underwent a thin slice (1mm) CT scan with good resolution. The skull base fracture deficiencies were identified during post-processing with coronal and sagittal reconstructions.

Patients who were able to tolerate the operation underwent magnetic resonance imaging (MRI). In addition to the augmentation of the magnetic resonance imaging to eliminate the likelihood of a brain abscess, the fistula was localized using a fast spin-echo sequence with fat saturation and strongly T2-weighted images. The “reservoir sign,” which was the capacity of a patient to leak CSF by flexing the head, was incorporated to enhance the possibility of discovering an undetected fistula.

Indications for extradural anterior skull base approach:

CSF rhinorrhea that is the result of complex frontobasal injuries or recalcitrant rhinorrhea is often treated using an extradural anterior skull base approach. Key factors influencing the decision to employ an extradural approach include the presence of extensive comminuted fractures or multiple defects in the anterior skull base, difficulty in pinpointing the exact location of a fistula, evidence of multiple fistulae, associated cerebrocranial injuries, and failure of previous surgical attempts to resolve the condition.

Surgical approach:

The anterior skull base approach was employed for all patients, utilizing a bifrontal coronal incision that extended from one zygomatic level to the other.

This approach enables the collection of an ample pericranial tissue supply. Following the extended bifrontal coronal incision and subgaleal dissection, a pericranial flap was fashioned, allowing for the creation of a standard pedicled pericranial flap. In cases where the pericranium was compromised due to previous surgeries or trauma, making the flap unavailable or insufficient, a vascular-pedicled flap typically sourced from the temporalis muscle with or without its associated fascia was predominantly used for reconstruction. If pedicled graft options were insufficient, an autologous fascia lata graft was obtained from the lateral thigh.

Subsequent to tissue flap preparation, a bifrontal craniotomy was performed. The bone window was positioned as close as possible to the orbital rim to optimize working angles. Using an operative microscope, the dura of the anterior cranial base was carefully detached from the underlying bone. The entire anterior cranial base was then thoroughly examined through a bilateral extradural subfrontal approach to identify and address any dura tears. Repairs were executed directly via suturing when feasible or indirectly by applying pericranium or alternative graft material secured with fibrin glue.

The repaired subfrontal dura is enveloped by a pedicled flap of pericranial tissue, which is initially expanded to encompass the entire anterior cranial base and then folded over. Subsequently, fibrin glue was utilised to affix the graft securely. The dura and anterior skull base were rebuilt extradurally. To facilitate retraction and alleviate brain tissue, or to assess the impermeability of the sutured dura, we generally perforate the dura when there is an associated intradural injury necessitating the evacuation or release of cerebrospinal fluid (CSF).

Postoperative management:

The patients were admitted to the intensive care unit for monitoring following the operation. The patients were maintained in a supine position for approximately seven days. Strenuous activity, straining, or nose blowing were prohibited for approximately 6 weeks after the surgery to prevent the graft from being disrupted. We opted to administer postoperative prophylactic intravenous antibiotics due to the fact that dissection happens through a polluted operative field. The length of postoperative antibiotic therapy was extended for individuals with preoperative definite meningitis. The usual use of a lumbar CSF draining catheter postoperatively was not seen. For patients with a confirmed cerebral infection or those who were unable to obtain a watertight dura seal intraoperatively, CSF drainage was implemented. The presence of postoperative meningitis was monitored with the frequent sampling of CSF for laboratory testing, either through serial lumbar puncture or lumbar draining.

Follow-up:

The outpatient clinic was utilized to conduct follow-up with the patients or their families. The follow-up data comprised nasal discharge, meningitis manifestation, wound or incision healing, and anosmia. The follow-up period lasted for 6 months.

Illustrative case:

A 53-years-old man had head trauma after falling from a height in home.

His forehead collided with the earth. The frontal skull bone was exposed and depressed, and many lacerations were found on the forehead. Continuous rhinorrhea of CSF was noticed. Urgent CT brain was done showing fracture of the frontal sinus and anterior base of the skull with pneumocephaly. Fig. (1).

The body did not exhibit any other injuries. The patient's pupils were receptive and regular, and they were alert. An urgent operation was scheduled to alleviate the infection from the open incision and the depressed fractures. He was transported to the operating room and administered general anesthesia. The frontal bone was revealed through a prolonged incision of the forehead lacerations following saline irrigation and aseptic scalp cleaning. The dura was exposed during a frontal craniotomy that was conducted at the fracture's edge. A dural defect was identified in the bone of the right frontal base.

The dural defect was primarily repaired using the graft of the frontal pericranium. Fig. (2).

Stitching-up was employed to reposition the bone fragments that were removed from the anterior cranial fossa. The comminuted frontal bones and craniotomy were successfully repaired. The beauty aspect was taken into account when the scalp was meticulously closed. There was no evidence of infection or CSF leakage subsequent to the procedure.

Post-operative CT brain was done to assess for postoperative bleeding and the pneumocephaly. Fig. (3).

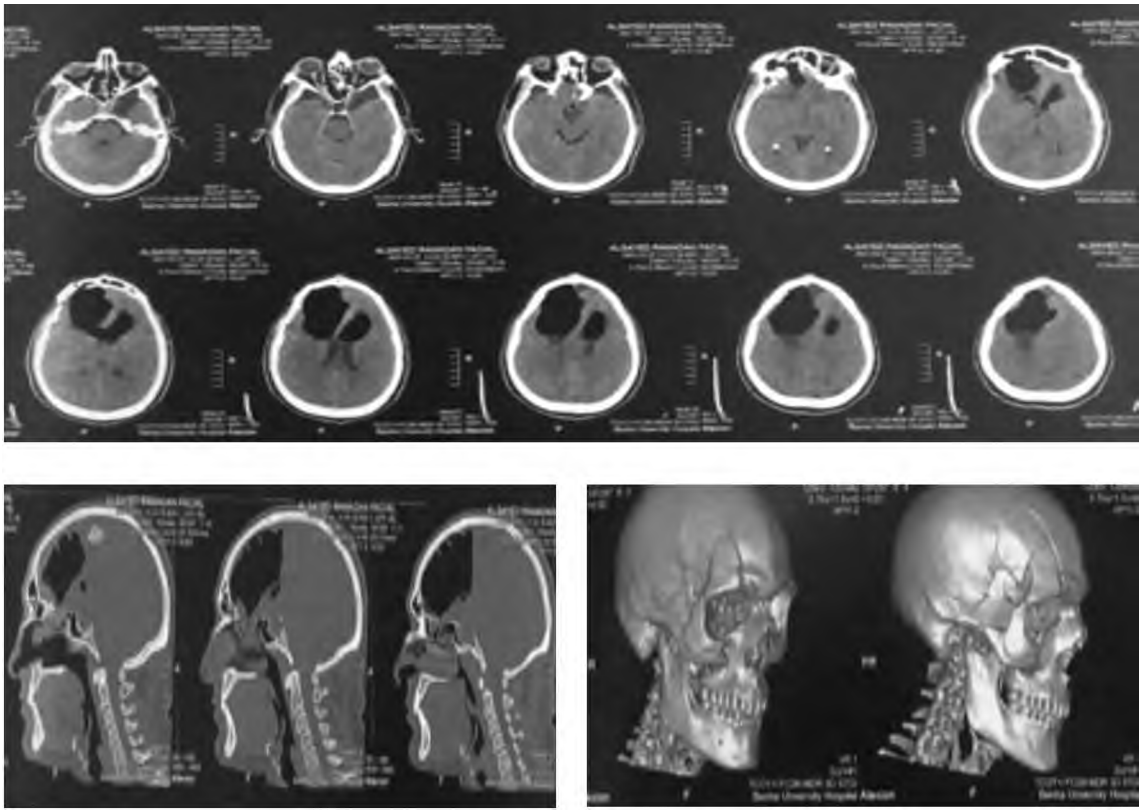

Fig. (1): Preoperative CT brain soft window axial view, bone window sagittal view and 3D reconstruction. (Benha University Hospital, Neurosurgery Department).

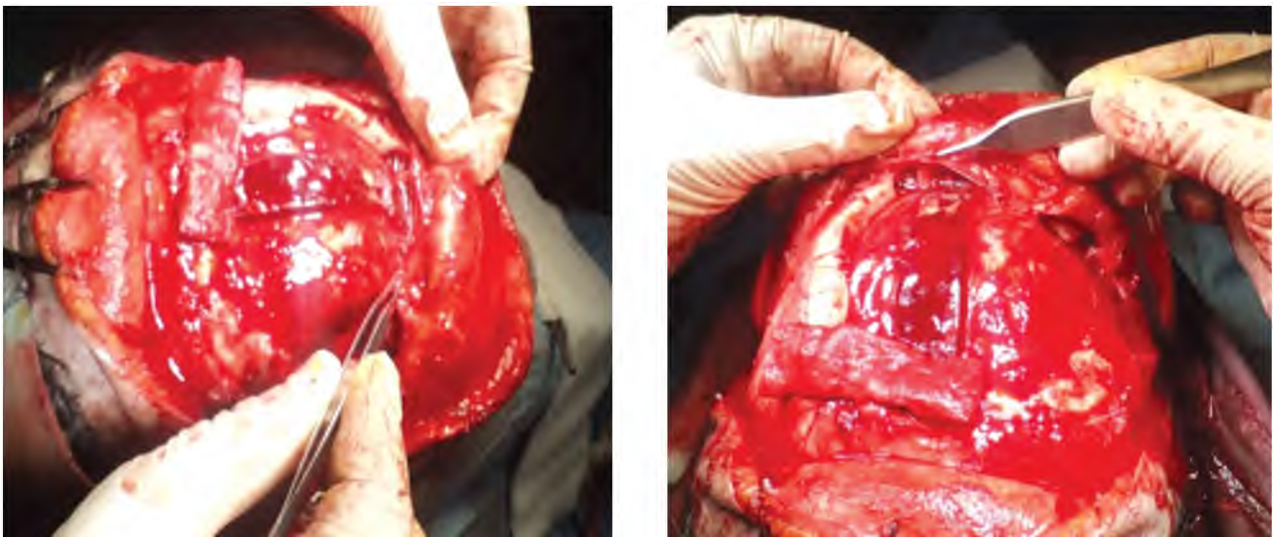

Fig. (2): Intraoperative images for repairing of the skull base dura by pericranium. (Benha University Hospital, Neurosurgery Department).

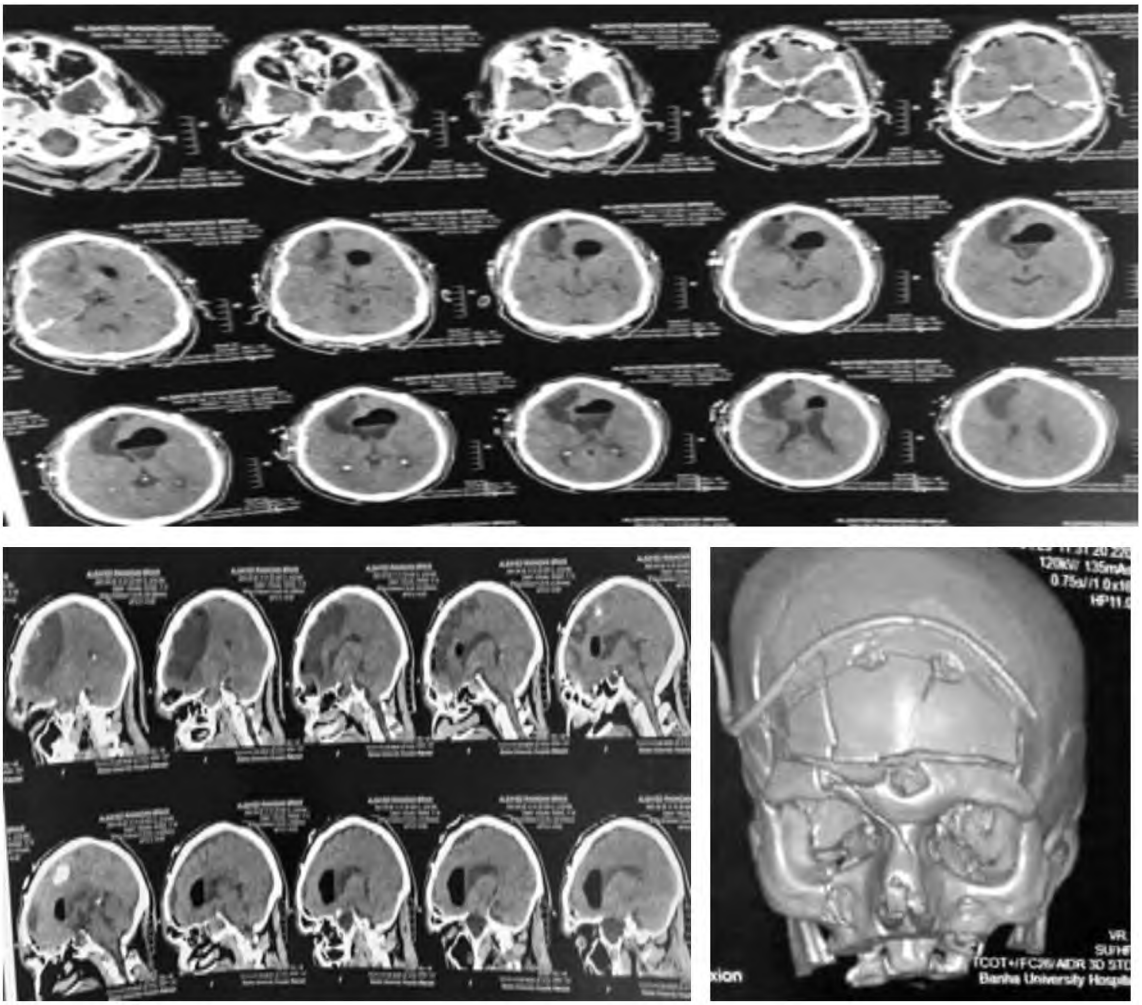

Fig. (3): Postoperative CT brain soft window axial view, soft window sagittal view and 3D reconstruction. (Benha University Hospital, Neurosurgery Department).

Results

Our research was executed prospectively in Benha University Hospitals on 25 cases suffering from post-traumatic CSF rhinorrhea occurred after extensive anterior skull base fracture whom were operated in Neurosurgery Department.

Age:

The age of the patients ranged between (30 and 53 years) with a mean of 41.5 years.

Sex:

In our study there was male predominance as there were 18 males and 7 females. Table (1).

No statistically significant difference was detected between the sex of patients and the outcome.

Table (1): Sex of patients.

Sex	Number of patients
Male	18 (72%)
Female	7 (28%)

Mode of trauma:

According to the mode of trauma we had 14 patients presented after road traffic accident, 6 patients after falling from a height and 5 patients after motorcycle accident. Table (2).

Table (2): Mode of trauma and number of patients.

Mode of trauma	Number of patients
Road traffic accident	14 (56%)
Falling from a height	6 (24%)
Motorcycle accident	5 (20%)

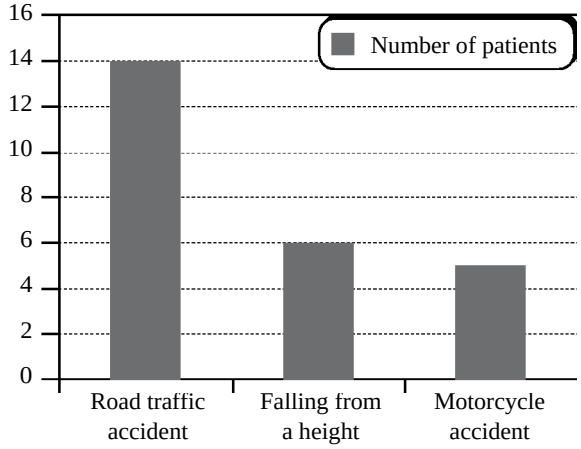

Diagram (1): Mode of trauma and number of patients.

Presenting symptoms:

At the time of presentation in the emergency room we had 12 patients complaining of headache only after trauma, also 7 patients complained of bleeding per nose and the remaining 6 patients had disturbed conscious level.

Table (3): Presenting symptoms.

Presenting symptoms	Number of patients
Headache	12 (48%)
Bleeding per nose	7 (28%)
Disturbed conscious level	6 (24%)

In our study we had 6 cases with history of meningitis for one attack and 8 cases with recurrent attacks while the remaining 11 case had no history of meningitis.

Onset of CSF rhinorrhea after trauma:

In our study all patients included had CSF rhinorrhea but the onset of rhinorrhea was different; 6 patients had CSF leak in the 1st day after trauma, 9 patients had CSF leak at the 3rd day and 10 cases had CSF leak at the 7th day.

Table (4): Onset of CSF rhinorrhea after trauma.

Onset of CSF rhinorrhea	Number of patients
1st day	6 (24%)
3rd day	9 (36%)
7th day	10 (40%)

Preoperative CT brain findings:

In the preoperative CT brain we had 18 cases with frontal sinus fracture and 20 cases with intracranial pathology like brain contusions or intracranial hemorrhage.

Table (5): Pre-operative CT brain findings.

Preoperative CT brain	Number of patients
Frontal sinus fracture	18 (72%)
Intracranial pathology	20 (80%)

In our study all cases with frontal sinus fracture had intracranial pathology like brain contusion, subdural hemorrhage or epidural hematoma.

Time of operation after trauma:

In our study we followed-up for conservative treatment at first by medical treatment and good positioning for the patients for at least one week.

We had 7 patients operated in the 2nd week after trauma, 11 cases operated after 2 weeks and 7 cases after 3 weeks from the time of trauma.

Table (6): Time of operation after trauma.

Time of operation after trauma	Number of patients
In the 2nd week after trauma	7 (28%)
After 2 weeks	11 (44%)
After 3 weeks	7 (28%)

Graft used in surgery:

In all cases we used an allograft to repair the site of leak in the anterior cranial fossa.

We used pericranium in 14 cases, Temporalis fascia in 4 cases, Temporalis muscle in 4 cases and Fascia Lata in 3 cases.

Table (7): Graft used in surgery.

Graft used in surgery	Number of patients
Pericranium	14 (56%)
Temporalis fascia	4 (16%)
Temporalis muscle	4 (16%)
Fascia Lata	3 (12%)

Postoperative complications:

In the follow-up after surgery we had some postoperative complications.

The most common complication was anosmia that occurred in 16 patients that improved in follow-up in only 9 cases.

Postoperative CSF leak happened in 3 cases that managed by insertion of lumbar drain in one case and redoing the surgery in 2 cases.

Postoperative wound infection occurred in 2 cases and treated by medical treatment by antibiotics.

Table (8): Postoperative complications.

Postoperative complications	Number of patients
Anosmia	16 (64%)
CSF leak	3 (12%)
Wound infection	2 (8%)

Discussion

In our study the age of the patients ranged between (30 and 53 years) with a mean of 41.5 years. Also there was male predominance as there were 18 males and 7 females. No statistically significant difference was detected between the sex of patients and the outcome.

According to the mode of trauma we had 14 patients presented after road traffic accident (56%), 6 patients after falling from a height (24%) and 5 patients after motorcycle accident (20%).

In our study we had 12 patients complaining of headache only after trauma (48%), also 7 patients complained of bleeding per nose (28%) and the remaining 6 patients had disturbed conscious level (24%).

The initial assessment of a patient who presents with CSF rhinorrhea commences with a thorough physical examination and medical history. After a head trauma, the most prevalent presenting symptom is a clear, watery discharge from the nose. In the supine posture, there is a possibility of an increase in postnasal drip. There is a high risk of developing meningitis.

In our study we had 6 cases with history of meningitis for one attack (24%) and 8 cases with recurrent attacks (32%) while the remaining 11 case had no history of meningitis (44%).

Schick et al., revealed that 61.9% of patients had meningitis, with 7 (33.3%) experiencing a single episode and 6 (28.6%) experiencing recurrent episodes which is consistent with our findings ***[14]***.

The physical examination is typically normal, with the exception of CSF rhinorrhea, which is a result of an increase in intracranial tension and occurs during forward bending or straining. The visualization of a ring or halo indication is a straightforward diagnostic for detecting the presence of CSF. This examination lacks specificity.

Dula et al., discovered that the ring sign manifested when blood was combined with water, saline, and other mucus ***[15]***.

In our study all patients included had CSF rhinorrhea but the onset of rhinorrhea was different; 6 patients had CSF leak in the 1^{st} day after trauma (24%), 9 patients had CSF leak at the 3^{rd} day (36%) and 10 cases had CSF leak at the 7^{th} day (40%).

Brijesh Kumar et al., an early onset rhinorrhea was observed in three cases (7.3%), early start rhinorrhea that improved with conservative care but recurred and continued in 12 cases (29.3%), and delayed onset rhinorrhea in 26 cases (63.9%) ***[16]***.

In order to identify bone defects, high-resolution CT scans should be conducted in all instances with CSF rhinorrhea. It is also capable of identifying hydrocephalus, soft tissue masses, and pneumocephalus.

In the preoperative CT brain we had 18 cases with frontal sinus fracture (72%) and 20 cases with intracranial pathology like brain contusions or intracranial hemorrhage (80%). In our study all cases with frontal sinus fracture had intracranial pathology like brain contusion, subdural hemorrhage or epidural hematoma.

MR exam was administered to those who were able to tolerate the procedure. In addition to the augmentation of the magnetic resonance image to exclude the potential of a cerebral abscess, a fast spin-echo sequence with fat saturation and strongly T2-weighted images were employed to identify the fistula and the presence of a meningoencephalocele.

Wakhloo et al., were able to identify one meningoencephalocele and three traumatic CSF fistulas in six CSF rhinorrhea patients who underwent MRI with T2 weighting. When it comes to identifying bone deformities, MRI is not as effective as CT and is significantly more costly. Surgical repair requires the precise location of the leak; otherwise, patients would remain at danger of meningitis, which can be fatal ***[17]***.

There are two approaches to treating CSF rhinorrhea: Conservative care and surgical management. Conservative control works effectively for most posttraumatic CSF leaks. The risk of meningitis is approximately ten times higher if a CSF leak persists.

Complete bed rest is part of conservative management. For seven to ten days, the patient is kept in bed with the head of the bed raised 15 to 30 degrees and is not allowed to cough, strain, or lift anything heavy.

According to reports, 90 to 95% of all traumatic CSF leaks recover on their own when treated in

this way. In our study we follow-up for conservative treatment at first by medical treatment and good positioning for the patients for at least one week.

We had 7 patients operated in the 2nd week after trauma (28%), 11 cases operated after 2 weeks (44%) and 7 cases after 3 weeks from the time of trauma (28%).

In our study we used the intracranial approach for direct visualization of a leak from above and allowing treatment of coexisting intracranial pathology.

In all cases we used an allograft to repair the site of leak in the anterior cranial fossa. We used pericranium in 14 cases (56%), Temporalis fascia in 4 cases (16%), Temporalis muscle in 4 cases (16%) and Fascia Lata in 3 cases (12%).

In the follow-up after surgery we had some postoperative complications. The most common complication was anosmia that occurred in 16 patients (64%) that improved in follow-up in only 9 cases.

Postoperative CSF leak happened in 3 cases (12%) that managed by insertion of lumbar drain in one case and redoing the surgery in 2 cases.

Brijesh Kumar et al., Postoperative CSF leak happened in 10 cases (24.4%) that managed by insertion of lumbar drain in 2 cases and redoing the surgery in 8 cases **[16].**

Postoperative wound infection occurred in 2 cases (8%) and treated by medical treatment by antibiotics.

Conclusion:

Particular attention is needed for posttraumatic CSF rhinorrhea. Conservative therapy is used initially, but if the leak continues after 7 to 10 days, surgery is necessary to fix it and prevent complications like meningitis. Preoperative imaging such as CT or MR can be used to locate the leak site, which is crucial for a successful surgical repair.

An prolonged intracranial extradural approach is frequently required for aggressive treatment of traumatic CSF rhinorrhea with substantial anterior skull base fractures. For anterior cranial base repair, vascularized tissue flaps work well as grafts, either by themselves or in conjunction with the temporalis muscle and accompanying fascia. Fascia Lata can also occasionally be used as a free autologous graft. The method is often saved for individuals who have anterior skull base injuries and post-traumatic CSF rhinorrhea.

Ethics approval and consent to participate:

This study was approved by the Ethical Committee of Scientific Research, Faculty of Medicine, Benha University under the number (RC14-5-2024).

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Conflicts of interest: There are no conflicts of interest.

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النهج الموسع لقاعدة الجمجمة الأمامية خارج الام الجافية لإدارة سيلان السائل النخاعى بعد الصدمة

الخلفيــة: يعد سيلان السائل النخاعى من الأنف حالة خطيرة وربما مميتة ولا تزال تمثل تحديًا كبيرًا من حيث تشخيصها وإدارتها . يتراوح معدل حدوث كسور الجمجمة القاعدية نتيجة عدم وجود صدمات نافذة فى الرأس بين ٧٪ و١٥,٨٪ من جميع كسور الجمجمة، ويحدث تسرب السائل النخاعى الشوكى المصاحب فى ١٠٪–٣٠٪ من هؤلاء المرضى. بسبب التصاق الأم الجافية بقوة بقاعدة الجمجمة، تكون تمزقات الجافية وتسرب السائل النخاعى اللاحق أمرًا شائعًا.

الهــدف: لتقييم التقنية والإدارة المحيطة بالجراحة لتسريب السائل النخاعى (CSF) بعد كسر قاعدة الجمجمة الأمامية عبر نهج قاعدة الجمجمة الأمامية خارج الأم الجافية.

المرضــى والطــرق: تم إجراء هذه الدراسة فى قسم جراحة المخ والأعصاب بمستشفيات جامعة بنها، مصر في الفترة من يونيو ٢٠٢٤ إلى ديسمبر ٢٠٢٤. وتم تضمين المرضى الذين يعانون من سيلان السائل النخاعى من الأنف بعد الصدمة بعد حدوث كسور واسعة النطاق فى قاعدة الجمجمة الأمامية جراحيًا عبر نهج ممتد لقاعدة الجمجمة الأمامية خارج الجافية.

النتائــج: كان إصابات الراس اكثر شيوعا في الرجال بنسبه (٧٢٪)، وكان إصابات حوادث الطرق الأكثر شيوعاً بنسبه (٥٦٪)، وكان عرض الصداع أكثر الاعراض تواجدا بالمرضى، وتم تجربه العلاج التحفظى مع المرضى وتم الاجراء الجراحى للمرضى خلال ٣ اسابيع فى اكثر الحالات.

الاســتنتاج: غالبًا ما يحتاج سيلان الأنف من السائل الدماغى الشوكى مع كسور واسعة النطاق فى قاعدة الجمجمة الأمامية إلى علاج قوى من خلال النهج خارج الجافية الممتد داخل الجمجمة. تعتبر اللوحات النسيجية الوعائية بمثابة ترقيع جيد لإعادة بناء قاعدة الجمجمة الأمامية.

يقتصر هذا النهج عادةً على المرضى الذين يعانون من سيلان الأنف فى السائل الدماغى الشوكى بعد الصدمة فى إصابات قاعدة الجمجمة الأمامية.