Skull Base Reconstruction Following Endoscopic Transsellar Approach, Utilization of Three-Layer Grafting Technique

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ABSTRACT

***Background*:** Endoscopic transsellar approaches effectively access skull base lesions but risk cerebrospinal fluid leaks. Three-layer grafting techniques reliably reinforce dural closure, reducing complications and supporting optimal healing.

Aim: Assessment of the efficacy and safety of the modified protocol for skull base reconstruction which is done by utilizing a three-layer grafting technique (Facia-Fat-Facia) for the patients who developed intraoperative CSF leak necessitating an immediate repair regardless the degree of the leak at time of repair.

Methods: A prospective study had been conducted at Skull Base Center and Neurosurgical Department of Ghazi Al-Hariri Martyr Hospital for Surgical Specialties, Medical City Complex of Baghdad through a period of 18 months, between January 2022 and June 2023, during which 43 patients with different pathologies underwent pure endoscopic endonasal sellar approach. Intra-operative CSF leaks were classified into four grades according to Esposito et al. Sellar reconstruction was performed by utilizing a three-layer grafting technique (Facia-Fat-Facia) for all patients regardless the degree of the leak at time of repair. Authors did not use any vascularized flaps or tissue glues and did not include any procedures of CSF diversions such as lumbar drainage.

Results: Among the 43 (29 adenomatous pathology and 14 non-adenomatous), CSF leak was 34.88% Grade I, 41.86 Grade II and 23.26 Grade III. A minimum of 18 months follow-up showed development of two postoperative CSF leaks (4.65%), one pneumocephalus (2.32%) and one bacterial meningitis (2.32%) cases.

Conclusion: Utilizing autologous facia lata and fat grafting in this modified three layered fashion is effective, reliable and safe procedure for reconstructing skull base defects regardless the CSF leak grading and severity, taking in consideration its tissue compatibility, availability and the ease of harvesting with negligible donor site morbidity, flexibility in size of the graft needed, it's a good substitute for vascularized regional flaps in cases of unavailability of difficult to be harvested and lastly, it's adding no cost on the patient when compared to other synthetic and artificial grafting substitutes avoiding the use of highly costed tissue glues and other synthetic sealant agents in most of cases.

Keywords: CSF Leak, Transsellar, Skull Base Reconstructions, Pituitary Adenoma.

إعادة بناء قاعدة الجمجمة باستخدام تقنية التنظير الداخلي عبر السرج، باستخدام تقنية التطعيم ثلاثي الطبقات

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الخلاصة

الخلفية: تُعد الطرق التنظيرية عبر الجيب الوتدي (الترانسسيلارية) فعالة في الوصول إلى آفات قاعدة الجمجمة، لكنها تحمل خطر حدوث تسرب السائل الدماغي الشوكي (CSF). تُعد تقنيات الترقيع ثلاثي الطبقات وسيلة موثوقة لتعزيز إغلاق الأم الجافية، مما يقلل من المضاعفات ويدعم الشفاء الأمثل.

الهدف: تقييم فعالية وأمان بروتوكول معدل لإعادة بناء قاعدة الجمجمة باستخدام تقنية الترقيع ثلاثي الطبقات (لفافة – شحم – لفافة) لدى المرضى الذين حدث لديهم تسرب للسائل الدماغي الشوكي أثناء العملية، والذين استدعى ذلك إصلاحاً فورياً بغض النظر عن شدة التسرب وقت الإصلاح.

المنهجية: أُجريت دراسة مستقبلية في مركز قاعدة الجمجمة وقسم جراحة الأعصاب في مستشفى غازي الحريري للجراحات التخصصية، ضمن مجمع مدينة الطب في بغداد، خلال فترة امتدت لـ ١٨ شهراً من يناير ٢٠٢٢ إلى يونيو ٢٠٢٣، حيث خضع ٤٣ مريضاً يعانون من أمراض متنوعة لنهج تنظيري صِرف عبر الأنف نحو الجيب الوتدي. تم تصنيف تسرب السائل الدماغي الشوكي أثناء العملية إلى أربع درجات حسب تصنيف Esposito وآخرين. أُجري إصلاح قاعدة الجمجمة لجميع المرضى باستخدام تقنية الترقيع ثلاثي الطبقات (لفافة – شحم – لفافة)، بغض النظر عن شدة التسرب. لم تُستخدم أي سدائل وعائية أو لواصق نسيجية، كما لم تُستخدم وسائل لتحويل السائل مثل التصريف القطني.

النتائج: من بين المرضى الـ ٤٣ (٢٩ منهم يعانون من أورام غدية، و١٤ من أمراض غير غدية)، كانت نسب تسرب السائل الدماغي الشوكي: ٣٤,٨٨% درجة أولى، ٤١,٨٦% درجة ثانية، و٢٣,٢٦% درجة ثالثة. أظهر الحد الأدنى من المتابعة لمدة ١٨ شهراً حدوث حالتي تسرب للسائل الدماغي الشوكي بعد العملية (٤,٦٥%)، وحالة واحدة من استرواح الجمجمة (٢,٣٢%)، وحالة واحدة من التهاب السحايا الجرثومي (٢,٣٢%).

الاستنتاج: يُعد استخدام رقعة لفافة الفخذ والشحم الذاتي بتقنية ثلاثية الطبقات المعدلة وسيلة فعالة وآمنة وموثوقة لإصلاح عيوب قاعدة الجمجمة، بغض النظر عن درجة وشدة تسرب السائل الدماغي الشوكي. يتميز هذا الأسلوب بتوافقه النسيجي، وتوفر مواده وسهولة حصادها، مع ندرة المضاعفات في موقع الجني، ومرونة في حجم الرقعة حسب الحاجة. كما يُعتبر بديلاً جيداً للسدائل الوعائية في حال تعذر استخدامها أو صعوبة الحصول عليها، ويتميز بعدم تحميل المريض تكاليف إضافية مقارنة بالبدائل الصناعية واللاصقات النسيجية باهظة الثمن.

الكلمات المفتاحية : تسرب السائل الدماغي الشوكي؛ النهج الترانسيلاري، ترميم قاعدة الجمجمة؛ الورم الغدي النخامي؛ الجراحة التنظيرية؛ تقنية الترقيع ثلاثي الطبقات.

INTRODUCTION

Approximately 10 to 15% of all intracranial neoplasms involve the pituitary gland and sellar region. Nearly 9% of these lesions are pituitary adenomas, with the remainder comprising neoplastic, inflammatory, vascular, or developmental abnormalities.[1,2] Over recent decades, significant advancements in endoscopic skull base surgery have occurred, driven largely by innovations in endoscope technology and high-resolution camera systems. These enhancements have dramatically improved visualization, particularly beneficial in managing larger tumors, resulting in fewer complications and reduced healthcare costs. Consequently, purely endoscopic approaches such as endonasal endoscopic transsphenoidal, transsellar, transtubercular, and transplanar procedures have become standard practices.[3]

Effective skull base reconstruction following endoscopic surgery is critical, primarily aiming to achieve a watertight barrier separating the cranial cavity from the sinonasal spaces. This barrier prevents postoperative cerebrospinal fluid (CSF) leakage and ascending intracranial infections, including meningitis, encephalitis, and intracranial abscess formation.[4-6] Multilayer closure techniques incorporating vascularized pedicle flaps are commonly employed to restore the anatomical and functional integrity of the region.[7-12]

Additional objectives of endoscopic skull base reconstruction include minimizing postoperative dead space, re-establishing sinonasal mucosal lining and drainage pathways, promoting rapid wound healing, and adequately covering exposed or prolapsed neural tissue and critical neurovascular structures to preserve their functional integrity.[13]

Despite general consensus on reconstruction's importance, considerable debate remains concerning optimal reconstruction techniques, graft material choices, and whether reconstruction is universally necessary for all procedures. Given that intraoperative CSF leakage strongly predicts postoperative leakage, several authors recommend intraoperative reconstruction specifically when a leak is observed, regardless of its severity.

PATIENTS AND METHODS

This prospective study was conducted over 18 months (January 2022 - June 2023) at the Otolaryngology and Skull Base Center and Neurosurgical Department, Ghazi Al-Hariri Martyr Hospital for Surgical Specialties, Baghdad Medical City Complex. The study assessed the efficacy and safety of a modified skull base reconstruction technique utilizing a three-layer graft (Fascia-Fat-Fascia [3F]) in patients experiencing intraoperative cerebrospinal fluid (CSF) leaks during endoscopic

transsellar approaches. Ethical approval and informed patient consent were obtained.

Patients underwent comprehensive preoperative evaluation including medical history, physical examination, nasal endoscopy, computed tomography (CT), magnetic resonance imaging (MRI), and relevant laboratory tests. Additional evaluations such as intracranial pressure measurements and consultations with ophthalmology, neurology, cardiology, and anesthesiology specialists were performed as indicated.

Among 188 patients undergoing transnasal endoscopic sellar surgery, only 43 (22.87%) with Esposito Grades 1-3 intraoperative CSF leaks were included. Patients with Grade 0 leaks, large defects (>3 cm), or prior radiation therapy were excluded. All procedures involved a consistent skull base surgical team using a four-handed binostril endonasal transsphenoidal technique. Reconstruction employed a three-layer method: subdural fascia lata inlay graft, intermediate fat graft, and extracranial fascia lata onlay graft, secured with Surgicel, Gelfoam, and Merocel nasal packing.

Postoperatively, patients received systemic antibiotics and Acetazolamide until packing removal (average five days). Follow-up included nasal debridement and endoscopic assessment weekly for the first month, biweekly in the second month, and monthly thereafter for three months. Primary outcomes recorded were postoperative CSF leaks, meningitis, re-exploration rates, and donor-site morbidity.

SPSS v 25.0 were used for data analysis to accomplishment aim of the study.

RESULTS

Table 1 Intraoperative CSF leak patient categorizations according to primary pathology

Adenomatous Pathology 29 Patients (67.44%)		
Adenoma Type	*No. of Cases*	*Percentage*
Non-Functioning	*15*	*51.72%*
PRL Secreting	*7*	*24.13%*
GH Secreting	*5*	*17.25%*
ACTH Secreting	*2*	*6.90%*
Non-Adenomatous Pathology 14 Patients (32.56%)		
Craniopharyngioma	*9*	*64.29%*
Meningioma	*5*	*35.71%*

Pituitary adenomatous tumors were the primary pathology in 29 cases accounting for (67.44%), from them the non-hormone secreting type was reported in 15 patients while the hormone secreting adenomas were reported in 14 patients and distributed between prolactin, growth hormones and ACTH secreting tumors in 7, 5 and 2 patients respectively. The non-adenomatous pathologies diagnosed in 14 patients accounting for (32.56%) and categorized into two types, craniopharyngioma and meningioma in 9 and 5 patients respectively. (Table 1)

Table 2 Categorization of adenoma size in patients with CSF leaks

Adenomatous Pathology 29 Patients (67.44%)		
Adenoma Size	*No. of Cases*	*Percentage*
Macroadenoma > 1 cm	*20*	*68.96%*
Microadenoma < 1 cm	*7*	*24.14%*
Giant adenoma > 4 cm	*2*	*6.90%*

Among those with adenomatous pathology, radiological size assessments revealed that the majority of patients (68.96%) had macroadenoma, while microadenoma was reported in (24.14%) and the least reported giant adenomas were accounting for (6.90%) (Table 2)

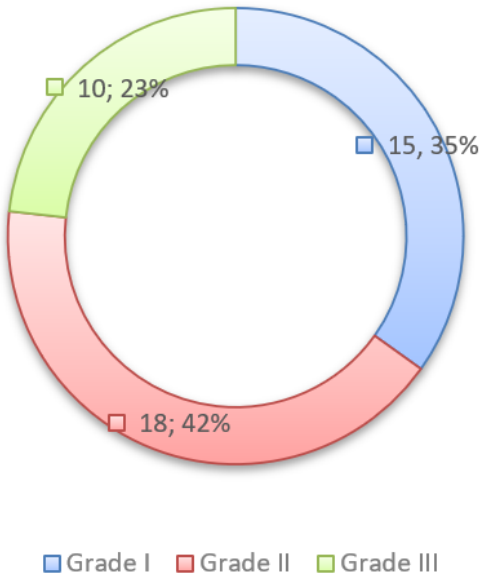

Fig. 1 Grading of intraoperative CSF leaks

Intraoperative CSF Leaks and Grading: All included patients were categorized into three grades according to the used grading system. Grade I (34.88%), grade II (41.86%) and grade III (23.26%) accounted in 15, 18 and 10 patients respectively. (Fig. 1)

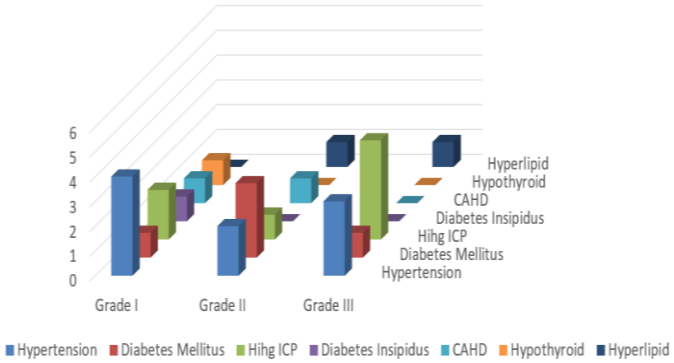

Fig. 2 Comorbidities and CSF grading

Hypertension disease was represented in (26.66%) of grade I group, (13.33%) of grade II group and (20%) of grade III group of intraoperative CSF leaks, figures detected for high ICP were (13.33%) of grade I, (5.55%) of grade II and (40%) of grade III group of study, diabetes mellitus was (6.66%) in grade I, (16.66%) in grade II and (10%) in grade III. Analyzing the incidence of other comorbidities for each group of patients was also shown below. (Fig. 2)

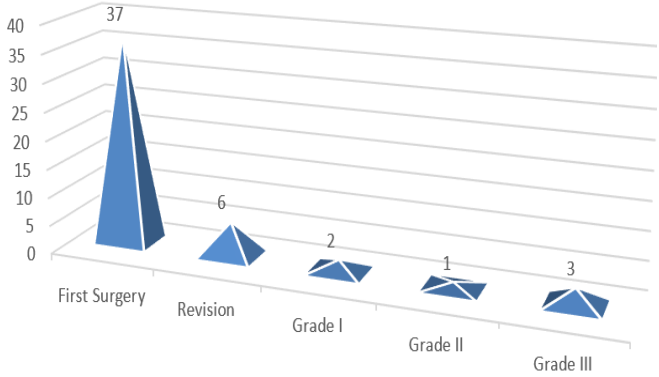

Fig. 3 Revision procedures and intraoperative CSF leaks

Patients of Revision Procedures: Only 6 out of the 43 studied patients were underwent previous surgery and submitted to revision one during our study and were representing (13.95%) of the studied sample, they distributed between the three studied groups as follow, 3 patients in grade III, 2 patients in grade I and finally only 1 patient in grade II CSF leak group. (Fig. 3)

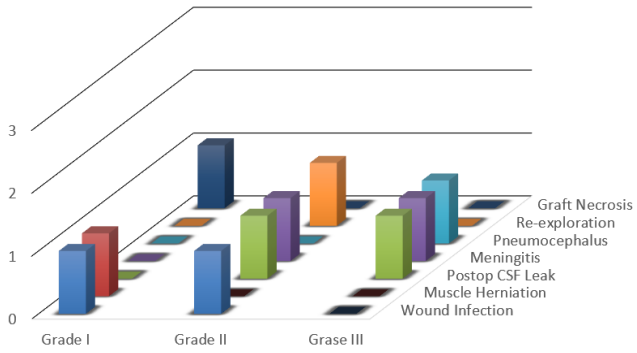

Fig. 4 Reported complications and its incidences

Re-exploration performed for one case of graft failure and continuous postoperative CSF leak which necessitate revision surgery in young male patient of grade III intra operative leak, he underwent re exploration under general anesthetics and repaired with new multi-layered grafting sealed by nasal flour mucosal graft and tissue glue. (Fig. 4)

DISCUSSION

Endoscopic skull base approaches are well known to be associated with less morbidity than open transcranial one and provide easier access to skull base lesions. However, intraoperative and postoperative CSF leakage is still the most frequently reported complications. Degree and severity of CSF leak depends on many factors which are patient and approach related, as the resection of pituitary adenomas is often an extra arachnoid procedure, with a small dural defect created to access the pathology and is therefore associated with a low rate of CSF leaks of a low to moderate grades as compared to the high-flow CSF leaks which are common in more extended approaches as in the resection of some craniopharyngiomas, meningiomas, giant pituitary adenomas, clival chordomas, and olfactory neuromas. Many literatures indicated various factors that had been postulated to be a risk for post-operative CSF leak including GH secreting adenoma, old aged patients, previous surgery or radiotherapy and surgical team experience, but arachnoid membrane violations and intraoperative CSF leak has been found to be the most important predisposing and prognostic factors affecting the risk of postoperative CSF leaks. Although, fascia lata harvesting may prolong the procedure and additional wound-related problems may arise, autologous fascia lata still considered the most commonly used and effective graft material for multilayer reconstruction and several techniques are available that use grafting materials to reconstruct the skull base in a watertight manner.

In this study, three-layered reconstruction was performed in an inlay–onlay fashion with using of fat layer in between (Fascia Fat Fascia) regardless the grade of CSF leak intraoperatively and comparing our results with similar studies of graded repairing of skull base defects based on intraoperative CSF grading and degree of leaks.

Out of all our procedures conducted during the period of this study, 22.87% had a recognized intraoperative CSF leak, including grade I (7,98%), grade II (9.57%) and grade III (5.32%) were accounted. (Fig. 1)

Esposito, et al[14] reported 56.6% intraoperative CSF leak, including grade I (32.5%), grade II (15.4%), and grade III (8.7%) leaks.

M. Jalessi, et al[15] found about 44.5% intraoperative CSF leak, including grade I (32.5%) and grade II (12%) as they used their own modification of the CSF grading system.

JH Park, et al.[16] as they found about 27.4% intraoperative CSF leak, including grade I (14.7%), grade IIa (4.6%), grade IIb (3%) and grade III (5.1%) as they also used their own modification of the CSF grading system. Analyzing the relations of intra operative CSF leakage with primary pathology and comparing with other similar studies, we reported that macroadenoma and craniopharyngioma representing highest associated primary risk factor for intraoperative CSF leak in all the three grades. Similarly arterial and intracranial hypertension in association with revision procedures all were significantly increase the risk of intraoperative CSF leaks during endoscopic endonasal transsellar surgical procedures. In order to directly compare the outcomes of three CSF leakage groups, we conducted an analysis only on the major and life-threatening post operative complications namely meningitis, pneumocephalus and repair failure with resultant postoperative CSF leak as the donor site morbidity was non significantly affecting the outcome and causing non-disabling consequences to almost all of our studied patients. There was only one reported case of culture proved bacterial meningitis related to grade II leaking group, representing 2.32% of the studied three groups.

Similarly, there was only one reported case of pneumocephalus, but was related to grade III leaking group, representing 2.32% of the studied three groups. Both were treated successfully without long standing or permanent consequences.

Grafting failure with resultant persistent post operative CSF leak was reported in two cases, representing 4.65% of the studied three groups and distributed equally between grade II and III CSF groups. Both were treated surgically with successful outcomes.

CONCLUSIONS AND RECOMMENDATIONS

Until currently, there is unclear evidence to guide the ideal and water tight repair technique after endoscopic transsellar pituitary and skull base tumor resection, so multicenter studies and data collections are of significant usefulness in determining the future practice and outcomes of similar procedures.

According to our findings and clinical outcomes, the use autologous facia lata and fat grafting in this modified three layered fashion technique is effective, reliable and safe procedure for reconstructing skull base defects regardless the CSF leak grading and severity, taking in consideration its tissue compatibility, availability and the ease of harvesting with negligible donor site morbidity, flexibility in size of the graft needed, it's a good substitute for vascularized regional flaps in cases of unavailability of difficult to be harvested and lastly, it's adding no cost on the patient when compared to other synthetic and artificial grafting substitutes avoiding the use of highly costed tissue glues and other synthetic sealant agents in most of cases.

ETHICAL DECLARATIONS

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Conflict of Interests

The authors declare that there is no conflict of interest.

Ethical Consideration

Approved by the ethical committee of Arabic Board Scientific Council for Medical Specialization Otolaryngology and Skull Base and verbal approved by participants.

Authors' Contributions

All authors have equal participation in the design, collection of the data, analysis of the results, and writing of the manuscript. All authors read and approved the final version of the manuscript.

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