

World Journal of *Clinical Cases*

World J Clin Cases 2023 October 16; 11(29): 6974-7260



MINIREVIEWS

- 6974** Applications of time series analysis in epidemiology: Literature review and our experience during COVID-19 pandemic

Tomov L, Chervenkov L, Miteva DG, Batselova H, Velikova T

ORIGINAL ARTICLE**Retrospective Cohort Study**

- 6984** Acute cholangitis: Does malignant biliary obstruction *vs* choledocholithiasis etiology change the clinical presentation and outcomes?

Tsou YK, Su YT, Lin CH, Liu NJ

Retrospective Study

- 6995** Usefulness of analyzing endoscopic features in identifying the colorectal serrated sessile lesions with and without dysplasia

Wang RG, Ren YT, Jiang X, Wei L, Zhang XF, Liu H, Jiang B

- 7004** Roles of biochemistry data, lifestyle, and inflammation in identifying abnormal renal function in old Chinese

Chen CH, Wang CK, Wang CY, Chang CF, Chu TW

- 7017** Clinical efficacy and safety of Guipi decoction combined with escitalopram oxalate tablets in patients with depression

Yu J, Xu FQ

- 7026** Artificial intelligence technology and ultrasound-guided nerve block for analgesia in total knee arthroplasty

Tong SX, Li RS, Wang D, Xie XM, Ruan Y, Huang L

- 7034** Axenfeld-Reiger syndrome: A search for the missing links

Morya AK, Ramesh PV, Sinha S, Nishant P, Nain N, Ramavath RN, Gone C, Prasad R

Observational Study

- 7043** Self-management of osteoarthritis while waiting for total knee arthroplasty during the COVID-19 pandemic among older Malaysians

Mahdzir ANK, Mat S, Seow SR, Abdul Rani R, Che Hasan MK, Mohamad Yahaya NH

- 7053** "In situ bone flap" combined with vascular pedicled mucous flap to reconstruction of skull base defect

Qian M, Chen X, Zhang LY, Wang ZF, Zhang Y, Wang XJ

- 7061** Reference values of gait parameters in healthy Chinese university students: A cross-sectional observational study

Yu JS, Zhuang C, Guo WX, Chen JJ, Wu XK, Xie W, Zhou X, Su H, Chen YX, Wang LK, Li WK, Tian K, Zhuang RJ

- 7075** Effect of T-regulatory cells and interleukin-35, interleukin-10, and transforming growth factor-beta on diffuse large B-cell lymphoma

Wu H, Sun HC, Ouyang GF

META-ANALYSIS

- 7082** Meta-analysis on the effectiveness of parent education for children with disabilities

Jang J, Kim G, Jeong H, Lee N, Oh S

- 7091** Meta-analysis of the efficacy and safety of daratumumab in the treatment of multiple myeloma

Wang P, Jin SY

CASE REPORT

- 7101** Varicella-zoster virus meningitis with hypoglycorrhachia: A case report

Cao LJ, Zheng YM, Li F, Hao HJ, Gao F

- 7107** Unusual presentation of penile giant condyloma acuminatum with spontaneous prepuce perforation: A case report

Hsu FC, Yu DS, Pu TW, Wu MJ, Meng E

- 7113** Primary renal lymphoma presenting as renal failure: A case report and review of literature from 1989

Lee SB, Yoon YM, Hong R

- 7127** Intravascular ultrasonography assisted carotid artery stenting for treatment of carotid stenosis: Two case reports

Fu PC, Wang JY, Su Y, Liao YQ, Li SL, Xu GL, Huang YJ, Hu MH, Cao LM

- 7136** Mucoepidermoid carcinoma of the lung with hemoptysis as initial symptom: A case report

Xie WX, Liu R, Li Z, Zhou PL, Duan LN, Fu DD

- 7144** Co-infection of *Chlamydia psittaci* and *Tropheryma whippelii*: A case report

Du ZM, Chen P

- 7150** Surgical treatment of severe anterior capsular organized hard core cataract: A case report

Wang LW, Fang SF

- 7156** First platelet transfusion refractoriness in a patient with acute myelocytic leukemia: A case report

Tu SK, Fan HJ, Shi ZW, Li XL, Li M, Song K

- 7162** Rare finding of primary aortoduodenal fistula on single-photon emission computed tomography/computed tomography of gastrointestinal bleeding: A case report

Kuo CL, Chen CF, Su WK, Yang RH, Chang YH

- 7170** Rituximab combined with Bruton tyrosine kinase inhibitor to treat elderly diffuse large B-cell lymphoma patients: Two case reports

Zhang CJ, Zhao ML

- 7179** Use of Ilizarov technique for bilateral knees flexion contracture in Juvenile-onset ankylosing spondylitis: A case report
Xia LW, Xu C, Huang JH
- 7187** Case of takotsubo cardiomyopathy after surgical treatment of liver hydatid cyst: A case report
Altaş Y, Abdullayeva Ü
- 7193** Laparoscopic choledocholithotomy and transductal T-tube insertion with indocyanine green fluorescence imaging and laparoscopic ultrasound: A case report
Yoo D
- 7200** Hematopoietic stem cell transplantation of aplastic anemia by relative with mutations and normal telomere length: A case report
Yan J, Jin T, Wang L
- 7207** Emphysematous thrombophlebitis caused by a misplaced central venous catheter: A case report
Chen N, Chen HJ, Chen T, Zhang W, Fu XY, Xing ZX
- 7214** Aggressive angiomyxoma of the epididymis: A case report
Liu XJ, Su JH, Fu QZ, Liu Y
- 7221** Gastric and intestinal ectopic pancreas: Two case reports
Zhang H, Zhao HY, Zhang FH, Liang W
- 7227** Congenital leukemia: A case report and review of literature
Yang CX, Yang Y, Zhang FL, Wang DH, Bian QH, Zhou M, Zhou MX, Yang XY
- 7234** Imaging misdiagnosis and clinical analysis of significant hepatic atrophy after bilioenteric anastomosis: A case report
Liang SY, Lu JG, Wang ZD
- 7242** Surgical treatment of mixed cervical spondylosis with spontaneous cerebrospinal fluid leakage: A case report
Yu Z, Zhang HFZ, Wang YJ
- 7248** Simultaneous thyroglossal duct cyst with parathyroid cyst: A case report
Chen GY, Li T
- 7253** Submandibular solid-cystic mass as the first and sole manifestation of occult thyroid papillary carcinoma: A case report
Chen GY, Li T

LETTER TO THE EDITOR

- 7258** Artificial intelligence and machine learning in motor recovery: A rehabilitation medicine perspective
Swarnakar R, Yadav SL

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Observational Study

“In situ bone flap” combined with vascular pedicled mucous flap to reconstruction of skull base defect

Ming Qian, Xi Chen, Long-Yao Zhang, Zhi-Feng Wang, Yi Zhang, Xue-Jian Wang

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At present, neuroendoscopy technology has made rapid development, and great progress has been made in the operation of lesions in the saddle area of the skull base. However, the complications of cerebrospinal fluid and intracranial infection after the operation are still important and life-threatening complications, which may lead to poor prognosis.

AIM

To investigate the method of in situ bone flap combined with nasal septum mucosal flap for reconstruction of enlarged skull base defect by endonasal sphenoidal approach and to discuss its application effect.

METHODS

Clinical data of 24 patients undergoing transnasal sphenoidal endoscopic approach in the Department of Neurosurgery, Affiliated 2 Hospital of Nantong University from January 2019 to December 2022 were retrospectively analyzed. All patients underwent multi-layer reconstruction of skull base using in situ bone flap combined with nasal septum mucosa flap. The incidence of intraoperative and postoperative cerebrospinal fluid leakage and intracranial infection were analyzed, and the application effect and technical key points of in situ bone flap combined with nasal septum mucosa flap for skull base bone reconstruction were analyzed.

RESULTS

There were 5 cases of high flow cerebrospinal fluid (CSF) leakage and 7 cases of low flow CSF leakage. Postoperative cerebrospinal fluid leakage occurred in 2 patients (8.3%) and intracranial infection in 2 patients (8.3%), which were cured after strict bed rest, continuous drainage of lumbar cistern combined with antibiotic treatment, and no secondary surgical repair was required. The patients were followed up for 8 to 36 months after the operation, and no delayed cerebrospinal fluid leakage or intracranial infection occurred during the follow-up. Computed tomography reconstruction of skull base showed satisfactory reconstruction after surgery.

CONCLUSION

The use of *in situ* bone flap combined with vascular pedicled mucous flap to reconstruction of skull base defect after endonasal sphenoidal approach under neuroendoscopy has a lower incidence of cerebrospinal fluid leakage and lower complications, which has certain advantages and is worthy of clinical promotion.

Key Words: *In situ* bone flap; Nasal septum mucosa flap; Multilayer reconstruction; Skull base reconstruction; Neuroendoscopy; Endonasal sphenoidal approach

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Core Tip: The use of "*in situ* bone flap" rigid reconstruction technology for the reconstruction of the sellar floor after nasal endoscopic surgery, which is an anatomical reduction repair technology, can not only reduce the incidence of postoperative cerebrospinal fluid leakage, but also has great advantages, worthy of clinical promotion.

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INTRODUCTION

At present, neuroendoscopy technology has made rapid development, and great progress has been made in the operation of lesions in the saddle area of the skull base. With the continuous improvement of the anatomy of the skull base, the continuous popularization of endoscopic technology and the continuous improvement of endoscopic equipment, neuroendoscopy has developed from simple operation of pituitary tumor to perisaddle and suprasellar lesions[1-4]. Now, neuroendoscopic transnasal approach can carry out a variety of lesions in the sellar region, such as pituitary giant adenoma that breaks through the sellar septum and suprasellar craniopharyngioma[5-7]. However, the complications of cerebrospinal fluid and intracranial infection after the operation are still important and life-threatening complications, which may lead to poor prognosis[8-9]. Postoperative skull base reconstruction, restoration of skull base structure and prevention of cerebrospinal fluid leakage and intracranial infection are important problems that must be solved by neuroendoscopists[10-13]. At present, many experts have carried out a variety of technical studies on the reconstruction of the skull base after neuroendoscopic sellar approach, such as mucosal flap reconstruction, fat reconstruction, fascia lata reconstruction and other ways[14-17]. However, a number of studies have pointed out that these skull base reconstruction techniques have insufficient support and cannot achieve a good skull base support function, and it is necessary to carry out bone reconstruction of skull base defect with a commission[16-19]. From January 2019 to December 2022, we performed transnasal endoscopic surgery in sellar region, and used *in situ* bone flap and pedicled mucosal flap to perform skull base bone reconstruction for 24 patients with sellar region tumors, and achieved satisfactory results. In this study, clinical data of this group were retrospectively analyzed, and are reported as follows.

MATERIALS AND METHODS

Ethics approval and consent to participate

This study was reviewed and approved by the Ethics Committee of Affiliated 2 Hospital of Nantong University. Informed consent has been obtained and this investigation has been conducted according to the principles expressed in the Declaration of Helsinki. And the authors have obtained written informed consent of all the patients or legal guardian.

Trial design

The study was a retrospective clinical study in patients undergoing neuroendoscopic sellar surgery with *in situ* bone flap combined with vascular pedicled mucosal flap reconstruction. The trial was done and analyzed according to the CONSORT guidelines.

General data

In the observation group, there were 16 males and 8 females; The average age was (40.1 ± 17.2) years, ranging from 21 to 67 years. All of them were confirmed by postoperative pathological examination, and the pathological types and distribution of tumors were shown in Table 1.

Surgical methods

In all patients, the skull base was reconstructed using the multi-layer reconstruction technique of the *in situ* bone flap with vascular pedicled mucosal flap. Skull base multi-layer reconstruction technique: The tumor cavity after tumor surgery was supported by gelatin sponge or hemostatic gauze (Johnson, United States), and the absorbable artificial dura (Tianyifu, China) was laid flat under the dural defect, and the epidural absorbable artificial dura (Tianyifu, China) was laid flat, followed by the *in-situ* bone flap, which covered the nasal mucosa flap. There were 2 patients who did not use a pedicled nasal septum mucosa flap, due to the failure to make a suitable mucosal flap during the operation in one, and the other case failed to obtain a mucosal flap due to preoperative nasal surgery.

(1) Making "pedicled nasal septum mucosal flap: Making nasal septum mucosal flap with vascular pedicle and placing it in the posterior nasal passage for use [16,20]; and (2) Fabrication of *in situ* bone flap of sellar floor: After grinding the anterior wall of sphenoid sinus, the posterior sphenoid platform, tuberculum sellae, sellar floor, bilateral optic neural tube, internal carotid artery eminence and other structures were exposed. The margin of the open bone window was designed according to the surgical plan. A small emery grinding head (diameter 2.5 mm) was used to gradually thin the bone along the internal carotid artery eminence, the root of the optic nerve canal, and the back of the sphenoid bone platform to form an "inverted U-shaped bone trough". During this period, the depth of the "bone trough" was checked periodically. Then we thin the bone slightly under the *in situ* bone flap of sellar floor. Finally, we grind out a ring of bone grooves, carefully push the "fracture" at the top of the bone groove with a small stripper, and then use the peel to lift the "inverted U-shaped" bone flap to make the "*in situ* bone flap". The bone flap was left on the bottom wall of the sphenoid sinus for standby application (Figure 1). Intraoperative navigation and Doppler ultrasound are helpful in determining bilateral internal carotid artery position.

Postoperative observation and follow-up

The postoperative complications (cerebrospinal fluid leakage, intracranial infection, etc.) were observed. Head computed tomography (CT) scan was performed postoperative day to determine the surgical area. Follow-up examination was performed 3 mo, 6 mo, once a year later. Periodic telephone follow-up was conducted to see if there were any delayed complications associated with skull base reconstruction.

RESULTS

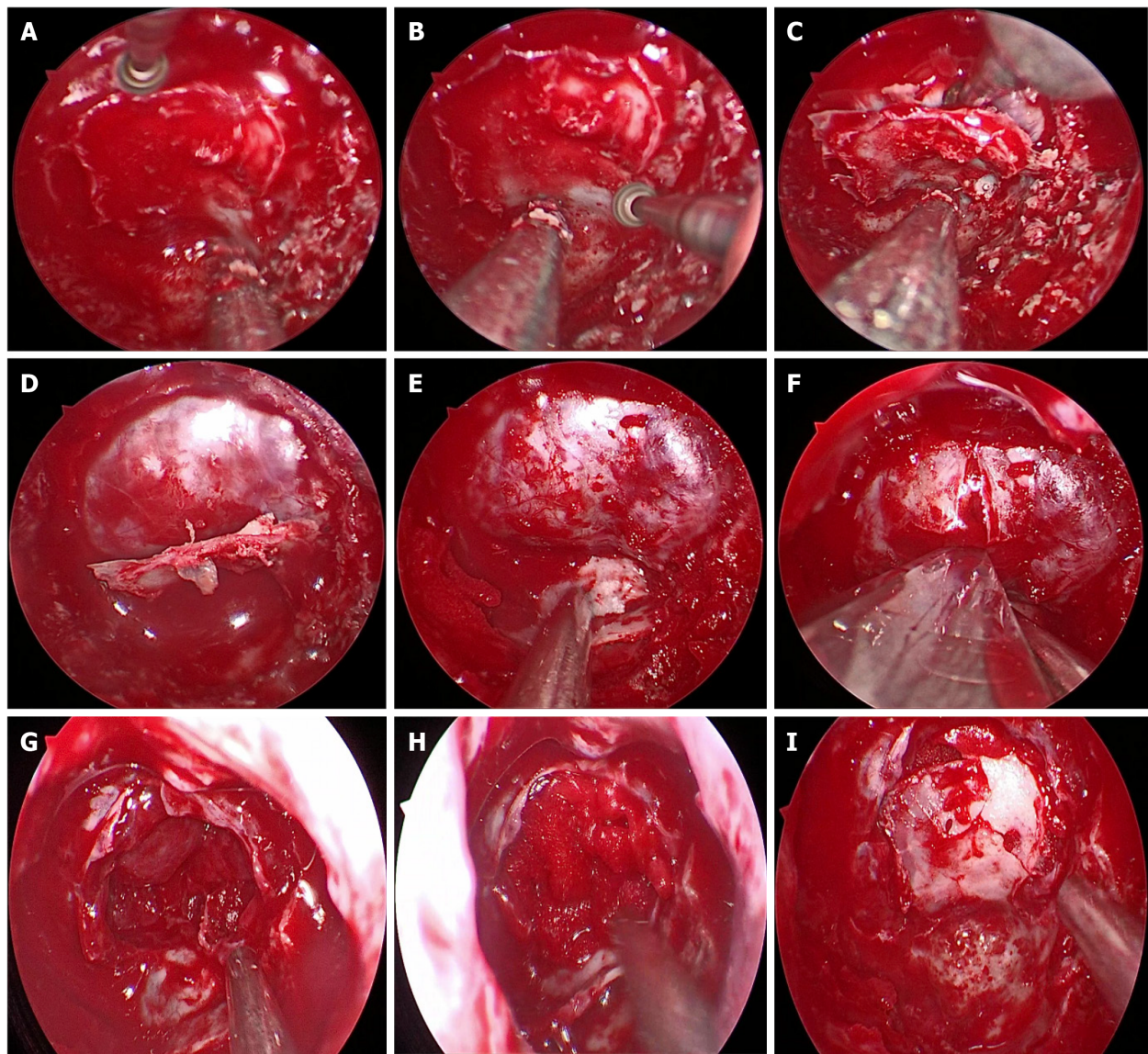
For this group of patients, no significant demographic differences were found in mean age, sex, or medical history and presentation of symptoms. Patients in this group were followed for an average of 22.6 mo, ranging from 8 to 36 mo. In this study, we mainly studied the methods and procedures of skull base reconstruction, and we have made a full description and picture display. In this paper, we did not give too much description and statistics on the vision protection, nerve function and endocrine status of patients. There was no statistical analysis on whether the intraoperative tumor was complete resection and the final recurrence rate.

In this group, there were 24 patients, 22 of whom were reconstructed with *in situ* bone flap and pedicled mucosal flap. There were 2 patients who did not use a pedicled nasal septum mucosa flap, due to the failure to make a suitable mucosal flap during the operation in one, and the other case failed to obtain a mucosal flap due to preoperative nasal surgery. There were 5 cases of high flow cerebrospinal fluid (CSF) leakage and 7 cases of low flow CSF leakage. Postoperative cerebrospinal fluid leakage occurred in 2 patients (8.3%) and intracranial infection in 2 patients (8.3%), which were cured after strict bed rest (one case was in bed for 5 d and the other case for 7 d), continuous drainage of lumbar cistern combined with antibiotic treatment, and no secondary surgical repair was required. The patients were followed up for 8 to 36 mo after the operation (fourteen patients were followed up for more than 24 mo, three were lost, and the rest were still being followed up), and no delayed cerebrospinal fluid leakage or intracranial infection occurred during the follow-up. CT reconstruction of skull base showed satisfactory reconstruction after surgery.

DISCUSSION

The application of neuroendoscopy in neurosurgery has made great progress. At present, neuroendoscopy can be used to perform surgery for many diseases, including transcranioscopy and transnasal endoscopy [21-26]. However, the problem of skull base reconstruction and cerebrospinal fluid in transnasal neuroendoscopic surgery has always been one of the difficult problems for neurosurgeons. With the continuous efforts of neurosurgeons to study various skull base reconstruction techniques, the incidence of cerebrospinal fluid leakage has been significantly improved [16,19], including vascular pedicled mucosal flap technique [27-30], artificial dura replacement material [31-32], or multi-layer reconstruction of autologous fat and fascia lata [16,33]. It has been reported that the incidence of cerebrospinal fluid leakage using the nasal septum pedicled mucosal flap technique is less than 5% [16].

Table 1 Pathological types and distribution of tumors in this group	
Pathological type of tumor	Number of cases
Pituitary adenoma	17
Craniopharyngioma	4
Rathke cleft cysts	3



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Figure 1 Surgical procedure for skull base reconstruction. A: The shape of inverted U was used to open the bottom bone of the saddle; B: Thin the bone beneath the bone flap; C: Break above the bone flap, thin bone along the underside, then fold it down; D: Inverted U-shaped flap formation; E: Lower the bone flap and place it underneath for use; F: Cut the dural membrane at the base of the saddle; G: The structure of the saddle revealed after the tumor was removed; H: The structure of tumor Cavity of the saddle was filled; I: The bone flap is rebacked to reconstruct the sole of the saddle.

However, at present, there are still restrictions in the control of cerebrospinal fluid in different hospitals and regions, the incidence is uneven, and the surgical effect is not optimistic. At present, the reconstruction of the skull base after neuroendoscopy is still mainly soft reconstruction, and a few of them use rigid reconstruction with alternative materials, which has not been well promoted and applied[18,31]. At present, the reconstruction is usually filled with gelatin material inside the sella, tile inside the artificial dura, supported by external hemostatic material or covered with mucosal flap. In fact, the surgical area is connected with intracranial pressure after operation, especially in patients with cerebrospinal fluid leakage, when the intracranial pressure increases with brain pulse/posture/cough, or due to factors such as tamponade or displacement of supporting materials and autologous tissue atrophy, the reconstruction is not enough to support, cerebrospinal fluid leakage and reconstruction failure, if complicated with intracranial infection, there

is a life-threatening risk.

If rigid reconstruction of autogenous material can be achieved, the relative stability will be improved, because rigid reconstruction can provide enough mechanical support to achieve near-anatomical "reset". Unlike materials such as mucosal flap, hard materials, such as bone materials, are not malleable. The anatomical structure variation of skull base bone and the uneven thickness and roughness of skull base bone make it difficult to obtain autorigid material effectively. Moreover, even if fixed material is available, it is difficult to fix it, which makes hard repair difficult[31].

Leng *et al*[12] first proposed the concept of skull base rigid reconstruction in 2008 and proposed gasket seal technology. None of the patients who underwent skull base rigid reconstruction had cerebrospinal fluid leakage after surgery and achieved good reconstruction results. In addition, many experts have proposed other rigid reconstruction technologies, including glass, artificial bone, titanium plate and other technologies. But these technologies also have corresponding drawbacks, can not be shaped or installed in place problems.

In view of the above situation, our team further studied the concept of rigid reconstruction, proposed and improved the "*in situ* bone flap technology", designed the bone flap of sellar floor, and made the *in situ* bone flap with a small grinding head under neuroendoscopy. During the operation, the upper and lateral edges of the bone flap were ground open, the lower bone was thinned, and then the bone flap was turned down and placed on the floor of the sphenoid sinus. After the operation, the bone flap was reconstructed in the sella, and the multi-layer repair method of the nasal septum mucosal flap with pedicle was used. All the patients in this group achieved satisfactory reconstruction results, two patients had craniocerebral infection after surgery, and were treated with active anti-infection. Postoperative cerebrospinal fluid leakage occurred in 2 patients (8.3%), and were cured after strict bed rest, continuous drainage of lumbar cistern combined with antibiotic treatment, and no secondary surgical repair was required. Even though there were many cases of high-flow cerebrospinal fluid leakage and low-flow cerebrospinal fluid leakage during the operation, the reconstruction results were still satisfactory. No complications related to the "*in situ* flap" were observed during postoperative follow-up.

Through the study of this group, we found that the "*in situ* bone flap" reconstruction technique provides a rigid reconstruction of the saddle bottom, and the results are safe and effective. We conclude that the "*in situ* bone flap" technique has the following advantages: (1) The application of this "*in situ* bone flap" technology, the bone flap comes from the operative area, does not need to remove the surgical area, reduces the process of entering and leaving the narrow space of the nasal cavity, reduces the damage of the nasal mucosa, and reduces the operation time[34,35]; (2) The bone flap is the bone of the surgical site, and the size and shape of the bone flap match the bone window of the skull base, which is a kind of anatomical reduction operation and fully meets the requirements of skull base reconstruction[36-39]; (3) After rigid bone reconstruction, the anatomical layers are clearly defined, and there are no disadvantages such as rejection and foreign body, which greatly reduces adhesion and postoperative scar formation in the operative area, and facilitates the expedient healing and re-operation of tumor recurrence[30,40,41]; and (4) Through rigid bone reconstruction, the direct impact of cerebrospinal fluid on mucosal flap is slowed down, the reconstruction is enhanced, and the medium is provided for the growth and adhesion of mucosal flap, which has a positive effect on the fixation and survival of mucosal flap after surgery[42,43].

CONCLUSION

In summary, the use of "*in situ* bone flap" rigid reconstruction technology for the reconstruction of the sellar floor after nasal endoscopic surgery, which is an anatomical reduction repair technology, can not only reduce the incidence of postoperative cerebrospinal fluid leakage, but also has great advantages, worthy of clinical promotion. At present, the number of patients in this group who have been treated with this technique is still small, and the follow-up time is still short. Further observation is needed to verify whether there are complications in the follow-up. Cerebrospinal fluid leakage after endoscopic nasal approach is an important complication that restricts this surgical method. According to the actual situation of the operation, relevant materials and techniques are adopted according to local conditions, and specific individual treatment plans are formulated for patients, so as to achieve the best surgical treatment effect.

ARTICLE HIGHLIGHTS

Research background

At present, neuroendoscopy technology has made rapid development, and great progress has been made in the operation of lesions in the saddle area of the skull base. However, the complications of cerebrospinal fluid and intracranial infection after the operation are still important and life-threatening complications, which may lead to poor prognosis.

Research motivation

At present, cerebrospinal fluid leakage is still one of the difficulties after transnasal endoscopic sellar surgery. Our center has also conducted a variety of reconstruction methods for training and clinical use, and this article is a summary of one of them.

Research objectives

To investigate the method of in situ bone flap combined with nasal septum mucosal flap for reconstruction of enlarged skull base defect by endonasal sphenoidal approach and to discuss its application effect.

Research methods

Clinical data of 24 patients undergoing transnasal sphenoidal endoscopic approach in the Department of Neurosurgery, Affiliated 2 Hospital of Nantong University from January 2019 to December 2022 were retrospectively analyzed. All patients underwent multi-layer reconstruction of skull base using in situ bone flap combined with nasal septum mucosa flap. The incidence of intraoperative and postoperative cerebrospinal fluid leakage and intracranial infection were analyzed, and the application effect and technical key points of in situ bone flap combined with nasal septum mucosa flap for skull base bone reconstruction were analyzed.

Research results

There were 5 cases of high flow cerebrospinal fluid (CSF) leakage and 7 cases of low flow CSF leakage. Postoperative cerebrospinal fluid leakage occurred in 2 patients (8.3%) and intracranial infection in 2 patients (8.3%), which were cured after strict bed rest, continuous drainage of lumbar cistern combined with antibiotic treatment, and no secondary surgical repair was required. The patients were followed up for 8 to 36 months after the operation, and no delayed cerebrospinal fluid leakage or intracranial infection occurred during the follow-up. Computed tomography reconstruction of skull base showed satisfactory reconstruction after surgery.

Research conclusions

In summary, the use of "in situ bone flap" rigid reconstruction technology for the reconstruction of the sellar floor after nasal endoscopic surgery, which is an anatomical reduction repair technology, can not only reduce the incidence of postoperative cerebrospinal fluid leakage, but also has great advantages, worthy of clinical promotion. At present, the number of patients in this group who have been treated with this technique is still small, and the follow-up time is still short.

Research perspectives

According to the actual situation of the operation, relevant materials and techniques are adopted according to local conditions, and specific individual treatment plans are formulated for patients, so as to achieve the best surgical treatment effect.

FOOTNOTES

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