Maxillary Swing Approach for Central Skull Base Lesions in Extreme Situations: A Single-Institutional Case Series

Fuxing Zuo[1], Shilu Ye[3], Haipeng Qian[1], Shaoyan Liu[2], Jinghai Wan[1]

OBJECTIVE: **Radical resection of complex lesions occupying multiple compartments at the central skull base remains a significant challenge, since surgical outcomes may be compromised by insufficient exposure and inappropriate techniques. However, the efficiency of the maxillary swing approach for these lesions has not been sufficiently evaluated. Careful assessment of lesion characteristics must be performed when selecting the appropriate procedure.**

METHODS: **Between May 2006 and February 2017, 17 patients underwent resection of extensive lesions in the central skull base using the maxillary swing approach. As shown in the representative cases, data regarding clinical findings and technical considerations were reviewed.**

RESULTS: **Complete resection was achieved in all patients. The pathological findings were diverse, and the majority were schwannomas (9 cases, 52.94%), followed by meningiomas (World Health Organization II) (3 cases, 17.65%). Complications were managed as described in the case illustrations, and symptoms improved with time. The follow-up duration ranged from 62 to 192 months (median, 114 months), while 2 patients were lost to the follow-up. No mortality was observed. Two patients who experienced malignancy relapse were still under observation due to their asymptomatic status.**

CONCLUSIONS: **Our preliminary results suggest that the maxillary swing approach can be an alternative option for managing extreme cases, such as large, extensive, hypervascularized masses with fibrous or calcified consistency, or for recurrent lesions in the central skull base. En bloc resection can be successfully obtained, resulting in long-term local control.**

INTRODUCTION

The extreme complexity of the central skull base is associated with challenging regional anatomy and variable lesion pathologies. Neoplasms arising from the paranasal sinuses, orbits, pterygopalatine fossa, infratemporal fossa, and clivus may exhibit a transdural growth pattern.[1-4] Moreover, subdural masses can also spread to the craniofacial region, displaying a more aggressive biological behavior. Technically, extirpation of large lesions extending toward multiple compartments remains formidable because of inadequate exposure in the proximity of vital neurovascular structures.[3,5]

Controversy remains regarding the optimal surgical procedure for extensive lesions in the central skull base.[2,3] The maxillary swing approach can provide broad access in cases of large tumors, allowing en bloc resection in one stage.[3,6-9] However, since the implementation of endoscopic techniques, surgeons would argue strongly against open surgery due to increased postoperative morbidity.[6,10,11] Lesion characteristics can be an essential parameter influencing the decision-making of the surgical approach. Full exposure to deep-seated extensive or recurrent tumors distorting the anatomical landmarks cannot be easily achieved through a narrow corridor.[1,8,12] In addition, the surgical struggle to dissect lesions with significant fibrosis or calcification within a restrictive surgical cavity may destroy vital neurovascular structures.[3,11] Likewise, piecemeal resection may cause severe intraoperative bleeding from the dissection planes of hypervascularized lesion remnants and pose a high risk of malignant recurrence.[11] Therefore, the maxillary swing approach may be feasible and appropriate under particular circumstances.

The efficiency of the maxillary swing approach for central skull base lesions is still debated, leaving the optimal treatment paradigm unresolved. In the present study, 17 patients with extensive lesions occupying multiple compartments underwent open surgery. Clinical data and technical considerations based on our

Key words
- Central skull base
- Lesion characteristics
- Maxillary swing approach

Abbreviations and Acronyms
MRI: Magnetic resonance imaging

From the Departments of [1]Neurosurgery, and [2]Head and Neck Surgery, National Cancer Center/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing; and [3]Department of Neurosurgery, The 901st Hospital of the Joint Logistics Support Force of PLA, Hefei, China

To whom correspondence should be addressed: Jinghai Wan, Ph.D., M.D. [E-mail: wanjinghai@sina.com]

Citation: World Neurosurg. (2022). https://doi.org/10.1016/j.wneu.2022.07.009

Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

Table 1. Demographics, Clinical, and Pathological Characteristics

Variables	Value
No. of eligible patients	17
Mean age, range (years)	47.3, 28–67
Gender, No. (%)	
Male	8 (47.06)
Female	9 (52.94)
Presenting symptoms, No. (%)	
Headache	6 (35.29)
Limitation of extraocular movements	6 (35.29)
Facial numbness/pain	6 (35.29)
Visual defects	6 (35.29)
Anosmia	6 (35.29)
Nasal stenosis/obstruction	5 (29.41)
Facial deformity	3 (17.65)
Hear impairment	2 (11.76)
Exophthalmos	2 (11.76)
Skin necrosis and ulceration	1 (5.88)
Facial palsy	1 (5.88)
Local relapse before admission to our hospital, No. (%)	8 (47.06)
Previous treatment, No. (%)	
Transcranial surgery	4 (23.53)
Endoscopic surgery + radiotherapy	2 (11.76)
Endoscopic surgery + transcranial surgery	1 (5.88)
Transcranial surgery + radiotherapy	1 (5.88)
Mean maximum diameter, range (cm)	7.08, 3.6–13.3
Extension across the midline, No. (%)	7 (41.18)
Transdural growth pattern, No. (%)	7 (41.18)
CS invasion, No. (%)	10 (58.82)
Complete resection rate (%)	100
Pathology, No. (%)	
Schwannoma	9 (52.94)
Meningioma (WHO II)	3 (17.65)
MPNST (WHO III)	2 (11.76)
Fibrous dysplasia	1 (5.88)
Paraganglioma	1 (5.88)
Inflammatory myofibroblastic tumor	1 (5.88)
Complications, No. (%)	
Facial numbness/pain	4 (23.53)
Dry eye	3 (17.65)
CSF leakage	2 (11.76)
Palatal fistula	2 (11.76)
Visual defects	1 (5.88)
Trismus	1 (5.88)
Epistaxis	1 (5.88)
Intracranial infection	1 (5.88)
Lost to follow-up, No. (%)	2 (11.76)
Median follow-up duration, range (month)	114, 62–192
Mortality (%)	0
Recurrence rate (%)	13.33 (2/15)

CS, cavernous sinus; CSF, cerebrospinal fluid; MPNST, malignant peripheral nerve sheath tumor.

experience were reviewed and discussed, as shown in the representative illustrated cases.

MATERIAL AND METHODS

Patient Population

This study was approved by the Ethical Committee of the National Cancer Center/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College. Informed consent was obtained from all patients included in our cohort.

Between May 2006 and February 2017, 17 patients with extensive lesions in the central skull base underwent surgical treatment using the maxillary swing approach in our department. The relevant clinical findings are summarized in Table 1.

Surgical Procedures

After administration of general anesthesia, the patient was placed in the supine position. Subsequently, the maxillary swing procedure was performed.[2] In brief,

1) A Weber-Ferguson incision was given and deepened up to the bone (Figure 1A);
2) Osteotomies were performed on the hard palate, maxillary tuberosity, pyriform aperture, temporal process, frontal process, and the floor of the orbit to separate the maxilla from all bony connections (Figure 1B and C);
3) The nasopharynx, oropharynx, parapharyngeal space, pterygopalatine fossa, infratemporal fossa, sellar, clivus, and even the contralateral compartments were exposed after lateral reflection of the entire maxilla (Figure 1D); and
4) Once extirpation of the lesion was achieved, multilayer reconstruction of the skull base was performed, followed by repositioning the maxillary osteocutaneous unit.

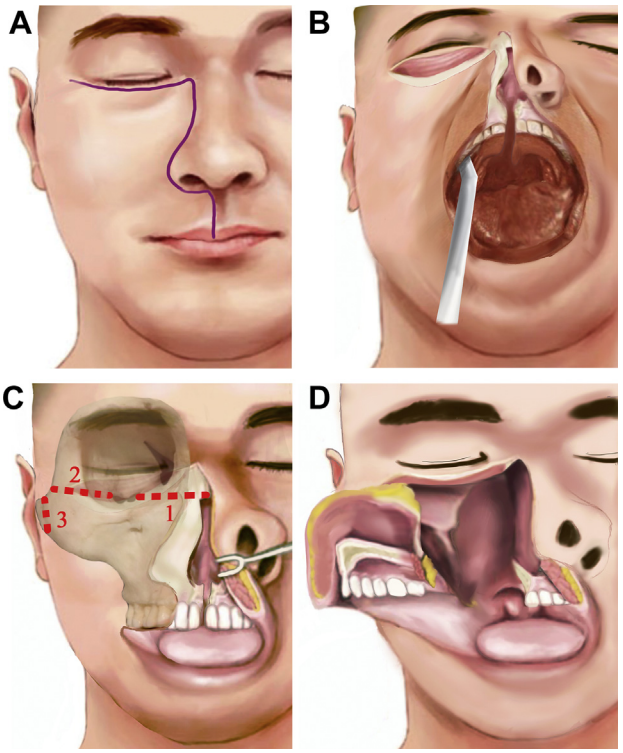

Figure 1. Original drawings of the maxillary swing procedures. (**A**) A facial incision was placed 5 mm below and parallel to the lower eyelid lash line, turning downwards at the inner canthus to follow the junction of the cheek and the lateral side of the nose, extending along the alar groove, and continuing in the midline of the philtrum to the vermilion of the upper lip. (**B**) The facial incision went through the subcutaneous tissue exposing the periosteum that was lifted off for osteotomies. The mucosa of the hard palate was incised along the midline, reaching the junction between the hard and soft palates. The incision turned laterally to follow the posterior edge of the hard palate to the retrotuberosity area. The hard palate was divided in the midline using the oscillating saw, and osteotomies were made to separate the maxillary tuberosity from the pterygoid plates by a curved osteotome. (**C**) Thereafter, horizontal osteotomies extended from the rim of the pyriform aperture to the inferior orbital fissure (red dotted line 1), and terminated at the frontal process of the zygomatic bone (red dotted line 2). A vertical cut was placed on the temporal process of the zygomatic bone (red dotted line 3). (**D**) Finally, the maxilla was freed from all bony connections and could be swung laterally, remaining pedicled on the cheek flap and masseter.

RESULTS

Surgical Aspects and Pathological Findings

Microscopically, total resection was achieved in all patients. The complications noted in our study are listed in Table 1 and were managed as shown in the case illustrations. Significant complications were few except for 1 patient (5.88%) with cerebrospinal fluid leakage and resultant intracranial infection resolved by lumbar drainage and antibiotic therapy. Facial numbness/pain happened in 4 patients (23.53%), and dry eye was found in 3 patients (17.65%). Two patients (11.76%) who developed postoperative palatal fistula received conservative treatment. Most of the fistulae shrunk within several weeks afterward, and the obturator was used to improve speaking and swallowing. The most common tissue diagnosis was schwannoma (9 cases, 52.94%), followed by meningioma (World Health Organization [WHO] II) (3 cases, 17.65%), malignant peripheral nerve sheath tumor (WHO III) (2 cases, 11.76%), fibrous dysplasia (1 case, 5.88%), paraganglioma (1 case, 5.88%), and inflammatory myofibroblastic tumor (1 case, 5.88%).

Follow-Up

Two patients were lost during the follow-up period. No mortality was observed, while 2 patients, 1 with meningioma (WHO II) and another with malignant peripheral nerve sheath tumor (WHO III), experienced locoregional tumor recurrence. Observation and monitoring were recommended in these 2 cases because of the asymptomatic status.

Case Illustrations

Case 1. A 29-year-old man initially presented with nasal obstruction and anosmia. He complained of blurring 8 months later and was referred to our clinic because of precipitate bitemporal hemianopsia and severe exophthalmos. Preoperative magnetic resonance imaging (MRI) and computed tomography showed a large lesion extending toward the nasal sinuses, orbits, sellar, clivus, petrous apex, and cavernous sinus, infiltrating the temporal lobe (Figure 2A-D). Considering the difficulties in resecting the extensive and calcified lesion in a bloodless view and reconstruction of the skull base, the maxillary swing approach was selected by expanding the nasal osteotomy to the contralateral side (Figure 2E-G). The bony-hard lesion was visualized and dissected along its capsule surface in attempt of keeping the displaced and stretched cranial nerves within the cavernous sinus intact. Pure circumferential stripping in a single piece along the brain-lesion interface was accomplished, followed by a reflection of the frontotemporal scalp flap to harvest malleable autologous tissue for reconstruction. The diagnosis of fibrous dysplasia was confirmed by pathological analysis. The postoperative course was uneventful, and the patient was discharged with improved visual function. He was followed up annually with fair cosmetic results, and no recurrence was detected on contrast MRI (Figure 2H-K).

Case 2. A 59-year-old man underwent transcranial surgery for skull base schwannoma 5 years ago. Although pathological examination revealed the tumor exhibiting characteristics of active proliferation, he did not receive postoperative radiotherapy. The chief complaints for which he sought medical help at our hospital included blurring, ptosis, and limitation of extraocular movement. The recurrent tumor occupied the lateral skull base as depicted in the contrast-enhanced MRI (Figure 3A and B). The maxillary swing approach was selected to provide enhanced lateral exposure of the tumor that firmly adhered to the adjacent tissues within the extracranial space, thereby challenging the dissection planes. Under direct visualization, stripping of the tumor from the lateral wall of the cavernous sinus in a single piece (Figure 3C) and confirmation of intact dura with negative margins by intraoperative fresh-frozen sectioning were performed to obtain local disease control. A postoperative MRI revealed total resection of the tumor (Figure 3D-F). He developed

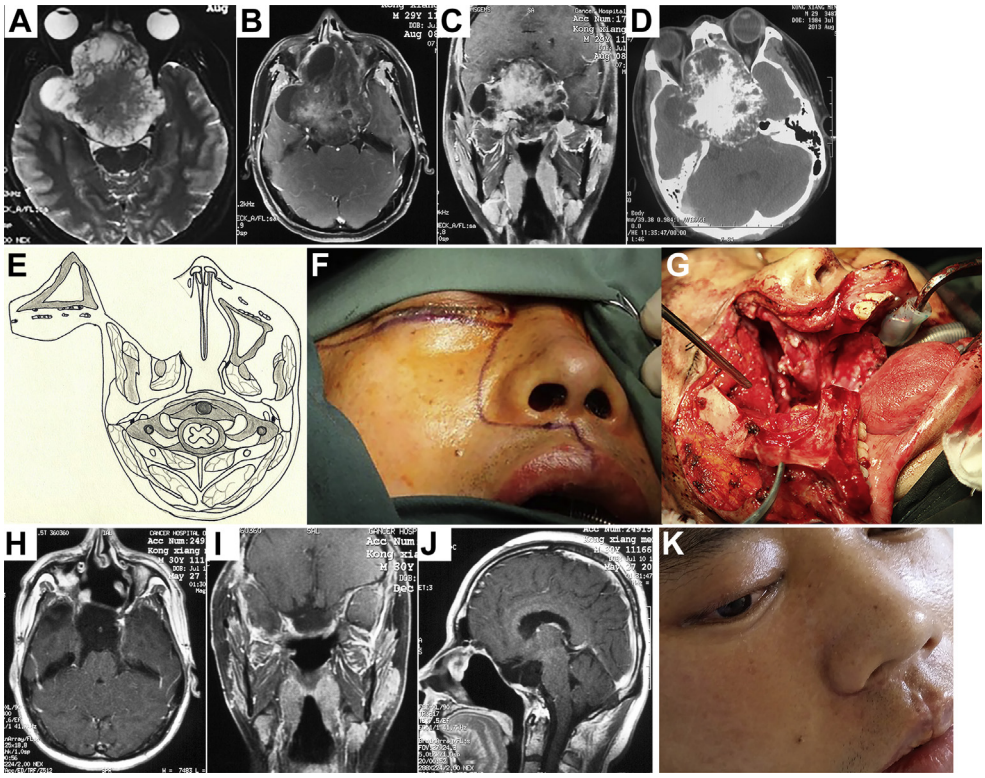

Figure 2. Representative case of fibrous dysplasia harboring transdural growth pattern. (**A**) Heterogeneous signal intensity on plain T2-weighted MRI demonstrated a large lesion containing cystic/necrotic areas. (**B, C**) The hypervascularized lesion infiltrated the brain parenchyma and was unevenly enhanced on T1-weighted post-gadolinium MRI. (**D**) There was stone-like calcification in the core of the mass, which also presented aggressive features of bone destruction on CT scans. (**E**) Diagram of the skull base illustrated the surgical techniques of the maxillary swing approach, and (**F**) the facial incisions were planned. After adequate exposure to the retromaxillary area, (**G**) complete excision of the lesion was accomplished, (**H**–**J**) confirmed by postoperative contrast MRI. (**K**) The cosmetic results were acceptable without visible facial scars 3 months after surgery. CT, computed tomography; MRI, magnetic resonance imaging.

trismus and palatal fistula after surgery. He wore an obturator dental plate to facilitate swallowing. Most of the fistulae shrunk with time, accompanied by trismus improvement. He had a definitive histological diagnosis of malignant peripheral nerve sheath tumor (WHO III) and refused adjuvant radiotherapy. Fortunately, no locoregional tumor recurrence was observed after 144 months.

Case 3. A 32-year-old man tolerated nasal obstruction, anosmia, and persistent facial numbness for 4 months and sought medical attention when facial deformity developed. Flattening of the left nasolabial fold and slight mouth drooping were observed on admission. Preoperative computed tomography and MRI scans showed a large and hypervascularized lesion centered at the petroclival region, destroying the bones, occupying multiple craniofacial compartments, and migrating into the subdural region (Figure 4A-D). Sufficient exposure and complete resection in one stage without severe bleeding could not be achieved with any standalone approaches. Therefore, the maxillary swing approach combined with Kawase's approach was performed. After lateral reflection of the maxilla, the lesion was exposed, and the internal maxillary artery was ligated and transected. The extracranial portion of the rubber-like multilobulated tumor was transected at its extension into the Meckel's cave using a scalpel because of its fibrous consistency. Dissection continued through the petroclival region to the cerebellopontine angle. The remnant subdural segment was then completely stripped away from the arachnoid membrane, allowing resolution of the mass effect on the brain stem. Following hemostasis and antibiotic irrigation of the surgical field, multilayer reconstruction of the skull base was started with dural suture. The extradural area was then packed with the temporalis fascia, periosteum, and pedicled temporalis muscle to reinforce the dural repair. Computed tomography scans immediately after surgery demonstrated complete resection of the lesion (Figure 4E). He developed facial numbness and experienced temporary dry eye postoperatively. Intracranial infection secondary

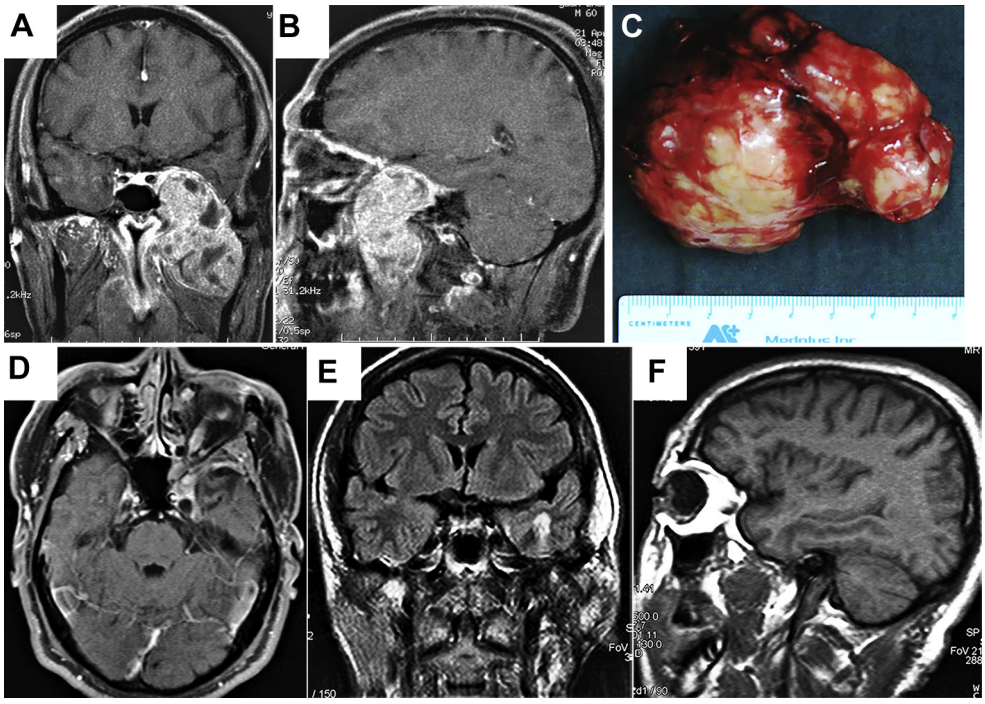

Figure 3. Recurrent MPNST (WHO III) allocated in the skull base were completely resected via the maxillary swing approach. A large and extensive tumor occupying multiple compartments, including the parasellar area, Meckel's cave, temporal fossa, PPF, ITF, and parapharyngeal space, as depicted in contrast T1-weighted MRI (**A, B**), exhibited heterogeneous enhancement due to necrosis or cystic degeneration. The patient experienced tumor resection in a piecemeal fashion before admission to our hospital. Following maxilla reflection, we identified and removed the recurrent tumor as a whole (**C**). Postoperative MRI confirmed total removal of the tumor (**D**–**F**). ITF, infratemporal fossa; MPNST, malignant peripheral nerve sheath tumor; MRI, magnetic resonance imaging; PPF, pterygopalatine fossa; WHO, World Health Organization.

to cerebrospinal fluid leak occurred 4 days after surgery and was resolved by antibiotic therapy accompanied by a lumbar drain. The final diagnosis was schwannoma based on the histological findings, and there was no evidence of recurrence (Figure 4F-H).

Case 4. A 34-year-old female patient suffered chronic headache and a 4-month history of progressive anosmia, blurring, and exophthalmos. On neurological examination, vision loss and partial cranial nerves I, II, III, and V palsy of the right eye were observed. A hypervascular tumor destructed bony structures in the central skull base and invaded the subdural space (Figure 5A-D). The minimally invasive surgery was not recommended because of i) severe bleeding due to tumor debulking, ii) poor prognosis caused by piecemeal resection, and iii) difficulties in reconstruction of composite skull base defects. Hence, the maxillary swing approach was performed, followed by excision of the hypervascular tumor in one piece. When negative margins were obtained, the defects created in the cranial fossa were repaired using the temporalis fascia, pedicled pericranial flap, and temporalis muscle. There were no surgical complications. The tissue diagnosis was paraganglioma. She was relieved of visual defects and limitation of extraocular movements at the follow-up. The MRI scans demonstrated no evidence of tumor regrowth (Figure 5E and F).

DISCUSSION

The central skull base represents a complex intersection between various anatomic structures, including the sellar, clivus, orbits, and nasopharynx.[4,13] Extensive lesions may wholly occupy several compartments or even cross the midline toward the contralateral side in communication with the subdural space, leading to surgical frustration and therapeutic dilemmas.[10,11] Therefore, the surgical approach that can provide excellent exposure to particular locations and allow for direct visualization of dissection planes in extreme situations is indispensable.

Several surgical techniques have reached central skull base lesions occupying multiple compartments, such as the Fisch preauricular infratemporal approach, Derome's approach, and endoscopic procedures.[14,15] First successfully performed by Joseph Gensoul in 1827, the maxillectomy paved the way for addressing central skull base lesions.[16] In 1986, Hernández Altemir[17] pioneered access to the clivus and retromaxillary areas by temporarily disarticulating the maxilla attached to the cheek, which was then named the maxillary swing approach.[7,18] The

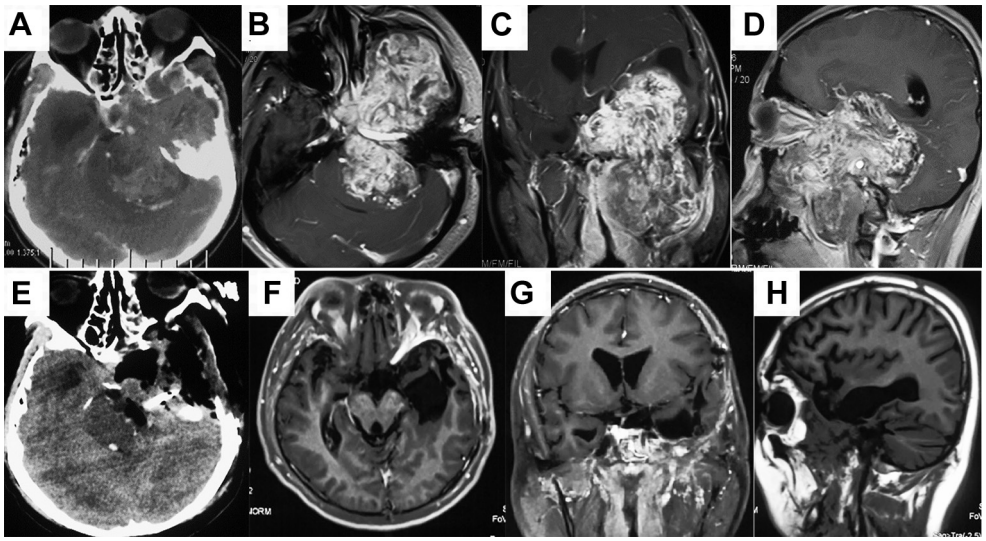

Figure 4. A combined craniofacial resection of the large and rubbery schwannoma was performed. (**A**) Preoperative CT scans revealed an extensive lesion destructed the petrous bone and migrated anteriorly and posteriorly. (**B**–**D**) Significant enhancement mixed with discrete hypointensity on contrast T1-weighted MRI demonstrated a hypervascularized lesion with features of fibrosis. After removing the extracranial portion via the maxillary swing approach, dissection proceeded along the intradural segment using Kawase's approach to obtain a complete resection in one stage, which was confirmed on (**E**) CT scans and (**F**–**H**) MRI. CT, computed tomography; MRI, magnetic resonance imaging.

indications were expanded by Wei et al.[17] who provided sufficient exposure down to the level of the parapharyngeal space.[18] Recently, the maxillary swing approach has still enabled sufficient visual field and working space by performing osteotomies with possibilities of further identifying the contralateral compartments and en bloc resection of extensive lesions.[3,10,17-20]

In the present study, we adopted the maxillary swing approach to address extensive lesions at the central skull base under exceptional circumstances. We believe that the maxillary swing approach remains valuable based on our retrospective data.

1) Adequate visualization for en bloc excision of large masses. Surgical freedom and angle of attack are determined by the bony structures impeding the maneuverability of instruments.[1,21] Reaching deep and lateral lesions that grow into multiple compartments may be difficult through a restrictive corridor because the surgical procedure is limited by the nares, nasolacrimal duct, and bony walls of paranasal sinuses.[8,21,22] Therefore, en bloc excision of malignant tumors can hardly be achieved, while piecemeal resection will lead to high rates of tumor dissemination and recurrence.[9,23] In our series, the maxillary swing approach has provided enhanced exposure due to lateral entry on the horizontal plane and a direct anteroposterior angle of attack in the sagittal section. The vision line on the surgical cavity was straight in almost all cases. Furthermore, a significantly augmented working space was achieved, decreasing the surgical struggle caused by the conflict between frustrated angled instrumentation. In the case of malignant tumors, radical extirpation without dividing the lesions has been accomplished, followed by intraoperative fresh-frozen sectioning that confirmed clean surgical margins, thereby resulting in long-term disease control.

2) Pure circumferential stripping of hypervascularized masses with fibrous or calcified consistency. It must be emphasized that the characteristics of the lesions should partially determine the choice of surgical approach.[24] For instance, circumferential dissection of the hypervascularized and hard mass as a whole is feasible and appropriate since severe bleeding cannot be effectively avoided when performing piecemeal resection, and few surgical instruments can provide fragmented debulking of tumors with features of stone-like calcification or rubber-like fibrosis. Instead, a widened approach can facilitate devascularization and ensure safe dissection of neurovascular structures.[23-26] In our study, the maxillary swing approach provided direct access to fibrous or calcified lesions, establishing sufficient margins around the masses which were then peeled off in a single piece, resulting in minimal blood loss.

3) Identifying dissection planes of recurrent tumors. The anatomical landmarks of the central skull base have always been distorted after local relapse, particularly when patients received adjuvant therapy.[24] The recurrent tumors that firmly adhere to the surrounding structures challenge the dissection planes, which may lead to a subtotal resection.[25] Following

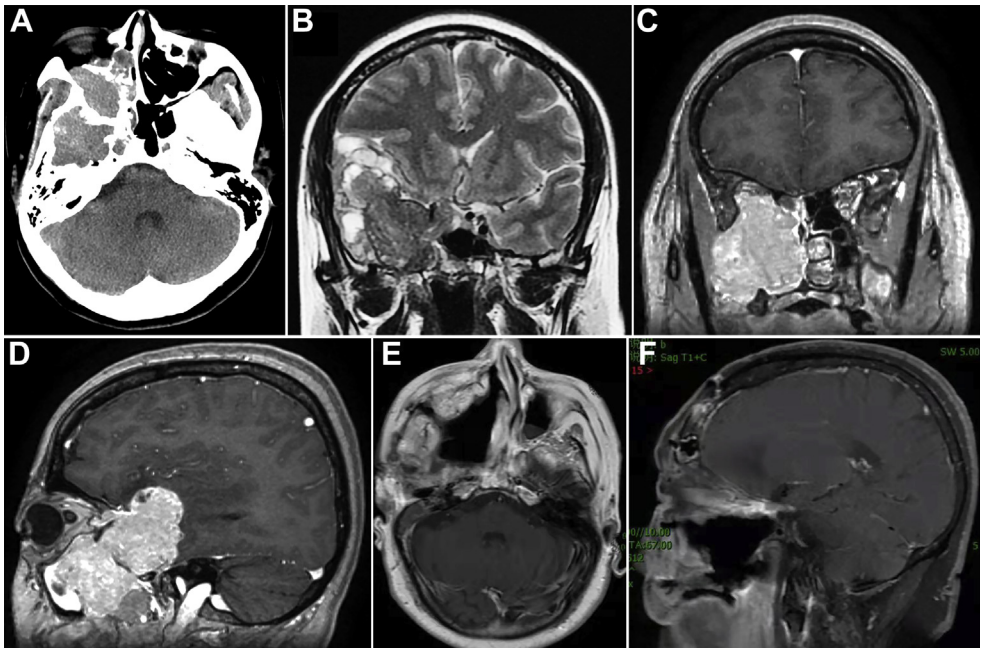

Figure 5. A rare case of the hypervascularized paraganglioma in the central skull base was radically resected as a single piece. (**A**) Extensive bone destruction caused by the heterogeneous density tumor could be observed on CT scans. Features of a highly vascular lesion included flow void signal as depicted in (**B**) plain T2-weighted MRI and (**C**, **D**) vivid contrast enhancement in T1-weighted post-gadolinium MRI. After radical excision of the tumor, the skull base defects were reconstructed. (**E**, **F**) Postoperative contrast MRI demonstrated an absence of tumor. CT, computed tomography; MRI, magnetic resonance imaging.

the swing of the maxilla, we established spacious access to identify the tumor interface and detach the planes of adherence using sharp dissection. Negative tumor borders were also verified by pathological analysis.

The maxillary swing approach may result in several complications, and the most common one is cranial nerves morbidity.[9,10,12] In this study, 4 patients suffered facial numbness/pain because of intraoperative traction, vascular insufficiency, or damage to the infraorbital neurovascular bundle. Elevating the periosteum of the maxillary sinus may result in infraorbital nerve paresthesia.[9,23] Three patients experienced dry eye caused by decreased lacrimation, presumably resulting from vidian nerve sacrifice related to this approach. Additionally, 2 patients developed palatal fistula, and an obturator was used to improve speaking and swallowing. Ng and Wei[27] described modifications to avoid the midline incision, which could minimize the formation of palatal fistula. Also, several techniques have been performed to repair the velopharyngeal insufficiency, such as sphincter pharyngoplasty and posterior pharyngeal wall augmentation.[9] The management of fistula will be conducted by using the pharyngeal flap in our further studies.

Although the maxillary swing approach is recommended for large extensive lesions located at the central skull base, perioperative complications and prolonged recovery time may raise doubts on whether minimally invasive surgery shall be preferred. The benefits and limitations of the maxillary swing approach have been considered (Table 2). In our retrospective study of extreme cases, given the limited number of patients and selection bias, it is difficult to draw a comparison of prognostic factors between different cohorts regarding diverse pathologies of the lesions. Nevertheless, our results suggest that the maxillary swing approach can be applied to extreme cases, as previously

Table 2. Pros and Cons of the Maxillary Swing Approach for Central Skull Base Lesions

Pros	Cons
■ Excellent exposure of large and deep-seated lesions occupying multiple compartments	■ Steep and long learning curve of surgical procedures
■ Peeling off hypervascularized and hard masses in 1 single piece	■ Longer operating time
■ En bloc excision with negative margins	■ Perioperative complications such as facial trauma, palatal fistula, and trismus
■ Avoiding severe bleeding	■ More medical expenses and prolonged recovery time
■ Tumors distorting the anatomical landmarks after relapse and adjuvant therapy	

illustrated when surgeons have reasonable doubts about using minimally invasive techniques.

CONCLUSIONS

We have provided case illustrations and reviewed the clinical data regarding the maxillary swing approach for lesions in the central skull base. The preliminary results suggest that this open procedure can be performed in extreme cases, such as 1) giant masses occupying multiple compartments, 2) hypervascularized lesions exhibiting features of significant fibrosis or stone-like calcification, and 3) recurrent tumors firmly adhering to the adjacent tissues and distorting the anatomical landmarks. Sufficient exposure has the advantage of en bloc resection with acceptable morbidity. Patients harboring recurrent tumors can also benefit from this technique.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Fuxing Zuo: Conceptualization, Methodology, Funding acquisition, Surgery, Perioperative management of patients, Investigation, Formal analysis, Writing — original draft, Finally approved the manuscript. **Shilu Ye:** Perioperative management of patients, Investigation, Formal analysis. **Haipeng Qian:** Conceptualization, Methodology, Surgery, Perioperative management of patients, Finally approved the manuscript. **Shaoyan Liu:** Surgery. **Jinghai Wan:** Conceptualization, Methodology, Funding acquisition, Surgery, Finally approved the manuscript.

ACKNOWLEDGMENT

The authors thank Meng-Yan Zhang for technical assistance.

REFERENCES

1. Simon F, Vacher C, Herman P, Verillaud B. Surgical landmarks of the nasopharyngeal internal carotid using the maxillary swing approach: a cadaveric study. *Laryngoscope*. 2016;126:1562-1566.
2. Ketcham AS, Wilkins RH, Vanburen JM, Smith RR. A combined intracranial facial approach to the paranasal sinuses. *Am J Surg*. 1963;106:698-703.
3. Kalra GS, Midya M, Bedi M. Access to the skull base - maxillary swing procedure - long term analysis. *Ann Maxillofac Surg*. 2018;8:86-90.
4. Borges A. Skull base tumours Part II. Central skull base tumours and intrinsic tumours of the bony skull base. *Eur J Radiol*. 2008;66:348-362.
5. Janecka IP, Sen CN, Sekhar LN, Arriaga M. Facial translocation: a new approach to the cranial base. *Otolaryngol Head Neck Surg*. 1990;103:413-419.
6. Krischek B, Carvalho FG, Godoy BL, Kiehl R, Zadeh G, Gentili F. From craniofacial resection to endonasal endoscopic removal of malignant tumors of the anterior skull base. *World Neurosurg*. 2014;82(6 Suppl):S59-S65.
7. Wei WI, Lam KH, Sham JS. New approach to the nasopharynx: the maxillary swing approach. *Head Neck*. 1991;13:200-207.
8. Roger V, Patron V, Moreau S, Kanagalingam J, Babin E, Hitier M. Extended endonasal approach versus maxillary swing approach to the parapharyngeal space. *Head Neck*. 2018;40:1120-1130.
9. London NR Jr, Chan JYW, Carrau RL. Transpalatal approaches to the skull base and reconstruction: indications, technique, and associated morbidity. *Semin Plast Surg*. 2020;34:99-105.
10. Dini LI, Isolan GR, Flores E, Lombardo EM, Heitz C. Anterior skull base tumors: the role of transfacial approaches in the endoscopic era. *J Craniofac Surg*. 2018;29:226-232.
11. Schwartz TH, Morgenstern PF, Anand VK. Lessons learned in the evolution of endoscopic skull base surgery. *J Neurosurg*. 2019;130:337-346.
12. Chan JY, Wei WI. Critical appraisal of maxillary swing approach for nasopharyngeal carcinoma. *Expert Opin Ther Targets*. 2012;16(Suppl 1):S111-S117.
13. Chapman PR, Bag AK, Tubbs RS, Gohlke P. Practical anatomy of the central skull base region. *Semin Ultrasound CT MR*. 2013;34:381-392.
14. Kawakami K, Yamanouchi Y, Kubota C, Kawamura Y, Matsumura H. An extensive transbasal approach to frontal skull-base tumors. Technical note. *J Neurosurg*. 1991;74:1011-1013.
15. Fisch U. Infratemporal fossa approach to tumours of the temporal bone and base of the skull. *J Laryngol Otol*. 1978;92:949-967.
16. Benmoussa N, Kerner J, Josset P, Conan P, Charlier P. A 1842 skull from Dupuytren's museum of Paris: an original artifact of Joseph Gensoul first maxillectomy technique. *Eur Arch Otorhinolaryngol*. 2017;274:175-179.
17. Hernandez Altemir F. Transfacial access to the retromaxillary area. *J Maxillofac Surg*. 1986;14:165-170.
18. Dubey SP, Molumi CP, Apaio ML. Total maxillary swing approach to the skull base for advanced intracranial and extracranial nasopharyngeal angiofibroma. *J Craniofac Surg*. 2011;22:1671-1676.
19. Origitano TC, Petruzzelli GJ, Leonetti JP, Vandevender D. Combined anterior and anterolateral approaches to the cranial base: complication analysis, avoidance, and management. *Neurosurgery*. 2006;58(4 Suppl 2):ONS-327-ONS-336 [discussion: ONS-336-ONS-337].
20. Mathur NN, Vashishth A. Extensive nasopharyngeal angiofibromas: the maxillary swing approach. *Eur Arch Otorhinolaryngol*. 2014;271:3035-3040.
21. Muhanna N, Chan H, Qiu J, et al. Volumetric analysis of endoscopic and maxillary swing surgical approaches for nasopharyngectomy. *J Neurol Surg B Skull Base*. 2018;79:466-474.
22. Liu JK, Decker D, Schaefer SD, et al. Zones of approach for craniofacial resection: minimizing facial incisions for resection of anterior cranial base and paranasal sinus tumors. *Neurosurgery*. 2003;53:1126-1135 [discussion: 1135-1127].
23. Kasemsiri P, Carrau RL, Ditzel Filho LF, et al. Advantages and limitations of endoscopic endonasal approaches to the skull base. *World Neurosurg*. 2014;82(6 Suppl):S12-S21.
24. Jacquesson T, Berhouma M, Tringali S, Simon E, Jouanneau E. Which routes for petroclival tumors? A comparison between the anterior expanded endoscopic endonasal approach and lateral or posterior routes. *World Neurosurg*. 2015;83:929-936.
25. Cappabianca P, Cavallo LM, Esposito F, De Divitiis O, Messina A, De Divitiis E. Extended endoscopic endonasal approach to the midline skull base: the evolving role of transsphenoidal surgery. *Adv Tech Stand Neurosurg*. 2008;33:151-199.
26. Kassam AB, Prevedello DM, Carrau RL, et al. The front door to meckel's cave: an anteromedial corridor via expanded endoscopic endonasal approach- technical considerations and clinical series. *Neurosurgery*. 2009;64(3 Suppl):ons71-ons82 [discussion: ons82-ons73].
27. Ng RW, Wei WI. Elimination of palatal fistula after the maxillary swing procedure. *Head Neck*. 2005;27:608-612.

Conflict of interest statement: This work was supported by the CAMS Innovation Fund for Medical Sciences (CIFMS) [grant number 2020-I2M-C&T-B-071] and the National Natural Science Foundation of China [grant numbers 81701262, 82072803].

Jinghai Wan and Haipeng Qian are co-corresponding author.

Received 15 April 2022; accepted 4 July 2022

Citation: World Neurosurg. (2022). https://doi.org/10.1016/j.wneu.2022.07.009

*Journal homepage: **www.journals.elsevier.com/world-neurosurgery***

*Available online: **www.sciencedirect.com***