Four hand technique in petroclival meningioma surgery: results from 44 Danish patients

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Abstract

Here, we present clinical data from 44 patients who underwent surgery for petroclival meningiomas over the last 15 years using four-hand technique with a median operative time of 3.2 hours in the most recent patients. In 87%, preoperative symptoms improved, but 77% developed a new neurological deficit, and 7% had a severe surgical complication. In 34% radiotherapy was used as adjuvant therapy. After a median follow-up time of 72 months, 43% had returned to work, but 23% were not working because of the disease.

Introduction

Petroclival meningiomas account for approximately 2% of intracranial meningiomas and represent a significant surgical challenge due to their deep location and proximity to critical neurovascular structures. The choice of surgical approach is guided by tumor and patient factors, and surgery carries a high risk of postoperative complications and neurological deficits. Consequently, the treatment paradigm has shifted from radical to 'functional-based resection'. Radiotherapy can be used as a primary or adjuvant treatment.

Since 2009, all major skull base surgeries in our department have been performed using the 'four hand technique.' This involves two dedicated skull base surgeons operating face-to-face across the patient's head, using a microscope with two opposite binocular eyepieces. This technique ensures three-dimensional stereoscopic imaging of the surgical field for both surgeons (**Figure 1**). In this series of 44 patients who underwent resection of petroclival meningiomas over the past 15 years at our institution, we examined patient, tumor, and surgical factors, postoperative complications, including new neurological deficits, and overall outcomes.

Figure 1. With 'four hand technique' the two surgeons are seated face-to-face on each side of the patient's head which enhances the use of the operating microscope and allows four hands to work simultaneously in the operating field

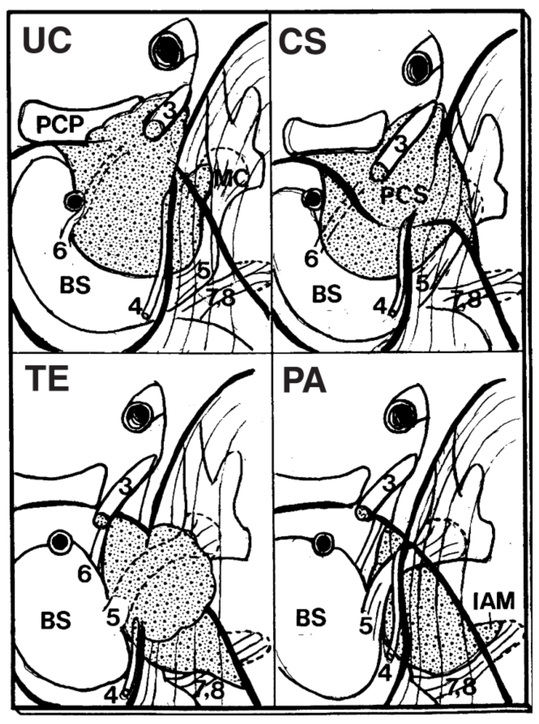

Figure 2. Four subtypes of petroclival meningiomas as described by Kawase (Ichimura et al., 2008)

BS, Brains stem; CS, Cavernous sinus type; MC, Meckel's cave; PA, Petrous apex type; PCP, Posterior clinoid process; PCS Posterior cavernous sinus; TE, tentorium type, UC, Upper clivus type

Methods and Materials

Study Design

Retrospective single-center cohort study of patients who underwent first-time surgical resection of a petroclival meningioma between January 2009 and December 2024. Petroclival meningiomas were defined according to Kawase (Ichimura et al., 2008) by their origin at the petroclival border medial to the internal auditory canal and further classified into four subtypes according to their major attachment and direction of trigeminal shift (**Figure 2**).

Patient and Tumor Variables

Patient variables included age, sex, surgery date, preoperative symptoms, preoperative Karnofsky performance status (KPS), and follow-up duration. Tumor variables included WHO grade and the following tumor MRI findings: maximum diameter, volume, subtype, involvement of cavernous sinus, Meckel's cave, internal auditory canal, or jugular foramen, peritumoral T2 cleft, presence of FLAIR signal changes in the brainstem, and secondary hydrocephalus. Tumor volume was quantified using BrainLab Smartbrush software (BrainLab AG, Germany).

Surgical Variables and Outcome

Surgical variables included single-stage vs. two-stage resection, surgical approach, operative time, need for ventricular-peritoneal shunt, extent of resection on postoperative MRI, and the use of postoperative radiotherapy. Outcomes of interest included improvement in preoperative deficits, severe surgical complications, i.e., infarct and postoperative hematomas requiring evacuation, and new neurological deficits.

Statistical Analysis

Categorical data are presented as frequencies and continuous data as medians and interquartile ranges (IQR) or ranges. We used IBM SPSS Statistics 29 for analysis (IBM, NY, USA).

Results

Table 1 presents patient and tumor characteristics. The median age was 54.5 years, with 84% women. Around 2/3 of the patients underwent surgery because of progressive symptom, and preoperatively, the most common symptoms were trigeminal neuropathy (59%), gait ataxia (48%), and ipsilateral hearing loss (41%). The median maximal tumor diameter was 35 mm, and the median tumor volume 15 cm^3.

Table 2 presents the surgical variables and outcomes. Half of the patients underwent a retrosigmoid approach, and 46% a combined petrosal approach. Only 3 patients had staged procedures. In the most recent 22 patients where data were available, the median operative time was 3.2 hours, and half of these were through a combined petrosal approach, where the median operative time was 3.5 hours. Gross or near-total resection was achieved in 21%, and 34% received postoperative radiotherapy.

In 33 of the 38 patients (87%) with preoperative neurological deficits the deficits improved. However, 34 of the 44 patients (77%) developed a new neurological deficit, most commonly abducens palsy (36%), trigeminal nerve palsy (33%) and ipsilateral hearing loss (27%). The perioperative mortality was 0%, but 3 patients (7%) had a stroke (PICA or SCA), and 1 (2%) required evacuation of a postoperative hematoma. At follow-up, 43% were still working, 23% were on sick leave or pension because of the disease, and 27% were on pension from other causes. Three patients (7%) had died in the follow-up period from unrelated causes. The median follow-up time was 72 months.

Table 1. Patient and tumor characteristics

Median age, years (range)	54.5 (28 - 81)
Sex, n (%)	
Men	7 (15.9)
Women	37 (84.1)
Side, n (%)	
Right	20 (45.5)
Left	24 (54.5)
Median KPS (range)	90 (70 - 90)
Tumor subtype, n (%)	
Upper clivus	11 (25.0)
Cavernous sinus	11 (25.0)
Tentorium	13 (29.5)
Petrous apex	8 (18.2)
Unknown	1 (2.3)
MRI findings	
Median maximal diameter, mm (range)[a]	35 (12 - 60)
Median tumor volume, cm^3 (range)[b]	15 (1 - 63)
Cavernous sinus involvement, n (%)	14 (31.8)
Meckel's cave involvement, n (%)	32 (72.7)
Internal auditory canal involvement, n (%)	29 (65.9)
Jugular foramen involvement, n (%)	12 (27.3)
FLAIR signal changes in brain stem, n (%)[c]	11 (25.0)
T2 cleft around tumor, n (%)[c]	11 (25.0)
Hydrocephalus, n (%)	9 (20.5)
Indication for surgery, n (%)	
Progressive symptoms	27 (61.4)
Tumor growth	12 (27.3)
Combination of symptoms and growth	5 (11.4)
Preoperative symptoms, n (%)	
Headache	11 (25.0)
Fatigue	13 (29.5)
Cognitive dysfunction	4 (9.1)
Trigeminal neuropathy	26 (59.1)
Diplopia (abducens palsy)	2 (4.5)
Facial palsy	2 (4.5)
Ipsilateral hearing loss	18 (40.9)
Hoarseness or dysphagia	6 (13.6)
Gait ataxia	21 (47.7)
Hemiparesis	3 (6.8)
WHO grade, n (%)	
1	41 (93.2)
2	3 (6.8)

FLAIR, Fluid-attenuated inversion recovery; KPS, Karnofsky performance status; MRI, Magnetic resonance imaging; WHO, World Health Organization

[a]n = 43, [b]n = 38, [c]n = 41

Table 2. Surgical variables and outcomes

Surgical approach, n (%)	
Subtemporal anterior transpetrosal (Kawase)	2 (4.5)
Retrosigmoid	22 (50)
Combined petrosal	20 (45.5)
Median operative time, hours (range)[a]	3.2 (1.1 - 5.3)
Staged procedures, n (%)	3 (6.8)
Ventriculoperitoneal shunt, n (%)	3 (6.8)
Extent of resection, n (%)	
GTR/NTR	9 (20.5)
STR	35 (81.4)
Postoperative radiotherapy, n (%)	15 (34.1)
Surgical complications, n (%)	
Postoperative cerebral infarction	*3 (6.8)*
Evacuation of post-operative hematoma	*1 (2.3)*
Perioperativ mortality	*0 (0.0)*
New neurological deficit, n (%)	
Hemiparesis	5 (12.2)
Gait ataxia	5 (21.7)
Occolomotor nerve	3 (6.8)
Trochlear nerve	11 (25.0)
Trigeminal nerve	6 (33.3)
Abducens nerve	15 (35.7)
Facial nerve	4 (9.5)
Cochlear nerve	7 (26.9)
Lower craniel nerves	2 (5.3)
Improvement in neurological deficits, n (%)	
Trigeminal nerve	19 (26.9)
Abducens nerve	2 (100)
Facial nerve	2 (100)
Cochlear nerve	14 (77.8)
Lower craniel nerves	6 (100)
Gait ataxia	12 (57.1)
Hemiparesis	3 (100)
Status at follow up, n (%)	
Working	19 (43.2)
Sickleave	4 (9.1)
Pension due to meningeoma	6 (13.6)
Pension other causes (age etc)	12 (27.3)
Dead	3 (6.8)
Median follow-up time, months (IQR)	71.5 (104)

GTR, Gross total resection; NTS, Near total resection; STR, subtotal resection

[a]n = 22

Discussion

Petroclival meningiomas are rare tumors often with complex growth along the petroclival border and into the surrounding anatomical spaces. This study describes the presenting symptoms and surgical outcomes of 44 patients operated in our department over the last 15 years using 'four hand technique.' The median surgery time for the most recent patients was 3.2 hours, which is lower than described in other newer studies (Nguyen et al., 2023; Wagner et al., 2022) and surgery time has previously been associated with surgical complications (Murphy et al., 2016; Nguyen et al., 2023). Only 20% of the patients had total or near-total resection, which is comparable to other recent case series (Nguyen et al., 2023; Wagner et al., 2022). Postoperatively, 34% received radiotherapy, which is comparable to a recent German study (Wagner et al., 2022) but lower than in another recent US study (Nguyen et al., 2023). This may reflect a local preference for documented tumor remnant growth before radiotherapy. The 9% surgical complication rate is lower than in other recent series, but 77% with new neurological deficits is comparable (Baric et al., 2022, Nguyen et al., 2023; Wagner et al., 2022). Limitations of this study include the retrospective design, relatively low patient number, and short follow-up time in some cases. A strength is the relatively long median follow-up time, which is higher than in comparable studies (Nguyen et al., 2023; Wagner et al., 2022).

Conclusions

Petroclival tumors continue to present a surgical challenge, but surgery time can be significantly reduced by four hand technique, where two dedicated skull base surgeons work together face-to-face on each side of the patient's head.

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