ORIGINAL ARTICLE

Successful Retractorless Surgery: A Single-Center Experience in the Management of Deep-Seated and Skull Base Lesions

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Background: In contemporary neurosurgical practices, there is a trend towards minimally invasive procedures and the utilization of advanced radiotherapeutic interventions (Neurointervention) to mitigate the impact on brain tissue. One approach employed is the reduction or elimination of fixed retraction during surgery.

Objective: To investigate the success outcomes and complications associated with the use of retractorless technique in surgeries involving deep-seated brain and the skull base lesions in Ratchaburi Hospital.

Materials and Methods: The retrospective study conducted data collection from the patient medical records diagnosed with brain tumors and cerebral aneurysms that underwent surgical treatment for lesions in the deep-seated and skull base regions at Ratchaburi Hospital. The present study spanned between August 2014 and August 2022 including cases operated on by single neurosurgeon, utilizing both fixed retraction and retractorless neurosurgical techniques.

Results: Four hundred thirty-one patients were included in the present study, with 222 cases (51.5%) presenting with aneurysms, and the remaining 209 cases (48.5%) diagnosed with tumors, predominantly meningiomas. Within the tumor group, retractorless was conducted in 196 out of 209 cases, representing 93.8%. In the aneurysm group, retractorless was performed in 183 out of 222 cases, constituting 82.4%. The overall success rate of retractorless surgery was 87.9%. No intraoperative complications were found.

Conclusion: Performing retractorless surgery contributes to a reduction in brain tissue trauma. Employing instruments during surgery aids in retracting brain tissue replacing the need for fixed retractors. Additionally, wide dissection of the arachnoid membrane is performed, patient positioning is optimized to use gravitational forces, which facilitates the process, and cerebrospinal fluid drainage results in brain decompression. The combination of these strategies, along with selecting surgical approaches that avoid traversing through brain tissue, collectively enhances the success rate of retractorless surgery.

Keywords: Brain edema; Brain retraction injury; Retractorless surgery; Minimally invasive surgery; Skull base

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Modern neurosurgery has been widely acknowledged as the conventional therapeutic approach for addressing deep-seated lesions within the skull base over decades. The integration of a microscope, along with the utilization of a fixed or rigid retractor, has been instrumental in achieving the operative objective[1,2]. However, reports of brain retraction injuries resulting from the use of fixed retractors have been documented, encompassing a spectrum of complications from local tissue injury to diminished blood flow and subsequent complications[3-6]. Various methods and techniques have been developed to diminish the risk of brain retraction injury. Intermittent retraction has been introduced as an alternative to continuous retraction[7,8], and the avoidance of fixed retraction[9,10], commonly referred to as retractorless or dynamic surgery.

In the present study, the author presented the success rate and complications associated with the use of retractorless technique in surgeries involving deep-seated brain and skull base lesions in Ratchaburi Hospital. The procedures were conducted by a single surgeon over an extended period, utilizing basic operating room instruments.

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Materials and Methods

The present study was conducted in a retrospective design, which the data was collected from medical records, and comprised patients with deep-seated and skull base lesions who underwent surgical treatment at Ratchaburi Hospital, between August 2014 and August 2022. The inclusion criteria encompassed individuals with deep-seated brain tumors, skull base tumors, and cerebral aneurysms. Exclusion criteria were individuals with a history of previous brain surgery and those that undergone transsphenoidal surgery. Notably, all surgical procedures were performed by a single surgeon (KS).

Each surgical procedure adhered to a standardized approach. Pterion and supraorbital approaches were used for anterior cranial fossa lesions and anterior circulation aneurysms. Suboccipital, far lateral, presigmoid approaches were used for posterior cranial fossa lesions and posterior circulation aneurysms. Interhemispheric approach was used for midline lesions. Lesions localized in lobes were approached according to their location.

Following anesthesia, mannitol was administered at a dose of 1 mg/kg, and lumbar drain was not utilized. Steroid was administered in cases involving tumors to mitigate edema. Standard microsurgical techniques tailored to the specific location of the lesions. The patient's head was strategically positioned to facilitate gravity-aided retraction. External ventricular drainage was instituted in cases of hydrocephalus. After durotomy, the arachnoid plane was expansively opened, and cerebrospinal fluid was aspirated to induce brain relaxation. In all cases, dynamic retraction was applied using the shaft of suction devices, bipolar electrocautery, and microinstruments to retract the brain, creating a broad operative field for lesion management. Basic microinstruments were employed exclusively, with no incorporation of advanced instruments. The operating microscope, lacking mouthpiece control (Mitaka MM 90, Mitaka Kohki Ltd.) was employed. For posterior cranial fossa lesions, nerve integrity monitoring was applied as appropriate.

The application of a fixed retractor (Budde-Halo self-retaining system) was instituted when the operation could not continue using the retractorless technique. These included cases of brain swelling and the inability to maintain an open corridor to the lesion continuously, thus compromising the safe management of the lesion.

Complications were divided into intraoperative and immediate postoperative, or within 24 hours. Intraoperative complications included large artery injury such as internal carotid, anterior cerebral, middle cerebral, posterior cerebral, and basilar, and cranial nerve injury. Immediate postoperative complications were documented when a new neurological deficit was detected. Complications were documented in separate groups for each location of lesions.

The present study received approval from the Ratchaburi Research Ethics Committees (RBHEC 043/65).

Statistical analysis was performed using IBM SPSS Statistics, version 21.0 (IBM Corp., Armonk, NY, USA). Data were analyzed in two distinct groups, the deep-seated and skull base tumor group, and the aneurysm group. Patient demographics, type of tumors, size and location of aneurysms, the microsurgical approach employed, and the Hunt and Hess grading[11] specifically in cases of aneurysms. Grade 1, 2, and 3 were defined as good grade while grade 4 and 5 were defined as poor grades. Size of aneurysm was recorded according to the Natural Course of Unruptured Cerebral Aneurysm in Japanese Cohort study[12]. Recording was conducted to document instances when a fixed retractor was employed. Nominal data were expressed as percentages. Differences in categorical variables between groups were assessed using chi-square test, with p-value of less than 0.05 was considered significant.

Results

Four hundred thirty-one patients were included in the present study. The predominant pathology among these patients was cerebral aneurysm, accounting for 222 cases out of the total (51.5%). The deep-seated and skull base tumor group comprised 209 cases out of the total (48.5%).

Within the aneurysm group, the demographic distribution revealed a higher incidence in women with mean age 59.1 years old (Table 1). The most prevalent subtype was posterior communicating artery aneurysm, accounting for 37.4% of cases. Aneurysms fell into small and medium size. Furthermore, according to the Hunt and Hess grading system, 73% of patients with aneurysms in the dynamic retractor group fell into grade 1, 2, and 3 categories, whereas those in the fixed retractor group fell into grade 4 and 5, which was 77%. The fixed retractor was employed in 39 patients (17.6%), and the usage frequency followed a descending order corresponding to the Hunt and Hess grading system,

Table 1. Patient demographics of aneurysm group

Characteristic	n (%)
Sex	
Male	63 (28.4)
Female	159 (71.6)
Age (years)	
Mean±SD	59.1±13.3
Range	16 to 93
Location	
PcomA	83 (37.4)
AcomA	64 (28.8)
MCA	43 (19.4)
Basilar	7 (3.2)
Others	25 (11.3)
Size of aneurysm (maximum dome diameter)	
Small (<5 mm)	143 (64.4)
Medium (5 to 10 mm)	69 (31.1)
Large (10 to 25 mm)	10 (4.5)
Hunt and Hess grade	
Good grade (grade 1, 2, 3)	143 (64.4)
Poor grade (grade 4, 5)	79 (35.6)

PcomA=posterior communicating artery; AcomA=anterior communicating artery; MCA=middle cerebral artery; SD=standard deviation

Table 2. Hunt and Hess grading in aneurysm patients and type of retractor

Hunt and Hess grade	Retractor; n (%)		p-value
	Dynamic retractor	Fixed retractor	
Good grade	134 (73)	9 (23)	<0.001
1	20 (11)	0 (0)	
2	96 (52)	4 (10)	
3	18 (10)	5 (13)	
Poor grade	49 (27)	30 (77)	
4	31 (17)	12 (31)	
5	18 (10)	18 (46)	

grade 5 at 46%, grade 4 at 31%, grade 3 at 13%, and grade 2 at 10% (Table 2).

The chi-square test of independence revealed a statistically significant association between Hunt and Hess grading and the type of retractor technique used ($p<0.001$) (Table 2).

Patients in the deep-seated and skull base tumor group numbered 209, with the majority being female with mean age 49.1 years old. Meningioma represents the most prevalent tumor type within this subgroup, constituting 80 out of the 209 cases (38.3%) (Table 3). Thirteen patients in this group required fixed retraction instruments (6%). This subgroup included four cases of thalamic glioma, three cases of basal ganglion lymphoma, three cases of intraventricular tumor, and one case each of corpus callosal glioblastoma, petroclival meningioma, and pinealocytoma (Table 4).

The pterion approach emerged as the predominantly utilized method in both groups (Table 4).

Three hundred seventy-nine patients (87.9%) underwent retractorless surgery. Dynamic retraction demonstrated a higher success rate in tumor cases compared to aneurysms, with success rates of 93.8%

Table 3. Patient demographics of tumor group

Characteristic	n (%)
Sex	
Male	76 (36.4)
Female	133 (63.6)
Age (years)	
Mean±SD	49.1±17.6
Range	1 to 85
Location	
Sellar, parasellar, suprasellar	50 (23.9)
Tuberculum sellae, planum sphenoidale	38 (18.2)
Cerebellopontine angle	46 (22.0)
Frontal, parietal, temporal	20 (9.5)
Medial sphenoid wing	18 (8.6)
Basal ganglion, thalamus	11 (5.3)
Cerebellum	9 (4.3)
Corpus callosal	6 (2.9)
Others (pineal, medulla, foramen magnum)	11 (5.3)
Type of tumors	
Meningioma	80 (38.3)
Pituitary adenoma/craniopharyngioma	43 (20.6)
Schwannoma	21 (10.0)
Glioma	30 (14.4)
Other skull base lesions	35 (16.7)

SD=standard deviation

Table 4. Microsurgical approaches and type of retractor

	Aneurysm n (%)	Tumor n (%)	p-value
Surgical approach			
Pterion	206 (92.8)	98 (46.9)	
Supraorbital	4 (1.8)	16 (7.6)	
Suboccipital	4 (1.8)	56 (26.8)	
Frontal/parietal/temporal	0 (0.0)	24 (11.5)	
Interhemispheric	8 (3.6)	11 (5.3)	
SCIT/far lateral/presigmoid	0 (0.0)	4 (1.9)	
Type of retractor			<0.001
Dynamic retractor	183 (82.4)	196 (93.8)	
Fixed retractor	39 (17.6)	13 (6.2)	

SCIT=supracerebellar infratentorial

Table 5. Complications of aneurysm group

	Total (n=222)	PcomA (n=83) n (%)	MCA (n=43) n (%)	AcomA (n=64) n (%)	Basilar artery (n=7) n (%)	Others (n=25) n (%)
Hemiparesis/hemiplegia	13	4 (4.8)	5 (11.6)	2 (3.1)	1 (14.3)	1 (4.0)
Infarction	4	4 (4.8)	-	-	-	-
Dysphasia, aphasia	2	-	2 (4.7)	-	-	-
Rebleeding	1	-	-	1 (1.6)	-	-
Ptosis	2	-	-	-	2 (28.6)	-
Blindness	1	-	-	-	-	1 (4.0)

PcomA=posterior communicating artery; MCA=middle cerebral artery; AcomA=anterior communicating artery

Table 6. Complications of tumor group

	Total (n=209)	Sellar (n=50) n (%)	TS, PS (n=38) n (%)	CPA (n=46) n (%)	F, P, T (n=20) n (%)	MSW (n=18) n (%)	BS, Thal (n=11) n (%)	Cor (n=6) n (%)	Others (n=11) n (%)
Ptosis	5	4 (8.0)	-	1 (2.2)	-	-	-	-	-
Visual acuity deterioration	8	6 (12.0)	1 (2.6)	-	-	1 (5.6)	-	-	-
Diplopia	1	-	-	1 (2.2)	-	-	-	-	-
Monoparesis	1	-	-	-	1 (5.0)	-	-	-	-
Hemiplegia/hemiparesis	13	1 (2.0)	-	2 (4.3)	-	3 (16.7)	5 (45.5)	1 (16.7)	1 (9.1)
Paraplegia	2	-	-	-	-	-	-	2 (33.3)	-
Quadriplegia	1	-	-	-	-	-	-	-	1 (9.1)
Facial palsy	5	-	-	5 (10.9)	-	-	-	-	-
Facial hypoalgesia	2	-	-	2 (4.3)	-	-	-	-	-
Cerebral infarction	1	-	-	-	-	1 (5.6)	-	-	-
Dysphasia	1	-	1 (2.6)	-	-	-	-	-	-
Rebleeding	6	3 (6.0)	1 (2.6)	-	-	-	-	2 (33.3)	-
Diabetes insipidus	1	1 (2.0)	-	-	-	-	-	-	-

Sellar=sellar, parasellar, and suprasellar; TS=tuberculum sellae; PS=planum sphenoidale; CPA=cerebellopontine angle; F=frontal; P=parietal; T=temporal; MSW=medial sphenoid wing; BS=basal ganglion; Thal=thalamus; Cor=corpus callosal; Others=pineal, medulla, foramen magnum

and 82.4%, respectively. Additionally, the tumor group utilized dynamic retractors significantly more than the aneurysm group, with statistical significance ($p<0.001$) (Table 4).

No intraoperative complications were documented in the present study. The most common immediate postoperative complication within 24 hours in both groups was hemiparesis or hemiplegia. In the aneurysm group, it was found in the middle cerebral artery (MCA) aneurysm surgery, accounting for 11.6% of cases (Table 5). In the tumor group, visual acuity deterioration and ptosis were common immediate postoperative complications in surgeries of sellar, parasellar, and suprasellar tumors, with percentages of 12% and 8%, respectively, while facial palsy was mostly found in surgeries of tumors in the cerebellopontine angle area (10.9%). Some patients experienced more than one complication (Table 6).

Discussion

Contemporary trends in neurosurgery are steering towards minimally invasive approaches, including endoscopic and endovascular treatments. Despite this shift, microneurosurgery continues to play a significant role in the treatment of lesions within the nervous system. The integration of a retractor, alongside the microscope, remains integral to this approach. The retractor serves to widen the angle of views in addressing deep-seated lesions. The introduction of a simple handheld retractor has proven instrumental in assisting surgical operations.

However, prolonged retraction has been associated with issues such as tremor and fatigue among assistants. In response, fixed or rigid self-retaining systems have been developed to mitigate these challenges. The implementation of such systems has significantly advanced and contributed to the success of microneurosurgery.

While modern microneurosurgical instruments and techniques have enabled successful treatment of difficult skull base and deep-seated lesions, the potential for brain retraction injuries still exists, particularly after prolonged traction by fixed retracting systems. Direct injury to brain parenchyma and compromise of vascular supply led to increase morbidity and mortality. Brain retraction injuries have been estimated to occur in 10% of skull base tumor surgeries and 5% of aneurysm surgeries[2,13-17]. Predicting the occurrence of injury from a fixed retractor is challenging, as it can vary from minimal edema to cortical damage.

To alleviate complications arising from fixed retraction, various measures have been developed. Both animal and human experiments, including autoradiography[2,4], somatosensory evoked potential mapping[18,19], and tissue microdialysis[20,21] have sought to identify cellular and molecular mechanisms of injury for minimizing adverse events. However, no definitive measures have been established to reduce these cascades. Intermittent release of the retractor every five minutes is recommended[8,9]. A modified retraction system that detects local cerebral perfusion pressure and alerts when it decreases has been proposed[22]. Other developments in retractors, such as sponge-based retraction systems[23,24], micro-balloon paddy[25], and rolled expanded polytetrafluoroethylene sheets[26], have been explored but have not gained popularity.

Spetzler and Sanai[27] reported a 97% success rate in treating vascular and skull base lesions in 223 patients over a 6-month period without using a self-retaining retractor. Various well-developed instruments, including fiberoptic-lighted malleable suction, nonstick fiberoptic-lighted bipolar electrocautery, and a variety of single-shafted instruments with rotating tips, were utilized. A mouthpiece-controlled microscope was employed to free the surgeon's hands.

Kalani[28] also reported a 94.25% success rate in treating vascular and skull base lesions in 119 patients over a 19-month period without a self-retaining retractor, even when performed by young surgeons. Nazim and Elborady[29] reported a 94.4% success rate in a retrospective collection of 123 cases, excluding aneurysm cases, treated without a self-retaining retractor and advanced operating room equipment.

The present study involved 431 patients with deep-seated and skull base lesions over an 8-year period, categorized into two groups, the tumor group, and the aneurysm group. Dynamic retraction demonstrated a higher success rate in tumor cases compared to aneurysms, with percentages of 93.8% and 82.4%, respectively. Due to subarachnoid hemorrhage from ruptured aneurysms producing brain swelling, especially in high grade groups according to Hunt and Hess grading system, the opportunity to use a fixed retractor was higher than in tumor operations.

The determination of appropriate approach was guided by the location of lesions. For the lesions in this present study, the pterion approach was used. Strategies included avoiding transcortical routes and utilizing natural cleavage planes along arachnoid avenues, such as the interhemispheric, supracerebellar infratentorial, or Sylvian fissure. These planes facilitated lesion access without the necessity of a fixed retractor.

Consistent patient positioning was employed to capitalize on gravity, aiding in pulling the brain lobe away from the falx or skull base, albeit with limited impact. Although external ventricular drainage and lumbar drainage were considered for brain relaxation, the present study did not utilize lumbar drainage in any case. Extensive arachnoid dissection, combined with cerebrospinal fluid aspiration, was another effective method to create a wide operative field and slacken the brain. These measures collectively facilitated retractorless surgery, achieved through the use of basic microneurosurgical instruments.

The present demonstrates that retractorless surgery can be conducted with a high success rate using simple techniques and instruments. No intraoperative complication was documented in this study. The most common immediate postoperative complication within 24 hours in the aneurysm group was hemiparesis or hemiplegia following MCA aneurysm surgery, which compromises blood flow to the MCA and affects the cerebral hemisphere in 11.6%. Postoperative stroke is a major complication of cerebral aneurysm clipping, and this rate is consistent with the stroke rates of 10% to 12% reported in current literature[30]. Visual acuity deterioration and ptosis complications were most commonly found in tumors adjacent to the optic pathway and oculomotor nerve. Tumors in the cerebellopontine angle often involved the facial nerve, making facial palsy a common complication, even though nerve integrity monitoring was used.

In cases involving brain tumors with vasogenic edema, steroid was administered, analogous to the administration of mannitol in nearly all cases. Fixed retractors were employed in thirteen tumor cases, for intrinsic tumors situated in the basal ganglion, thalamus, intraventricular, and corpus callosum. These cases necessitated a fixed retractor to maintain an open corridor to the lesion continuously, as the cortices would close together upon removal of the fixed blades or handheld instruments. Two cases requiring a fixed retractor were attributed to cerebellar edema in petroclival meningioma and pineal region tumors.

Within the aneurysm group, a statistically significant association was found between Hunt and Hess grading and the type of retractor technique used (p<0.001). The use of dynamic retractor was more prevalent in cases classified as grade 1, 2, and 3, while fixed retractor was more prevalent in cases classified as grade 4 and 5, according to the Hunt and Hess grading, particularly due to brain swelling following subarachnoid hemorrhage.

The present study had limitations, including the lack of a control group and the absence of long-term outcome data for both retractorless and fixed retractor techniques. Future research with multicenter cohorts and extended follow-up periods is necessary to provide more comprehensive information.

Conclusion

Retractorless neurosurgery, also known as dynamic retraction, can be safely employed for addressing deep-seated and skull base lesions, minimizing serious complications through the application of simple microsurgical techniques and basic microsurgical instruments. Techniques such as arachnoid plane dissection, employing appropriate microsurgical approaches, releasing cerebrospinal fluid, and optimizing patient positioning to enhance gravity retraction collectively contribute to reduce the necessity for fixed retraction. Successful retractorless neurosurgery also hinges on factors such as decision-making, the surgeon's experience, and optimal anesthesia management.

What is already known on this topic?

Retractorless neurosurgery helps reduce the occurrence of brain retraction injury. It can be performed on deep-seated and skull base lesions with a high success rate using advanced microneurosurgical instruments. However, there is still limited research on the use of basic microneurosurgical instruments.

What does this study add?

The present study demonstrates successful performance of retractorless neurosurgery using basic microneurosurgical instruments in deep-seated and skull base lesions over an extended period.

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Conflict of interest

The authors declare no conflict of interest.

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