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Clinical Analysis and Surgical Management of Intracranial Meningiomas

İntrakraniyal Menenjiomların Klinik Analizi ve Cerrahi Yönetimi

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ABSTRACT

Objective: The current study analyses the patients who underwent surgical resection with intracranial meningiomas.

Methods: This study reviewed the data of eighty-four patients diagnosed and operated with intracranial meningioma. The study was conducted retrospectively by analyzing the clinical characteristics and the histopathological results of the patients. Age at surgery, gender, and tumor location according to World Health Organization (WHO) 2021 tumor classification criteria were determined. Brain computed tomography and cranial magnetic resonance imaging was used to assess the tumor before operation and presence of recurrence/residual lesion at follow-up. Surgical management was evaluated according to Simpson resection grade.

Results: Fifty-nine were women (70%) and 25 were men (30%). Female/male ratio was 2.36/1. The average age was 55.58 years (range: 28-79 years). The most common locations of surgical intracranial meningiomas were convexity, and parasagittal/falcine. Fifty-four (64.3%) patients with Simpson grade I and II, 26 (30.9%) with grade III, and 4 (4.8%) patients with grade IV resection were carried out. The most common histopathological results were transitional meningioma 28 (33.3%) patients, atypical 22 (26.2%) patients, meningothelial meningioma 21 (25.0%) patients. Sixty (71.4%) patients had WHO grade I tumor, 22 (26.2%) patients grade II tumor, and 2 (2.4%) patients grade III tumor.

Conclusion: Although meningiomas are more common in female patients, grade II and III meningiomas show gender equality. The main goal of surgery is to remove the meningioma completely, including dura and bone if needed. Maximal safe surgical resection should be performed in surgery and preserve the patient's neurological functions.

Keywords: Intracranial meningioma, surgical resection, Simpson resection grade, WHO tumor classification

ÖZ

Amaç: Bu çalışmanın amacı intrakraniyal menenjiom nedeniyle cerrahi rezeksiyon uygulanan hastaları incelemektir.

Yöntem: Bu çalışmada intrakraniyal menenjiom tanısı konulan ve opere edilen seksen dört hastanın verileri incelendi. Çalışma, hastaların klinik özellikleri ve histopatolojik sonuçları retrospektif olarak incelenerek yapıldı. Dünya Sağlık Örgütü (DSÖ) 2021 tümör sınıflaması göz önüne alınarak hastaların ameliyat esnasındaki yaşı, cinsiyeti ve tümör lokalizasyonları belirlendi. Ameliyat öncesi tümörün tesbitinde, ve sonraki takip sürecinde nüks/rezidü lezyon varlığı için beyin bilgisayarlı tomografi ve kraniyal manyetik rezonans görüntüleme kullanıldı. Cerrahi tedavi Simpson rezeksiyon derecesine göre değerlendirildi. Menenjiomların histopatolojik alt tipleri ve DSÖ dereceleri belirlendi.

Bulgular: Hastaların 59'u kadın (%70), 25'i erkekti (%30). Kadın/erkek oranı 2,36/1 idi. Yaş ortalaması 55,58 (aralık: 28-79) idi. Cerrahi intrakraniyal menenjiomların en sık yerleşim yeri konveksite ve parasagital/falks idi. 54 hastada (%64,3) Simpson grade I ve II, 26 hastada (%30,9) grade III, ve 4 hastada (%4,8) Simpson grade IV rezeksiyon yapıldı. En yaygın histopatolojik sonuçlar; transizyonel menenjiom 28 (%33,3) hasta, atipik (grade II) menenjioma 22 (%26,2) hasta, ve meningotelyal menenjioma 21 (%25) hasta şeklindeydi. 60 (%71,4) hasta DSÖ grade I, 22 (%26,2) grade II, ve 2 (%2,4) hasta grade III menenjiom saptandı.

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Sonuç: Menenjiomlar kadın hastalarda iki kat oranında fazla görünse de, grade II ve III menenjiomlar cinsiyet eşitliği gösterirler. Cerrahinin temel amacı, gerekirse dura ve kemiği de içermek üzere, menenjiomun tamamen çıkarılmasıdır. Ameliyatta maksimum güvenli cerrahi rezeksiyon yapılmalı ve hastanın nörolojik fonksiyonları korunmalıdır.

Anahtar Kelimeler: İntrakraniyal menenjiom, cerrahi rezeksiyon, Simpson rezeksiyon derecesi, DSÖ tümör sınıflandırması

INTRODUCTION

Meningiomas are generally benign, slow-growing tumors that can be treated with surgery. However, some meningiomas could be life-threatening depending on the pathological type, size and location of the tumor. Meningiomas are the most common extra-axial primary brain tumors, approximately 26% of all intracranial tumors. The incidence of meningiomas is 7.8 per 100,000 people per year. It is most common at the age of 30-60 years.[1,2] Meningiomas are grouped into three according to World Health Organization (WHO) 2021 histopathological criteria as benign (typical, grade I), atypical (grade II), malignant (anaplastic, grade III) subtypes.[3-5]

METHODS

This study reviewed the data of eighty-four patients diagnosed and operated with intracranial meningioma at the Department of Neurosurgery, University of Health Sciences Turkey, İzmir Bozyaka Training and Research Hospital between January 2017 and December 2020. The study was conducted retrospectively by analyzing the clinical characteristics and the histopathological results of the patients. Patients under the age of 18, with incomplete information, multiple meningiomas, or spinal meningiomas were excluded. We first evaluated the patients in terms of demographic characteristics and tumor locations. Brain computed tomography and cranial magnetic resonance imaging was used to assess the tumor before the operation and the presence of recurrence or residual lesion at the follow-up (Figures 1, 2, 3). Electroencephalogram was taken in patients with seizure risk during the preoperative period. Each patient was operated by the same experienced surgeons. Surgical treatment was evaluated as total resection, subtotal resection or biopsy with Simpson grading system on meningioma resection. Postoperative complications and recurrence of the patients were analysed. Follow-up period differs between 12 and 36 months (average 18 months). The patients were evaluated for histopathological diagnose by the same pathologists at our hospital. The results are grouped according to WHO 2021 classification of central nervous system (CNS) tumors. The informed consent form was collected from all individual participants included in the study. This study was approved by the Institutional Ethics Review Committee of University of Health Sciences Turkey, İzmir Bozyaka Training and Research Hospital (date: 23.02.2022, issue no: 2022/37) in accordance with the World Medical Association Declaration of Helsinki and its most recent amendments.

Statistical Analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 22.0. In all tables, continuous variables are expressed as mean SPSS values.

RESULTS

The study includes 84 patients with intracranial meningioma who underwent neurosurgical microsurgery. Fifty-nine of them were women (70%) and 25 were men (30%). Female/male ratio was 2.36/1. The mean age of the patients was 55.58 years and the range was 28-79 years (Table 1). The most common complaints at presentation were symptoms related to increased intracranial pressure such as headache and vomiting (72 patients, 86.7%), and neurological symptoms such as extremity paresis and muscle weakness (18 patients, 21.4%). In 36 (42.8%) patients, the neurological examination was normal. Neuroimaging studies showed that the tumor was found at convexity in 36 (42.8%) patients, parasagittal/falcine in 12 (14.3%), posterior fossa/tentoriel in 11 (13%), sphenoid wing in 10 (11.9 %), tuberculum sella in 6 (7.1 %), clinoid in 5 (5.9%), olfactory groove in 2 (2.4%), and intraventricular in 2 (2.4%) patients (Table 1). The most common locations of surgical intracranial meningiomas in our study were convexity, and parasagittal/falx. All the patients in this study underwent microneurosurgical resection in our hospital and evaluated with Simpson grading system. Ten (12%) patients with Simpson grade I, 44 (52%) patients with Simpson grade II, 26 (31%) patients with Simpson grade III, and 4 (5%) patients with Simpson grade IV were carried out (Table 2).

The meningiomas in this study are divided into subtypes by histopathological examination according to WHO 2021 classification of CNS tumors. The results of meningiomas as follows; transitional meningioma 28 (33.3%) patients, atypical (grade II) meningioma 22 (26.2%) patients, meningothelial 21 (25.0%) patients, angiomatous meningioma 3 (3.6%), psammomatous, fibrous, secretory, papillary (grade III) meningioma 2 (2.4%), microcystic, metaplastic meningioma 1 (1.2%) patients (Table 3). Sixty (71.4%) patients had a WHO grade I tumor, 22 (26.2%) patients had a grade II (atypical) tumor, and 2 (2.4%) patients had a grade III tumor. The ages at surgery, median years (range) were 54.4 (28-79), 60.7 (33-

73), 37.5 (33-42), respectively. On the recommendation of radiation oncologist, the patients with atopic or anaplastic meningiomas with high mitotic index and Ki-67 index received cranial radiotherapy. During the follow-up period, 6 of the 84 (7%) patients had recurrent lesion, all of which were grade II or III meningiomas. These patients reoperated with microneurosurgical procedures. Postoperative complications included wound site infection in eight (9%) patients, postoperative epilepsy in four (5) patients, frontal lobe syndrome in three patients, hemiparesis in two patients, and afaria in one patient. All wound site infections were cured with antibiotics. Postoperative epilepsy of these patients was improved with the addition or replacement the antiepileptic drugs.

DISCUSSION

Meningiomas are typically benign intracranial tumoral formations. These tumors originate from arachnoid cap cells that cover the brain. They usually grow slowly. However, if they are countless, they could be severely disabling and life-threating in some locations.[6,7] Intracranial meningiomas are mostly seen in female patients, with a ratio of 2/1. In our study, for all types of meningiomas, we analysed higher frequency in females compared to men. The female/male ratio was 2.36/1, in line with the literature. However, grade II and grade III meningiomas are seen nearly in the same frequency in women and men. The number of them are equal in our study. In this study, meningiomas were seen mostly in convexity, parasagittal/falcine, and posterior fossa/tentorial, in line with the literature.

The WHO 2021 brain tumor classification of is the most common used tool for grading tumor types. WHO classification consists 15 variations of meningiomas according to microscopic cell type. These histopathological subtypes are organized into three grades as WHO grade I-benign, grade II-atypical, grade III-malignant.[8,9] 20% of all meningiomas are atypical meningiomas. In our study, the incidence of atypical meningiomas is 26%.

Table 1. Clinical characteristics of the patients. Age at surgery, gender, and tumor location according to WHO CNS tumor classification criteria

Clinical data	WHO CNS tumor classification criteria					
Age at surgery (years) Median and range	Benign (n=60) 54.4 (28-79)		Atypical (n=22) 60.7 (33-73)		Anaplastic (n=2) 37.5 (33-42)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Gender						
Female	47	78.3	11	50.0	1	50.0
Male	13	21.7	11	50.0	1	50.0
Location						
Convexity	26	43.3	9	40.9	1	50.0
Parasagittal/falcine	9	15.0	3	13.6		
Posterior fossa/tentoriel	8	13.3	3	13.6		
Sphenoid wing	7	11.7	3	13.6		
Tuberculum sella	4	6.7	2	9.0		
Clinoid	3	5.0	1	4.5	1	50.0
Olfactory groove	2	3.3				
Intraventricular	1	1.7	1	4.5		

WHO: World Health Organization, CNS: Central nervous system

Table 2. Surgical management of the patients according to Simpson resection grade

Simpson resection grade	Definition	Frequency	Percent
I	Macroscopically complete tumor resection with removal of affected dura and underlying bone	10	11.9
II	Macroscopically complete tumor resection with coagulation of affected dura only	44	52.4
III	Macroscopically complete tumor resection without removal of affected dura or underlying bone	26	30.9
IV	Subtotal tumor resection	4	4.8
V	Decompression with or without biopsy	-	-

This can be explained by the increasing tendency of atypical meningiomas. They often characterized by brain invasion or high mitotic rate. They grow faster than benign meningiomas and have a higher recurrence rate.[10,11] Malignant meningiomas have increased cellular abnormalities and enlarge faster than the other meningiomas. Rhabdoid and papillary subtypes are grade III. 1.7% of all meningiomas are malignant. Grade II and grade III meningiomas have a much more aggressive natural history, and a high risk of recurrence.[12,13]

Table 3. Histopathological subtypes and WHO grades of meningiomas in this study. WHO grade I-benign, grade II-atypical, grade III-malignant

WHO grade subtype frequency percent			
I	Transitional	28	33.3
I	Meningothelial	21	25.0
I	Angiomatous	3	3.6
I	Psammomatous	2	2.4
I	Fibrous	2	2.4
I	Secretory	2	2.4
I	Microcystic	1	1.2
I	Metaplastic	1	1.2
II	Atypical	22	26.2
III	Papillary	2	2.4
Total		84	100

WHO: World Health Organization

The risk of meningiomas increases with patient's age. Ionizing radiation has been associated with the development of meningiomas. Neurofibromatosis type 2 (NF-2) could predispose to develop meningiomas. A higher female-to-male incidence ratio could be due to a correlation between hormones and meningiomas.[14,15] The presenting symptoms of intracranial meningiomas depend upon size and location of the tumor. Meningiomas may remain asymptomatic in some patients. Sphenoid wing meningiomas could lead vision problems, facial numbness, and seizures (Figure 1). A parasagittal meningioma in the midsection of the brain can cause weakness and numbness at the extremities or seizures (Figure 2). Intraventricular meningiomas could block the cerebrospinal fluid flow, causing in obstructive hydrocephalus, headaches and stupor (Figure 3). Tuberculum sella meningiomas could press optic nerves and chiasm, causing vision defects. Posterior fossa meningiomas could lead facial symptoms or hearing loss due to compression of 7. and 8. cranial nerves.[16,17]

The tumors that are growing and cause symptomatology are suitable for surgery. The main purpose of surgery is

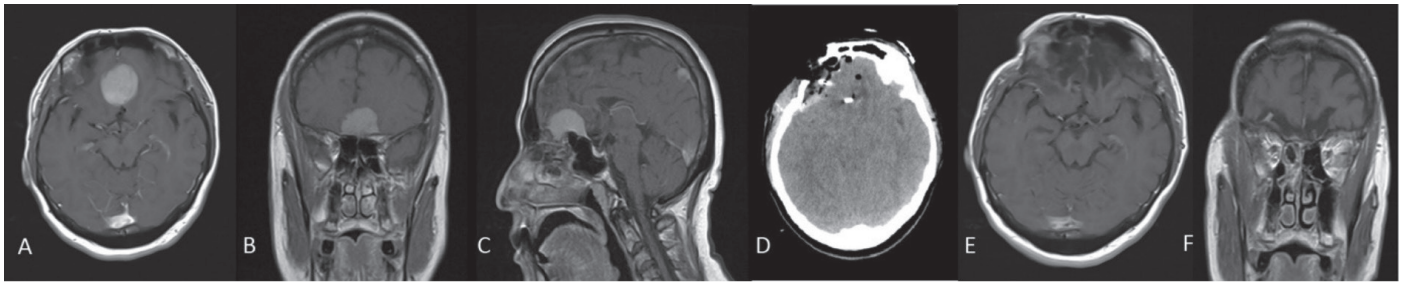

Figure 1. Preoperative T1W cranial magnetic resonance imaging (MRI) axial (A), coronal (B), sagittal (C) showing homogenous contrast 35x30 mm extraaxial sphenoid wing meningioma. Postoperative 1. day brain computed tomography (D) showing total resection of the tumor. T1W MRI axial (E), coronal (F) on the second year of operation, no recurrent tumor detected

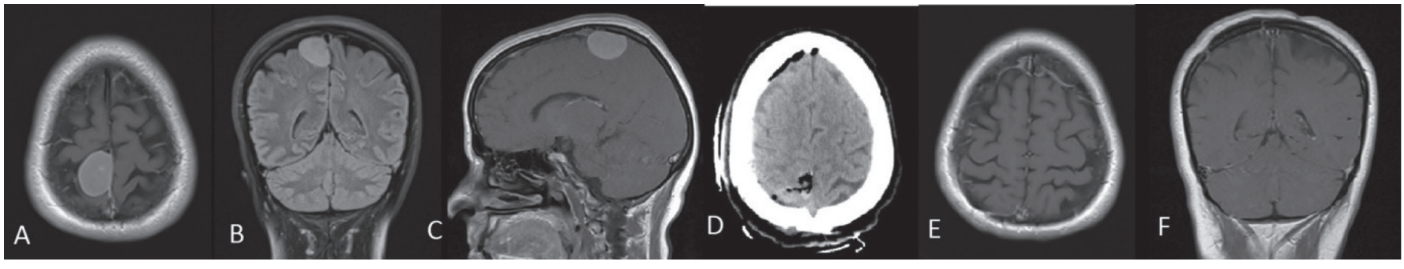

Figure 2. Preoperative T1W cranial magnetic resonance imaging (MRI) axial (A), coronal (B), sagittal (C) demonstrating 30x25 mm homogenously enhancing and well-circumscribed parasagittal meningioma adjagent to superior sagittal sinus in right frontal lobe. On the first day of operation, brain computed tomography (D) showing total resection of the tumor. MRI (E, F) on the second year of surgery showed no residual or recurrent lesions

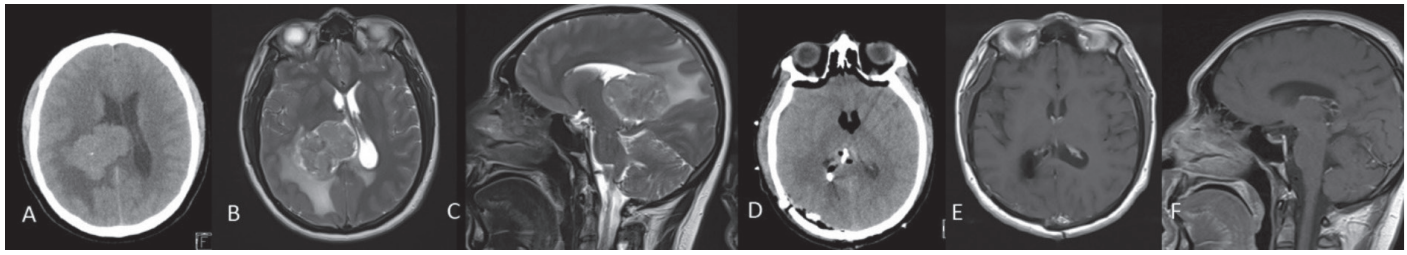

Figure 3. Preoperative brain computed tomography (CT) (A) showing a 60x45 mm ventricular tumor extending to the left of the midline on right lateral ventricle posterior horn. T1W axial (B), and sagittal (C) cranial magnetic resonance imaging (MRI) demonstrating intense contrast enhancing tumor and causing 6 mm shift in the midline. Postoperative 1. day brain CT (D) showing total resection of the tumor. Axial (E), and sagittal (F) cranial MRI two years after the surgery, no residual or recurrent lesion was observed

to resect the meningioma completely, including dura and bone if needed. However, complete resection could carry significant risks in some locations. The neurosurgeon should perform maximal safe surgical resection and preserve the patient's neurological functions. The ability to perform complete resection can be limited by a number of factors, such as tumor location, invasion to dural venous sinuses, involvement of arteries and cranial nerves. In our study, 54 of the 84 patients (64.3%) underwent Simpson I or II resection. 30.9% of the patients underwent macroscopically total tumor resection without removal of affected dura or bone. These percentiles showed high surgical success, considered together with low complication rates. Neuroanatomical location determines the surgical approach. Convexity meningiomas are relatively simple to resect. Parasagittal meningiomas can invade the sagittal sinus, thus their resection can be difficult. Skull base meningiomas (sphenoid wing, tuberculum sella, clinoid, olfactory groove, cerebellopontin angle) require further surgical techniques.[18] Recently, anterior skull base tumors could be resected through an endoscopic endonasal approach. Preoperative embolization of the tumor can be useful in vascular meningiomas. Radiation therapy in grade II or III meningiomas. Stereotactic radiosurgery such as Gamma Knife or Cyberknife could be a treatment option.[19,20] The outcome of meningiomas mostly depends to the patient's age and total surgical resection.

Study Limitations

The limitation of the study was that its retrospective nature, and it only included a restricted number of patients at a single-center. Patients under the age of 18, with incomplete information, multiple meningiomas, or spinal meningiomas were excluded in this study.

CONCLUSION

Although meningiomas are more common in female patients, grade II and III meningiomas show gender equality. The main purpose of surgery is to resect the meningioma completely, including dura and bone if needed. Maximal safe surgical resection should be performed in surgery and preserve the patient's neurological functions.

Ethics

Ethics Committee Approval: All steps of this study were approved by the Institutional Ethics Review Committee of University of Health Sciences Turkey, İzmir Bozyaka Training and Research Hospital (date: 23.02.2022, issue no: 2022/37) in accordance with the World Medical Association Declaration of Helsinki and its most recent amendments.

Informed Consent: Informed consent was obtained from all individual participants included the study.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices - Concept - Design - Data Collection or Processing - Analysis or Interpretation - Literature Search - Writing: H.B.B., A.Y.

Conflict of Interest: No conflict of interest was declared by the authors.

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