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Ümit Kocaman,
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Evaluation of the need for debulking in meningioma surgery by a retrospective analysis of our case series. Is debulking mandatory?

Ümit Kocaman, Emre Çavuşoğlu

İzmir Bakırçay University, School of Medicine, Neurosurgery Department, Çiğli Educational and Research Hospital, TURKEY

ABSTRACT

Introduction: The primary aim of meningioma surgery should be total excision. However, subtotal excision is considered first if the main vascular structures and the cranial nerves are at risk. The 'primum non nocere' principle should always be considered. A clinical study where the emphasis is on en bloc resection without debulking in suitable cases, in contrast to the classic approaches, could therefore prove useful.

Method: The meningioma cases operated at the İzmir Bakırçay University Çiğli Training and Research Hospital's Neurosurgery Clinic between 2021 and 2023 were retrospectively evaluated. There were no exclusion criteria. The demographic features of the patients who had undergone debulking or en bloc resection and the anatomical, pathological, surgical and clinical features of the meningiomas were evaluated and the results were presented as percentages.

Results: A total of 21 patients, consisting of 5 males (23.8%) and 16 females (76.2%), were included in the study. The mean age was 58.8 (28-90) years. En bloc resection was performed in 18 (85.7%) and debulking in 3 (14.3%) of the 21 cases. The other results are presented within the article.

Conclusion: En bloc resection could be an important surgical strategy to decrease the surgical duration and bleeding amount in appropriate cases.

Keywords
meningioma,
surgery,
en bloc resection

Corresponding author:
Ümit Kocaman

İzmir Bakırçay University, School of Medicine, Turkey

umitkocaman80@gmail.com

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INTRODUCTION AND BACKGROUND

Meningiomas constitute 36.6% of all primary central nervous system (CNS) tumors and 53.2% of benign CNS tumors. The general incidence of meningioma is 8.3 per 100,000 people. There is a female dominance of 2.3:1. Besides 81.1% of meningiomas reported as grade 1 (typical), 16.9% as atypical, and 1.7% as anaplastic (8). Ionizing radiation to the skull is considered a risk factor for meningioma development and increases the relative risk six to ten times following a variable latent period without a clear dose-response relationship (9). Epidemiological factors such as a history of head injury, smoking, and cell phone use have not been consistently shown to be associated with an increased risk of meningioma (8). The most common inherited cause is

neurofibromatosis type 2 (NF2), which is characterized by autosomal dominant inheritance. Phenotypic NF2 is rare in the general population and occurs in <1% of meningioma cases (10). Other important meningioma-related disorders include the Li-Fraumeni, Gorlin, and von Hippel-Lindau syndromes, Cowden's disease, and multiple endocrine neoplasia (MEN) type 1(11).

Meningioma surgical strategies have played an important role in the development of neurosurgery. Meningioma surgery has always been one of the favorite areas of the discipline. The general principles are complete removal of the tumor, or reducing its volume to a level that eliminates mortality/morbidity if this is not possible; choosing the shortest and safest route for the surgical approach; preserving important vascular structures and neural tissue; and concluding the surgery within a reasonable time. As in every medical intervention, the principle of 'primum non nocere' should always be considered during the surgery. Taking all these into account, we believe it may be useful to present a different perspective that includes en bloc resection for meningioma surgery through our own case series.

Material and Method

Meningioma cases operated in İzmir Bakırçay University Çiğli Training and Research Hospital's Neurosurgery Department between 2021 and 2023 were retrospectively analyzed. The study has ethics committee approval from İzmir Bakırçay University with decision number 1197. We have no conflict of interest about this study. The study inclusion criteria were 'cases that had undergone meningioma surgery', with no exclusion criteria. The cases were evaluated in terms of the patient age and gender, and the meningioma anatomical origin, size (in mm), hemispheric side (right/left), Simpson resection grading, pathology, debulking/en bloc resection technique, Glasgow outcome score, surgical duration, and arterial penetration of the meningioma. The meningiomas were also divided into four groups as Type 1 or small (< 20 mm), Type 2 or moderate (20-39 mm), Type 3 or large (40-59 mm), and Type 4 or giant (>60 mm). Based on these four types, the debulk/en bloc resection technique was then evaluated.

The Simpson resection grade rates of the tumors resected with the debulking/en bloc technique was calculated. Besides, the success of the en bloc resection technique was determined in cases with arterial penetrance. Finally, the en bloc resection rates of moderate and large meningiomas were calculated. All data were evaluated as percentages.

Results

There were 21 patients, consisting of 5 males (23.8%) and 16 females (76.2%), in the study. The mean age was 58.8 (28-90) years. There were 2 spheno-frontal meningiomas (9.5%), 8 convexity meningiomas (38%), 1 tentorial meningioma (4.8%), 2 parasagittal meningiomas (9.5%), 1 falx meningioma (4.8%), 2 lateral sphenoid wing meningiomas (9.5%), 2 medial sphenoid wing meningiomas (9.5%), 1 tuberculum sella meningioma (4.8%), 1 spheno-Sylvian meningioma (4.8%), and 1 thoracic meningioma (4.8%). When evaluated by size, none of the Type 1 'small' size meningiomas were operated on. There were 10 (47.6%) type 2 'moderate' size meningiomas that underwent surgery, 9 (90%) by resection en bloc while debulking was performed in 1 (10%) meningioma of tentorial origin. There were 10 (47.6%) type 3 'large' size meningiomas that underwent surgery with 8 (80%) resected en bloc and 2 (20%) with debulking.

A total of 2 (100%) medial sphenoid wing meningiomas were also resected by debulking. One type 4 'giant' size meningioma was operated on. The Simpson grade was 2 in 18 (100%) patients that underwent en bloc resection, and 2 in 2 (9.5%) patients and 4 in 1 (4.8%) patient that underwent debulking. The pathology result of 4 (19%) of the 21 patients was 'atypical meningioma'. The Glasgow outcome score was 5 in 20 (95.2%) patients and 4 in 1 (4.8%) debulked medial sphenoid wing meningioma. Penetration with important arterial structures was detected in 7 (33.3%) of the 21 cases; en bloc resection was performed in 5 (71.4%) and debulking in 2 (28.6%) of these 7 cases. The number of Type 3 'large' and Type 4 'giant' meningiomas was 11, and en bloc resection was performed in 9 (81%) of them.

Discussion

The classic disciplines in meningioma surgery focus on four basic phases of excision: 1. Devascularization, 2. Detachment from the origin, 3. Debulking and 4. Dissection (1,7). These phases may not always have a sequential relationship during surgery. A partial circumferential dissection can be

performed before devascularization, or the debulking phase can precede all these stages. The 360-degree dissection can first be slightly advanced a little deeper by preserving the tumor form. This is related to the relaxation state of the tumor and brain at that moment and the surgeon's perspective on the current clinical picture. For example, the feeding with blood of a falx meningioma may be partially impaired after dural opening. The devascularization and detachment from the falx cerebri, the area to which the tumor is attached, then occur simultaneously. Meanwhile, the dissection proceeds deeper into the falx. Following full devascularization and detachment, the classic discipline recommends moving to the 'debulking' phase.

	Age	**Gender**	**Origin**	**Size (mm)**	**Side**	**Simpson**	**Pathology**	**Debulking**	**En bloc**	**GOS**	**OT**	**AP**
1	76	M	Spheno-frontal	45x45x53	Left	2	Atypical	No	Yes	5	120	-
2	28	F	Parietal Convexity	30x35x24	Right	2	MM	No	Yes	5	90	-
3	44	F	Tentorial	30x30x25	Left	2	Fibrous	Yes	No	5	150	-
4	57	M	Temporal Convexity	25x25x25	Left	2	Transitional	No	Yes	5	100	-
5	54	M	Frontal Convexity	30x51x35	Right	2	Atypical	No	Yes	5	100	-
6	52	F	Parasagittal	40x52x44	Right	2	Transitional	No	Yes	5	140	-
7	39	F	Parietal Convexity	25x24x25	Left	2	Transitional	No	Yes	5	60	-
8	74	F	Frontal Convexity	40x42x32	Right	2	Atypical	No	Yes	5	90	-
9	90	M	Parasagittal	42x41x40	Right	2	Transitional	No	Yes	5	120	-
10	44	F	Spheno-frontal	30x30x30	Left	2	Transitional	No	Yes	5	90	-
11	63	F	Frontal Convexity	56x61x55	Left	2	Transitional	No	Yes	5	120	-
12	59	F	Falx	33x31x33	Left	2	MM	No	Yes	5	120	+
13	50	F	Lateral sphenoid wing	27x25x25	Right	2	MM	No	Yes	5	90	+
14	65	F	Spheno-Sylvian	33x25x34	Left	2	Transitional	No	Yes	5	80	+
15	52	F	Tuberculum sella	30x24x20	-	2	MM	No	Yes	5	150	+
16	65	F	Thoracic	30x20x20	-	2	Psammomatous	No	Yes	5	120	-
17	80	F	Frontal Convexity	33x47x42	Right	2	Atypical	No	Yes	5	90	-
18	67	F	Lateral sphenoid wing	40x40x42	Right	2	Angiomatous	No	Yes	5	120	+
19	56	M	Frontal Convexity	56x55x58	Right	1	MM	No	Yes	5	120	-
20	67	F	Medial sphenoid wing	45x52x46	Left	4	MM	Yes	No	4	180	+
21	52	F	Medial sphenoid wing	46x35x52	Left	2	MM	Yes	No	5	150	+

GOS: Glasgow Outcome Score, OT: Operation Time (minutes), AT: Arterial Penetrance, MM: Meningotheliomatous

The debulking phase means removing the meningioma tissue piece by piece while making sure it remains inside the tumor capsule. The aim here is to facilitate dissection by allowing the capsule to tip towards the center in large meningiomas. By performing a circumferential dissection, the tumor capsule is released and removed. The debulking phase is often performed by using an ultrasonic aspirator or a monopolar cauter with a ring-shaped tip. Our observations have shown that the debulking duration for a meningioma of approximately 4 cm can be up to 60 minutes. When debulking is performed, all tumoral tissue up to the tumor capsule must be removed so that the capsule can become flexible and be bent. This procedure takes quite a long time.

The issue I want to discuss in this article is not whether the debulking phase facilitates tumor removal or not but whether it is absolutely necessary. This stage is emphasized in all written and visual material, resulting in it being perceived as indispensable among trained surgeons. Tumor debulking was actually required in only 14.2% of our cases. Briefly stated, our strategy starts with opening the dura after dural coagulation. Then, we place our cotton pads around the tumor following limited dissection so that the borders are clear. We then proceed according to the source of the meningioma. For example, we proceed to the falx connection in falx meningiomas, and the tubercle connection in tuberculum sella meningiomas.

A detachment is secured both by burning the connection towards the tumor with bipolar cautery as well as with the support of a cotton pad, and the dissection is advanced deeper at the same time. Devascularization and tumor shrinkage are ensured at this stage. We then place cotton pads on the dissection area, paying attention to important vascular structures and preserving the arachnoid plane. The dissection is deepened in the areas where we are sure of the dissection, and the tumor tissue is reduced by burning it towards the center with bipolar cautery. We also make small maneuvers that mobilize the tumor from its place during the burning procedure.

Burning should not be performed without understanding the relationship of the main vascular structures with the tumor, and any forceful maneuvers should be avoided during dissection. At the same time, vascular structures and cranial nerves adherent to the tumor capsule should be patiently and carefully separated from the capsule. If the tension in the tumor capsule during these vital dissections will cause difficulty in separating these structures from the capsule, we always proceed to the debulking procedure. The vascular structures should be separated from distal to proximal by careful dissection that is as sharp as possible following the debulking. Sharp dissection is the key (3).

The arachnoid plane to be cut must be distinguished beforehand, and sharp dissection must be continued with small moves. Otherwise, a vascular injury that will develop, for example in a sphenoid wing meningioma adherent to the MCA branches, may cause serious morbidity and mortality. We continue the circumferential dissection until the tumor tissue is completely released from all its attachments. Finally, and only after full release is achieved, the tumor tissue is removed en bloc. Another important point is that the vascular penetration area is determined exactly if we come across the main vascular structures when turning around the periphery of the tumor or if the main vascular structures providing cerebral perfusion are penetrating into the tumor.

The dissection is continued by skipping this section in this case. The next thing to do after fully turning around the tumor is to follow the vascular structure. This is possible with controlled incisions and partial resections in the tumor tissue in that area. I believe it is not correct to call resection of the capsule together with the pieces debulking. I believe that resection with this strategy is more controlled than with debulking in cases where the main vascular structures are surrounded by the tumor. However, debulking should be performed very carefully if the distal or proximal section of vascular penetration cannot be detected and tumor removal has to be continued.

Radiological results should be thoroughly evaluated before the surgery. Film footage should be available during surgery. The use of neuro-navigation may also be beneficial. The circumferential dissection should be deepened in a controlled manner and should not cause tension in the vascular structure. Gross total resection should be decided on by considering the profit-loss relationship. The principle of 'primum non nocere' should always be considered. For example, it may be more important to decide under the guidance of this perspective when working on medial sphenoid wing meningiomas and paraclinoid meningiomas.

Yasuo Suga et al. describe the birth-like excision of a giant falx meningioma following intraoperative acute brain swelling in their case report. They mention that the mass was pushed out en bloc by the brain after the falx connection was separated. It is emphasized that the relative hyperemia in the tissue surrounding the tumor due to sudden brain swelling induced by the craniotomy and the sudden decrease in intracranial pressure facilitates the en bloc pushing of the tumor from the brain. One of the conclusions that can be drawn here is that brain elasticity may allow circumferential dissection even in giant meningiomas. This may be an indirect

indication that internal decompression is not an essential stage even in such meningiomas. (1).

Sivashanmugam Dhandapani et al. have reported that internal decompression may increase the amount of bleeding and the duration of the surgery, especially for meningiomas with high intra-mass vascularity, in their series where debulking was not used. Less bleeding and shorter surgery duration were emphasized as the most important advantages of en bloc removal. En bloc resection was decided on after separation from the dural connection in this article. In our opinion, if a suitable arachnoid plane was located, en bloc removal was performed by deepening the circumferential dissection without internal decompression. We believe there is a clear contraindication for en bloc extraction when the main vascular structures remain inside the tumor. However, the circumferential dissection should be advanced as far as possible to the vascular region while preserving the arachnoid plane even when en bloc extraction is not possible. Entry should be made by cutting the capsule in areas where vascular structures remain on the inside. Otherwise, intra-tumor decompression will increase bleeding from the first moment and the possibility of distinguishing tumor cleavage and proceeding with the case in a controlled manner will be lost. The preservation of intratumoral or peritumoral vascular structures may also become difficult in these cases (2).

Kaarakhan et al. have mentioned en bloc resection to be the most important surgical option in a giant meningioma case with extra- and intracranial spread (4). A long duration of surgery will greatly increase the amount of bleeding in giant meningiomas. The biggest factor in prolonged surgery is the lost time during the debulking phase and continuous bleeding in the form of oozing. The aim should therefore be the rapid decrease of the peroperative tumor burden to the desired levels and if possible total removal, in addition to safe surgery. Surgical maneuvers such as total removal may be the most important strategy for large and giant meningiomas where the main vascular structures are not penetrating. Our recommendation in this regard is the preoperative consideration of en bloc resection, taking our previously mentioned guidelines into account.

Debulking is generally not necessary during surgery for small meningiomas, especially for small meningiomas in the frontal, parietal, or occipital convexity. We believe that the localization of the tumor is more important than its size. Debulking is not required for a 3 cm convexity meningioma but may be primarily required during dissection of the vessels and cranial nerves in the tuberculum sella or clinoid. Debulking was not required during the resection of the 3 cm tuberculum sella meningioma in our series, and the tumor was resected en bloc with no additional neurodeficiency developing in the patient. The decision here will of course be shaped according to the experience and peroperative opinion of the surgeon. Circumferential dissection was not possible in another 3 cm meningioma case of tentorial origin due to adhesions in the pial area, and the tumor was debulked and resected. Tumor pathology of the fibrous type could have contributed to this result.

We performed en bloc resection in 18 of the 21 meningioma cases in this series. No additional neurodeficit occurred in any of these patients. Debulking was performed in 3 of the patients. Two of these were medial sphenoid wing meningiomas while one case was tentorial meningioma. We want to emphasize two cases in particular. In one of the two patients with medial sphenoid wing meningiomas, the M1 segment and the lateral lentriculostriate arteries arising from it were completely surrounded by the meningioma. Subtotal resection was performed in this patient. Although the left upper extremity was 2/5 hemiparetic and the left lower extremity was 4/5 hemiparetic in the postoperative period, a remarkable recovery was observed at the one-year follow-up. In the other medial sphenoid wing meningioma, the MCA segments were adherent to the tumor capsule distally in the supero-posterior section, and the anterior temporal branch course was in the middle posterior. After debulking, all vascular structures were released from distal to proximal by sharp dissection and the tumor was grossly totally removed. The patient was discharged with no postoperative deficit.

En bloc resection is contraindicated in meningiomas where the vascular structures are surrounded by the tumor. Debulking should be performed if the tumor elasticity does not allow dissection in cases where the vascular structures or cranial nerves are adherent to the tumor capsule. However, if the dissection is progressing well, the decision to debulk may be left to the surgeon's

opinion and experience. Sharp dissection and vascular dissection from the periphery to the central area should be performed, once a clear view is obtained.

One of the striking points of the current study is that surgery was preferred for some small convexity meningiomas as well. Choosing follow-up or radiosurgery for small meningiomas may cause an increase in the size of the convexity meningiomas. Surgery becomes more complex in the case of growth of small convexity meningiomas when radiosurgery is not successful or the patients do not come for follow-up. The mean postoperative complication rate for these patients is around 10%(5). A large tumor lodge may increase the risk of intracerebral hematoma, CSF fistula, and infection (5).

Surgery is therefore the gold standard for convexity meningiomas up to 2.5 cm in diameter, if the patient's age is also suitable. En bloc resection was performed in all of the convexity meningiomas we operated on. None of them required debulking, enabling a short duration of surgery with a low amount of bleeding.

An interesting technical note regarding convexity meningiomas in the literature is that a vacuum retractor system that is connected to the operating room aspiration system has been reported. The authors emphasized that the pulling effect of this system on the neurovascular structures around the tumor was safer than with classic methods and allowed for fast and safe en bloc resection of convexity meningiomas with little or no pressure on the surrounding cerebral tissue (6). We would like to mention the importance of the current article that highlights en bloc resection with a new technique where a vacuum assistant was used. Although our surgery were more classical, the objective was again safe en bloc resection.

The advantages of the en bloc resection method have been reported as less bleeding, shorter surgical duration, low probability of residual tumor, and low recurrence rate in the meningioma series of Dhandapani. One disadvantage is that the method requires good cleavage, which may not be possible in anaplastic or malignant meningiomas. Fibrous type meningiomas may also not be suitable for en bloc resection, as in our case. In addition, the method is contraindicated if the tumor has encircled major vascular structures. It has been reported that deeply located tumors may not be suitable for this method and we partially agree with this point of view. En bloc resection of deep-seated meningiomas, and especially large-diameter ones, should be avoided if there is a risk of strain or damage to normal cerebral tissue during maneuvering with the bipolar cauter. Debulking is necessary in these cases. We would also like to point out that we performed en bloc resection of a 3 cm tuberculum sella meningioma. Even though this tumor is deeply located, trans-Sylvian intervention may have provided us an advantage as regards retraction of the brain. Therefore, it may be more accurate to decide on the en bloc or debulking method during the surgery

One of the remarkable points in our study is that brain and tumor elasticity allowed the release of the ICA/MCA/ACA and distal branches adhering to the tumor capsule in 5 of the 7 meningioma cases penetrated by ICA/MCA/ACA and branches. This was especially true for the distal MCA/ACA segments. However, release and en bloc resection were also possible in the case of tuberculum sella meningioma, which was also adherent in the ICA, A1-M1 region. The optic nerve was elongated unilaterally due to tumor growth in this case. En bloc resection should not be attempted in any case where the optic nerve is stretched. En bloc resection is possible for spheno-sylvian or lateral sphenoid wing meningiomas. The most appropriate method for medial sphenoid wing or paraclinoid meningiomas is to reduce the tumor volume by debulking. Mobility is also low in the proximal arterial segments and performing gradual resection by debulking can be vital. Debulking was performed for two medial sphenoid wing meningiomas in our series. The main option is total or sub-total resection for tumors with significant arterial structure penetration.

The biggest advantage of en bloc resection may be the significant shortening of the surgery, due to skipping of the debulking phase. The amount of bleeding may also decrease significantly in these cases, as evident in our series.

The Glasgow Outcome Score was 5 in all our cases that had undergone en bloc resection. This may indicate that the en bloc resection technique does not harm the patient in properly chosen cases.

Conclusion

Although debulking is an important step in meningioma surgery, it may not be beneficial for

every case. On the contrary, it can prolong the duration of surgery. However, debulking or en bloc resection may be preferred according to the opinion and experience of the surgeon in cases where the main vascular structures and cranial nerves are adherent to the capsule of the meningioma. En bloc resection is contraindicated in meningiomas where the main vascular structures are encircled and subtotal resection can also be considered in these cases.

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