Contemporary Surgical Management of Cavernous Sinus Meningiomas: Surgical technique and Case Series

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Introduction

The cavernous sinus is an anatomically complex region of the skull base comprised of an extensive plexus of veins and sinusoids, a sinuous stretch of the ICA, and several cranial nerves. It is also bordered by the optic nerve, the temporal lobe, the pituitary, the sphenoid sinus and the pterygoid space. In more recent years, we have developed complex surgical approaches capable of accessing the cavernous sinus and dealing with potential complications.

Various approaches exist, including upfront radiation, subtotal removal with adjuvant radiation, and aggressive resection, with or without revascularization techniques.

We consider a single surgeon's large series of cavernous sinus tumors and describe an individualized approach to treatment strategy.

Methods

All patients that underwent surgery at the *Harborview Medical Center* by the senior author (L.N.S.) between January 2005 and January 2024. Demographic data and outcomes were collected on all patients. We assessed for tumor progression (growth of known residual) or recurrence after gross total resection during the entire follow up period. Clinical outcomes data were collected. We recorded anatomical location of tumor epicenter and extension. We defined the tumor epicenter as the main anatomic compartment that was affected by the tumor, and tumor extension as the additional anatomic compartment involved by the tumor. We divided the patients into four groups: WHO grade 1 meningiomas that are primarily based in the cavernous sinus (Group 1), WHO grade 1 meningiomas that are based elsewhere and extend into the cavernous sinus (Group 2), recurrent or WHO grade 2 or 3 meningiomas (Group 3), and tumors other than meningiomas (Group 4).

	GROUP 1: GRADE 1 TUMORS WITH EXTENSION (N=23)	GROUP 2: PRIMARY CAVERNOUS SINUS GRADE 1 (N=14)	GROUP 3: RECURRENT OR HIGH GRADE (N=13)	GROUP 4: OTHER DIAGNOSES (N=57)	
AGE (YEARS)	51.5 ± 16.1				
SEX (F)	19 (82.6%)	12 (85.7%)	8 (61.5%)		0.244
TUMOR RESECTION					0.043
GTR	5 (21.7%)	3 (21.4%)	1 (7.7%)	20 (35.1%)	
NTR	2 (8.7%)	0 (0%)	1 (7.7%)	7 (6.5%)	
STR	10 (43.5%)	5 (35.7%)	3 (23.1%)	24 (42.1%)	
PR	6 (26.1%)	5 (35.7%)	8 (61.5 %)	9 (15.8%)	
BIOPSY	0 (0%)	1 (7.1%)	0 (0%)	1 (0.9%)	
BYPASS	2 (8.7%)	2 (14.3%)	3 (23.1%)	3 (5.3%)	0.219
DISPOSITION					
HOME	14 (60.1%)	9 (69.2%)	8 (61.5%)	45 (78.9%)	0.320
REHAB/SKILLED NURSING FACILITY/OTHER	9 (39.1%)	4 (30.8%)	5 (38.5%)	12 (21.2%)	
POST-OP ADDITIONAL TREATMENT					0.166
NONE	9 (39.1%)	7 (50.0%)	8 (61.5%)	23 (41.1%)	
SURGERY	3 (13.0%)	0 (0%)	0 (0%)	11 (19.6%)	
SRS	6 (26.1%)	5 (35.7%)	0 (0%)	2 (3.6%)	
PROTON THERAPY	3 (13.0%)	0	1 (7.7%)	7 (12.5%)	
FSRT	2 (8.7%)	2 (14.2%)	3 (23.1%)	2 (3.6%)	
CHEMO/IMMUNOTHERAPY				3 (5.4%)	
PROTON THERAPY + CHEMO/IMMUNOTHERAPY	0 (0%)	0 (0%)	1 (7.7%)	1 (1.8%)	
FSRT+CHEMO/IMMUNO	0 (0%)	0 (0%)	0 (0%)	1 (1.8%)	
SRS + FSRT	0 (0%)	0 (0%)	0 (0%)	1 (1.8%)	
SURGERY + FSRT	0 (0%)	0 (0%)	0 (0%)	2 (3.6%)	
OTHER	0 (0%)	0 (0%)	0 (0%)	3 (5.4%)	
TUMOR RECURRENCE OR PROGRESSION	3 (13.0%)	1 (7.1%)	3 (23.1%)	17 (29.8%)	0.184
LENGTH OF FOLLOW-UP (MONTHS)	36 ± 29.5	16.5 ± 22.7	31.3 ± 21.3	23.8 ± 30.0	0.165

Results

Of 107 patients, 62.6% were female with a mean age of 50.8 years. The most common tumor type was meningioma (47.6%) followed by chordoma (15.9%), chondrosarcoma (8.4%) and pituitary adenoma (8.4%). Less common tumors included metastases (6.5%), schwannomas (5.6%), hemangiomas, (4.7%), as well as 1 epidermoid cyst, 1 craniopharyngioma, and 1 neurofibroma.

Tumor extension was variable with a significant portion having extension into the middle fossa (58.9%), sella (50.5%), posterior fossa (47.7%), orbital apex (33.6%), sphenoid sinus (31.8%), and infratemporal fossa (21.5%). 33.6% had had previous surgery and 15.9% had had previous radiation.

A gross total resection was achieved in 28% of all cases. A near total resection was achieved in 5.6% of cases, a subtotal resection achieved in 39.3% of cases, and a partial resection in 27.1% of cases. After surgery, patients were hospitalized for a mean of 12.1 days, with 3.8 days of ICU stay. The majority were able to be discharged home (71%). Additional treatment was required in 54.9% of cases. Additional treatment included additional surgery (13.1%), any kind of radiation (32.4%) or chemotherapy or immunotherapy (2.8%). Most patients had additional therapy because of tumor residual (45.8%) or histology that required adjuvant treatment (25.4%). During the entire follow up period, 26.8% of patients with follow-up (n=97) had either tumor progression or recurrence.

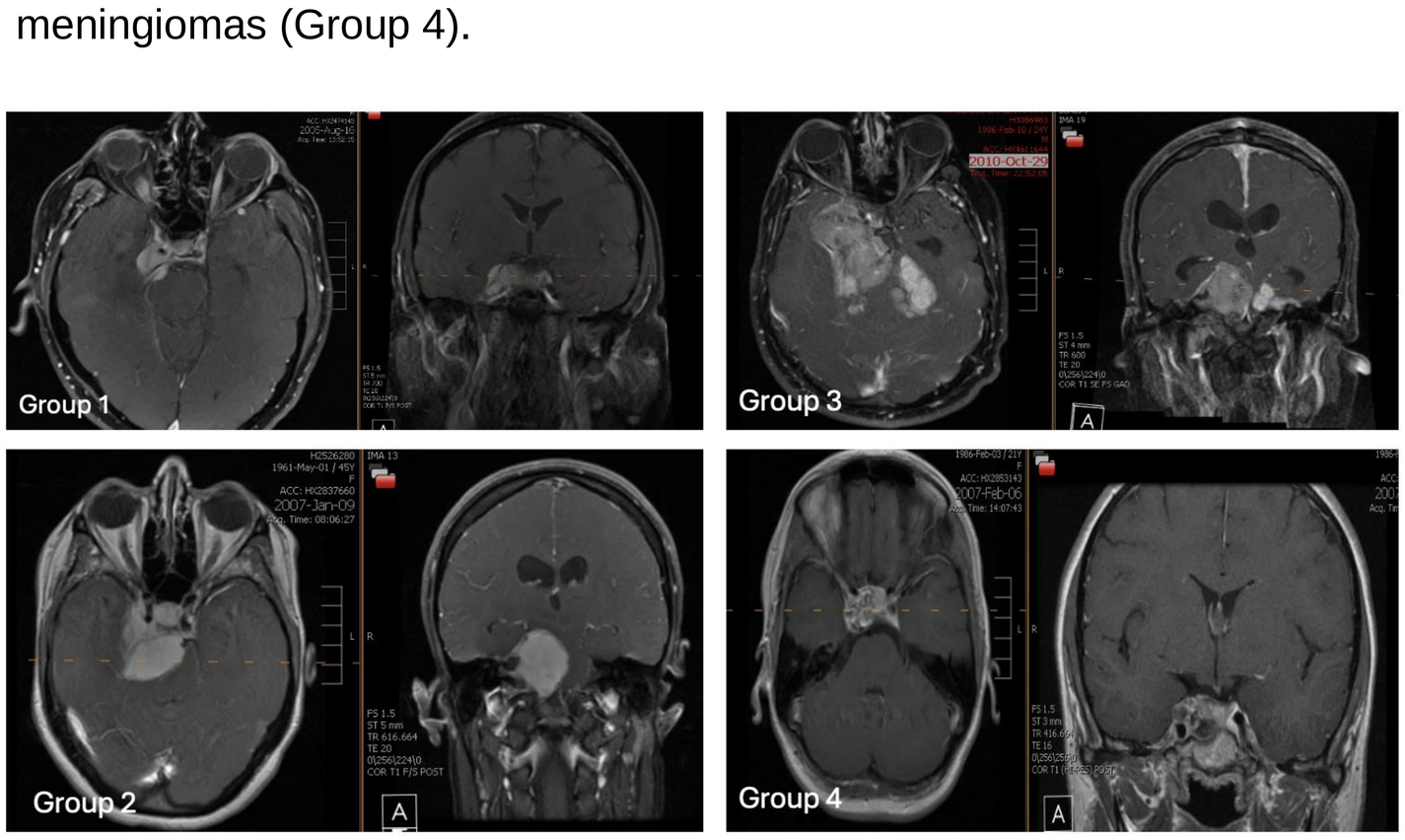

Figure 1: Representative examples of Group 1 (grade 1 primary CS meningioma), group 2 (petroclival meningioma with extension into CS), group 3 (recurrent malignant meningioma) and group 4 (petrous chondrosarcoma with extension into CS).

Conclusion

Our large series of transcranial approach to cavernous sinus tumors describes a heterogenous set of treatment strategies tailored to each patient's tumor. We demonstrate the varying degrees of risk of recurrence or progression in the context of a wide variety of treatments. While malignant tumors such as chondrosarcomas and chordomas require an aggressive surgical approach along with radiation, on the other end of the spectrum are WHO grade 1 primary cavernous sinus meningiomas. These tumors have low rates of recurrence or progression despite inability to completely resect most tumors. Given this natural history, a more conservative approach is warrants. As we develop new techniques such as advanced endoscopic access to skull base tumors and more refined radiosurgery, neurosurgeons have more tools to access the cavernous sinus and adjacent areas, and future work can help tailor the optimal approach for a given lesion.