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Posterior cranial fossa meningiomas: Comparison of results between patients older and younger than 70 years

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ABSTRACT

Introduction: Surgical strategy for meningioma resection in the elderly is controversial: diverse studies in the literature have pointed at the age as a negative prognostic factor in terms of postoperative results.
Research question: The aim of this study is to compare surgical outcomes after resection of posterior fossa meningiomas in <70 and ≥ 70 years-old age groups.
Material and methods: We reviewed 72 patients affected by posterior fossa meningiomas who underwent surgical treatment at San Filippo Neri Hospital, Rome, Italy between September 2010 and December 2022. We analyzed data regarding tumor size, clinical presentation, extent of resection and complication/mortality.
Results: The groups consisted of 52 (72,2%) young and 20 (27,8%) elderly patients. Gross total resection rate was significantly higher among youngsters ($p = 0{,}013$), mainly for planned subtotal removal in older patients. At 3-month follow-up, clinical improvement was seen in 19 (36,5%) young and 7 (35,0%) elderly patients, which raised at last follow-up, being 84,6% (44) and 80,0% (16), respectively ($p = 0{,}406$). Two cases of progression/recurrence among the elderly and 1 among youngsters were observed; one case of mortality among the elderly was reported.
Discussion and conclusions: Safety data regarding postoperative complications and mortality in our series seem to confirm that there is no significant difference between older and younger patients, as long as older patients are carefully selected. Therefore, if surgery is proposed, it should be radical if gross total resection could be safely attempted.

1. Introduction

Meningioma accounts for 30% of all primary intracranial neoplasms (Ostrom et al., 2019). As an intrinsically heterogeneous pathology, the clinical course of a meningioma depends on numerous factors, the foremost being age at diagnosis (Amano et al., 2018; Ikawa et al., 2017; Yamamoto et al., 2017), clinical presentation (Pintea et al., 2016), location (Bassiouni et al., 2004, 2006; Chen et al., 2011; Colli et al., 2008; Corniola et al., 2019; Hart and Lillehei, 1995; Little et al., 2005; Nanda et al., 2018; Pintea et al., 2016; Ramina et al., 2008; Roche et al., 2017; Sanai and McDermott, 2010; Shukla et al., 2009; Tatagiba et al., 1996; Voss et al., 2017) and extent of resection (Ehresman et al., 2018; Gousias et al., 2016; Lam Shin Cheung et al., 2018; Little et al., 2005; Quddusi and Shamim, 2018; Slot et al., 2018; Voss et al., 2017) in case of surgical treatment.

Surgical strategy for meningioma resection in the elderly is controversial: diverse studies in the literature have pointed at the age as a negative prognostic factor in terms of postoperative functional state, morbidity and mortality rates (Bartek et al., 2015; Boviatsis et al., 2007; Poon et al., 2014; Schul et al., 2012; Zhao et al., 2018). However, a growing body of evidence has outlined that age is not prognostically negative per se; it is rather associated to cofactors such as worse preoperative state and comorbidities (Boviatsis et al., 2007; Ikawa et al., 2017). Thus, surgery is being advocated more and more frequently in the treatment of meningiomas of the elderly, with satisfactory tumor control outcomes (Amano et al., 2018; Brokinkel et al., 2017; Corniola et al., 2019; Ikawa et al., 2017; Konglund et al., 2013; Maurice-Williams and Kitchen, 1992; Meling et al., 2019; Poon et al., 2014; Yamamoto et al., 2017).

As far as tumor location is concerned, posterior fossa meningiomas (PFM) represent 10% of all meningiomas (Roberti et al., 2001) and constitute a peculiar cohort in terms of surgical complexity due to their proximity to noble anatomical structures. In general, PFM are associated with worse preoperative functional state, neurological defects and/or elevated intracranial pressure at presentation, lower extent of resection

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Abbreviations

PFM	posterior fossa meningiomas
EoR	extent of resection
PFS	progression-free survival
CPA	cerebello-pontine angle
PC	petroclival
TPR	tentorium and petrous ridge
FM	foramen magnum
GTR	gross total resection
OS	overall survival
ELITE	extreme lateral infrajugular transcondylar
MF	middle fossa
MSO	Median suboccipital approach
KPS	Karnofsky Performance Score

(EoR) and worse long-term outcome (Corniola et al., 2019). In particular, EoR -measured according to Simpson grading system-affects the natural history of such neoplasms: lower Simpson grades (Simpson, 1957) are associated with prolonged progression free survival (PFS). However, it has been questioned whether the risk of recurrence differs significantly across different Simpson grades (Nanda et al., 2018; Voss et al., 2017).

In our study, we reviewed a series of 72 patients divided into Group 1 (52 cases) aging <70 and Group 2 (20 cases) ≥70 years old, with PFM that underwent surgical treatment at San Filippo Neri Hospital, Rome, Italy between September 2010 and December 2022. We analyzed data regarding tumor size, clinical signs and symptoms, EoR and clinical outcome at follow up to address eventual significant differences between the two age groups.

2. Materials and methods

This single-center study was carried out at a tertiary care referral hospital. It was conducted after obtaining clearance from the Internal Ethics Committee of our institution and in accordance with the principles of the Helsinki Declaration. A written consent for scientific treatment of personal data was obtained from any patient before surgery. Cohorts included all patients who underwent surgery in the San Filippo Neri Hospital of Roma for Posterior Cranial Fossa Meningioma between September 2010 and December 2022. All patients were followed up till December 2023.

2.1. Data collection and classification

We retrospectively reviewed 72 consecutive cases of patients who underwent surgical treatment for PFM in the neurosurgical department of San Filippo Neri Hospital, Rome, Italy within a period of eight years (September 2010–December 2022). Clinical notes, pre- and post-operative scans, surgical records as well as follow up clinical records were reviewed. Patients were classified as "young" or "elderly" based on the age cutoff of 70 years. Based on preoperative anaesthesiological evaluation, ASA score was assigned to each patients and elderly ones with ASA>3 were not surgically treated. The tumor location was defined according to Al-Mefty's terminology (Al-Mefty et al., 2011) as follows: cerebello-pontine angle (CPA), petroclival (PC), tentorium and petrous ridge (TPR), foramen magnum (FM). Tumor size was defined as maximum diameter on contrast-enhanced MRI scan (or contrast-enhanced CT scan, if any contraindications to MRI had been posed). Preoperative symptoms were classified into the categories of state-of-consciousness alterations, cranial nerve disorders, motor defects and headache.

All the surgical procedures involving the vestibular-acoustic-facial bundle were performed with facial nerve monitoring through means of direct electrical stimulation and continuous EMG (Nimbus i-Care-100, Hemodia, Labege, France), with electrodes inserted in orbicularis oris and orbicularis oculi muscles. In addition, in these cases, each patient received the first ABR (Nicolet Viking III, Viasys HealthCare, Madison, USA) immediately before surgery: ABRs were evoked with LS-CEChirp stimuli (Eclipse-EP15, Interacoustics, Middelfart, Denmark), by means of subdermal needles or surface electrodes placed at vertex (Cz) and on each earlobe (A1 and A2). The description of such neurophysiological monitoring techniques is beyond the scope of this work and is reported elsewhere (Di Scipio and Mastronardi, 2015; Mastronardi et al., 2016). Moreover, all the surgical procedures involving the lower cranial nerves were performed monitoring the laryngeal adductor reflex by means of an endotracheal tube with electrodes for stimulating and recording recurrent laryngeal nerve responses (EMG Endotracheal-Tube, Nuvasive, San Diego, USA).

The choice of surgical approach was tailored according to tumor site, size and extension.

Postoperative complications were defined as cranial nerve disorders, motor defects, seizures and wound dehiscence. Maximum safely achievable tumor resection was attained in all patients. EoR was assessed using Simpson grading system (Simpson, 1957) in conjunction with postoperative CT or MRI scans obtained at three months after surgery; gross total resection (GTR) was defined as Simpson Grades I, II and III according to the European Association of Neuro-Oncology (Goldbrunner et al., 2016).

2.2. Statistical analysis

Calculations were performed using commercial statistical Software (IBM SPSS Statistics, Version 27). Absolute and relative frequencies have been reported for categorical variables and means ± standard deviation (SD) have been reported for continuous ones. Fisher's exact test and Student's t-test have been performed for categorical and continuous variables, respectively, while comparing young and elderly groups. The statistical significance was set at $p < 0{,}05$.

2.3. Clinical follow-up

Clinical and radiological follow-up was scheduled at minimum 3 months after operation and then once a year; follow-up period ranged between 12 and 147 months (mean 73, median 75).

3. Results

3.1. Patients characteristics and clinical presentation

Our cohort consisted of 72 patients, 14 (19.5%) males and 58 (80.5%) females and was subdivided into two groups according to age -age cutoff being 70 years. The resulting groups were composed of 52 (72.2%) young and 20 (27,8%) elderly patients, mean age being 50,67 ± 8,45 and 74,35 ± 4,71 years, respectively. As for the young group, 11 (21.1%) patients were asymptomatic before surgery. Among those who presented with symptoms, 5 (9.6%) complained of headache, 5 (9.6%) had motor disturbances (one case of monoparesis, two cases of hemiparesis and two of tetraparesis) and 31 (59,6%) had cranial nerve defects (Table 1). Among the elderly, 4 (20.0%) were asymptomatic, 16 (80,0%) referred cranial nerve disorders and 2 (10,0%) referred headache. The percentage of symptomatic patients was not significantly different between the two groups ($p = 0{,}989$). Two young and one elderly patients had previously undergone surgical resection at other institutions.

3.2. Tumor characteristics

Mean tumor diameter was similar between the two groups: 3,44 ± 0,85 cm among the young and 3,72 ± 0,61 cm among the elderly. Such

Table 1
Patient demographics and clinical presentation. NB Percentages of symptoms at presentation among young patients sum up to more than 100 due to more symptoms reported by singles patients. NS: not significant.

	Young (<70)	Elderly (≥70)	
Cohort size	52	20	
Sex	10 M, 41 F	4 M, 16 F	
Age (mean ± SD)	50,67 ± 8,45 years	74,35 ± 4,71 years	
Asymptomatic at presentation	11 (21,1%)	4 (20,0%)	NS, *p* = *0,989*
Symptomatic at presentation	41 (78,9%)	16 (80,0%)	
Motor defect	5 (9.6%)		
Headache	5 (9.6%)	2 (10,0%)	
Cranial nerve disorders	31 (59,6%)	16 (80,0%)	
Mean ASA Class	1,86 (range 1–3)	2,63 (range 1–3)	
Comorbidities	Diabetes 3 Obesity 1	Diabetes 1	

difference did not prove statistically significant ($p = 0{,}133$). Side distribution was rather homogeneous: 28 (53,9%) and 9 (45,0%) right-sided tumors in young and elderly groups, respectively ($p = 0{,}616$). No statistical difference emerged when comparing anatomical site distribution between the groups ($p = 0{,}264$); the details of tumor location within each group are reported in Table 2. In addition, no significant association emerged between tumor site and preoperative symptom presentation ($p = 0{,}989$). In all cases, the tumor was considered as a WHO I meningioma on histological exam, except for a patient -reoperated on three years after the first gross total removal-for relapse of tumor, showing an atypical transformation (WHO grade II).

3.3. Surgical management

The retrosigmoid (RS) approach was used in the majority of cases, 44 (84,6%) among the young and 18 (90,0%) among the elderly. Median suboccipital (MSO) approach was used in 3 instances (twice among the youngsters, once among the elderly) of FM meningioma. For five (14.3%) cases, namely 3 foramen magnum (FM) and 2 petro-clival (PC) meningioma of the young group, extreme lateral infrajugular transcondylar (ELITE) approach was chosen. Finally, one PC meningioma in each group required a middle fossa approach (MF).

EoR was assessed according to Simpson grading system and verified by postoperative contrast-enhanced MRI or CT. In the young group, resections were reported as follows: 24 (46,1%) grade 1, 21 (40,4%) grade 2, two (3,8%) grade 3 and five (9,6%) grade 4. In the elderly group, EoR was assessed as grade 1 in 4 (20,0%) cases, grade 2 in 7 (35,0%) cases, grade 3 in two (10,0%) case and grade 4 in another 7 (35,0%) cases. Holding grades 1 to 3 as gross total resection, it was accomplished significantly more often in the young group ($p = 0{,}013$).

Transient cranial nerve occurred in 3 cases in the young group, namely: one transient glossopharyngeal nerve, one permanent cochlear nerve injury, some spinal accessory rootlets sacrificed during a PC meningioma excision in one patient, with minor deficit of trapezius muscle fibers. Slight permanent facial paresthesias and transient lower cranial nerves disturbances occurred in one case of PC meningioma within the elderly group.

Table 2
Tumor characteristics and site distribution. CPA: cerebellopontine angle; FM: foramen magnum; PC: petroclival; TPR: tentorium and petrous ridge; NS: not significant.

	Young (<70)	Elderly (≥70)	
Maximum tumor diameter (mean ± SD)	3,44 ± 0,85 cm	3,72 ± 0.61 cm	NS, *p* = *0,133*
Right-sided tumors	28 (53,9%)	9 (45,0%)	NS, *p* = *0,616*
Anatomical site			
CPA	13 (25,0%)	5 (25,0%)	NS, *p* = *0,264*
FM	7 (16,7%)	0	
PC	18 (34,6%)	8 (40,0%)	
TPR	14 (26,9%)	7 (35,0%)	

3.4 Postoperative complications and long-term follow up.

Immediate and late permanent postoperative complications were evaluated within three months after the operation and during the follow-up controls. Early postoperative complications, comprising wound dehiscence and transient cranial nerve defects, were reported in 14 (26,9%) and 6 (30.0%) of young and elderly patients, respectively; such difference did not prove significant ($p = 0{,}439$), even after stratification according to complication type (Table 3).

At one year of follow up, clinical improvement of neurological status, in comparison to the preoperative or early postoperative ones, was seen in 19 (36,5%) young patients and 7 (35,0%) elderly ones; such difference did not prove to be significant ($p = 0{,}170$). At last clinical follow up, the rate of clinical improvement raised in both the groups at this time, being 84,6% (44) among the young and 80,0% (16) within the elderly group ($p = 0{,}406$). Long-lasting neurological morbidity occurred in 8 (15.4%) young patients and 3 (15.0%) elderly ($p = 0{,}924$).

One case of mortality (5.0%) was reported in the elderly cohort two months after surgery, due to pneumonia during postoperative rehabilitative period.

Two cases of progression/recurrence (10,0%) among the elderly and 1 among youngsters were reported: a TPR meningioma in a <70yo woman, first treated with gross total resection (Simpson grade 2), required re-operation at three years for relapse and atypical transformation of tumor (WHO grade II); after the second gross total removal, stereotactic radiotherapy was performed and the patient is still alive with minor neurological deficits. Other two patients operated on for PC meningioma, first treated with subtotal resection (Simpson 4), wherefore re-surgery was indicated, both refused the intervention and underwent stereotactic radiotherapy.

Table 3
Postoperative complications and long-term follow up. FN = facial nerve; HB = House Brackmann.

	Young (<70)	Elderly (≥70)	
Mortality	0	1 (5,0%): 2 months after surgery due to pneumonia	NS, *p* = *0,439*
Perioperative complications	14 (26,9%)	6 (30,0%)	NS, *p* = *0,439*
Cranial nerve disorders	9 (19,3%): 2 permanent HBII FN deficit 3 transient HBII-HBIII FN deficit 2 permanent hearing loss 2 permanent facial paresthesias	5 (25,0%): 1 transient dysphagia 1 permanent dysphagia 2 permanent hearing loss, 1 permanent HBIII FN deficit	
Motor defects	2 (3,8%): 1 transient hemiparesis 1 permanent tetraparesis	0	
Hydrocephalus/DVP shunt	1	0	
Wound dehiscence/ infection	2 (3,8%): 1 wound infection 1 CSF leak	1 (5,0%): 1 wound infection	
Clinical improvement at 1 year	19/52 (36,5%)	7/20 (35,0%)	NS, *p* = *0,170*
Clinical improvement at last follow up (median 75 mos)	44/52 (84,6%)	16/20 (80,0%)	NS, *p* = *0,406*

4. Discussion

PFM represent 10% of all meningiomas (Roberti et al., 2001) and constitute a peculiar cohort in terms of surgical complexity due to their proximity to noble anatomical structures. In general, PFM are associated with worse preoperative functional state, neurological defects and/or elevated intracranial pressure at presentation, lower EoR and worse long-term outcome (Corniola et al., 2019). The data in the literature regarding PFM resection and outcomes in the young versus elderly population are quite sparse. Indeed, numerous reports compare surgical results according to age groups but without stratification per anatomical site (Amano et al., 2018; Boviatsis et al., 2007; Brokinkel et al., 2017; Ikawa et al., 2017; Islim et al., 2019; Lam Shin Cheung et al., 2018; Maurice-Williams and Kitchen, 1992; Poon et al., 2014; Schul et al., 2012; Yamamoto et al., 2017; Zhao et al., 2018); on the other hand, other case series discuss the outcomes after PFM surgery but without stratification according to age (Bassiouni et al., 2006; Colli et al., 2008; Corniola et al., 2019; Hart and Lillehei, 1995; Little et al., 2005; Meling et al., 2019; Nanda et al., 2018; Ramina et al., 2008; Roberti et al., 2001; Roche et al., 2017; Shukla et al., 2009; Tatagiba et al., 1996). To the best of our knowledge, this is the first case series focusing on how age affects surgical outcomes after PFM resection.

In our cohort, 21.1% of young and 20.0% of elderly patients were asymptomatic before surgery ($p=$ ($p = 0,989$), in line with previous studies (Ikawa et al., 2017). Among those who presented with symptoms, cranial nerve disorders were the most common complaint, while symptoms of raised intracranial pressure were rarely referred by youngsters and never reported by the elderly. Such presentation differs from what previously described elsewhere (Corniola et al., 2019; Zhao et al., 2018), wherefore seizures and intracranial hypertension are reported in 7.1% and 45.5% of cases respectively (Corniola et al., 2019), with no significant differences between age groups (Zhao et al., 2018). An explanation may be due to the inclusion criteria of our study, wherefore elderly patients with ASA>3 were excluded. Thus, old patients harboring PFM whose general and neurological status heavily affected their general clinical conditions may have been excluded from the study, which should be regarded as a recruiting bias. As far as tumor size is concerned, it did not differ significantly between the two age groups -in contrast to the work by Zhao et al. (2018), where tumors were not divided into anatomical site groups. In addition, in our study no association between tumor location and symptoms at presentation was found.

In our study, gross total resection (GTR) was defined as Simpson Grades I, II and III -according to the European Association of Neuro-Oncology (Goldbrunner et al., 2016)- and was achieved in 90,3% of cases among young patients and 65,0% among the elderly ($p = 0,013$). Such figures compare favorably to the data reported by Corniola et al. (2019), who compared surgical results of PFM with supratentoral meningiomas resection without age stratification. In that study, GTR after PFM excision was achieved in 59.6% of cases. Another study reported a GTR rate of 82% in case of PFM across all age groups (Voss et al., 2017). Yamamoto et al. (2017) performed a retrospective study examining surgical outcome after meningioma resection in the elderly: among 21 cases of Simpson grade 3 or 4, 90% were skull base lesions. As far as differences of EoR according to age are concerned, diverse studies have reported that there is no evidence of significantly more extensive resection among youngsters rather than elderly (Amano et al., 2018; Boviatsis et al., 2007; Brokinkel et al., 2017; Ikawa et al., 2017; Yamamoto et al., 2017).

Early postoperative complications, comprising wound dehiscence and transient cranial nerve defects, were reported in 26,9% and 30.0% of young and elderly patients of our series, respectively ($p = 0,439$); long-lasting morbidity was observed in 8 (15.4%) young patients and 3 (15,0%) elderly. A comparison can be made with data regarding complication rate after meningioma surgery in the elderly, without specific focus on anatomical site. Reported neurological complication rate ranges between 2.7% and 49.4% (Ikawa et al., 2017; Poon et al., 2014; Yamamoto et al., 2017) and general complications are described in 2.7–26.8% of cases (Yamamoto et al., 2017). Boviatsis e al. (Boviatsis et al., 2007) reported a significantly higher incidence of complications among the elderly rather than the youngsters, with a higher risk of postoperative hematoma for older patients while the risk of surgical site infection seemed evenly distributed across age groups. Bartek et al. (2015) found that older age, preoperative Karnofsky Performance Status (KPS) < 70 and length of surgery >4hrs were associated with a higher risk of postoperative complications. In contrast to these literature data, in our study postoperative complications did not occur differently between elderly and youngsters, nor were the types of complications different, probably due to our inclusion criteria. Our seemingly high complication rates take into account neurological, local -i.e. wound- and general complications occurring in a period extending from the immediate postoperative days to the third postoperative month; therefore, they reflect cumulative peri-operative morbidity.

At last clinical follow up, the rate of clinical improvement raised in both the groups, being 84,6% among the young and 80,0% within the elderly group ($p = 0.406$). Such figures are in line with the literature (Amano et al., 2018; Zhao et al., 2018) and underline that age alone does not influence postoperative recovery rate, though our data may suggest that neurological improvement could occur earlier among younger patients.

Two cases of progression/recurrence (10,0%) among the elderly and 1 among youngsters were reported. Our data seem not to be in line with the conclusions by Bronkinkel et al. (Brokinkel et al., 2017), who reported a recurrence rate of 15% for PFM and an increased risk of perioperative and absolute mortality and decreased overall survival among the elderly after meningioma surgery -without further anatomical site stratification. On the other hand, increased mortality among older patients harboring meningiomas is debated, other works reporting no differences in morbidity and mortality between elderly and youngsters (Boviatsis et al., 2007; Ikawa et al., 2017); in particular, recurrence rates as high as 31.7% have been reported for TPR meningiomas (Nanda et al., 2018).

Mortality among elderly after meningioma surgery has been reported in 3.9–9.6% (Ikawa et al., 2017; Poon et al., 2014; Zhao et al., 2018); one case of mortality (5.0%) was reported in our elderly cohort, due to pneumonia during postoperative rehabilitative period.

The surgical strategy to PFM resection in the elderly should take into account diverse factors favoring aggressive or judicious resection. Preoperative KPS <70 may be due to neurological symptoms caused by the tumor and that can be relieved by the operation (Brokinkel et al., 2017), so it should not be regarded as an absolute contraindication to surgery. However, it has been reported that lower preoperative KPS is associated with postoperative complications (Bartek et al., 2015) and that higher preoperative KPS is associated with increased overall survival and progression-free survival (Corniola et al., 2019). This is the reason why we chose to apply strict inclusion criteria regarding preoperative clinical conditions, as already suggested by Schul et al. (2012). In diverse case series of meningiomas not stratified per anatomical site, age has been significantly associated with higher WHO grades (Amano et al., 2018; Brokinkel et al., 2017; Corniola et al., 2019; Ikawa et al., 2017; Meling et al., 2019; Yamamoto et al., 2017), which in turn correlate with decreased overall survival (Corniola et al., 2019) and increased recurrence rate (Ehresman et al., 2018; Gousias et al., 2016). Due to such less benign biological profile, meningiomas of the elderly must be considered for resection, also taking into account that age per se has been found not to correlate with statistically significant higher rates of complications (Yamamoto et al., 2017), progression-free survival (Brokinkel et al., 2017), recurrence rate (Brokinkel et al., 2017) or mortality (Boviatsis et al., 2007; Ikawa et al., 2017). In case of asymptomatic patients and documented tumor progression, a wait-and-see strategy does not seem justified by age only: even though Ikawa et al. (2017) reported that only 6% of elderly patients develop clinical symptoms in a follow up course of 5 years -thus favoring a watchful waiting conduct, Amano et al. (2018) argued that 7.5% of WHO grade II asymptomatic meningiomas eventually progress after radiotherapy and that 3.5% of them require surgical excision. In addition, if postoperative recovery is considered, the elderly show similar clinical improvement rates as youngsters, as reported previously (Amano et al., 2018; Zhao et al., 2018) as well as in our study. Safety data regarding complications and mortality in our series seem to confirm that there is no significant difference between older and younger patients, as long as older patients are carefully selected. Therefore, if surgery is proposed, it should be radical if GTR could be safely attempted (Gousias et al., 2016; Hart and Lillehei, 1995; Maurice-Williams and Kitchen, 1992).

In conclusion, our study seems to confirm that age itself does not influence negatively surgical outcomes of PFM surgery, as long as older patients are selected according to strict inclusion criteria, in particular the acceptable preoperative general condition (ASA $\leq$3). Due to the relatively small sample size of the cohort, further studies are needed to confirm our preliminary findings.

5. Limitations

The main aim of our research was to evaluate if the microsurgery for symptomatic posterior cranial fossa meningioma has the same efficacy and safeness among patient under and over the age of 70.

Apart from the retrospective nature of the study, the main limitation is that the sample size was limited. In addition, the different locations of meningiomas in the posterior cranial fossa make the comparison less affordable. Another limitation is that patients >70 harboring PFM whose general and neurological status heavily affected their general clinical conditions have been excluded from the study, representing a possible recruiting bias. Lastly, the selection of surgical approach limits further the comparative analysis of results.

6. Conclusions

PFM represent 10% of all meningiomas and constitute a peculiar cohort in terms of surgical complexity due to their proximity to noble anatomical structures. The surgical strategy to PFM resection in the elderly should take into account diverse factors favoring aggressive or judicious resection. Safety data regarding complications and mortality in our series seem to confirm that there is no significant difference between older and younger patients, as long as older patients are carefully selected. Therefore, if surgery is proposed, it should be radical and a safely GTR should be attempted.

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Availability of data and material

All data relevant to the study are included in the article.

Author's contribution

L.M.: study design, study conception, data extraction, data analysis, manuscript writing. A.C.: study design, study conception, data extraction, data analysis, manuscript co-writing; A.A.: data analysis, statistical analysis, critical review of the manuscript

Ethics approval

The study involves human participants: for this reason, it has been reviewed and approved by local Ethics committee of the Hospital (Lazio1, ASLRoma1). A written consent for scientific treatment of personal data was obtained from any patient before surgery. No potentially identifiable human images or data are presented in this study.

Consent to participate

We confirm that the manuscript has been read and approved by all named authors; there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

Consent for publication

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. Moreover, the authors affirm that human research participants provided informed consent regarding publishing their personal data. Authors are responsible for correctness of the statements provided in the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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