Clinical Neurology and Neurosurgery 152 (2017) 68–75

Contents lists available at ScienceDirect

Clinical Neurology and Neurosurgery

journal homepage: www.elsevier.com/locate/clineuro

Petroclival meningiomas: Remaining controversies in light of minimally invasive approaches

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ARTICLE INFO

Article history:
Received 12 September 2016
Received in revised form 17 November 2016
Accepted 28 November 2016
Available online 29 November 2016

Keywords:
Meningioma
Brain tumor
Clivus
Skull base
Endoscopy

ABSTRACT

Surgical resection of petroclival meningiomas remains challenging due to their deep location and relationship to vital neurovascular structures. Although the natural history of these tumors involves a slow course, the incidence of cranial nerve deficits and the extent of tumor resection vary widely in the literature. Some reviews on this topic have been conducted, but data remain fragmentary and based on retrospective case series, which hinders attempts at meta-analysis. Within this context, research into the use of minimally invasive approaches, including in neuroendoscopy, continues to emerge. The objective of this narrative review is to analyze the available literature on the surgical treatment of petroclival meningiomas, with a focus on attempts at endoscopy-assisted resection.

Contents

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http://dx.doi.org/10.1016/j.clineuro.2016.11.021

1. Introduction

Meningiomas are usually benign lesions that account for 20–25% of intracranial tumors, and 10% occur in the posterior fossa. Of these, 5–11% affect the petroclival region, accounting for 0.15% of intracranial masses overall [1,2]. Surgical resection of petroclival meningiomas remains challenging due to their depth and relationship to vital neurovascular structures.

In 1953, Castellano and Ruggiero classified posterior fossa meningiomas into five groups: cerebellar convexity, tentorial, posterior aspect of the petrous bone, clival, and foramen magnum [1]. Yasargil et al. revised this classification in 1980, suggesting that these tumors arose along the petroclival line and graded them into clival, petroclival, sphenopetroclival, foramen magnum, and cerebellopontine angle meningiomas [3]. In 1986, Mayberg and Symon published a series using the terminology "meningiomas of the clivus and apical petrous bone," popularizing the term "petroclival meningioma" [4].

Although the natural history of petroclival meningiomas involves a slow course, the incidence of cranial nerve deficits and the extent of tumor resection vary widely in the literature (Table 1).

This reflects different treatment philosophies, which often include planning for subtotal resection, especially since the advent of radiosurgery [36–39] and new radiotherapy techniques [40]. In general, these approaches are complex, time-consuming and require substantial expertise. Some reviews on this topic have been conducted [5,18,41], but data remain fragmentary and based on retrospective case series, which hinders attempts at meta-analysis. Within this context, research on the use of minimally invasive approaches is emerging, including in neuroendoscopy [42–48]. The objective of this narrative review is to analyze the available literature on the surgical treatment of petroclival meningiomas, with particular emphasis on endoscopy-assisted resections.

2. Definitions

The petroclival area corresponds to the body of the sphenoid and the anterior central portion of the occipital bones, and is bounded laterally by the petrous apex. Its important neurovascular structures, such as the basilar artery and its branches, are often surrounded or displaced by petroclival meningiomas. The petrous vein is usually displaced posteriorly; cranial nerves III and IV are displaced superiorly and cranial nerve VI is usually surrounded by tumor or displaced superiorly [18].

By definition, petroclival meningiomas originate medial to cranial nerves V, VII, VIII, IX, X, and XI and reach the tentorium. They often extend to the middle fossa, cavernous sinus, prepontine space and down to the foramen magnum; they may invade the pia mater and cause compression of the brainstem [18]. Lower clivus meningiomas (foramen magnum meningiomas) [19], cerebellopontine angle meningiomas (tentorial or petrous meningiomas) [49], and sphenoid wing meningiomas can reach these areas, but are not considered petroclival in origin [18]. Petroclival meningiomas that involve the cavernous sinus may be classified as sphenopetroclival [31].

Table 1
Major published surgical series of petroclival meningiomas.

Author, year	n	Gross total resection [a] (%)	Mortality (%)	Major morbidity (%)	New cranial nerve deficits (%)
Yasargil et al. [3]	20	35	10	26	50
Mayberg and Simon [4]	35	26	9	34	54
Nishimura et al. [2]	24	63	8	33	91
Tatagiba et al. [5]	54	70	2	24	37
Bricolo et al. [6]	33	79	9	39	76
Spetzler et al. [7]	18	78	0	11	39
Kawase et al. [8]	42	76	0	12	36
Coudwell et al. [9]	109	69	3.7	15	33
Zentner et al. [10]	19	68	5	11	34
Goel [11]	24	67	0	29	29
Abdel Aziz et al. [12]	35	37	0	9	31
Little et al. [13]	137	40	0.7	26	22
Park et al. [14]	49	20	2	28.6	28.6
Mathiesen et al. [15]	29	48	0	7	21
Natarajanet et al. [16]	150	32	0	22	20.3
Bambakidis et al. [17]	46	43	0	41	30
Ramina et al. [18]	67	55	3	12	33
Tahara et al. [19]	15	50	13	20	50
Seifert [20]	148	37	0	31	22
Li et al. [21]	57	58	2	42	67
Yang et al. [22]	41	61	0	66	8
Yamakami et al. [23]	32	59	6	28	22
Watanabe et al. [24]	26	42	0	15	15
Shi et al. [25]	14	86	0	43	43
Chen et al. [26]	82	56	5	44	39
Nanda et al. [27]	50	28	6	44	32
Kusumi et al. [28]	23	47	0	22	43
Matsui [29]	15	67	0	27	27
Li et al. [30]	259	52.5	1.2	54	28.2
Almefty et al. [31]	64	64	8	25	39
Morisako et al. [32]	$60_{(24/36)}$ [b]	EOR 96.1/92.7 [c]	1.7	25	46.7
Silva et al. [33]	8/16	87.5	0	37.5	37.5
[d] Tatagiba et al. [34]	29/87	66	0	24	34
[d]Zhou et al. [35]	24	33.3	0	20.8	37.5

[a] Simpson grades 1, 2, and 3.
[b] 24 cases in the early group (1990–1999) and 36 cases in the late group (2000–2009).
[c] Extent of resection (EOR) was calculated as follows: EOR(%) = (preoperative tumor volume − postoperative tumor volume)/preoperative tumor volume × 100.
[d] Employed endoscopic assistance.