



## Surgical Management of Petroclival Lesions – Quest for the Holy Grail !!

### Neurosurgery

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### ABSTRACT

**Background :** Surgical management of petroclival regions remains particularly challenging for the neurosurgeon . This is so because the relative inaccessibility of this region surgically, the tenacious nature of these lesions and the presence of numerous critical neurovascular structures in this region. The pendulum of accepted wisdom keeps swinging between extensive total removal and maximal safe resection. We analysed our results to see what is optimal for such patients., what is the " holy grail" in managing these patients surgically.

**Methods :** All patients with clinical and radiological evidence of lesions involving the petroclival region operated between 2009 and 2015 were included. Radiological evaluation was with contrast MRI. DSA was reserved for selected cases. Surgical approach was decided based on the size and exact disposition of the lesions.

**Results:** There were 14 females and 09 males .Age range was 19 to 64 years. Clinical presentation included only headache(04),cranial nerve involvement(19),cerebellar signs(09),pyramidal signs(08) and raised ICP(09). Surgical approach was decided on the exact location of the lesion. Surgical approaches used were anterior petrosal (06),posterior petrosal(09),combined petrosal(02), middlefossa subtemporal (05) and transpharyngeal with LeFort osteotomy(01).Total excision could be achieved in 14 patients and 09 had subtotal or partial excision. HPE revealed meningiomas(11),epidermoids(07),chordomas(03) and neurofibroma(02).

**Conclusions:** Petroclival lesions are typically difficult to manage surgically. With improving neurosurgical skull base techniques their management is improving, however they are still associated with significant morbidity due to involvement of lower cranial nerves. The current "holy grail" seems to achieve maximal safe resection without adding to the preoperative deficit of these patients.

### KEYWORDS:

Petroclival lesions, Meningioma, chordomas, petrosal approaches

### Introduction

The Greek mythology tells us about the toils of Sisyphus , who was condemned to eternal , hard and frustrating labour . He had to push a large boulder up a hill and every time he would do it , the boulder would roll back and he had to do it again , and again , and again !! Surgery for large petroclival tumors can be equally physically demanding and frustrating. It is still a challenge for the majority of neurosurgeons. Over the years the surgical results have improved due to improvement in microneurosurgical techniques, new and innovative skull base approaches .Still a feeling of frustration is evident as the mortality is relatively high and total excision,without morbidity, remains something of an elusive mirage – a "Holy Grail" !! [1,2,3,4].

### Material and Methods

All patients with clinical and radiological evidence of lesions involving the petroclival region operated between 2009 and 2015 were included. Radiological evaluation was with CMRI to evaluate the tumor morphology and with appropriate CT scans to evaluate the bony destruction/involvement of the skull base so as to facilitate surgical planning.4 vessel cerebral DSA was reserved for selected cases in which either the tumor was very large (with an aim to preoperatively embolise the lesion) or where critical vessel involvement was suspected (with an aim to plan surgical strategy).

Surgical approach was decided based on the tumor morphology , bony and surrounding vessel involvement as gleaned by the above evaluation. Patients with significant hydrocephalus and clinically raised ICP underwent preoperative VP shunt. Others were taken up directly for definitive surgery.At surgery the aim was to resect the lesion totally without causing additional neurological deficit . Where this was not considered possible, due to intraop assessment of tumor consistency/vascularity and its relation/adherence to critical neurovascular structures, maximal safe resection was done. Surgical technique and outcome were reviewed based on clinical and radiological follow up which has ranged from 3 months to six years.

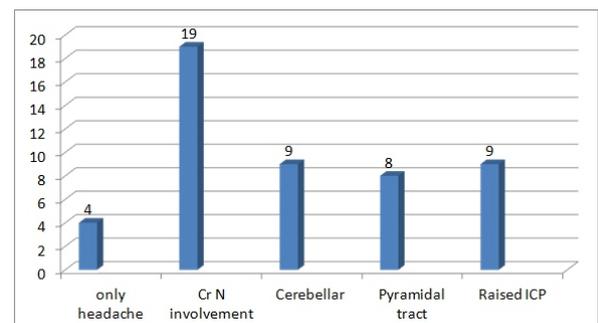
### Results

There were a total of 23 patients. Patient details are mentioned in table 1.

**Table 1 . Details of patients ( n=23).**

Total patients	23
Female	14
Male	09
Age (range)	19-64 yrs
Lesions	
Fresh presentation	16
Recurrent / residual lesion	07

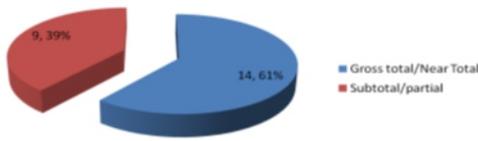
Clinically, the most common mode of presentation was cranial nerve involvement, followed by raised ICP and cerebellar signs. The modes of presentation are shown in Fig 1. Most patients had a mix of these features.



**Fig 1. Clinical presentation in 23 patients of petroclival lesions**

Based on preoperative evaluation the surgical approaches were as follows. Anterior petrosal (06), posterior petrosal (09), combined petrosal (02), middle fossa subtemporal (05) and transpharyngeal with Le Fort I osteotomy (01). Gross/near total resection could be achieved in 39% and partial/subtotal resection was done in 61%

cases ( fig 2) keeping in mind the surgical philosophy that the aim was maximal safe resection without aggravating the preoperative neurological deficit and to keep the surgical morbidity minimal.



**Fig2.Extent of resection in 23 patients of petroclival lesions.**

Histological evaluation revealed the tumor pathology as listed in table 2.

**Table 2 .Histopathological diagnosis in 23 patients with petroclival lesions.**

Meningioma	11
Epidermoid	07
Chordoma	03
Neurofibroma	02

There were expected complications which have been listed in table 3.

**Table 3.Post operative complications in 23 operated cases of petroclival lesions.**

Event	No
Fresh /worsened Cranial nerve deficit	08 ( 06 recovered)
Paresis	04 ( 02 recovered)
Ataxia	03 ( 02 recovered)
Meningitis	02
Chest related complications	04
Deaths	03

There were 03 deaths due to meningitis and chest related complications. Eight patients developed fresh cranial nerve deficit of which six recovered at follow up ( Figs 3 &4).



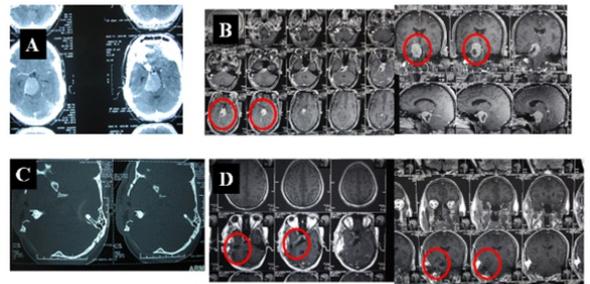
**Fig3.Third nerve deficit in the immediate post op period.**



**Fig 4. Complete resolution of all Cranial nerve deficit at follow up.**

**Interesting representative cases.**

A 22 years old male presented with headache. Radiological evaluation revealed a petroclival meningioma on the right side ( Fig 5). He had been operated by a retromastoid approach elsewhere, but there was a significant residual lesion. He was operated upon by a combined petrosal approach and the tumor could be completely excised . He had transient post operative third nerve paresis which completely resolved on follow up ( Figs 3 &4).



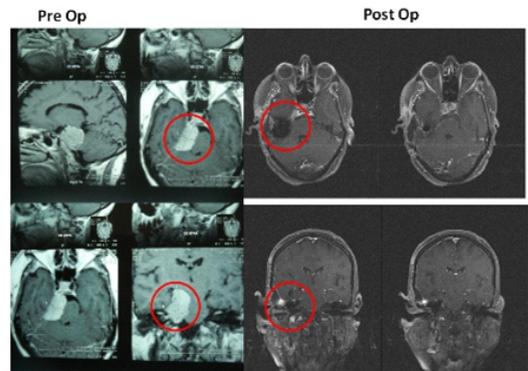
**Fig5. A Pre Op CT scan showing petroclival meningioma.**

**B Post Op MRI showing residual lesion after initial surgical excision through a retromastoid approach elsewhere.**

**C. Immediate post op CT scan after combined petrosal approach at our centre. The extensive bone work can be seen.**

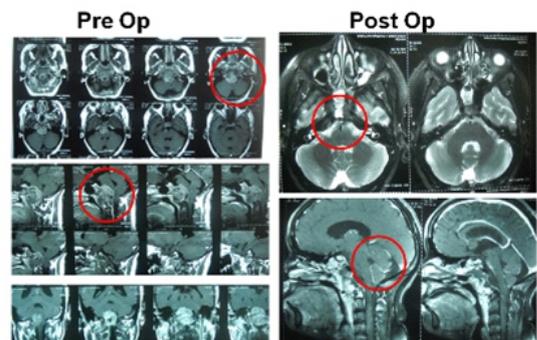
**D. Post Op MRI (after surgery at our centre) showing complete tumor excision.**

A 55 years old lady presented with right side V1 and V2 hypoesthesia. Radiology showed right sided petroclivalmeningioma(Fig 6). This was completely excised using an anterior petrosal approach.



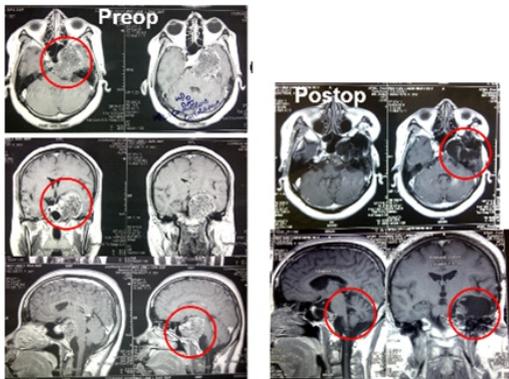
**Fig6. Complete excision of right petroclival meningioma.**

Another 26 year old lady presented with symptoms of brain stem compression . Radiological evaluation revealed an anteriorly placed clival lesion extending across the midline ( Fig 7). Complete excision was achieved through a transpharyngeal Le Fort osteotomy approach. HPE turned out to be chordoma



**Fig 7. Complete excision of clival chordoma.**

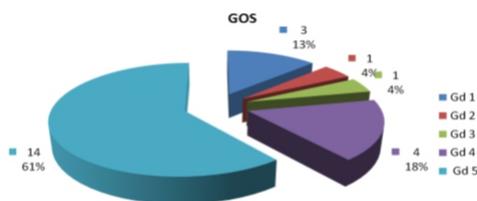
Another 35 year old lady presented with left sided ophthalmoplegia . Radiological evaluation ( Fig 8) revealed a large left sided petroclival lesion which was completely excised and turned out to be chordoma.



**Fig 8. Complete excision of left petroclival chordoma**

**Outcomes**

At a follow up ranging from 06 months to 03 years the outcomes were as shown in fig 9. 79% patients had good outcome ( GOS 4 or 5).



**Fig 9. Outcome as per Glasgow outcome scale in 23 patients of petroclival lesions.**

**Discussion**

Petroclival lesions are rare and not many large series are reported in literature. Most of these lesions are meningiomas. These lesions are difficult to excise surgically and over period of time the surgical philosophy has been swinging between complete excision through extensive skull base approaches causing significant morbidity and safe subtotal/near total excision but with no worsening of preoperative deficit[1,2,3,4].

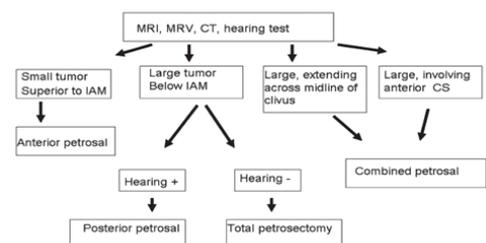
Histopathologically, most common lesions are meningiomas[5]. Most of the meningiomas are considered asymptomatic and benign ,however they can lead to head and neck manifestations as they can extend through skull foramen, cranial suture or through a bone defect due to tumor induced destruction of the skull bone.[6] 10% of all intracranial meningiomas occur in the posterior fossa and fifty percent of these are in the petroclival region. Other lesions encountered in this region are epidermoids ,schwannomas, chordomas, chondrosarcomas, giant cell tumors and ependymoma [2,5,7,8,9].

The indications for surgery of petroclival lesions like meningiomas are evident growth, development of neurological deficits, or raised intra cranial pressure[10]

With an aim to develop surgical strategy the petroclival region has been subdivided into various zones by different authors and based on the exact origin and extent the tumors have also been classified into different types. One of the initial definition was by Yasargil [11] who divided these lesions into clival, petroclival and sphenopetroclival. Then came the division of this area into three zones by Aziz et al[12].Recently Kawase et al [13] have divided these lesions into upper clival , cavernous , tentorial and petrous apex types. All these classifications are basically to try and identify the optimal approach for each type of the lesion.

There have been a plethora of approaches described to excise these lesions, each with its own advantages, restrictions and disadvantages. Extensive work has been done to try and work out the distance to the petroclival region through different approaches[14]. Controversies are still there for the preference to surgical approach and depends on the age of the patient, on evaluation of preoperative cranial nerve deficits, and the preference of the surgeon.[15]

Over the years various authors have described different approaches to this region like the presigmoid sinus approach by Mario et al. [16] Samii et al, the combined supra-infratentorialpresigmoid sinus approach[17], petrosal approach by Al Mefty et al. [18], a combined retroauricular and preauriculartranspetrosal-transtentorial approach by Hakuba et al [19], Kawase’sMiddle fossa transpetrosaltranstentorial approach [20] , combined petrosal approaches [21], reterosigmoid approach [22] [23], reterosigmoid intradural suprameatal approach by Samii et al [24], the more recent Expanded Endonasal Approach (EEEA) [25] and so on and on. Excellent reviews of the pros and cons of these approaches are available [26,27,28]. In essence the craniotomy can either be pterional ,frontoorbitozygomatic, temporal or retromastoid. Thereafter based on the surgical corridor the approach could be anterior temporal, subtemporal, presigmoid, reterosigmoid or transtentorial . And based on the extent of removal of petous bone it could be anterior petrosal , posterior petrosal , combined petrosal or complete petrosectomy. A practical algorithm for choice of approach in an individual patient based on different parameters has been described by Ware et al [29] and is shown in Fig 10.



**Fig 10. Choice of surgical approach in a patient with petroclival tumor. From Ware et al [29].**

It is to be kept in mind that there are many factors that prevent gross total resection of the tumor and are independent of the various surgical approaches planned or even of the skill or experience of the surgeon. These factors include invasion of the cavernous sinus, brainstem pial invasion, encasement of the neurovascular structures, and tumor consistency.[28][30]

Once the tumor has been approached the next critical decision is to decide how much to remove. Not very long ago the philosophy was to design extensive skull base approaches to completely excise the tumor ,not withstanding the morbidity. In this regard perhaps it is wise to heed to Cushing’s words when he says *“When to take great risks; when to withdraw in the face of unexpected difficulties; whether to force an attempted enucleation of a pathologically favorable tumor to its completion with the prospect of an operative fatality, or to abandon the procedure short of completeness with the certainty that after months or years even greater risks may have to be faced at a subsequent session—all these take surgical judgement which is a matter of long experience”.*

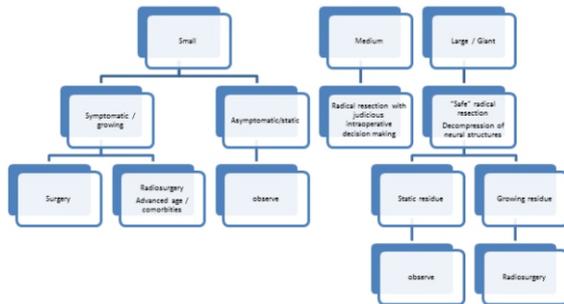
Various authors have questioned whether radical resection of these lesions is always the best option [31,32].No significant difference in survival benefits have been reported between the two groups. Studies have even reported that there is no significant difference in recurrence rates and disease progression between total and subtotally resected groups[4,33].

Now a days the advancements in stereotactic radiosurgery (SRS), has shown excellent control over tumor-growth, preservation of neurological status at long term follow up and has also affected

treatment strategy, particularly in meningiomas [34,35,36,37,38]. However, the various studies for meningiomas did not clearly conclude the results separately for the petroclival subgroup. Various studies on SRS show cranial nerve deficits occurrence up to 8% of patients.[39] In patients with large tumors who are not candidates for surgery some authors have recommended staged SRS [40] and some author have advocated SRS for residual tumor after surgery.[4]

Comprehensive reviews of all the studies reported in literature [3] and large personal series of established authorities over periods as long as 20 years [41] have analysed the shift in surgical philosophy over the years. Based on various parameters, different options like , surgery alone , surgery with radiosurgery, radiosurgery alone , radiotherapy alone and observation with no treatment have been analysed. The jury may well be out on this one, but the current consensus seems to be that the surgical aim should be to achieve maximum resection while maintaining or improving neurological function and residual or recurrent disease should be treated with stereotactic radiosurgery[3,4,,31,32,33,41]. Based on these studies a treatment algorithm is shown in fig 11, which would be in consonance with the philosophy of “ eternal quest for preservation of quality of life”[41].

**Fig 11 .Treatment algorithm for petroclival tumors in consonance with the “eternal quest for preservation of quality of life”.** [41]



## Conclusions

Petroclival lesions are relatively uncommon. Due to their location they are typically difficult to manage surgically. With improving neurosurgical skull base techniques their management is improving, however they are still associated with significant morbidity due to involvement of lower cranial nerves. The surgical philosophy over the years has shifted from total excision through extensive skull base approaches which cause significant morbidity to maximal resection with preservation/improvement of neurological function and to treat the residual/recurrent disease with stereotactic radiosurgery. “The Holy Grail” seems maximal safe resection with preservation of quality of life.

**Conflicts of Interest:** The authors have none to declare

**Disclosures:** None .No financial grant utilized.

## References

- Al Mefty O, Smith R: Clival and petroclival meningioma. In: Al Mefty O (ed): Meningioma. New York, Raven Press 1991, pp517-538
- Couldwell WT, Fukushima T, Giannotta SL, Weiss MH: Petroclival meningiomas: Surgical experience in 109 cases. *J Neurosurg* 1996; 84:20-28
- Michael L, Diluna, M.D., Ketan R, Bulsara, M.D. Surgery for Petroclival Meningiomas: A Comprehensive Review of Outcomes in the Skull Base Surgery Era . *Skull Base* 2010;20:337-342.
- Nanda A ,Javalkar V , Banerjee AD. Petroclival meningiomas : study on outcomes , complications and recurrence rates. *J Neurosurg* 114 : 1268-1277, 2011.
- Ashok K Mahapatra, Deepak Agrawal, GD Satyarthee. Surgery of petroclival tumours: A series of 45 cases. *Pan Arab Journal Of Neurosurgery*. 12:31-36, 2008.
- Wu CK, Wang CH, Lin YY, Chen HC. Petroclival meningioma: a rare cause of serous otitis media. *J Coll Physicians Surg Pak*. 2014 Nov; 24 Suppl 3: S233-4
- Spetzler RF, Dasipit CP, Pappas CT: The combined supra- and infratentorial approach for lesions of the petrous and clival regions: Experience with 46 cases. *J Neurosurg* 1992; 76:588-599
- Weber AL, Liebsch NJ, Sanchez R, Sweriduk ST, Jr.: Chordomas of the skull base: Radiologic and clinical evaluation. *Neuroimaging Clin N Am* 1994; 4:515-527
- Yang X, Ren Y, Wu W, Wang X, Liu X, Zhang Y. Intracranial extra-axial ependymoma involving the petroclival region: a rare case report. *Int J Clin Exp Pathol*. 2014 Dec

- 17(12):9067-71.
- Xu F, Karampelas I, Megerian CA, Selman WR, Bambakidis NC. Petroclival meningiomas: an update on surgical approaches, decision making, and treatment results. *Neurosurg Focus*. 2013 Dec; 35(6):.
- Yasargil M, Mortara R, Curcio M. Meningiomas of basal posterior cranial fossa. In: Krayenbuhl H, ed. *Advances and Technical Standards in Neurosurgery*. Vol. 7. Austria: Springer-Verlag; 1980:1-115
- Abdel Aziz KM, Sanan A, van Loveren HR, Tew JM Jr, Keller JT, Pensak ML. Petroclival meningiomas: predictive parameters for transpetrosal approaches. *Neurosurgery*. 2000 Jul; 47(1):139-50.
- Ichimura S, Kawase T, Onozuka S, Yoshida K, Ohira T. Four subtypes of petroclival meningiomas: differences in symptoms and operative findings using the anterior transpetrosal approach. *Acta Neurochir* 2008; 150:637-645.
- Murilo S, Meneses Ana Lucila Moreira, Kelly C, Bordignon Ari A, Pedrozo Ricardo Ramina, and Jeziel G. Nikoski. Surgical Approaches to the Petrous Apex: Distances and Relations with Cranial Morphology. *Skull Base: An Interdisciplinary Approach/Volume 14, Number 1* 2004, 9-20.
- Panigrahi M, Vooturi S, Patibandla MR, Kulkarni D. Novel classification for surgical approach of petroclival meningiomas: A single-surgeon experience. *Neurol India*. 2015 Sep-Oct; 63(5):718-22.
- Mario Ammirati, and Madjid Samii. Presigmoid Sinus Approach to Petroclival Meningiomas. *Skull Base Surgery, Volume 2, Number 3, July 1992* 124-128.
- Samii M, Ammirati M: The combined supra-infratentorial presigmoid sinus avenue to the petroclival region. Surgical technique and clinical applications. *Acta Neurochir (Wien)* 956-12, 1988
- Al Mefty O, Fox JL, Smith RR: Petrosal approach for petroclival meningiomas. *Neurosurgery* 22:510-517, 1988.
- Hakuba A, Nishimura S, Jo Jang B: A combined retroauricular and preauricular transpetrosal-transtentorial approach to clivus meningiomas. *Surg Neurol* 30:108-116, 1988
- Kawase T, Shiobara R, Toya S. Middle fossa transpetrosal-transtentorial approaches for petroclival meningiomas. Selective pyramid resection and radicality. *Acta Neurochir (Wien)* 1994; 129(3-4):113-120
- Cho CW, Al-Mefty O. Combined petrosal approach to petroclival meningiomas. *Neurosurgery* 2002; 51(3):708-716; discussion 716-718
- Siwanuwatn R, Deshmukh P, Figueiredo EG, Crawford NR, Spetzler RF, Preul MC: Quantitative analysis of the working area and angle of attack for the retrosigmoid, combined petrosal, and transcochlear approaches to the petroclival region. *J Neurosurg* 104:137-142, 2006
- Chen LF, Yu XG, Bu B, Xu BN, Zhou DB. The retrosigmoid approach to petroclival meningioma surgery. *J Clin Neurosci*. 2011 Dec; 18(12):1656-61.
- Samii M, Tatagiba M, Carvalho GA: Retrosigmoid intradural suprameatal approach to Meckel's cave and the middle fossa: surgical technique and outcome. *J Neurosurg* 92:235-241, 2000
- Jacquesson T, Berhouma M, Tringali S, Simon E, Jouanneau E. Which Routes for Petroclival Tumors? A Comparison Between the Anterior Expanded Endoscopic Endonasal Approach and Lateral or Posterior Routes. *World Neurosurg*. 2015 Jun; 83(6):929-36.
- Erkmen K, Pravdenkova S, Al-Mefty O. Surgical management of petroclival meningiomas: factors determining the choice of approach. *Neurosurg Focus* 2005; 19(2):E7
- Bambakidis NC, Kakarla UK, Kim IJ, et al. Evolution of surgical approaches in the treatment of petroclival meningiomas: a retrospective review. *Neurosurgery* 2007; 61(5, Suppl 2):202-209; discussion 209-211
- Xu F, Karampelas I, Megerian CA, Selman WR, Bambakidis NC. Petroclival meningiomas: an update on surgical approaches, decision making, and treatment results. *Neurosurg Focus*. 2013 Dec; 35(6):E11.
- Ware ML, Pravdenkova S, Erkmen K, Ossa Mefty O A. Petroclival and Upper Clival Meningiomas I: An Overview of Surgical Approaches. Lee Joung H, editor. In: *Meningioma: Diagnosis, Treatment, and Outcome*. London: Springer; 2009. p. 412.
- Tahara A, de Santana PA Jr, Calfat Maldaun MV, Panagopoulos AT, da Silva AN, Zicarelli CA, Pires de Aguiar PH. Petroclival meningiomas: surgical management and common complications. *J Clin Neurosci*. 2009 May; 16(5):655-9.
- Josef Zentner, Bernhard Meyer, Uwe Vieweg, Claus Herberhold, Johannes Schramm. Petroclival meningiomas: is radical resection always the best option?. *Journal of Neurology, Neurosurgery, and Psychiatry* 1997; 62:341-345
- Natarajan SK, Sekhar LN, Schessel D, Morita A. Petroclival meningiomas: multimodality treatment and outcomes at long-term follow-up. *Neurosurgery* 2007; 60(6):965-979; discussion 979-981
- Little KM, Friedman AH, Sampson JH, Fukushima T. Surgical management of petroclival meningiomas: Defining resection goals based on risk of neurological morbidity and tumor recurrence rates in 1337 patients. *Neurosurgery* 56:546-559, 2005
- Davidson L, Fishback D, Russion JJ, Weiss MH, Yu C, Pagnini PG, et al: Postoperative Gamma Knife surgery for benign meningiomas of the cranial base. *Neurosurg Focus* 23(4):E6, 2007
- Kreil W, Luggin J, Fuchs I, Weigl W, Eustacchio S, Papaefthymiou G: Long term experience of gamma knife radiosurgery for benign skull base meningiomas. *J Neurol Neurosurg Psychiatry* 76:1425-1430, 2005
- Milker-Zabel S, Zabel-du Bois A, Huber P, Schlegel W, Debus J: Intensity-modulated radiotherapy for complex-shaped meningioma of the skull base: long-term experience of a single institution. *Int J Radiat Oncol Biol Phys* 68:858-863, 2007
- Starke RM, Williams BJ, Hiles C, Nguyen JH, Elsharkawy MY, Sheehan JP: Gamma Knife surgery for skull base meningiomas. Clinical article. *J Neurosurg* 116:588-597, 2012
- Yamakami I, Higuchi Y, Horiguchi K, Saeki N: Treatment policy for petroclival meningioma based on tumor size: aiming radical removal in small tumors for obtaining cure without morbidity. *Neurosurg Rev* 34:327-335, 2011
- Subach BR, Lunsford LD, Kondziolka D, Maitz AH, Flickinger JC: Management of petroclival meningiomas by stereotactic radiosurgery. *Neurosurgery* 42:437-445, 1998
- Iwai Y, Yamanaka K, Nakajima H: Two-staged gamma knife radiosurgery for the treatment of large petroclival and cavernous sinus meningiomas. *Surg Neurol* 56:308-314, 2001
- Seifert V. Clinical management of petroclival meningiomas and the eternal quest for preservation of quality of life. *Acta Neurochir* 2010, 152:1099-1116.