Papillary Tumor of the Pineal Region: Case Report and Literature Review

Tumor papilífero da região pineal: relato de caso e revisão da literatura

Vitor Nagai Yamaki[1] Felipe Romero Vera[2] Renan Ribeiro Ribeiro[3] Raphael Salles Scortegagna Medeiros[3] Manoel Jacobsen Teixeira[1] Eberval Gadelha Figueiredo[1]

[1] Department of Neurosurgery, School of Medicine, Universidade de São Paulo, SP, Brazil
[2] Department of Neurosurgery, Hospital Barros Luco Trudeau, Santiago, Chile
[3] Department of Pathology, School of Medicine, Universidade de São Paulo, SP, Brazil

Address for correspondence Vitor Nagai Yamaki, Rua Dr. Eneas de Carvalho Aguiar, 255, Pinheiros, SP, Brazil (e-mail: vitoryamaki@gmail.com).

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Abstract

Papillary tumor of the pineal region (PTPR) is a neuroectodermal tumor thought to originate from cells of the subcommissural organ. Its oncologic properties are still under investigation, as well as the most suitable therapeutic measures for this type of neoplasm. We report the case of a 36-year-old woman with a 1-year history of headache and intermittent diplopia. The magnetic resonance imaging (MRI) scan showed a heterogeneously enhancing mass in the pineal region that caused an acute hydrocephalus, and an emergency shunt derivation was necessary. One week later, the patient was submitted to subtotal tumor resection, and remained asymptomatic in the post-operative period. In the follow-up, the patient remained asymptomatic; in the imaging control 3.5 years after the surgical resection, local recurrence was identified, and the patient was submitted to a local radiation protocol. Our literature review showed an early clinical onset due to intracranial hypertension signs. Definitive clinical onset might be reached only through a histopathological examination. Gross total resection followed by radiotherapy is the current standard of care. Local recurrence is often observed, with rare dissemination to the cerebral spinal fluid. The natural history of the PTPR remains unknown, as well as the best treatment strategy. Large case series with longer follow-ups are necessary for further conclusions.

Keywords
- pineal gland
- brain tumor
- surgical procedures
- local recurrence

Resumo

O tumor papilífero da região pineal (TPRP) tem origem neuroectodérmica nas células do órgão subcommissural. Suas propriedades oncológicas ainda estão sob investigação, assim como as medidas terapêuticas mais adequadas para este tipo de neoplasma. Relatamos o caso de uma paciente do sexo feminino, de 36 anos, com um histórico de um ano de cefaleia e diplopia intermitente. O exame de imagem de ressonância

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magnética (RM) evidenciou massa em topografia da glândula pineal com captação heterogênea ao contraste. Tal lesão tumoral provocou hidrocefalia aguda obstrutiva, com necessidade de derivação de emergência do ventrículo peritoneal. Após 1 semana, a paciente foi submetida a ressecção subtotal do tumor e permaneceu assintomática no período pós-operatório. Durante o acompanhamento, a paciente manteve-se assintomática, com recorrência local da lesão após 3,5 anos, e foi submetida a um protocolo local de radiação. Após revisão da literatura, grande parte dos tumores papilíferos da região pineal tiveram diagnóstico precoce, especialmente devido a sinais de hipertensão intracraniana. Os achados em exames de imagem não são específicos, e o diagnóstico definitivo só pode ser obtido por meio de avaliação histopatológica. Ressecção cirúrgica seguida de radioterapia tem se mostrado a melhor alternativa terapêutica. A recorrência local sido é observada de modo frequente em tumores tratados, mas raramente com disseminação a distância para o líquido cefalorraquiano. A história natural dos tumores papilíferos da região pineal ainda está sob investigação, assim como a melhor estratégia de tratamento. Séries de casos com amostras maiores e acompanhamento mais prolongado são necessárias para que se obtenham conclusões mais consistentes.

Palavras-chave
- glândula pineal
- tumor cerebral
- tratamento cirúrgico
- recorrência local

Introduction

The pineal region is the site for the occurrence of several unique tumors, each with a distinct biological behavior and, therefore, with a specific treatment and prognosis.[1–3] Parenchymal neoplasms are the most common finding in this region (that is, pineoblastoma, pineocytoma); however, germ cell tumors, meningiomas, ependymomas and astrocytomas have also been described.[4,5]

Papillary tumor of the pineal region (PTPR), a rare entity, has been described in the medical literature by Jouvet et al[6] in 2003, and included in the World Health Organization (WHO) classification of central nervous system (CNS) tumors as of 2007.[7] Papillary tumor of the pineal region is a neuroectodermal tumor that is thought to originate from cells of the subcommissural organ.[8] Its oncologic properties are still under investigation, as well as the most suitable therapeutic measures for this type of neoplasm. Since its recognition as a distinct entity, several case reports and case series have addressed the features of PTPR. The present paper describes our experience with a case of PTPR, followed by a review of the literature regarding this rare neoplasm.

Case Report

A 36-year-old woman with a 1-year history of headache and intermittent diplopia was under investigation at our institution. The neurologic exam was unremarkable. The magnetic resonance imaging (MRI) scan showed a 2.0 × 1.5 × 1.0-cm, heterogeneously-enhancing mass at the pineal topography. The lesion was hyperintense in T1, with multiple small cysts inside the tumor and a close relationship with both internal cerebral veins (►**Fig. 1**). One week later, the patient was recruited through the elective surgery schedule; however, she did not attend the hospital.

Two weeks later, the patient was admitted to the emergency department with progressive deterioration of her level of consciousness. A computed tomography (CT) scan demonstrated complete obstruction of the cerebral aqueduct and the onset of acute hydrocephalus. The patient was taken to the operating room for a ventricle derivation, with complete resolution of the symptoms of hydrocephalous. One week after the emergency surgery, the patient underwent a subtotal tumor resection through a supracerebellar infratentorial approach, as the lesion infiltrated the superior segment of the midbrain (►**Fig. 2**). The postoperative period was uneventful, with early hospital discharge. During follow-up, she remained asymptomatic. The MRI scan showed regrowth 3.5 years after the surgery (►**Fig. 3**). She was then submitted to adjuvant radiotherapy with local irradiation. The tumor remained stable after irradiation.

Histopathologic Findings

A microscopic examination of the lesion revealed a proliferation of polygonal epithelioid cells arranged in a predominantly papillary pattern, surrounding broad fibrovascular cores. The nuclei were round to oval, with finely speckled chromatin and little pleomorphism. The immunohistochemistry was performed. The neoplastic cells stained diffusely positive for cytokeratin 35 β H11. Focal S-100 staining and scattered glial fibrillary acidic protein (GFAP) reactivity were noted. The K_i-67 proliferative index was estimated as 10%. Other markers, such as the epithelial membrane antigen (EMA), the placental alkaline phosphatase (PLAP), synaptophysin and neurofilament were negative (►**Table 1**).

Discussion

Tumors of the pineal region account for less than 1% of brain tumors in Europe and North America.[9] Despite their rarity, a plethora of different entities can be found at this site.[9]

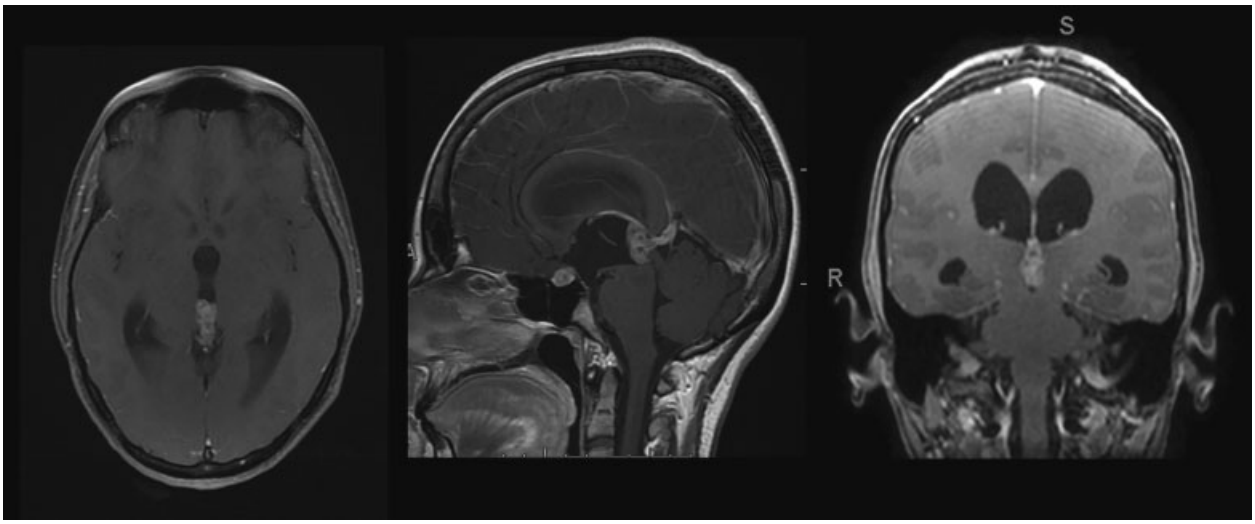

Fig. 1 Heterogeneous pineal mass with multiple cysts within a solid enhanced component in T1 postcontrast image.

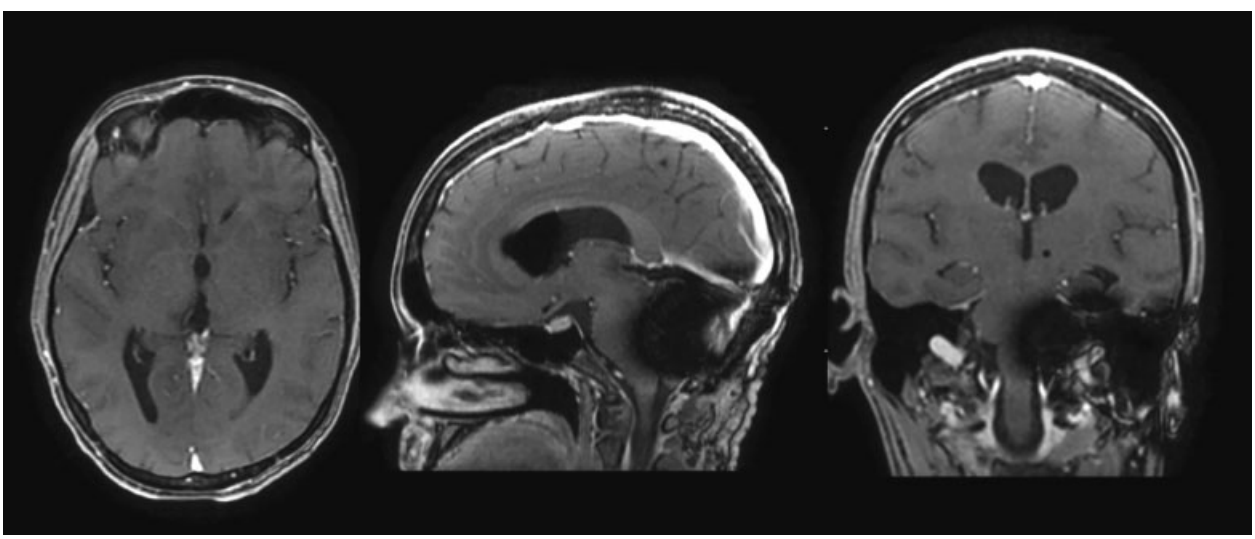

Fig. 2 Axial, sagittal and coronal T1 postcontrast image demonstrating subtotal resection of the pineal mass.

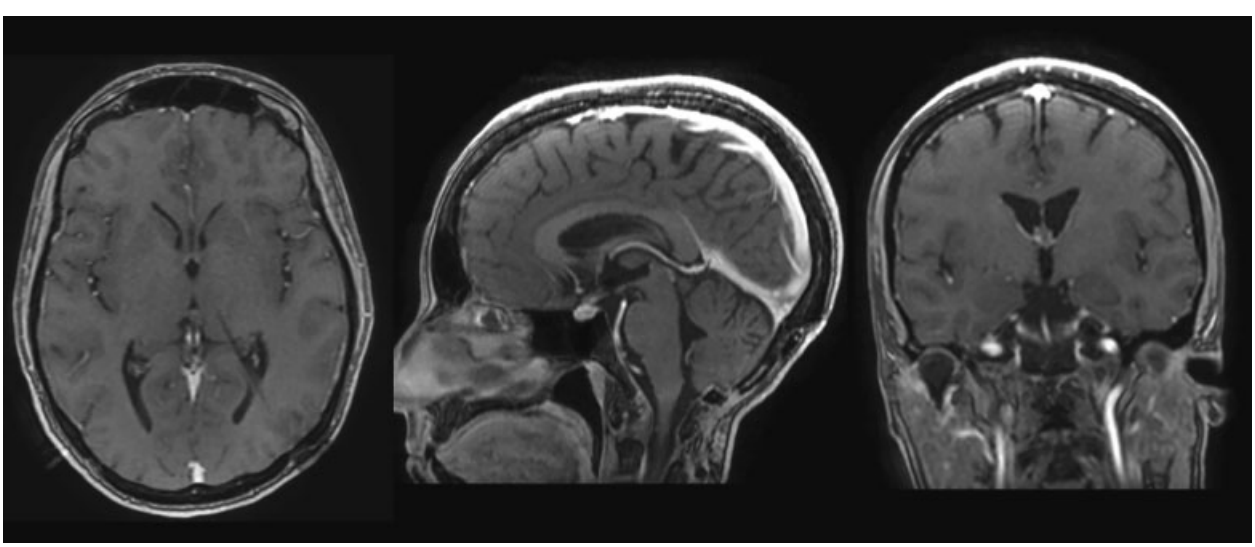

Fig. 3 Axial, sagittal and coronal T1 postcontrast image demonstrating local recurrence of the PTPR, measuring 2.1 × 1.3 cm, especially in the posterior part of the III ventricle.

Table 1 Immunohistochemical characteristics of the neoplasm

Cytokeratin 35βH11	+[a]
EMA	−
PLAP	−
GFAP	+[b]
Synaptophysin	−
S-100	+[c]
Neurofilament	−
K_i−67	+[d]

Abbreviations: −, negative immunoreactivity; EMA, epithelial membrane antigen; PLAP, placental alkaline phosphatase; GFAP, glial fibrillary acidic protein; +[a], positive immunoreactivity; +[b], Weak immunoreactivity; +[c], Focal expression of S-100; +[d], K_i−67 index was estimated as 10%.

Histopathological examination following tumor biopsy or resection is required to achieve a definitive diagnosis. Our patient developed the typical clinical presentation of a pineal tumor, with visual disturbance and headache as initial symptoms, eventually complicated by an acute hydrocephalous that required an urgent shunt procedure.

Most papers advocate surgical removal as the main therapeutic measure for PTPR;[2,3,10–18] however, the proper adjuvant therapy and its efficacy remain unknown. Our patient underwent surgery as the initial treatment, and local radiation at recurrence, and remains with a good functional outcome.

Clinical Presentation

The pineal gland produces and secretes melatonin.[1,2] Symptoms from tumors located in the pineal region are, however, related to its mass effect against adjacent structures. In the literature, the most common clinical presentation is cerebral aqueduct occlusion and consequent hydrocephalous. Therefore, in ∼ 80% of case reports patients exhibited signs of increased intracranial pressure, such as bilateral papilledema, abducens nerve palsy, morning headache or vomiting without nausea. Long-term visual disturbances were also often described, which may be attributed to compression of the mesencephalic tectal area or of the superior colliculus. Parinaud syndrome was described in less than 10% of the cases, and it might be misdiagnosed in an emergency situation of acute hydrocephalus.[1–3,6–8,10–68]

Regarding its biological behavior, PTPR shows a high propensity toward local recurrence, but only rarely disseminates to the spine. Hong et al[15] reported tumor dissemination to the spinal cord at the level of L3. Kim et al[37] described the case of a 39-year-old woman with secondary implants at the pituitary stalk and bilateral internal acoustic canals. Moreover, Nowicka et al[65] evidenced cerebral spinal fluid (CSF) dissemination of PTPR to the subependymal region of the frontal horns and the stem of the lateral ventricles. Therefore, the authors have encouraged an MRI scan of the whole cerebrospinal axis after the histopathologic diagnosis. More accurate case series with longer follow-ups are necessary to determine the accurate natural history of the PTPR.

Imaging

The differential diagnosis of pineal tumors by imaging methods is vast. A heterogeneous enhancing mass with some cystic component might be representative of a great variety of CNS neoplasms, such as pineal parenchymal tumors, ependymal tumors, germ cell tumors and even metastatic carcinomas. The intensity of the PTPR is variable in MRI weighting images.[1,4,26] Tumor size usually ranges from 2 to 3 cm, and the volume ranges from 10 to 14 cm.[3]

Histopathology

Papillary tumors of the pineal region are epithelial-like neoplasms arranged in papillary or solid architecture. In papillary areas, fibrovascular cores are broad, and may have multiple capillaries with a pseudoangiomatous appearance. These vessels are covered by a multilayered large columnar epithelium with a pale eosinophilic cytoplasm. In more solid areas, the cytoplasm may become clear or vacuolated, harboring an eosinophilic periodic acid-Schiff positive intracytoplasmic mass.

The nuclei are round to oval and basally situated. Chromatin is finely stippled, and small nucleoli may be seen. Some tumor cells feature anisonucleosis, hyperchromasia and multinucleation – these changes are thought to be more reactive in nature rather than reflecting a more aggressive biological behavior. Perivascular pseudorosettes, true rosettes, tubules and canals have been reported, and are more prominent in areas with solid architecture. This should warrant a differential diagnosis with ependymoma. Mitotic figures are variable, ranging from none to frequent. Necrosis is a common finding.[6,35,69,70]

Careful evaluation of the immunophenotype is pivotal to the diagnosis of PTPR. Strong reactivity for a broad spectrum of cytokeratins (Cam 5.2, AE1/AE3, CK8, and CK18), especially CK18, appears to be the most distinctive feature of this neoplasm. Staining for S100, neural cell adhesion molecule (NCAM), neuron-specific enolase and transthyretin is frequent. Immunoreactivity for GFAP, synaptophysin, chromogranin and neural antigens is usually absent, although some cases may exhibit focal, weak staining. Ki67 staining is variable, and the correlation with the biological behavior has not been established. Some authors advocate that a higher proliferative activity is found in younger patients.[12]

Although there are well-defined diagnostic criteria for PTPR, divergent findings in the literature and the low number of cases have deterred the establishment of a histologic grading scale that correlates with the prognosis. Therefore, systematic review studies are needed so that evidence-based conclusions regarding PTPR can be drawn.

Treatment

The therapeutic planning for PTPR is guided by effective treatments for other pineal tumors and by the opinion of experts. Most papers agree that tumor resection should be the first step in the treatment protocols. The actual need and efficacy of adjuvant therapy remain unknown. Surgical resection followed by local radiation was the most employed strategy to manage this type of tumor.

Freve-Montange et al[12] published one of the largest series in the current literature, reporting 31 cases of PTPR. Adjuvant radiotherapy was used in 40% (12/30) of these patients, with a mean survival of 57.4 months. Recurrent tumors were treated with radiotherapy alone.

Dagnew et al,[1] in 2007, reported 3 illustrative cases of PTPR treated by partial surgical resection followed by stereotactic radiosurgery (SRS) 1 month after surgical resection. In the last follow-up, the patients had remained with a good functional status 50 months after the treatment.

Cardenas et al[25] and Kim et al[37] used gamma-knife radiosurgery without surgical resection, and both of their patients presented early recurrence and needed additional therapy. Adjuvant platinum-based and temozolomide chemotherapy in addition to radiotherapy were the main treatments chosen in the studies retrieved, especially in cases of recurrence or evidence of CSF dissemination.

Conclusion

Papillary tumor of the pineal region must be included in the differential diagnosis of pineal masses. The definitive diagnosis relies on the histopathological evaluation. Gross total resection followed by radiotherapy is the current standard of care in most studies. The precise biological behavior of PTPR is not determined; local recurrence is common after the first treatment, and rare cases of CSF dissemination have been described. Large case series with longer follow-ups are necessary in order to draw further conclusions.

Conflict of Interests

The authors have none to declare.

Funding Information

The authors have none to declare.

Ethical Statement

We confirm that this study is original, never before published, and it is not under consideration by any other journal. This research is in compliance with ethical standards, and informed consent was obtained from all individual participants included in the study.

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The authors have none to make.

References

1 Dagnew E, Langford LA, Lang FF, DeMonte F. Papillary tumors of the pineal region: case report. Neurosurgery 2007;60(05): E953–E955, discussion E953–E955
2 Fauchon F, Hasselblatt M, Jouvet A, et al. Role of surgery, radiotherapy and chemotherapy in papillary tumors of the pineal region: a multicenter study. J Neurooncol 2013;112(02):223–231
3 Santoro A, D'Elia A, Fazzolari B, et al. Four-year clinical and neuroradiological follow-up of a papillary tumor of the pineal region. Neurol Sci 2012;33(04):931–935
4 Deiana G, Mottolese C, Hermier M, Louis-Tisserand G, Berthezene Y. Imagery of pineal tumors. Neurochirurgie 2015;61(2-3):113–122
5 Mottolese C, Beuriat PA, Szathmari A. Pineal tumours: Experience of the French National Register and the Lyon School, results and considerations. Neurochirurgie 2015;61(2-3):223–235
6 Jouvet A, Fauchon F, Liberski P, et al. Papillary tumor of the pineal region. Am J Surg Pathol 2003;27(04):505–512
7 Patil M, Karandikar M. Papillary tumor of pineal region: A rare entity. Asian J Neurosurg 2016;11(04):453
8 Kern M, Robbins P, Lee G, Watson P; >M. K. Papillary tumor of the pineal region–a new pathological entity. Clin Neuropathol 2006; 25(04):185–192
9 Mottolese C, Szathmari A, Beuriat PA. Incidence of pineal tumours. A review of the literature. Neurochirurgie 2015;61(2-3):65–69
10 Kaloshi G, Rroji A, Lame A, et al. Natural history of papillary tumor of the pineal region: new insights on biological explanation. J Neurooncol 2010;100(03):487–488
11 Heim S, Coras R, Ganslandt O, et al. Papillary tumor of the pineal region with anaplastic small cell component. J Neurooncol 2013; 115(01):127–130
12 Fèvre-Montange M, Hasselblatt M, Figarella-Branger D, et al. Prognosis and histopathologic features in papillary tumors of the pineal region: a retrospective multicenter study of 31 cases. J Neuropathol Exp Neurol 2006;65(10):1004–1011
13 Edson MA, Fuller GN, Allen PK, et al. Outcomes After Surgery and Radiotherapy for Papillary Tumor of the Pineal Region. World Neurosurg 2015;84(01):76–81
14 Cimino PJ, Gonzalez-Cuyar LF, Perry A, Dahiya S. Lack of BRAF-V600E Mutation in Papillary Tumor of the Pineal Region. Neurosurgery 2015;77(04):621–628
15 Hong B, Nakamura M, Brandis A, Becker H, Krauss JK. Spinal metastasis of papillary tumor of the pineal region. Clin Neurol Neurosurg 2011;113(03):235–238
16 Patel SK, Tomei KL, Christiano LD, Baisre A, Liu JK. Complete regression of papillary tumor of the pineal region after radiation therapy: case report and review of the literature. J Neurooncol 2012;107(02):427–434
17 Poulgrain K, Gurgo R, Winter C, Ong B, Lau Q. Papillary tumour of the pineal region. J Clin Neurosci 2011;18(08):1007–1017
18 Wong YS, Chan AWH, Ng HK, et al. 45 year old man with a pineal region tumor for over 15 years. Brain Pathol 2012;22(02):255–258
19 Hasselblatt M, Blümcke I, Jeibmann A, et al. Immunohistochemical profile and chromosomal imbalances in papillary tumours of the pineal region. Neuropathol Appl Neurobiol 2006;32(03):278–283
20 Kawahara I, Tokunaga Y, Yagi N, Iseki M, Abe K, Hayashi T. Papillary tumor of the pineal region. Neurol Med Chir (Tokyo) 2007;47(12):568–571
21 Kuchelmeister K, Hügens-Penzel M, Jödicke A, Schachenmayr W. Papillary tumour of the pineal region: histodiagnostic considerations. Neuropathol Appl Neurobiol 2006;32(02): 203–208
22 Shibahara J, Todo T, Morita A, Mori H, Aoki S, Fukayama M. Papillary neuroepithelial tumor of the pineal region. A case report. Acta Neuropathol 2004;108(04):337–340
23 Chang AH, Fuller GN, Debnam JM, et al. MR imaging of papillary tumor of the pineal region. AJNR Am J Neuroradiol 2008;29(01): 187–189. Doi: 10.3174/ajnr.A0784
24 Buffenoir K, Rigoard P, Wager M, et al. Papillary tumor of the pineal region in a child: case report and review of the literature. Childs Nerv Syst 2008;24(03):379–384
25 Cardenas R, Javalkar V, Haydel J, et al. Papillary tumor of pineal region: prolonged control rate after gamma knife radiosurgery - a case report and review of literature. Neurol India 2010;58(03):471–476
26 Cerase A, Vallone IM, Di Pietro G, Oliveri G, Miracco C, Venturi C. Neuroradiological follow-up of the growth of papillary tumor of the pineal region: a case report. J Neurooncol 2009;95(03):433–435
27 Coello AF, Torres A, Acebes JJ, Boluda S. Papillary tumor of the pineal region. Neurology 2009;73(06):486
28 Cohan JN, Moliterno JA, Mok CL, Lavi E, Boockvar JA. Pineal parenchymal tumor of intermediate differentiation with papillary

features: a continuum of primary pineal tumors? J Neurooncol 2011; 101(02):301–306
29 Cykowski MD, Wartchow EP, Mierau GW, Stolzenberg ED, Gumerlock MK, Fung KM. Papillary tumor of the pineal region: ultrastructural study of a case. Ultrastruct Pathol 2012;36(01):68–77
30 Dhillon J, Krishnamurthy S, Fuller GN. Papillary tumour of the pineal region: diagnosis by cytology smear. Cytopathology 2010; 21(04):267–269
31 Epari S, Bashyal R, Malick S, et al. Papillary tumor of pineal region: report of three cases and review of literature. Neurol India 2011; 59(03):455–460
32 Fèvre-Montange M, Grand S, Champier J, Hoffmann D, Pasquier B, Jouvet A. Bcl-2 expression in a papillary tumor of the pineal region. Neuropathology 2008;28(06):660–663
33 Gutenberg A, Brandis A, Hong B, et al. Common molecular cytogenetic pathway in papillary tumors of the pineal region (PTPR). Brain Pathol 2011;21(06):672–677
34 Husain N, Husain M. Endoscopic diagnosis of a pineal papillary glioneuronal tumor with extensive ventricular involvement: case report with review of literature. Neurol India 2009;57(06):792–795
35 Inoue T, Kumabe T, Kanamori M, Sonoda Y, Watanabe M, Tominaga T. Papillary tumor of the pineal region: a case report. Brain Tumor Pathol 2008;25(02):85–90
36 Jeruc JPM. Papillary tumor of the pineal region, a case report. Clin Neuropathol 2008;27:192
37 Kim YH, Kim JW, Park CK, et al. Papillary tumor of pineal region presenting with leptomeningeal seeding. Neuropathology 2010; 30(06):654–660
38 Lechapt-Zalcman E, Chapon F, Guillamo JS, et al. Long-term clinicopathological observations on a papillary tumour of the pineal region. Neuropathol Appl Neurobiol 2011;37(04):431–435
39 El Majdoub F, Blau T, Hoevels M, et al. Papillary tumors of the pineal region: a novel therapeutic option-stereotactic 125iodine brachytherapy. J Neurooncol 2012;109(01):99–104
40 Matyja E, Grajkowska W, Nauman P, Bonicki W. Folia Neuropathologica. Vol 49. Termedia; 2005. https://www.termedia.pl/,20,17401,0,1.html. Accessed January 25, 2018
41 Murali R, Scheithauer BW, Chaseling RW, Owler BK, Ng T. Papillary tumour of the pineal region: cytological features and implications for intraoperative diagnosis. Pathology 2010;42(05):474–479
42 Nakamura H, Makino K, Kochi M, Nakazato Y, Kuratsu J. Successful treatment of neoadjuvant therapy for papillary tumor of the pineal region. Brain Tumor Pathol 2009;26(02):73–77
43 Rickard KA, Parker JR, Vitaz TW, Plaga AR, Wagner S, Parker JC Jr. Papillary tumor of the pineal region: two case studies and a review of the literature. Ann Clin Lab Sci 2011;41(02):174–181
44 Sun IS, Kirollos R, Santarius T. No 5-ALA fluorescence seen in a recurrent papillary tumour of the pineal region (PTPR). Acta Neurochir (Wien) 2015;157(02):215–216
45 Sato TS, Kirby PA, Buatti JM, Moritani T. Papillary tumor of the pineal region: report of a rapidly progressive tumor with possible multicentric origin. Pediatr Radiol 2009;39(02):188–190
46 Sharma MC, Jain D, Sarkar C, et al. Papillary tumor of the pineal region–a recently described entity: a report of three cases and review of the literature. Clin Neuropathol 2009;28(04):295–302
47 Vandergriff C, Opatowsky M, O'Rourke B, Layton K. Papillary tumor of the pineal region. Proc Bayl Univ Med Cent 2012;25(01):78–79
48 Varikatt W, Dexter M, Mahajan H, Murali R, Ng T. Usefulness of smears in intra-operative diagnosis of newly described entities of CNS. Neuropathology 2009;29(06):641–648
49 Yano H, Ohe N, Nakayama N, Shinoda J, Iwama T. Clinicopathological features from long-term observation of a papillary tumor of the pineal region (PTPR): a case report. Brain Tumor Pathol 2009;26(02):83–88
50 Abela L, Rushing EJ, Ares C, et al. Pediatric papillary tumors of the pineal region: to observe or to treat following gross total resection? Childs Nerv Syst 2013;29(02):307–310
51 Aggarwal SK, Agarwal P, Sahu RN. Papillary tumor of pineal region with an unusual clinical presentation: Case report and review of the literature. Asian J Neurosurg 2016;11(01):78–79
52 Alkhotani A, Bilbao JM, Mainprize TGA. A 49 year-old woman with a pineal mass. Brain Pathol 2014;24(02):191–192
53 Chatterjee D, Gupta K, Kumar N, Chhabra R, Radotra BD. Papillary tumor of the pineal region-report of three cases with literature review. Neurol India 2015;63(04):567–570
54 Cohen AL, Salzman K, Palmer C, Jensen R, Colman H. Bevacizumab is effective for recurrent papillary tumor of the pineal region: First report. Case Rep Oncol 2013;6(02):434–440
55 Hua X, Yang P, Zhang M, Zhao Y, Wang B. Papillary tumor of the pineal region: A case report and review of the literature. Exp Ther Med 2015;10(04):1375–1379
56 Iacoangeli M, Colasanti R, Esposito D, et al. Supraorbital subfrontal trans-laminar endoscope-assisted approach for tumors of the posterior third ventricle. Acta Neurochir (Wien) 2017;159(04): 645–654
57 Ishida A, Shibuya M, Komori T, et al. Papillary tumor of the pineal region: a case involving isocitrate dehydrogenase (IDH) genotyping. Brain Tumor Pathol 2013;30(01):45–49
58 Jiménez-Heffernan JA, Bárcena C, Gordillo C, Cañizal JM. Cytologic features of papillary tumor of the pineal region: A case report showing tigroid background. Diagn Cytopathol 2016;44(12): 1098–1101
59 Kaloostian PE, Chen H, Tran HP. Malignant papillary glioneuronal tumor of the pineal gland: Case presentation and literature review of a distinct entity. Am J Case Rep 2013;14:164–168
60 Kamamoto D, Sasaki H, Ohara K, Mizutani K, Yoshida K. A case of papillary tumor of the pineal region with a long clinical history: molecular characterization and therapeutic consideration with review of the literature. Brain Tumor Pathol 2016;33(04):271–275
61 Koziarski A, Grala B, Skrobowska E. Papillary tumor of the pineal region. Report of two cases and literature review. Neurol Neurochir Pol 2014;48(05):356–362
62 Magalhães J, Rostad S, Foltz G, Pytel P, Rodriguez FJ. Cellular pleomorphism in papillary tumors of the pineal region. Brain Tumor Pathol 2013;30(02):93–98
63 Mbekeani JN, Ahmed M, Hassounah MI, Abdulshafi K, Al Hazzaa SA, Al Hindi H. Papillary tumor of the pineal region presenting with Foster Kennedy sign. Hematol Oncol Stem Cell Ther 2015;8 (03):140–142
64 Mobley BC, Kumar M, Sanger WG, et al. Papillary tumor of the pineal region with synchronous suprasellar focus and novel cytogenetic features. Hum Pathol 2015;46(08):1232–1236
65 Nowicka E, Bobek-Billewicz B, Szymaś J, Tarnawski R. Late dissemination via cerebrospinal fluid of papillary tumor of the pineal region: a case report and literature review. Folia Neuropathol 2016;54(01):72–79
66 Riis P, van Eck ATCJ, Dunker H, Bergmann M, Börm W. Stereotactic radiosurgery of a papillary tumor of the pineal region: case report and review of the literature. Stereotact Funct Neurosurg 2013;91 (03):186–189
67 Shakir HJ, Qiu J, Prasad D, Mechtler LL, Fenstermaker RA. Papillary tumor of the pineal region with extended clinical and radiologic follow-up. Surg Neurol Int 2015;6(19, Suppl 18):S451–S454
68 Shiramizu H, Hori T, Matsuo S, et al. Anterior callosal section is useful for the removal of large tumors invading the dorsal part of the anterior third ventricle: operative technique and results. Neurosurg Rev 2013;36(03):467–475
69 Roncaroli F, Scheithauer BW. Papillary tumor of the pineal region and spindle cell oncocytoma of the pituitary: new tumor entities in the 2007 WHO Classification. Brain Pathol 2007;17(03):314–318
70 Heim S, Beschorner R, Mittelbronn M, et al. Increased mitotic and proliferative activity are associated with worse prognosis in papillary tumors of the pineal region. Am J Surg Pathol 2014;38 (01):106–110