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## CASE REPORT

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# Foramen Magnum Papillary Meningioma: Review of Imaging and Histopathological Features

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### ABSTRACT

*This report is of a patient with foramen magnum papillary meningioma. The condition is rare and this report highlights its unusual 10-year clinical course. Angiographic features underestimated the extreme vascularity at the initial surgery when the diagnosis was made. Subsequently, multiple debulking and decompression procedures were performed to prevent cord compression. Multiple lesions with similar histopathological features developed in the thoracic and lumbosacral spine and a recurrence occurred at the skull base.*

**Key Words:** Foramen magnum; Magnetic resonance imaging; Meningioma; Pathology; Surgery

### INTRODUCTION

Meningiomas are the most common primary intracranial tumours, but frank malignancy occurs in only 1% of patients.<sup>1</sup> Of these, approximately 2.5% of tumours demonstrate metachronous features.<sup>2</sup> This report is of a patient with a rare papillary variant of malignant meningioma. The molecular pathogenesis, histopathology, and imaging findings of papillary malignant meningioma are also discussed.

### CASE REPORT

A 27-year-old man presented in 1997 with a 3-year history of neck pain, increasing during the previous 6 months. He had no bowel or urinary signs. Magnetic resonance imaging (MRI) showed an extramedullary intradural mass at the foramen magnum, extending from the outlet of the fourth ventricle to the C2/C3 disc level inferiorly (Figure 1). The tumour was of uniformly low-signal intensity in T1-weighted sequence and high-signal intensity in T2-weighted images. There was inhomogenous but marked enhancement following

intravenous contrast. A vertebral angiogram showed a vascular tumour, mainly supplied by the left vertebral artery, with small feeders arising from the left posterior inferior cerebellar artery (Figure 2). There was uniform staining of the tumour at the venous phase. The feeders were considered too fine for preoperative embolisation. The MRI and angiographic features suggested a foramen magnum meningioma.

Surgery showed a large soft, fleshy vascular tumour wrapping the upper cervical cord. Total surgical resection was attempted, but was unsuccessful because of severe bleeding. Frozen section showed a highly vascular meningioma. Paraffin sections showed that the tumour was composed of oval meningotheial cells with perivascular arrangement resembling pseudorosettes of ependymomas. A papillary growth pattern was also present. Immunostaining was positive for vimentin and epithelial membrane antigen (EMA), and negative for 5D3 keratin, pankeratin, S-100 protein and glial fibrillary acidic protein (GFAP). Based on these latter features, a histological diagnosis of papillary meningioma was made (Figure 3). Radiotherapy provided symptomatic relief.

The patient presented again 5 years later with increasing neck pain. Repeat MRI showed the foramen magnum lesion had increased in size (Figure 4). He

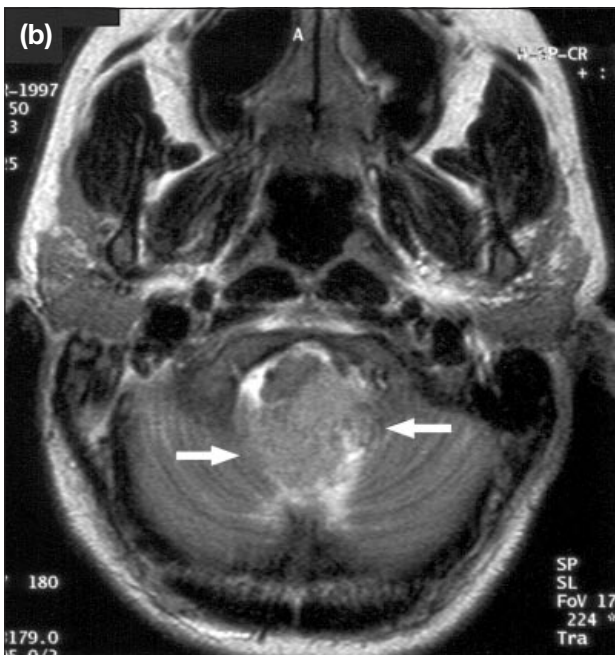
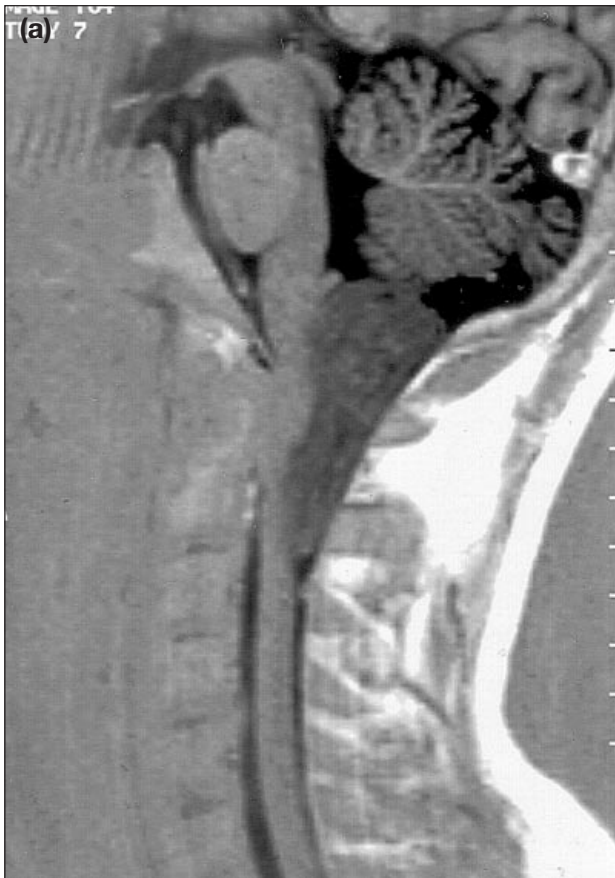
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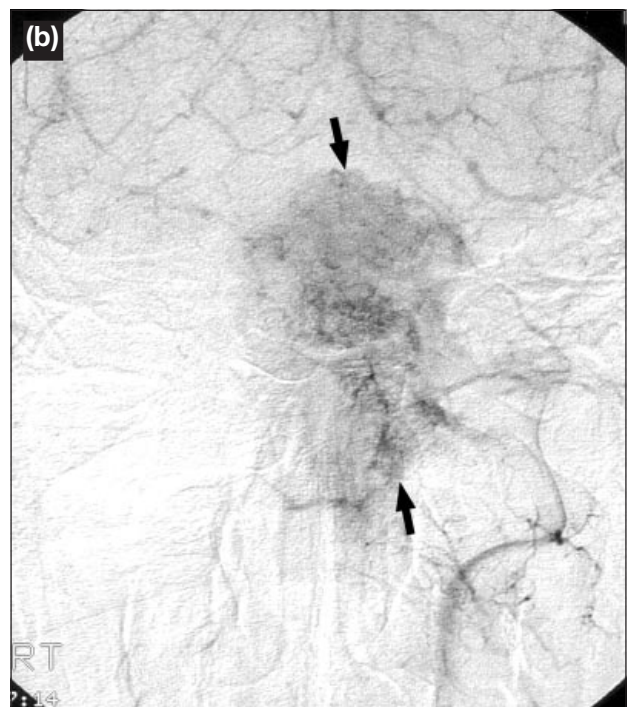
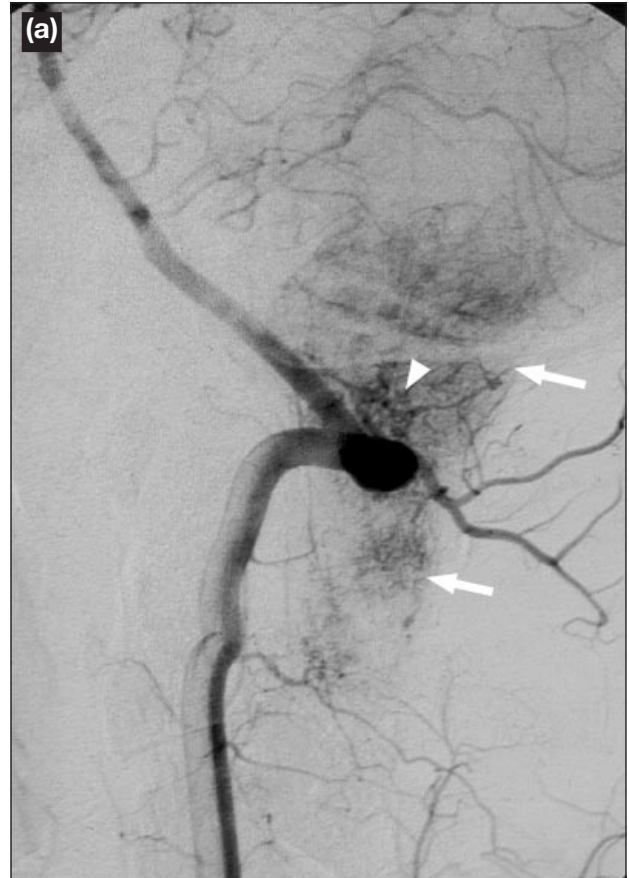
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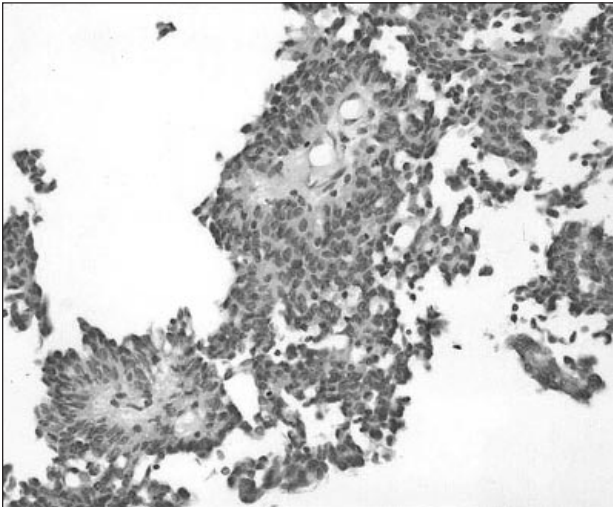
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**Figure 1.** Magnetic resonance imaging of a patient with papillary meningioma. (a) Sagittal T1-weighted image shows a well-defined low-signal intensity mass extending from below the fourth ventricle outlet through the foramen magnum to the upper cervical spine — compression of the upper cervical cord is evident; and (b) axial T2-weighted image shows an irregular high-signal intensity mass (arrows) above the foramen magnum level — there is extrinsic compression of the lower medulla oblongata by the mass.



**Figure 2.** Intra-arterial digital subtraction angiogram of the left vertebral artery. (a) Lateral projection of the mid-arterial phase shows staining of the tumour (arrows) — small unnamed feeders are arising from the posterior inferior cerebellar artery (arrowhead); and (b) frontal projection of the venous phase shows uniform tumour staining (arrows).



**Figure 3.** Tumour cells arranged in perivascular pseudorosettes and papillae characteristic of papillary meningioma (haematoxylin and eosin stain; original magnification, x 100).

underwent radical resection of the foramen magnum tumour with excellent response. However, the tumour recurred 2 years later. Repeat MRI showed the foramen magnum lesion had increased in size and there were thoracic and lumbar intradural extramedullary lesions consistent with multiple meningiomas (Figure 5a). Small enhancing lesions were present along the cauda equina nerve roots (Figure 5b). Neurofibromatosis II was suspected but was excluded by genetic assessment. The patient underwent thoracic laminectomy to debulk a lesion at T8/T9 followed by resection of a lumbar tumour a few months later. Histology showed atypical

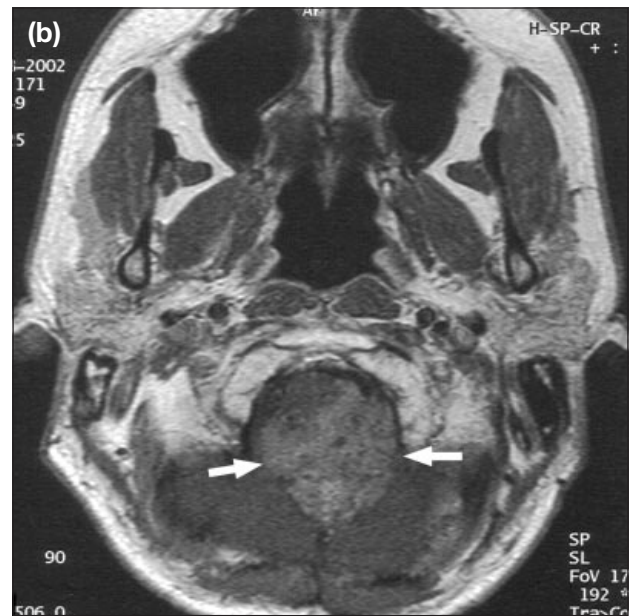
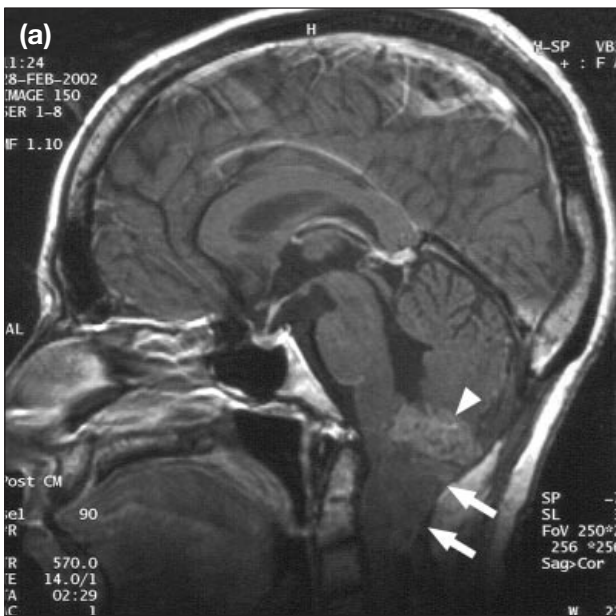
papillary meningiomas, similar to the foramen magnum lesion.

He underwent 2 more surgical decompressions of the craniocervical junction for recurrence, and by the 10th year of his illness, he had undergone 6 operations. He is currently undergoing spinal rehabilitation at another institution.

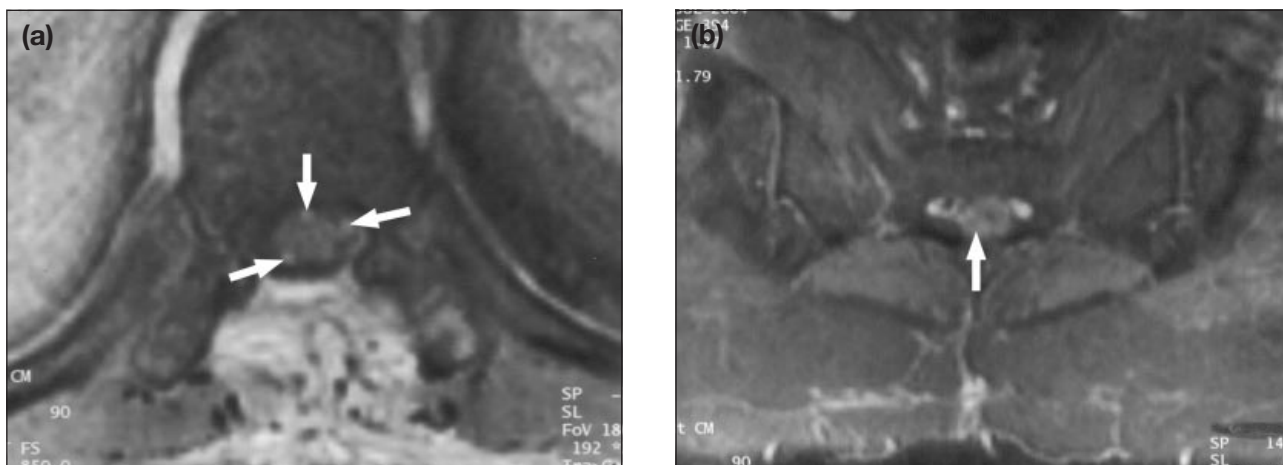
## DISCUSSION

Papillary meningioma is a rare variant of meningioma defined by the characteristic perivascular papillary pattern. Papillary meningioma tends to occur in young patients, including children, and has a high incidence of recurrence,<sup>3</sup> as illustrated by this patient. The aggressive clinical behaviour of local invasion, brain invasion, and extracranial metastasis, culminating in death, has resulted in papillary meningioma being classified as a World Health Organization (WHO) grade III tumour.<sup>4</sup>

The existence of atypical and malignant meningiomas was first recognised by Cushing and Eisenhardt.<sup>5</sup> In their classic monograph, these authors described a variant of meningioma characterised by a papillary pattern of epithelial cells and brain infiltration. One patient underwent 17 separate operations for a meningioma that became increasingly papillary with each subsequent recurrence, and eventually resulted in lung metastasis. The patient described in this report differs in that the initial presentation was a papillary meningioma. Thus,



**Figure 4.** Magnetic resonance imaging following intravenous contrast. (a) Midline sagittal T1-weighted image shows recurrence at the foramen magnum (arrows) — some inhomogeneous enhancement is present in the cranial component of the lesion (arrowhead); and (b) the recurrent tumour shows inhomogeneous enhancement in this axial T1-weighted image through the foramen magnum (arrows).



**Figure 5.** Post-contrast T1-weighted axial image through (a) the lower thoracic spine showing 3 small well-defined rounded lesions intradurally (arrows); and (b) the lower sacrum showing a rounded enhancing lesion arising from the cauda equina nerve roots (arrow).

papillary meningioma may present *de novo*, as in this patient, or develop from malignant transformation of a pre-existing benign (grade I) meningioma.

The WHO 2000 classification recognises 3 major groups of meningiomas.<sup>4</sup> Meningiomas with low risk of recurrence and aggressive growth (grade I), and meningiomas with a greater likelihood of recurrence and/or aggressive behaviour (grades II and III). Grade I tumours are typical meningiomas, which include meningothelial, fibroblastic, transitional, psammomatous, angiomatous, microcystic, secretory, clear-cell, chondroid, lymphoplasmacyte-rich, and metaplastic subtypes. Grade II tumours are atypical meningiomas and the special variants of clear-cell meningioma and chordoid meningioma. Grade III tumours include rhabdoid meningioma, papillary meningioma, and anaplastic (malignant) meningioma, which are characterised by aggressive clinical behaviour and special histological features.

It is difficult to differentiate true multiple meningiomas from simple recurrence, or variant of neurofibromatosis II. In a report of 9 patients with multiple meningiomas, Geuna et al found that only 5 had true multiple meningiomas.<sup>6</sup> Of the 5 patients, 4 had multiple simultaneous (synchronous) meningiomas, and only 1 had lesions of similar histology at different locations (metachronous) over successive years. This patient also demonstrates the difficulty of distinguishing multiple meningiomas associated with neurofibromatosis. There is a suggestion that the lesions are metachronous, related to the aggressive behaviour of papillary meningiomas.

Currently, the molecular pathogenesis of malignant meningiomas is poorly understood. A recent study

identified a protein 4.1 gene, termed DAL-1 (differentially expressed in adenocarcinoma of the lung), located on chromosome 18p11.3. DAL-1 loss has been identified in 60% of sporadic meningiomas, and is an early event in malignant transformation.<sup>7</sup> A monoclonal antibody to Ki67 (mindbomb homologue 1 [MIB1]), a nuclear protein related to cell proliferation, has also been found to be useful for assessing the overall prognosis, with the MIB1 score index showing good correlation with clinical features.<sup>8</sup> In addition, the proliferating cell nuclear antigen index is a useful parameter for estimating the biological behaviour of meningiomas.<sup>9</sup> General histologic parameters that have been identified as indices of aggressive behaviour of meningiomas or predictors of rapid recurrence include loss of architecture (loss of whirling and/or fascicles), hypercellularity, mitotic rate, foci of necrosis, nuclear pleomorphism, and invasion of adjacent structures.<sup>10</sup>

Diagnosis of papillary meningioma is based on assessment of typical histology as well as immunohistochemical features of the tumour. Al-Sarraj et al have reported a patient with papillary meningioma similar to that described in this report, with histology showing polygonal cells with rounded regular nuclei, with the cells arranged in perivascular pattern.<sup>11</sup> Mitosis was also frequent. Immunohistochemistry showed reactivity to vimentin and neurone specific enolase, whereas GFAP, 5D3 keratin, EMA, S100 protein, and synaptophysin were negative. Al-Sarraj et al also reported on the ultrastructural features.<sup>11</sup>

There has been little consensus regarding imaging features of malignant meningiomas.<sup>12</sup> Computed tomography (CT) and MRI are the investigations of choice,

but there are no specific radiological features. A CT triad of extracranial soft tissue tumour, osteolysis of the skull vault, and intracranial extension of the same tumour is considered an indicator of malignancy.<sup>13</sup> In a study by New et al, using CT criteria, most malignant meningiomas were hyperdense with minimal calcification, and indistinct tumour margins on plain scans.<sup>14</sup> These authors coined the term ‘mushrooming’ to describe the extending fingers of the tumour interdigitating with brain substance, well away from the globoid mass. CT findings correlated with microscopic findings of malignant meningiomas in another study, where tumoural necrosis was used to explain heterogeneous enhancement.<sup>15</sup> The irregular tumour outline was thought to be due to brain invasion.

MRI is used as an adjunct for making a diagnosis. In a study by Chen et al, hyperintensity relative to grey matter on T2-weighted imaging was correlated with increased vascularity — malignant and angioblastic meningiomas were especially hyperintense on T2-weighted imaging relative to grey matter.<sup>16</sup> For the patient in this report, the paucity of signal voids in both T1- and T2-weighted images suggested a relatively non-vascular lesion. Although the tumour was noted to be vascular at angiography, the significance of the tiny feeders was underestimated. Preoperative embolisation of these feeders would have made the lesion more amendable to surgery initially.

MRI and angiographic features of a papillary meningioma are therefore non-specific. They are essentially a study of the extent and morphology of a lesion, as for this patient. The final diagnosis rests with the characteristic histopathological and immunochemical findings. A study by Zimmerman et al showed no relationship between tumour enhancement on MRI and tumour vascularity, although gross and microscopic evidence of vascularity was found to be highly correlated with the degree of aggressiveness.<sup>17</sup>

Diffusion-weighted MRI findings of atypical/malignant meningiomas, and typical meningiomas are different. Malignant meningiomas have lower intratumoural apparent diffusion coefficient (ADC) values than typical meningiomas,<sup>18</sup> but mean ADC values for peritumoural oedema do not differ between typical and atypical meningiomas.<sup>19</sup>

Peritumoural brain oedema (PTBO) is a serious complication in the management of malignant meningiomas,

and the extent of PTBO is known to correlate poorly with histological malignancy.<sup>20</sup> Current studies suggest that vascular endothelial growth factor expression contributes to PTBO formation, but only when a cerebral-pial blood supply exists.<sup>21</sup> Growth fractions, as determined by MIB1 immunostaining, are also closely related to tumour aggressiveness and PTBO.<sup>22</sup>

In summary, although post-contrast MRI is helpful for monitoring the progress of metachronous papillary meningiomas, the diagnosis is established through histopathology and the use of immunohistostaining.

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