

Dural tail sign adjacent to different intracranial lesions on contrast-enhanced MR images

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Abstract

Introduction: The aim of this study is to determine the prevalence of dural tail sign (DTS) in meningiomas, glioblastomas multiforme, metastasis, pituitary macro-adenomas, acoustic neuromas, medulloblastomas, lymphomas and Wegener's granulomatosis, and to reveal if DTS is specific for meningiomas.

Methods: In this retrospective, cross sectional study 96 patients were included with 95 intracranial and 1 extracranial lesions. The study was conducted in the period from January 2008 to May 2010 and the group pattern was made consecutively. The patients underwent surgery and all 96 lesions were examined by histopathology analysis. DTS was analysed on contrast T1- weighted spin echo images after injection of 0.1 mmol/kg gadolinium contrast medium. The presence of this sign was defined using Goldsher et al's criteria.

Results: Histopathology results of the 96 lesions revealed the presence of: 35 meningiomas, 25 glioblastomas multiforme, 13 metastasis, 10 pituitary adenomas, 5 acoustic neuromas, 4 medulloblastomas, 3 lymphomas and 1 Wegener's granulomatosis. On the contrast-enhanced T1 MR images, DTS was noted in 31 (32.3%) lesions, in the following histological samples: meningioma, GBM, adenoma, schwannoma, medulloblastoma and Wegener's granulomatosis, while in the cases of metastasis and lymphomas DTS was not noted. We found the dural tail sign to have a sensitivity of 68.6% and specificity of 88.5% in the diagnosis of meningioma.

Conclusion: The dural tail is a common but not a pathognomic sign of meningioma on contrast-enhanced T1 MR images. Other intracranial lesions, such as glioblastoma multiforme, pituitary adenoma, schwannoma, medulloblastoma and Wegener's granulomatosis may also be represented with this sign.

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Keywords: dural tail sign, intracranial lesions, magnetic resonance, contrast enhanced study

Introduction

“Dural tail sign” (DTS), also known as the “meningeal sign”, “dural thickening” or “flare sign”, was first described by Wilm et al. in 1989. It is a linear thickening of the dura adjacent to an intracranial pathology on contrast-enhanced T1 MR images (1) (Figures 1, 2, 3). The exact histological nature of DTS is controversial. It was initially proposed that DTS is a result of direct tumour extension within or at the surface of the dural membrane (1, 2), but some other authors have been able to show little or no direct tumour in-

volvement. They suggested that DTS might be attributed to fibrous tissues with loose connective tissue proliferation, hypervascular reaction and vascular dilatation (2, 3). It is possible that two mechanisms (tumour invasion and hypervascular reaction) may be responsible for DTS (4). In 1990, Goldsher et al. (2) devised the following three radiological criteria to reliably establish the presence or absence of DTS: 1) The tail should be identified on two successive sections through the tumour, 2) the tail should taper smoothly away from the tumour, and 3) the tail must have an enhancement greater than that of the tumour itself. If present, as imaging slices tend to be less than 5 mm, there should always be at least three sections showing the dural tail, depending on the slice thickness (5). DTS was first thought to be pathognomonic of

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meningioma, but many later studies demonstrated DTS adjacent to various intra and extra-cranial pathologies as well as in spinal lesions (4, 6). The aim of this study is to determine the prevalence of DTS in meningiomas and some other intracranial lesions, and to reveal if DTS is specific for meningiomas.

Methods

Patients

In this cross-sectional study, we retrospectively examined the magnetic resonance findings of 95 intracranial lesions and 1 extracranial lesion in 96 patients (mean age 51.9 years, ranging from 5 to 76 years) with no history of previous intracranial surgery, trauma or intracranial haemorrhage. In the study, which was conducted in the period from January 2008 to May 2010, we included all patients with discovered intracranial and extracranial lesions which may be associated with DTS. We studied patients with meningiomas, glioblastomas multiforme, metastasis, pituitary macroadenomas, acoustic neuromas, medulloblastomas, lymphomas and Wegener's granulomatosis. We did not have patients with some other lesions which could be associated with DTS such as chloroma, multiple myeloma, aspergillosis, chordoma, pituitary apoplexy, hypophysitis, pleomorphic xanthoastrocytoma, eosinophilic granuloma, Erdheim-Chester disease, sarcoidosis, giant posterior cerebral artery aneurysm, dural cavernous hemangioma, hemangiopericytoma. We excluded patients with cerebellar stroke. All patients included in this study underwent surgery and all of 96 lesions were examined by histopathology analysis.

Procedure

MR were performed at the Department of Radiology and Nuclear Medicine, surgical treatment at the Department of Neurosurgery, and pathohistological analysis at the Department of Pathology of the Polyclinic for Laboratory Diagnostics of the University Clinical Centre, Tuzla. MRI was performed on a 1.5 T MR scanner (Avanto, Siemens, Erlangen Germany). DTS was analysed on contrast T1- weighted spin echo images after 0.1mmol/kg gadolinium contrast medium injection with the following parameters: TR 500 ms, TE 8.1 ms, 5mm section thickness, 230 mm

field of view, 256x256 matrix. MR images were obtained on three planes: axial, coronal and sagittal plane. The presence of DTS was defined using Goldsher et al's criteria (2): a) the tail was identified on two successive sections through the tumour, b) the tail was taper smoothly away from the tumour, c) the tail had an enhancement greater than that of the tumour itself. The MR findings were interpreted by one of two radiologists.

Statistical analysis

The sensitivity and specificity (95% confidence interval-CI) of DTS in diagnosis of meningioma were calculated with diagnostic test analysis (2 by 2) in "Arcus Quickstat Biomedical" software (Version 1.0-build 88; 1997).

Results

Histopathology results of the 96 intracranial lesions revealed the presence of: 35 (36.5%) meningiomas, 25 (26%) glioblastomas multiforme (GBM), 13 (13.5%) metastasis, 10 (10.4%) pituitary macroadenomas, 5 (5.2%) acoustic neuromas or schwannomas, 4 (4.2%) medulloblastomas, 3 (3.1%) lymphomas and 1 (1%) Wegener's granulomatosis.

TABLE 1. Presence of the dural tail sign in different intracranial lesions

Intracranial lesions	Dural tail sign	
	Present (%)	Absent (%)
Meningiomas	24 (68.6)	11 (31.4)
Glioblastomas multiforme	2 (8)	23 (92)
Metastasis	0 (0)	13 (100)
Pituitary adenomas	2 (20)	8 (80)
Schwannomas	1(20)	4 (80)
Medulloblastomas	1(25)	3 (75)
Lymphomas	0	3 (100)
Wegener's granulomatosis	1 (100)	0 (0)
Total lesions	31 (32.3%)	65 (67.7%)

TABLE 2. Presence of the dural tail sign in meningiomas and other cranial lesions (Data for diagnostic test analysis 2 by 2)

Intracranial lesions	Dural tail sign		Total
	Present (test positive)	Absent (test negative)	
Meningiomas	24	7	31
Other cranial lesions	11	54	65
Total	35	61	96

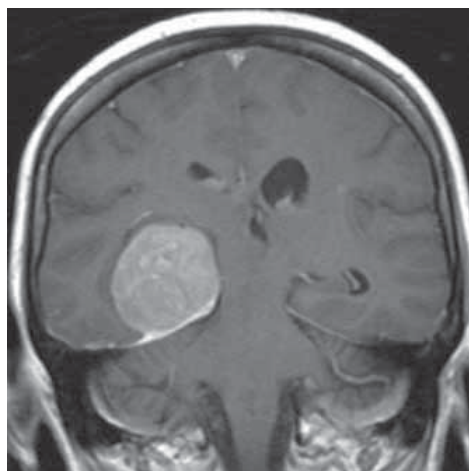


FIGURE 1. The coronal contrast-enhanced T1-weighted image shows a right temporal meningioma with the “dural tail sign” below and lateral to the lesion, along the right tentorium.

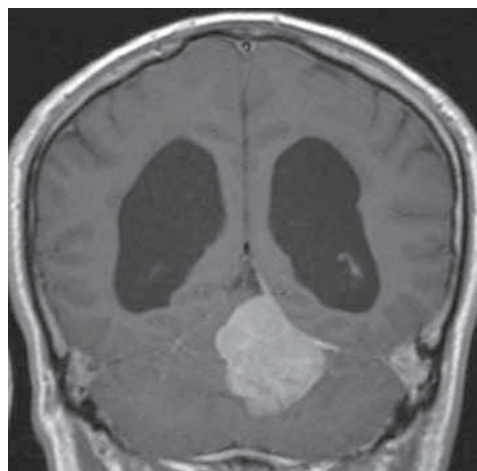


FIGURE 2. The coronal contrast-enhanced T1-weighted image reveals the left tentorial meningioma with the dural tail sign along left tentorium

Of these 96 intracranial lesions, 7 tumours were located in the cerebellopontine angle (CPA) (5 schwannomas and 2 meningiomas), 11 tumours were located in the sellar and parasellar region (all 10 pituitary adenomas and 1 meningioma), 4 medulloblastomas and 1 meningioma were located infratentorially, while all of the 25 GBMs, 31 meningiomas and 1 Wegener’s granulomatosis were located supratentorially. The linear thickening of the dura adjacent to an intracranial pathology (DTS) was noted on the contrast-enhanced T1 MR images in 31 (32.3%) lesions, while in 65 (67.7%) DTS was absent. DTS were present in the following histological samples: meningioma, GBM, adenoma, schwannoma, medulloblastoma and Wegener’s granulomatosis, while in the cases of metastasis and lymphomas DTS was not noted (Table 1). With diagnostic test analysis (Table 2) we found that DTS had a sensitivity of 68.6% (CI: 50-83%) and specificity of 88.5% (CI: 77-95) for diagnosis of meningioma with a positive predictive value of 77.4 (CI: 58-90), negative predictive value of 83.1 (CI: 71-91), positive likelihood ratio of 6, (CI: 2.8-12.4) and a negative likelihood ratio of 0.4 (CI: 0.2-0.5). In the CPA, DTS was present in 1 schwannoma and 1 meningioma, while in the parasellar location, DTS was present in 2 adenomas and 1 meningioma.

Discussion

The aim and task of every radiologist is not only

to reveal intracranial pathology but also to give a diagnosis of the revealed lesion as close as possible to the histopathology diagnosis. The majority of meningiomas exhibit highly stereotypic imaging characteristics, when combined with their select intracranial dural-adherent localizations, which often facilitates their diagnosis, especially on MRI (7). However, it may sometimes be difficult to differentiate between meningiomas and other tumours in some intracranial locations. For example, a meningioma in the CPA near to the internal auditory canal may be mistaken for an acoustic neurinoma, while a meningioma in the parasellar region may be mistaken for a pituitary adenoma. DTS describes a linear enhancement along the dura mater on contrast T1-weighted resonance images (Figure 1, 2, 3). This sign is considered as common and useful for distinguishing meningioma from other intracranial lesions and was at first thought to be pathognomonic of meningioma. Many later studies demonstrated the presence of this sign adjacent to other intra- and extra-cranial pathologies: lymphoma, chloroma, metastasis, multiple myeloma, GBM, aspergillosis, chordoma, schwannoma, pituitary adenoma, pituitary apoplexy, hypophysitis, pleomorphic xanthoastrocytoma, eosinophilic granuloma, Wegener’s granulomatosis, Erdheim-Chester disease, sarcoidosis, medulloblastoma, giant posterior cerebral artery aneurysm, dural cavernous hemangioma, hemangioperi-

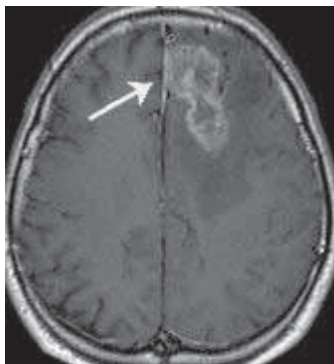


FIGURE 3 and 4. The axial and coronal contrast-enhanced T1-weighted images show the dural tail sign adjacent to the heterogeneously enhanced tumour, which corresponds to glioblastoma multiformetorium.

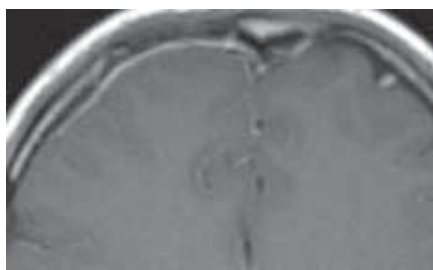
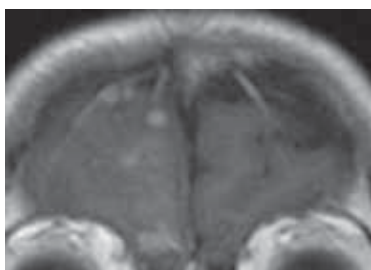


FIGURE 5 and 6. The coronal and axial contrast-enhanced T1-weighted images show a right frontal heterogeneously enhanced mass, with linear enhancement of the adjacent dura, which is better visualised on an axial image.



FIGURE 7. The control MR axial contrast-enhanced T1-weighted image shows a heterogeneously enhanced tumour, with dural tail sign medial of the tumour. Histopathology exam revealed the glioblastoma multiforme.

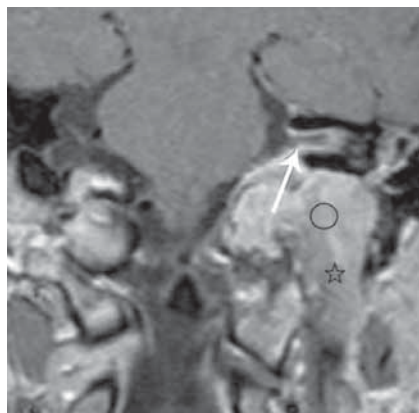


FIGURE 8. The coronal contrast-enhanced T1-weighted image shows intense enhancement in a mass in the left cerebellopontine angle and in the jugular foramen (circle), which corresponds to a meningioma. The mass spreads into the internal auditory canal with an evident “dural tail sign” (white arrow)

cytoma and in cerebellar stroke (8-30). In previous studies, DTS has been reported in 52-72% of meningiomas on MRI (2, 4, 12, 29, 30, 31). Goldsher et al. (2) proposed that DTS was a highly specific sign for meningioma. They found DTS in 18 of 30 meningiomas (60 %), while Aoki et al. (30) found DTS in 13 of 18 meningiomas (72 %). In 2006, Rokni-Yazdi and Sotoudeh (12) indicated that DTS has a sensitivity of 58.6 % and a specificity of 94.02% for the diagnosis of meningioma. In their study, 22 patients with intracranial masses exhibited DTS (18 meningiomas, 2 pituitary adenomas, 1 primary cerebral lymphoma and 1 fungal brain abscess). In 2009, Rokni-Yazdi et al. (13) noted DTS in 17 cases of tumours (12 meningiomas, 3 pituitary adenomas and 2 schwannomas). In our study, we found that DTS has a sensitivity of 68.6% for the diagnosis of meningioma, which is in accordance with the published results. This result is most similar to the 72% sensitivity achieved

by Aoki et al. (30). For diagnosis of meningioma, we found that DTS has a specificity of 88.5%. This specificity is 5.52% lower than the specificity noted by Rokni-Yazdi and Sotoudeh (12). DTS has been reported in only a few

gliomas. In the published literature, we found only eight cases of GBM associated with DTS (5, 9, 33, 34). In all eight cases, the dura mater had a normal appearance on the histological examination, without tumoural invasion (9, 33). Also, because GBM is rarely fed by the vessels of the dura mater, the enhanced DTS is not likely to develop from vascular congestion or proliferation (5). In our study we found DTS in 2 of 25 GBM cases (Figure 3, 4, 5, 6, 7). In one of the GBM, the first MR exam showed non-specific radiological findings for GBM. The tumour appeared as a few smaller intra-axial lesions in the right frontal lobe, slightly hypointense on the T1-weighted image and slightly hyperintense on the T2-weighted image, with strongly contrast enhancement and linear enhancement along the

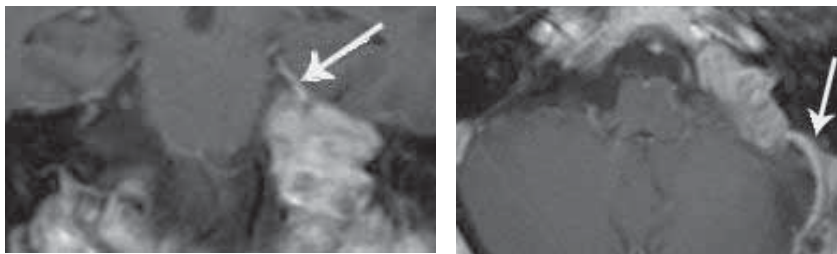


FIGURE 9 and 10. The axial coronal contrast-enhanced T1-weighted images show an acoustic neuroma in the left cerebellopontine angle with the dural tail sign adjacent to the neuroma

dura mater around the lesions (Figure 5, 6). On the second MRI, control scans showed the classic appearance of GBM (Figure 7). The diagnosis of GBM was confirmed by the pathologic examinations. An acoustic neuroma, which arises from the vestibular portion of the 8th cranial nerve, is the most common of all CPA neoplasms, followed by meningiomas. Aoki et al. (30) in their study reported 4 meningiomas in the CPA with linear enhancement along the internal auditory canal. It was suggested that this DTS might be useful in the differential diagnosis of dural-based and other neoplasms. Some other studies reported DTS adjacent to an acoustic neuroma that can mimic a meningioma, but its hypersignal intensity in the T2-weighted image and narrower dural attach-

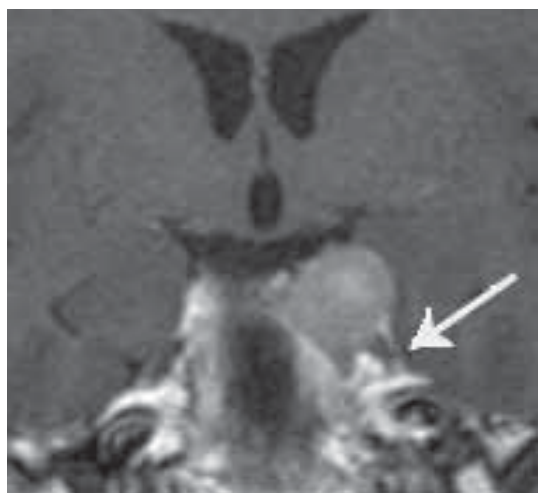


FIGURE 11. The coronal contrast-enhanced T1-weighted image shows a homogeneously enhancing sellar and left parasellar mass with a dural tail sign. The lesion corresponds to a pituitary macro-adenoma.

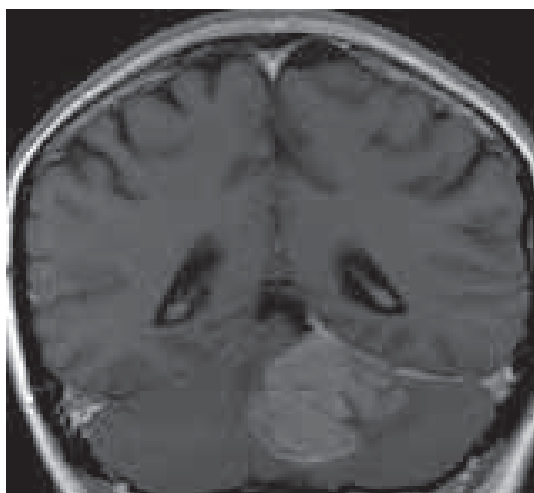


FIGURE 12. The coronal contrast-enhanced T1-weighted image shows intense enhancement in the intra-axial mass in the left cerebellar hemisphere, with the dural tail sign along the left tentorium. Histopathology exam revealed the medulloblastoma.

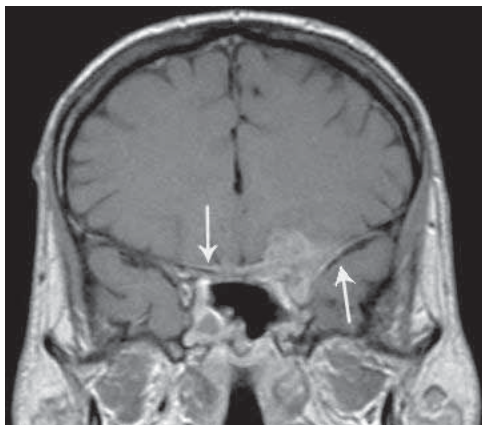


FIGURE 13. The coronal T1-weighted contrast-enhanced MR image shows an inflammatory mass in the left frontal lobe in the patient with Wegener's granulomatosis, focal thickening and enhancement of the dura overlying the anterior aspect of the left temporal lobe-dural tail sign.

ment can differentiate this tumour from a meningioma (6, 10, 11, 35). In our study 7 tumours were located in the CPA (5 acoustic neuromas and 2 meningiomas). We noted DTS in both meningiomas (Figure 8) and 1 neuroma (Figure 9, 10). Although DTS is a useful sign for differentiating between pituitary adenomas and meningiomas in the sellar region, in this case DTS is also not specific for meningioma. DTS can be seen adjacent to pituitary adenomas in 30% of cases. The pathophysiology of dural thickening in a pituitary adenoma is not clear. It is probably the result of venous congestion and meningeal inflammation (6, 17, 36). Cases of DTS with pituitary adenomas have been reported mainly with haemorrhagic adenomas (18). In study conducted by Catin et al. (36), DTS was common with both haemorrhagic and non-haemorrhagic adenomas. DTS

mostly extends into the planum sphenoidale and carotid sulcus. Catin et al. noted slight dural thickening in the presellar region in 50% and marked thickening in 40% of all cases of pituitary adenomas (36, 17, 36). In our study we noted DTS in 2 (20%) of 10 pituitary adenomas (Figure 11). In the published literature we found DTS adjacent to medulloblastoma in two cases (37, 38). In our study we noted DTS in 1 of 4 medulloblastomas (Figure 12). Wegener's granulomatosis of the paranasal sinuses, with cerebral and meningeal involvement, may present with DTS (24, 40). In our study we also had one patient with Wegener's granulomatosis with DTS present (Figure 13). DTS has also been reported in dural-based metastasis and cortical intraparenchymal metastasis, mostly in prostate and neuroblastoma metastasis (9, 39), but in our study in the 13 cases of metastasis we did not note DTS. Also we did not find DTS in any of the 3 cases of lymphomas.

Conclusion

Our study suggests that the dural tail is a common but not a pathognomic sign of meningioma on contrast-enhanced T1 MR images. Other intracranial lesions, such as glioblastoma multiforme, pituitary adenoma, schwannoma, medulloblastoma and Wegener's granulomatosis, also can present with this sign. In our study we found the dural tail sign to have a sensitivity of 68.6% and specificity of 88.5% in diagnosis of meningioma.

Competing interests

The authors declare that they have no conflict of interest. This study was not sponsored by any external organization.

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