Role of Apparent Diffusion Coeffecient (ADC) Value in the Evaluation of Benign Intradural Extramedullary Spinal Canal Lesions

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ABSTRACT

Introduction: Diffusion weighted sequence is a special type of sequence used in the MR imaging.It is based on the microscopic movement of the water molecules within the cells. Highly cellular lesions show reduced diffusion of the water molecules. ADC value is calculated from the diffusion weighted imaging which measures the diffusion values in all the voxels. The ADC value decreases with reduced diffusion and vice versa.In this study we have evaluated the ADC values of different intradural and extra medullary spinal canal lesions**.** Study aimed to perform the diffusion weighted imaging and evaluate the apparent diffusion coefficient values of benign intradural extra medullary spinal canal lesions.

Material and Methods: The study was performed in the Department of radiology during January 2014 to April 2017 using 1.5T GE and 1.5T Siemens Magnetom Avanto MRI system. The study included 35 patients with intradural extra medullary spinal canal lesions which was confirmed on conventional MRI and for whom subsequently diffusion weighted MRI was performed. The ADC values were calculated and correlated with the Histopathologic examination reports.

Results: The mean ADC value of benign intradural extramedullary lesions is 1.62 $x10^{-3}mm^2$ /sec varying between 0.82-2.82 $x10^{-3}mm^2$ /sec. 74% of the lesions were seen in the males. The commonest lesions are Meningiomas, Ependymomas, Nerve sheath tumours and Arachnoid cysts. The Epidermoid cyst has the lowest ADC values whereas the Arachnoid cyst has the highest ADC value.

Conclusion:Diffusion Weighted Imaging and Apparent Diffusion Coefficient values aid in the evaluation of benign intradural extramedullary spinal canal lesions.

Keywords: Diffusion Weighted Imaging, Spinal Canal Lesions

INTRODUCTION

Magnetic Resonance Imaging (MRI) is the technique of choice for spinal cord imaging because of its high sensitivity for different pathologic intradural extramedullary changes. Diffusion weighted MR imaging provides unique tissue contrast that reflects the microscopic motions of tissue water. Knowledge of the diffusion weighted imaging appearance of intra spinal abnormalities should be helpful to physicians who interpret MR studies of the spine.[1]

In diffusion-weighted MRI imaging, images are produced based on the change in motion of water molecules. The cell membrane which form the important component of cell architexture impedes the movement of water molecule.

Apparent diffusion coefficient (ADC) is calculated from the diffusion weighted MR imaging and a ADC map is created from the values of all the voxels. Reduced ADC values are seen in restricted movement of water molecules.

In this study we have evaluated the ADC values of the different intradural and extramedullary spinal canal lesions.

Study aimed to perform the Diffusion Weighted Imaging and evaluate the Apparent Diffusion Co-efficient values of benign intradural extramedullary spinal canal lesions.

MATERIAL AND METHODS

This retrospective study was performed in the department of Radiology and Imaging Sciences during the span of January 2014- April 2017. All studies were performed on 1.5T GE SIGNA HDXT and 1.5 T SIEMENS MAGNETOM Avanto MRI systems.

The study included 35 patients of either sex (male-26, female-9) with intradural extramedullary spinal canal lesions which were evident on conventional MRI sequences. Patients with intramedullary spinal canal lesions were excluded from the study.

The age of the patient ranged between 6 to 86 years with a mean of 36.11years. The clinical history of all the patients were elucidated. The studies were reviewed by a radiologist on PACS viewer.

Conventional MR sequences, Sagittal and Axial T2W and T1W (Pre and post contrast) sequences were acquired with 3.2 mm thickness,300 mm field of view, 256 x 224 matrix, T2W FSE sequences with a TR of 3000-5000ms, TE of 60-80 ms, turbo factor of 8, T1W FSE TR of 560 - 700ms, TE of 15-35 ms, 2D myelogram with a slab thickness of 40 mm was performed in sagittal and coronal planes.

All individual MRI examinations were monitored by a radiologist during the procedure and DWI were suggested only in studies which revealed intradural extramedullary spinal canal lesions on conventional sequences

DWI MRI was acquired using a multisection single shot

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spin echo EPI sequences with diffusion sensitivity of b-value 800 sec/mm^2. The images were archived in PACS. ADC maps were automatically generated in the SIEMENS MAGNETOM Avanto, whereas in GE SignaHDXt post processing was required to generate ADC maps. Circular region of interest (ROI) of approximately 20-30mm in diameter was placed in the center of the tumor to obtain ADC value with b factor 800 sec/mm^2. Same sized ROI was placed in normal spinal canal to calculate its ADC value with same b factor 800 sec/mm^2. The mean ADC value in intradural extramedullary spinal canal lesions and mean ADC value in normal spinal canal were calculated. [1]

The radiological impression and differential diagnosis of all 35 studies were noted down.

Patients demographic details (age, sex and unique hospital identity), b factor, ADC value in spinal canal lesions, ADC value in normal spinal canal lesions and radiological diagnosis / differential diagnosis and histopathological evaluation(HPE) reports were tabulated.

STATISTICAL ANALYSIS

Descriptive statistics like percentage was used for analysis. Microsoft office 2007 was used.

RESULTS

The retrospective analysis of MRI spine in 35 patients with intradural extramedullary lesions included 29 males and 9 females (Table-1). Age of the study population ranged from 6 years to 86 years.

Among 35 studies 13 were plain and 22 were plain and contrast studies performed before and after intravenous contrast administration (Gadodiamide) at the dose rate of 0.2ml/kg body weight.

Intradural extramedullary spinal canal lesion in all 35 patients were interpreted as benign spinal canal lesions (Table-2). The radiological imaging features of the 6 patients were suggestive of Meningiomas, 5 Ependymomas including 1 myxopapillary ependymoma, 10 nerve sheath tumors, 1Paraganglioma,1 Hemangioblastoma, 1 tuberculoma and 11 spinal canal cysts which included 1 Dermoid cyst, 3 Epidermoid cysts and 7 Arachnoid Cysts.

Sl. No	Sex	Numbers	Percentage
1	Male	26	74%
2	Female	9	26%
Total		35	100

Table-1: Distribution of sex

Differential diagnosis	No. of cases
Ependymoma	5 (14%)
Nerve Sheath Tumor	10(29%)
Meningioma	6(17%)
Tuberculoma	1(3%)
Paraganglioma	1(3%)
Hemangioblastoma	1(3%)
Dermoid Cyst	1(3%)
Epidermoid Cyst	3(8%)
Arachnoid Cyst	7(20%)
Total number of cases	35

Table-2: Distribution of pathologies

In our study, meningioma, ependymoma, nerve sheath tumors and arachnoid cysts were the most common pathologies with the mean age of presentation being 37.5 years, 54.4 years, 47.7 years and 45 years respectively.

Regarding the conventional MRI characterization MR imaging were evaluated based on the lesions size, site, margin, signal intensity on T1W and T2W images, pattern of enhancement and presence/absence of hemorrhage.

Additionally restricted diffusion and ADC values were also evaluated.

The mean value of ADC of Ependymoma is 1.74 x10^{-3} mm^2/sec, ranging from 0.82-2.82 x 10^{-3} mm^2/sec. The mean value of ADC in Nerve sheath tumors is 1.47x 10^{-3} mm^2/sec, ranging from 1.22-2.37 x 10^{-3}mm^2/sec. The mean value of ADC in Meningioma is 1.12 x 10^{-3} mm^2/sec, ranging from 1.03 -1.17 x 10^{-3} mm^2/sec. The mean value of ADC in Epidermoid cyst is 0.85 x 10^{-3}mm^2/sec, ranging from 0.19 – 1.39 x 10^{-3}mm^2/sec.

The mean value of ADC in Arachnoid cyst is 2.18 x 10^{-3}mm^2/sec, ranging from 1.89 – 2.30 x 10^{-3}mm^2/sec. The ADC value in Paraganglioma is 1.79 x 10^{-3}mm^2/sec. The ADC value in Hemangioblastoma is 1.78 x 10^{-3}mm^2/sec. The ADC value in Tuberculoma is 2.08 x 10^{-3}mm^2/sec. The ADC value in Dermoid cyst (cystic part) is 2.1 x 10^{-3}mm^2/sec.

The ADC mean value in normal spinal cord is 2.69 x 10^{-3}mm^2/sec, ranging from 2.8 to 3.9 x 10^{-3}mm^2/sec.

Previous studies have found that mean ADC values of benign intradural extramedullary lesions is 1.17 x 10^{-3}mm^2 / sec varying between 0.52 and 2.38 x10^{-3}mm^2 /sec.[1,8]

In our study, the mean ADC value of benign intradural extramedullary lesions is 1.62 x10^{-3}mm^2 /sec varying between 0.82-2.82 x10^{-3}mm^2 /sec.

Histopathology examination reports were available for all the studies and HPE reports correlated with the radiological findings in all 34 cases. One patient with Tuberculoma was undergone medical management.

DISCUSSION

Diffusion-weighted imaging

Diffusion-weighted-imaging (DWI) provides information about movement of water molecules which is not possible using conventional magnetic resonance imaging. DWI measures the random (Brownian) extra, intra and transcellular motion of water molecules[1]. Apparent-diffusion-coefficient (ADC) is a quantitative value calculated from the combined effects of water diffusion and capillary perfusion. ADC map is created using the ADC values of all the voxels. Later, by drawing a region of interest (ROI) on these ADC maps, diffusion parameter of any tissue can be calculated in a quantitative manner.

In human body, the moment of water molecules in intracellular space, extracellular space and intravascular spaces contribute to DWI signal. Since, increased vascularity is seen in the tumors, the moment of molecules within the intravascular space contribute to the signal in tumor.

Since the malignant tumors have high cellularity and enlarged nuclei they show restricted diffusion and reduced ADC values.

These histopathologic characteristics reduce the extracellular matrix and the diffusion space of water protons in the extracellular areas, with a resultant decrease in the ADC value.

Intradural extramedullary Lesions

Intradural extramedullary lesions are seen outside the spinal cord but within the duramater. They are commonly benign lesions and may cause limb weakness and pain

MOST COMMON TUMORS

Nerve Sheath Tumors

Neurofibroma and Neurilemoma(Schwannoma) are the benign nerve sheath tumours. They arise from schwann cells surrounding the axons of the nerve roots as they exit the spinal cord.

Schwannomas are commonly solitary and they donot involve the nerve fibres, whereas the neurofibromas are commonly multiple and they involve the nerve fibres resulting in sacrifice of the nerve during surgery.

Nerve sheath tumours are dumb bell shaped and are intradural or extradural in location. They are commonly hypointense on T1 and hyperintense on T2 weighted images.

Administration of intravenous gadolinium improves the contrast with the surrounding structures by the strong enhancement of the lesions. Gadolinium is less helpful for extradural lesions because the enhancing tumor becomes isointense to the surrounding fat.

Fat suppression techniques are used in post contrast images to make the extradural lesions clearly visible.[2]

Schwannoma

Schwannomas are the commonest intradural extramedullary spinal canal lesion. They are well encapsulated and involve the periphery of the nerve so that the lesion can be excised without compromising the nerve fibres[2].

Schwannomas are primarily isointense to the spinal cord on T1W images, hyperintense to the cord on T2W images and show intense enhancement after contrast administration. The imaging pattern will vary with the degree of cystic degeneration, presence of hemorrhage or fatty degeneration (figure-1).

Meningioma

They arise from the meninges surrounding the spinal cord and they are commonly seen in thoracic region and in females.

Meningiomas are well encapsulated and are attached to the duramater. They are commonly posterolateral in location whereas in cervical region they are commonly anterior in location.

The commonest symptom is pain. Other symptoms are numbness, paresthesias, weakness and bladder or bowel disturbances, these symptoms are commonly due to the cord compression

Meningiomas appear T1 hypointense and T2 isointense to the gray matter of the spinal cord (figure-2).

Post-contrast T1 weighted image shows intense and homogeneous enhancement.[3]

Ependymomas

Ependymomas arise from the cells lining the central canal within the spinal cord. These tumors are well defined and are located centrally within the spinal cord. They are commonly seen in the cervical region. The common clinical features are pain, neurological deficits and bladder or bowel dysfunction The imaging characteristics of ependymomas are isointense to hypointense on plain T1-weighted images, and hyperintense on T2-weighted images. Classically, ependymomas have shown intense, homogeneous and sharply demarcated focal enhancement.

Gadolinium enhancement is virtually always seen, the enhancement pattern that in part, depends on the amount of haemorrhage.

Myxopapillary ependymoma is a subtype of ependymoma that is predominantly found in the region of the conus medullaris and filum terminale. Myxopapillary ependymoma

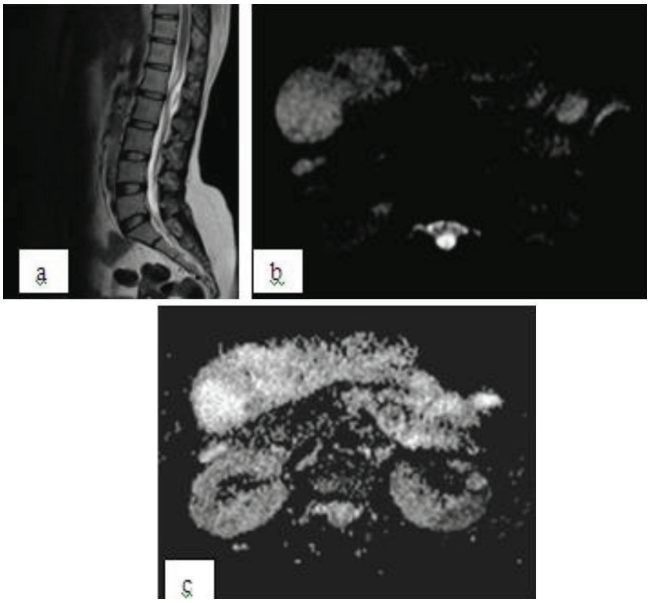


Figure-1: Schwannoma. Sagittal T2W image(a) axial DWI(b) and axial ADC images(c) show a intradural lesion at the level of L1/L2. The lesion appear T2 hyperintense with mild restricted diffusion. the nerve roots are seen displaced anteriorly.

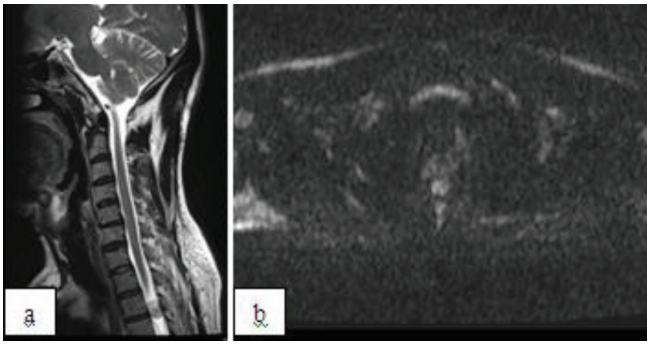


Figure-2: Meningioma. Sagittal T2W image (a) show a intradural extra axial lesion at the level of D2. the lesion appear mildly T2 hypointense. (b) on DWI the lesion appear mildly bright.

is also the most common neoplasm of the conus medullaris. If the tumor is small it tend to displace the nerve roots of the cauda equina, whereas large tumors often compress or encase them. These lesions are often described as sausage shaped, well-demarcated and/or encapsulated.

The Myxopapillary ependymoma subtype is prone to hemorrhage, and can present with subarachnoid hemorrhage. Myxopapillary ependymomas are isointense in T1 weighted images and prominent mucinous component may even result in T1 weighted hyperintensity. Hemorrhage and calcification can also lead to region of hyper or hypointense signal in T1 wt images.

On T2 weighted images high and low mixed signal intensity is seen at the tumor margin because of hemorrhage. Calcification may also lead to region of low T2 weighted signal (figure-3). On Gadolinium administration, enhancement is seen homogenously, variable enhancement is also seen depending on the amount of hemorrhage [6].

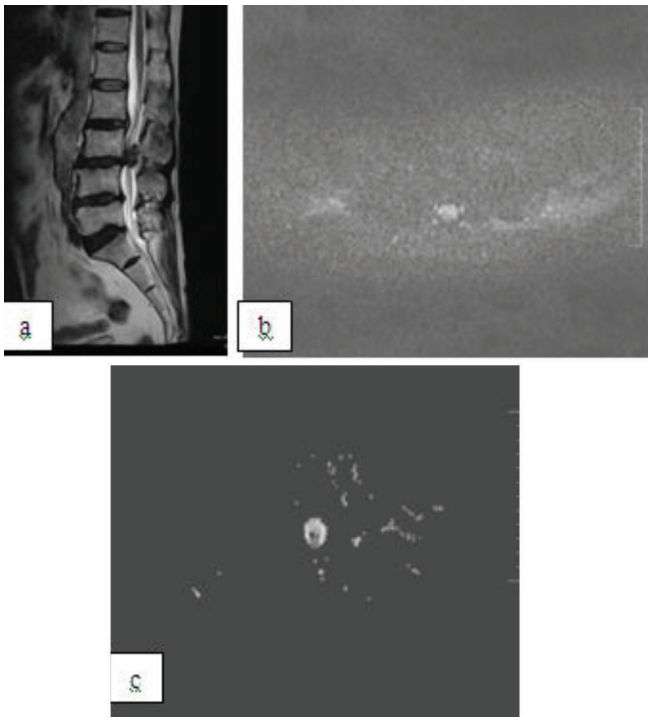
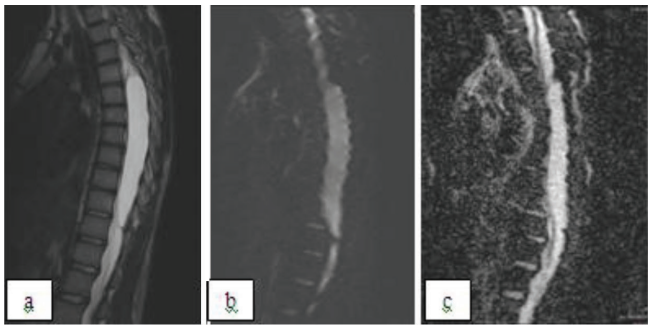


Figure-3: Ependymoma. Sagittal T2W image(a), axial DWI(b) and axial ADC(c) images show a T2 hypointense extraaxial mass at the level of L3 indenting the nerve roots.



Figure–4: Arachnoid cyst. sagittal T2W image(a) sagittal DWI(b) and sagittal ADC images(c) show a long segment intradural extramedullary CSF isointense cyst in the dorsal region.

Spinal arachnoid cyst

The Spinal arachnoid cysts are relatively rare. They can be extradural or intradural. Majority of them are asymptomatic and are incidental finding. Rarely symptomatic patients presents with weakness, pain, numbness, bladder and bowel incontinence. Symptoms may be exacerbated by postural changes and the Valsalva maneuver.

As the cysts follow the intensity of CSF and their walls are generally not visible, they may not be identified unless the cord is displaced on T1weighted images.

On T2 weighted images, the cyst may even be brighter than CSF, since there is no signal loss from pulsation/flow (figure-4).

On gadolinium administration, no contrast enhancement is seen. Phase-contrast imaging show decreased CSF flow within the cyst. DWI show no evidence of restricted diffusion[4,5].

Spinal epidermoid cyst

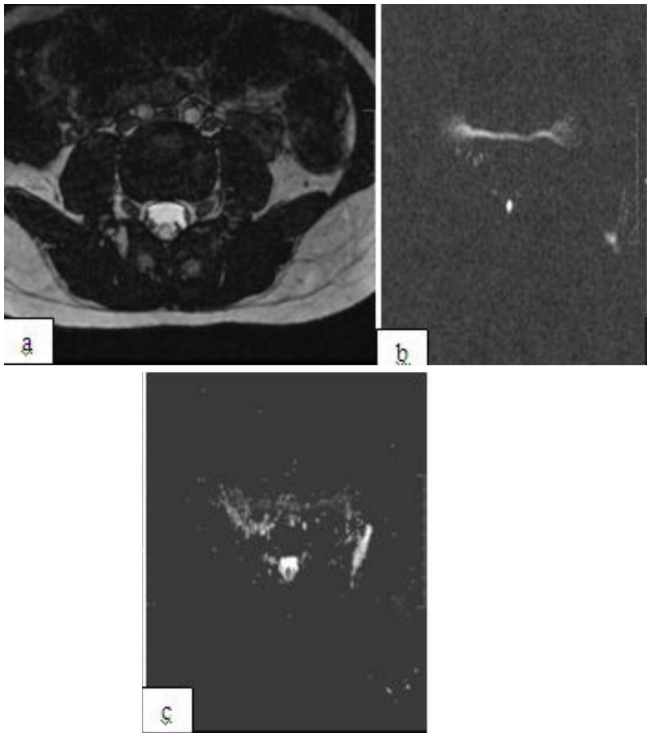
Spinal epidermoid cysts are cystic tumors lined by squamous epithelium. They are usually extramedullary but rarely can be intramedullary. They may be congenital or acquired. They are well-defined lesions with no perilesional oedema.

On T1weighted images, they are hypointense and on T2 weighted images they are hyperintense (figure-5).

On gadolinium administration no enhancement or a thin rim of capsular enhancement is seen.

On diffusion weighted imaging (DWI) they show bright signal intensity and may be homogeneous or heterogeneous according to the variable water, lipid and protein composition of the cyst[4,5].

Hypercellular tumors show restricted diffusion and



Figure–5: Epidermoid cyst. axial FIESTA-C (a) axial DWI (b) and axial ADC images (c) show a small intradural cyst placed dorsally within the lumbar spinal canal. Restricted diffusion is seen.

appear bright on diffusion weighted imaging (DWI).the corresponding ADC values are lower and appear dark on the ADC map.the ADC value gives a measure of the degree of diffusion of water molecules.

Lesions cellularity increases with increasing grade, and with this increasing cell density, the impeding effect of membranes is expected to increase, thus decreasing the ADC value. Predictably, an inverse correlation exists between lesion cellularity and ADC value. Therefore, in general, the higher the grade of lesion and the more cellular the lesions type in the nucleus-to-cytoplasm ratio, the lower the ADC value. DWI signals and ADC value of spinal canal lesions depend on the cellularity and extracellular matrix[7].

CONCLUSION

In this study DWI and ADC values for the intradural extramedullary spinal canal lesions with HPE diagnosis were determined.

The epidermoid cyst has the lowest ADC values whereas the arachnoid cyst has the highest ADC value. Diffusion Weighted Imaging and Apparent Diffusion Coefficient values aid in the evaluation of benign intradural extramedullary spinal canal lesions.

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