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Role of DTI (Diffuse Tensor Imaging) in Spinal Tumors: Prospective Observational Study

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Abstract: ***Introduction: In management of spinal tumors, preoperative assessment of tumor type, predicting resectibility and postoperative outcomes is crucial for guiding treatment decisions and improving patient care. DTI has emerged as a valuable tool in this context, providing detailed information about tissue microstructure and white matter integrity and has shown promising results in differentiating between spinal cord tumor types and predicting their resectability. Methods: In this prospective study DTI parameters to predict the margin for spinal tumorresectabilitywere analysed and patients were grouped as completely resectable and non resectable. The intraoperative findings were noted and correlated with the preoperative DTI findings. The sample size of our proposed study was 23 cases. Results: DTI showed that, 91.3% cases had clear resectability cleavage planes & 8.7% cases were not having clear resectable cleavage planes. During the intraoperative stage, gross resection could be done in 82.6% cases and in 17.4% cases, subtotal resection was possible. There was no significant difference between pre-operative evaluation than the intra-operative evaluation (p=0.665) Conclusion: The study supports the utility of DTI in evaluating spinal tumors and its impact on the spinal cord. Its potential for guiding clinical decision-making makes it an invaluable imaging modality in this context.***

Keywords: Diffuse tensor imaging, Magnetic resonance imaging, spinal tumors, respectability

1. Introduction

Now a days, magnetic resonance imaging (MRI) is the most significant method of imaging the central nervous system (CNS)[1]. It offers superior anatomical details on the microstructure of the spinal cord [2,3]. MRI uses customizable protocols to provide super contrast resolution and multiplanar imaging, enabling the identification of tumors, lesion boundaries, and prognostic modalities. Given the poor prognosis associated with spinal tumor excision, a combined method utilising conventional MRI, Diffusion Tensor Imaging (DTI), and tractography can be utilised to more sensitively visualise lesions and their infiltration patterns [4]. This allows for complete and secure excision at a discernible plane of cleavage where the tumor and spinal cord meet [5].

DTI is a sophisticated non-invasive magnetic resonance (MR) technique that uses the diffusion of water molecules as a probe to measure tissue microstructure. This allows for the visualisation of white matter tracts and measurement of their integrity both qualitatively and quantitatively [6, 7].

Two primary metrics are used to quantify the diffusion tensor imaging (DTI) results: the fractional anisotropy (FA) value, which is a relative number that increases with anisotropic diffusion within the tissue under study and represents the directional dependence of the diffusion process, and the apparent diffusion coefficient (ADC) value, which measures the overall diffusivity of the tissue regardless of its direction. [8-10].

For nearly all spinal cord tumors, surgery is recommended. The tumor may typically be removed from the spinal cord during resection surgery for spinal ependymomas. No more therapy is necessary if total separation is possible. As a result, surgery is nearly always insufficient for spinal cord gliomas, which invade the myelin. Determining the best patient management options therefore requires distinguishing between spinal cord tumors that have infiltrated and those that have not. A higher degree of tissue nonintegrity and a larger degree of water molecular diffusion heterogeneity are found in infiltrating tumorswhen compared to noninfiltrating tumors. [11–15]

The present study has been conducted to evaluate the role of DTI in determining the white matter tracts and their relation with the tumor, so that resectability of the tumor can be evaluated preoperatively. Also we compared the intraoperative findings with the DTI results so as to validate the usefulness of DTI in spinal tumor evaluation and predicting complete and safe resetion of the tumor.

2. Materials and Methods

This prospective observational study was conducted on the patients admitted in the Department of Neurosurgery, SMS Hospital, Jaipur. Ethical approval was obtained from the institutional ethical committee and informed consent was obtained from the patients. The sample size calculation was done using G*Power 3.1.9.2 software. Considering 5% alpha error, 20% beta error and 80% power for the study, the total sample size for this study was calculated as 23. The patients were enrolled in the study based on their diagnosis of spinal tumors. Patients below 5 years of age, with multiple spinal lesionsorwith droplets metastatic intramedullary lesion were excluded from the study.

Investigation with preoperative DTI of spine was obtained. This prospective study was conducted to examine the utility of DTI in assessing spinal cord tumors, differentiating tumor types, predicting their resectability. On a 3T MRI, DTI of the lesions was carried out with medium resolution using the following imaging parameters: TR 6248 TE 60; Axial Plane B values: 0, 1000; Number of directions: 15; Slice width: 2 mm, interslice spacing: 0.5 mm; NSA: 2 and Matrix 112 x 112 bandwidth: 29.8.DTI parameters to predict the margin for tumorresectability included- Tumor matrix FA, tumor cord interface FA and tractograms. These parameters were analysed and patients were grouped as completely resectable and non resectable. The intraoperative findings were recorded and correlated with the DTI findings.

Statistical Analysis

The data are tabulated in Microsoft excel and analysed with SPSS V.24 software. The continuous variables are presented with mean and standard deviation. The categorical variables are presented with frequency and percentage. Fisher's exact test was used for the statistical analysis.

3. Results

The mean age of the 23 patients was 37.30±18.08 years among whom 15 were male and 8 were female. The MRI findings showed that majority of the cases were intraduralextramedullarytumors (65.2%) followed by intramedullary tumors (26.1%) and epidural tumors (8.7%). (Table 1, 2). DTI was used to obtain tumor characteristics and classify the lesion as completely resectable and non resectable.

DTI showed that, 91.3% cases had clear resectability cleavage planes & 8.7% cases were not having clearresectable cleavage planes. During the intraoperative stage, gross resection could be done in 82.6% cases and in 17.4% cases, only subtotal resection waspossible. (Table 3, 4, 5, 6)

Table 7 shows the comparison of pre-operative and intra-operative evaluations. There was no significant difference between pre-operative evaluation than the intra-operative evaluation(p=0.665).

Table 1: Demographic characteristics

Demographic characteristics	Value
Age (Mean±SD)	37.30±18.08 years
Sex (Male:Female)	15:8

Table 2: MRI findings

MRI findings	N	%
Intradural-extramedullarytumor	15	65.2%
Intramedullary tumor	6	26.1%
Epidural tumor	2	8.7%

Table 3: Resectability

Resectability	N	%
Resectable	21	91.3%
Not resectable	2	8.7%

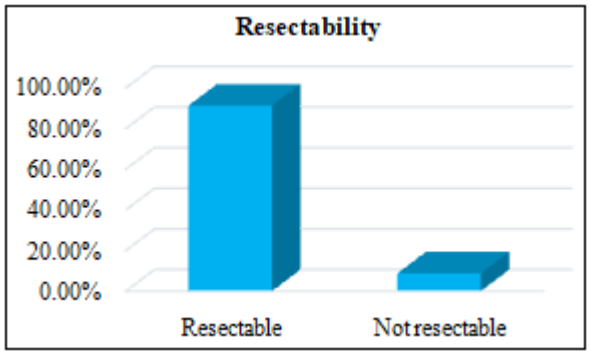

Table 4: Resectability among the cases of intramedullary tumors

Resectability	N	%
Resectable	4	66.7%
Not resectable	2	33.3%

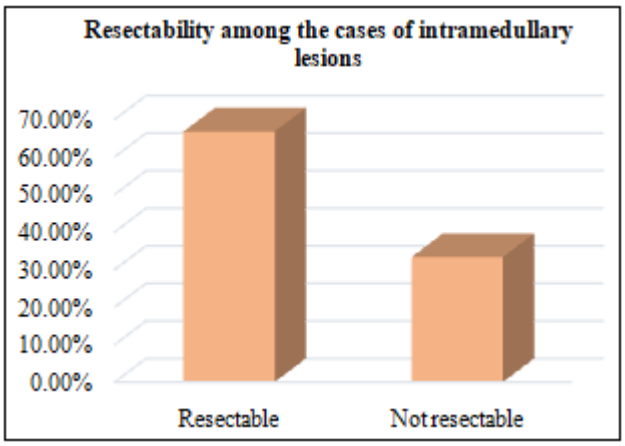

Table 5: Pre-operative evaluation

DTI planes	N	%
Clear plane	21	91.3%
Not clear plane	2	8.7%

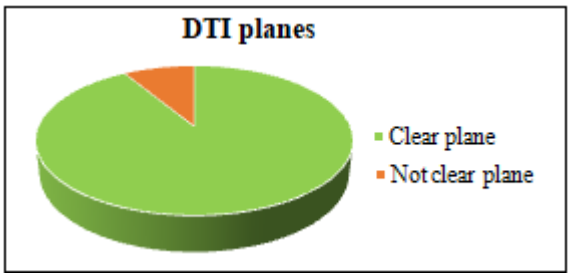

Table 6: Intra-operative evaluation

Surgical margins	N	%
GTR	19	82.6%
STR	4	17.4%

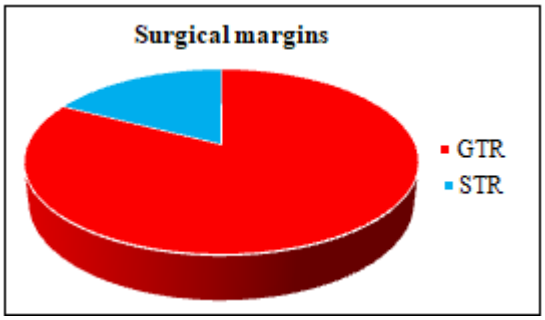

Table 7: Comparison of pre-operative and intra-operative evaluations

Evaluations		N	%	P value
Pre-operative	Clear plane	21	91.3%	0.665
	Not clear plane	2	8.7%	
Intra-operative	Clear plane	19	82.6%	
	Not clear plane	4	17.4%	

4. Discussion

The type and purpose of treatment for spinal tumors are determined in part by the histologic data obtained from them. Astrocytomas in adults are highly susceptible to less favourable results from aggressive surgery. The primary treatment for intramedullary spinal cord tumors in children and spinal cord ependymomas in adults is surgical resection. Adjuvant therapy is usually used for infiltrative and high-

grade spinal tumors since resection is not an option. Although partial tumor resection is not as effective in predicting patient outcomes as gross-total and subtotal resections, preoperative neurological status is one of the strongest predictors of patient outcome [16, 17].

Diffusion tensor imaging (DTI) is anoninvasive method to estimate the direction and integrity of white matter tracts. Preliminary work has suggested that DTI of adult spinal tumors can differentiate astrocytomas from ependymomas. [18,19]DTI could be used to evaluate the structural integrity of the white matter tracts in these spinal tumors, potentially reducing the need for a biopsy or at the very least enabling attempts at resection as the primary surgical procedure for patients with suspected ependymomas.[20, 21]

Tumorresectability and preoperative differential diagnosis were the main findings of earlier DTT (diffusion tensor tractography) studies on spinal cord tumors. For improved preoperative monitoring of tumor boundaries in patients with spinal cord astrocytoma, Ducreux et al. [22] used the diffusion tensor tracking technique. Three categories of spinal tumors were identified by Setzer et al. [23] based on the preoperative diffusion tensor results of 13 patients with ependymoma, astrocytoma, and lymphoma: Type 1: lesion was solid; Type 2: lesion was crossed but fibres did not extend through most of the lesion volume; and Type 3: lesion was fully encased in tumor. Seven of the fully resected tumours in their study had a good cleavage plane, and six of the tumors were thought to be resectable. Furthermore, preoperative DTT demonstrated a strong correlation with intraoperative results, indicating that preoperative DTT for spinal tumors could forecast the lesion's tumorresectability.

Preoperative DTT was used by Choudhri et al. [24] to detect cervicothoracic intramedullary tumors. The results were consistent with those of Setzer et al.; displacement of fibre tracts was predictive of a discrete margin to the tumor and resectability, while biopsy might be necessary if there was white matter tract infiltration. The information demonstrated that, as paediatric intramedullary tumors differ from adult intramedullary tumors in that ependymoma is a rare type and astrocytoma is the most common, preoperative planning can be especially beneficial for these patients. Thus, DTT holds great promise for the surgical planning of intraspinaltumors of the cervical region.

In our study the MRI findings showed that majority of the cases were intraduralextramedullarytumors (65.2%) followed by intramedullary tumors (26.1%) and epidural tumors (8.7%). DTI was used to obtain tumor characteristics and classify the lesion as completely resectable or non resectable. DTI showed that, 91.3% cases had clear resectability cleavage planes & 8.7% cases were not having clear resectable cleavage planes. During the intraoperative stage, gross resection could be done in 82.6% cases and in 17.4% cases, only subtotal resection was possible. There was no significant difference between pre-operative evaluation than the intra-operative evaluation (p=0.665).

Although DTI is a promising advanced technique for studying the spinal tumors, it has a number of technical drawbacks, including the small area of the cord, the complex and uneven spine anatomy, motion artefacts related to the heart and lungs, and susceptibility artefacts. [25-27]

5. Conclusion

The study supports the utility of DTI in evaluating spinal tumors and its impact on the spinal cord. Its potential for guiding clinical decision-making makes it an invaluable imaging modality in this context. As research in this area continues to progress, the role of DTI in routine clinical practice is likely to become more established, further improving patient care for those with spinal tumors.

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