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Original Research Article

Role of helical CT and MRI in the evaluation of spinal dysraphism

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ABSTRACT

Background: Spinal dysraphism is a complex congenital anomaly involving the spine and spinal cord. Some lesions seldom require imaging. The aim was to study the usefulness of helical CT and MRI in the evaluation of various presentation of spinal dysraphism, to identify, characterize the lesions and its association with other anomalies which helps in giving an accurate diagnosis based on specific imaging findings.
Methods: Seventy patients including 33 males and 37 females' age ranging from 1year to 30 years clinically suspicious for spinal dysraphism were evaluated using helical CT and MRI in the Department of Radiodiagnosis, Government Kilpauk Medical College and Hospital, Chennai, India.
Results: Statistical data analyzed based on imaging findings.56 patients were of open spinal dysraphism type and 14 patients were of occult spinal dysraphism. Different imaging features in spinal dysraphism were evaluated to give composite diagnosis for management.
Conclusions: Helical CT and MRI are adjuvant in evaluating cases of spinal dysraphism. MRI is excellent in characterizing the soft tissue spinal anomalies of spinal dysraphism helical CT is an excellent imaging modality for characterization of vertebral bony anomalies.

Keywords: Helical CT, MRI Imaging, Spinal dysraphism

INTRODUCTION

Spinal dysraphism is a complex congenital anomaly involving the spine and spinal cord. Some lesions seldom require imaging. To characterize the lesion Helical CT and MRI are very much helpful.[1] Spinal dysraphism are mainly divided into open spinal dysraphisms in which there is exposure of neural elements to exterior through a defect in skin and closed spinal dysraphisms in which there is skin coverage to underlying spinal malformation.[2-9] This study depicting the various imaging features of Spinal dysraphism and the importance of Helical CT and MRI in the evaluation of Spinal dysraphism. Aim of the study was to assess the role of Helical CT and MRI in the identification of various forms of spinal dysraphism, characterization of the lesions and associated anomalies, giving a composite diagnosis based on specific Imaging findings.

METHODS

This study was prospective, comprises of 70 patients including 33 males and 37 females age ranging from 1year to 30years. The study was conducted for a period of 20 months from January 2015 to August 2016.

The patients were referred from Department of Neonatology and Neurology, Government Kilpauk Medical College and Hospital, Chennai, India to Department of Radiodiagnosis, Kilpauk Medical College and Hospital, Chennai, India for radiological evaluation. Clinically the most common cause for referral was swelling in the back predominantly lumbosacral region.

The other symptoms were sensory/motor deficit, bladder/bowel disturbances, spinal curvature deformities, cutaneous features like dermal dimple, hypertrichosis, silky hair, dermal sinus & capillary hemangioma etc.

MRI done with GE 1.5 Tesla and image acquisition done. MRI Imaging sequences include sagittal, fast-spin echo T1W and T2W sequences (3 mm thickness). Axial T1W and T2W images were acquired in abnormal areas. Fat suppressed sequences were used to assess the fat content of the lesion.

Helical CT examination done with toshiba asteion four slice CT.

Inclusion criteria

- All cases of open spinal dysraphism
- Cases presenting with lumbosacral swelling
- Cases presenting with Dimple, tuft of hair, nevi
- Cases showing vertebral anomalies in Plain radiograph
- Cases presenting with bladder/bowel incontinence since childhood
- Cases presenting with motor or sensory deficit since childhood
- Cases presenting with congenital scoliosis/ kyphoscoliosis/ kyphosis etc.

Exclusion criteria

- Treated cases
- Spinal tumors

For interpretation the following aspects of spinal dysraphism were studied and analyzed in these patients.

Types

Open spinal dysraphism

Myelomeningocele, myelocele, meningocele

Occult spinal dysraphism

Spinal lipomas, diastematomyelia, dorsal dermal sinus, tight filum terminale syndrome, anterior sacral meningocele, sacral agenesis

Distribution in spine

Lumbosacral, lumbar, dorsal, cervical

CT characteristics

Vertebral anomalies

Spina bifida, Butterfly Vertebra, Hemivertebra , Block vertebra and Others

Spinal location

Lumbosacral, lumbar, dorsal, cervical

Spinal curvature

Scoliosis, kyphosis, lordosis

Lesion attenuation

Fluid - menigocele, Soft tissue with fluid-menigomyelocele, soft tissue - myelocele, fat with soft tissue-lipomyelocele, fat with soft tissue and fluid-lipomyelomeningocele, fat - dural lipomas, filar lipomas

Septum in diastematomyelia

Bony, fibrous

MRI characteristics

- Signal intensities of lesion T1, T2, flair sequences
- CSF Intensity - meningocele
- CSF intensity+neural tissue-myelomeningocele
- neural tissue-myelocele
- Fat intensity+neural tissue-lipomyelocele
- Fat intensity+CSF intensity + neural tissue - lipomyelomeningocele
- Fat intensity-intradural lipomas, filar lipomas

Septum in diastematomyelia

- Bony, fibrous
- Tethering
- Vertebral anomalies
- Spinal distribution
- Spinal curvature
- Chiari association
- Hydromyelia
- Hydrocephalus

The contributions of CT and MR towards the above mentioned aspects were analyzed for arriving at the radiological diagnosis.

RESULTS

A total of 70 cases of spinal dysraphism were analyzed using helical CT and MRI

Table 1: Open spinal dysraphism.

Type	No. of cases	Percentage
Myelomeningocele	53	75.71
Myelocele	2	2.86
Meningocele	1	1.43
Total	**56**	**80**

Incidence

56 Patients were of open spinal dysraphism type and 14 patients were of occult spinal dysraphism accounting for 80% and 20% respectively (Table 1 and 2).

Gender

In open spinal dysraphism there were 23 males and 33 females accounting for 58.93% and 41.01% respectively thus showing female predominance (M:F 1:1.43) (Table 3 and 4) comparable with the study by Steinbok P, Irvine B, Cochrane DD, Irwin B et al.[1]

Table 2: Occult spinal dysraphism.

Type	No. of cases	Percentage
Spinal lipomas	6	8.57
Diastematomyelia	4	5.17
Dorsal dermal sinus	1	1.43
Tight filum terminale	1	1.43
Anterior sacral meningocele	1	1.43
Sacral agenesis	1	1.43
Total	**14**	**20**

Table 3: Gender distribution in open spinal dysraphism.

Open spinal dysraphism	No. of cases	Male	Percentage	Female	Percentage	Total
Myelomeningocele	53	22	41.51	31	58.91	100%
Myelocele	2	1	50	1	50	100%
Meningocele	1	0	0	1	100	100%
Total	**56**	**23**	**41.07**	**33**	**58.93**	**100%**

M:F=1:1.43.

Table 4: Gender distribution in occult spinal dysraphism.

Type	Number	Male	Percentage	Female	Percentage	Total
Spinal lipoma	6	5	83.33%	1	16.67%	100%
Diastematomyelia	4	2	50%	2	50%	100%
Dorsal dermal sinus	1	0		1	100%	100%
Tight filum terminale	1	1	100%	0	-	100%
Anterior sacral meningocele	1	1	100%	0	-	100%
Sacral agenesis	1	1	100%	0	-	100%
Total	**14**	**10**	**71.43%**	**4**	**28.57%**	**100%**

M:F=2.5:1.

Table 5: Age group distribution in open spinal dysraphism.

Age group	Myelo-meningocele	Myelocele	Meningocele
1-10	53	2	1
11-20	0	0	0
21-30	0	0	0
Total	**53**	**2**	**1**

Mean age of presentation is 1.21 years.

Table 6: Age group distribution in occult spinal dysraphism

Age group	Spinal lipomas	Diastematomyelia	Dorsal dermal sinus	Tight filum terminale	Anterior sacral meningocele	Sacral agenesis
1-10	4	4	1	1	0	0
11-20	2	0	0	0	1	1
21-30	0	0	0	0	0	0
Total	**6**	**4**	**1**	**1**	**1**	**1**

Mean age of presentation 6.57years

In closed spinal dysraphism males constituted 10 cases and females 4 cases accounting for 71.43% and 28.53% respectively showing marked male predominance. (M:F 2.5:1)

Age presentation

All open SD s occurred in the first year of life with no cases beyond that age (Mean age of presentation is 1.21yrs).

In occult SD patients presented at later age in the first, second and third decade with most of the cases occurring in the first decade. (Mean age of presentation is 6.57 years) (Table 5 and 6).

Table 7: Spinal lipomas.

Type	Number of cases	Percentage
Lipomyelocele	1	1.43
Lipomelomeningocele	3	4.29
Dural lipomas	1	1.43
Filar lipomas	1	1.43
Total	**6**	**8.57**

Table 8: Diastematomyelia.

	Fibrous septum	Bony septum	Total	Percentage
Diastematomyelia in occult SD	2	2	4	5.71%
Diastematomyelia in open SD	5	5	10	14.29%
Total	**7**	**7**	**14**	**20%**
Percentage	10%	10%	20%	

Table 9: Diastematomyelia: sites of involvement in the spine.

Type	Cervical	Dorsal	Dorsolumbar	Lumbar	Lumbosacral	Total
Open SD	0	1	4	3	2	10
Occult SD	0	0	2	2	0	4
Total	**0**	**1**	**6**	**5**	**2**	**14**

Table 10: Tethering.

Type	Tethering	No tethering	Total
Spinal lipomas	4	2	6
Diastematomyelia	1	3	4
Open SD	4	52	56
Dorsal dermal sinus	0	1	1
Tight filum terminale	1	0	1
Anterior sacral meningocele	0	1	1
Sacral agenesis	0	1	1
Total	**10**	**60**	**70**
Percentage	14.29%	85.71%	100%

Table 11: Vertebral anomalies.

	Hemivertebra	Butterfly	Block	Spina bifida	Others
Open SD	21	23	10	56	2
Spinal lipomas	2	3	1	6	
DDS		1		1	
Diastematomyelia	2		1	3	
Tight filum terminale		1			
Anterior sacral meningocele	1			1	
Sacral agenesis		1		1	
Total	**26**	**29**	**12**	**68**	
Percentage	37.14	41.43	17.14	97.14%	

Neurological complications

Neurological complications were reported in all the cases of open SD. In occult SD neurological manifestations were less severe and were present in 11 of the 14 cases. These findings correlate with Mclone DG, Naidich TP. Myelomeningocele: outcome and late complications.[2]

Cutaneous signs

Among the cutaneous manifestations of occult SD, most common finding was mass in the back (50%) predominantly in the lumbosacral region followed by dermal dimple, hypertrichosis, silky hair, dermal sinus, capillary hemangioma etc correlating with studies conducted by Hoffman et al and Kahn P et al (Table 18).

Open spinal dysraphism

Among the open SD the most common lesion was myelomeningocele accounting for 53 cases out of 56 cases (75.71%) followed by myelocele 2cases (2.86%) and meningocele 1 case (1.43%) (Table 1). The lesions were distributed in the cervical, dorsal, lumbar and lumbosacral regions. The lumbosacral region was the most common site accounting for 39.29% followed by lumbar (32.14%) and dorsal (21.43%) correlating with Brau RH et al.[3]

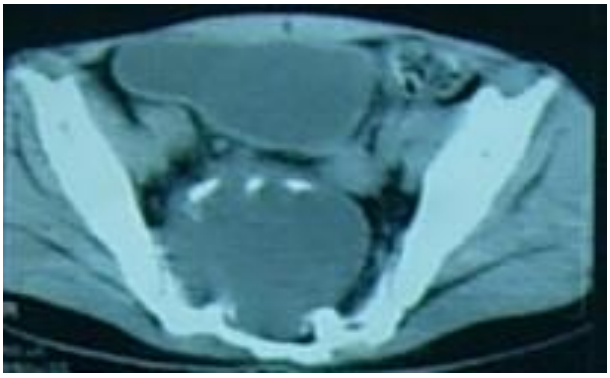

Figure 1: Axial CT image showing anterior sacral meningocele.

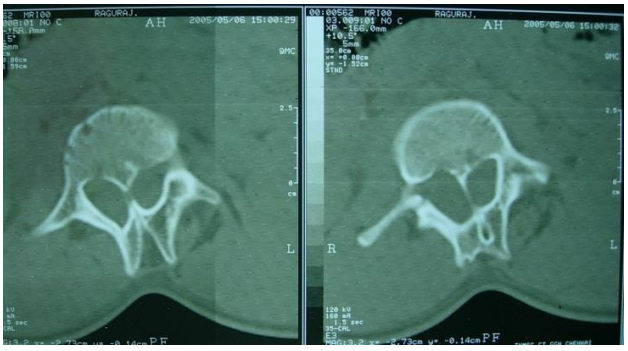

Figure 2: Axial CT showing complete bony septum in diastematomyelia.

Occult spinal dysraphism

Among the occult SD, Spinal lipomas accounted for 6 out of 14 cases. The most common spinal lipoma was lipomyelomeningocele (Figure 4) accounting for 4.29% followed by lipomyelocele (1.43%) and dural lipomas (1.43%) and filar lipomas (1.43%) correlating with Naidich TP, McLone DG, Mutleur S4 (Table 2).

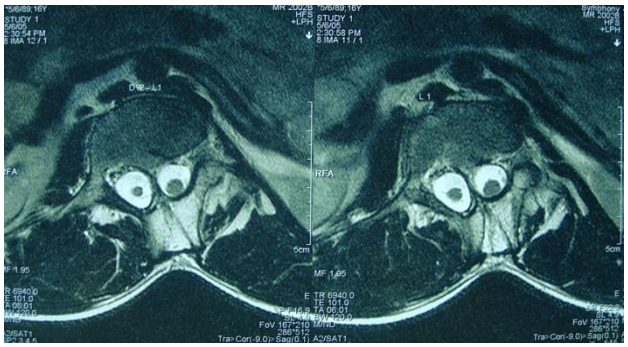

Figure 3: Axial T2W MRI shows splitting of cord into two hemicords by bony septum in Diastematomyelia.

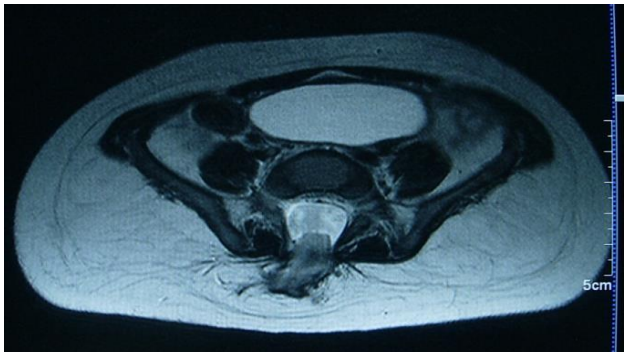

Figure 4: Axial T2W MR with sacral lipomyelomeningocele showing subcutaneous fatty mass.

Dorsal dermal sinus occurred in only one case accounting for 1.43% proving that it is an uncommon lesion among the occult SD correlating with Haworth JC, Zachary RB and Wright RL.[5] Tight filum terminale syndrome accounted for only 1.43% in our series proving that it is an uncommon lesion among the occult SD which concurred with Fitz CR, Harwood-Nash DC. AJR and Love JG, Daly DD, Harris LE.[6,7] Among the rare caudal spinal anomalies Anterior sacral meningocele (Figure 1) and sacral agenesis accounted for 1.43% proving them to uncommon lesions in concurrence with Pang D Meizner I, Press F, Jaffe A, Carmi R. J Clin Ultrasound.[8,9]

Diastematomyelia

A total of 10 cases occurred in open SD and 4 cases in Occult SD. Fibrous and bony septum occurred equally in both types. In open spinal dysraphism, Diastematomyelia occurred most commonly in the dorsolumbar region followed by lumbar and lumbosacral regions.[2-4] In occult SD diastematomyelia occurred equally in dorsolumbar and lumbar regions (Table 8 and 9). (Figure 2 and 3). These Findings concur with Han JS et al.[10]

Table 12: Spina bifida distribution in spine.

Types	Spina bifida cases	Distribution in spine				Total
		C	D	L	Ls	
0pen SD	56	4	12	18	22	56
Occult SD	12	1	2	4	5	12
Total	**68**	**5**	**14**	**22**	**27**	**68**
Percentage	97.14%	7.14%	20%	31.43%	38.57%	97.14%

Table 13: Distribution of spinal dysraphism in spine.

Types	Cases	Distribution in spine								Total
		C		D		L		Ls		
0pen SD	56	4	7.14%	12	21.43%	18	32.14%	22	39.29%	56
Occult SD	14	1	7.14%	2	14.29%	4	28.57%	7	50%	14
Total	**70**	**5**		**14**		**22**		**29**		**70**
Percentage	100%	7.14%		20. %		31.43%		41.43%		100%

Table 14: Spinal curvature.

Spinal curvature	Scoliosis			Kyphosis		Lordosis
Region	**C**	**D**	**LS**	**D**	**L**	
Open SD	1	6	5	4	2	4
Occult SD	1	5	4	5	3	3
Total	**2**	**11**	**9**	**9**	**5**	**7**
Percentage	2.86%	15.71%	12.86%	12.86%	7.14%	10%

Table 15: Hydromelia association.

Type	Hydromyelia		Total
	Present	**Absent**	
Open SD	15	41	56
Occult SD	7	7	14
Total	**22**	**49**	**70**
Percentage	31.43%	68.57%	100%

Tethering

Tethering occurred in 4 cases of open SD and 6 cases of closed SD representing 14.29 % of the total cases.

One case in the occult SD represented tight filum terminale syndrome (Table 10) Related studies include Fitz CR, Harwood-Nash DC.[5,7]

Table 16: Hydrocephalus in spinal dysraphism.

Spinal dysraphism	Hydrocephalus	
	Present	**Absent**
Open SD	25	31
Occult SD	5	9
Total	**30**	**40**
Percentage	42.86%	57.14%

Vertebral anomalies

Among the vertebral anomalies spina bifida occurred in 68 of the 70 cases representing 97.14 % as the most common vertebral anomaly followed by butterfly vertebra, hemivertebra, block vertebra and others. (Table 11) related study include Hadley HG.[11]

Spina bifida distribution

Spina bifida was most common in Lumbosacral spine (38.57%) followed by lumbar spine (31.43%), dorsal spine (20%) and cervical (7.14 %) (Table 12).[12]

Spinal curvature anomaly

The most common spinal curvature anomaly was scoliosis (31.43%) followed by kyphosis (20%) and lordosis (10%) (Table 14). In open spinal dysraphism, scoliosis was most common in dorsal spine (6 cases) followed by Lumbosacral region (5cases). Occult spinal dysrapism also showed similar distribution. In both open

and occult SD Kyphosis was most common in dorsal spine followed by lumbar spine lordosis occurred in lumbar spine.[13-16]

Table 17: Chiari association.

	Chiari II	Chiari I	Percentage
Open SD	51	0	91.07
Occult SD	0	2	14.29

Table 18: Cutaneous manifestation of occult spinal dysraphism.

Cutaneous signs	Dermal dimple	Hyper trichosis	Silky hair	Palpable mass	Dermal sinus	Capillary hemangioma	Rudimentary tail	Atretic meningocele
OccultSD (14 cases)	2	2	1	7	1	1	0	0
Percentage	14.29%	14.29%	7.14%	50%	7.14%	7.14%	0	0

Table 19: Neurological manifestations in spinal dysraphism.

	Motor deficit sensory deficit	Bowel incontinence bladder incontinence
Open SD	56	56
Occult SD	6	5

Table 20: comparison of Ct andMRI in spinal dysraphism.

Characteristics	CT	MRI
Open spinal dysraphism		
Meningomyelocele	+	++++
Myelocele	+	++++
Meningocele	+	++++
Occult spinal dysraphism		
Spinal lipomas	++	++++
Diastemettamyelia	++	++++
Dorsal dermal sinus	+	++++
Tight filum terminale		++++
Anterior sacral meningocele	+	++++
Vertebral anomalies	++++	++
Distribution in spine	+++	+++
Spinal curvature	+++	+++
Tethering		++++
Chiari association	+	++++
Hydromyelia	+	++++
Hydrocephalus	+	++++

+ poor, ++ good, +++ equivocal, ++++ excellent

Hydromelia

Hydromelia was present in 22 of the cases accounting for 31.43%. Open SD accounted for 21.43% of cases while occult SD comprised 10% of cases (Table 15). These findings concurred with Breningstall GN et al.[17]

Chiari malformations

Chiari II malformation occurred in 51 of the 56 cases in open SD accounting for 91.07% (Table 17). These findings correlate with Gammel T et al.[18]

Chiari I was present in 2 cases of the 14 cases of occult SD accounting (14.29%) according to Naidich TP, McLone DG, Mutleur S.[19]

Hydrocephalus

Hydrocephalus was present in 30 cases accounting for 42.86% correlating with comparative study of complex spina bifida and split cord malformation Kumar R et al (Table 16).

DISCUSSION

CT and MRI evaluation

Midline fusion anomalies involving neural elements, bone and mesenchymal components constitute spinal dysraphism. Plain radiograph is not good enough in the evaluation of the posterior elements of spine. MRI is excellent in characterising the soft tissue spinal anomalies of spinal dysraphism multiplanar reformatted CT is an excellent imaging modality for characterization of vertebral bony anomalies like spina bifida, hemivertebra, butterfly vertebra, block vertebra, coronal cleft etc.[1]

Meningomyelocele, myelocele and meningocele are identified by both CT and MR. However MR shows better characterization of the lesion and detection of associated soft tissue spinal anomalies.[2,3]

Spinal lipomas are best characterised by MR using fat suppression sequences.[4] CT also depicts fat attenuation in spinal lipomas. Dorsal dermal sinus is detected by both CT and MR. However characterization, extent and direction of tract, associated anomalies are best demonstrated in MR.[5] MRI is excellent in demonstrating tethering of cord.[6]

Fibrous septum in Diastematomyelia is best depicted in MR while bony septum is best demonstrated in CT.[7-9] Further characterization into Split Cord Malformation – Type 1 and 11, location, extent, associated anomalies is best demonstrated by MR.[10-13]

Multiplanar reformatted CT is good enough in demonstrating spinal curvature anomalies like scoliosis, kyphosis, lordosis.[14] MRI is also equal to CT due to its inherent multiplanar capability.[15,16] Chiari malformations, Hydromelia and hydrocephalus are best characterized in MRI.[17] Caudal spinal anomalies are best depicted and characterized in MR.[18] Coronal plane image acquisition well demonstrates spinal curvature and conus morphology.

The T1-weighted sequence depicts the anatomic details of neural structures. The high signal intensity neural structures are clearly seen adjacent to the low signal intensity extra neural elements in this sequence.[19,20]

On T2-weighted sequence depicts the extradural soft tissue and bony components. Field strength of 1.5 T allows significant reduction in imaging time with improvement in image quality.[19,20]

CONCLUSION

MRI is excellent in characterizing the soft tissue spinal anomalies of Spinal dysraphism. Multiplanar reformatted CT is an excellent imaging modality for characterization of vertebral bony anomalies associated with spinal dysraphism and bony septum in Diastematomyelia.

Study shows that helical CT and MRI should be done in the initial evaluation of spinal dysraphism.

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