Original Research Article

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

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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.²³ This study depicting the various imaging features of Spinal dysraphism and the importance of Helical CT and MRI in the evaluation of Spinal dysraphism. Aims 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 1 year to 30 years. 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 for radiological evaluation. Clinically the most common cause for referral was swelling in the back predominantly lumbar 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 - meningocele, 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

| 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%  |
| Myelocoele                   | 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    | 100%       | 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 | Myelocoele | 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 6.57 years

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         |       |              | 1      |
| Diastematomyelia     | 2            | 1         | 1     |              | 3      |
| Tight filum terminale| 1            | 1         |       |              | 1      |
| Anterior sacral meningocele | 1    | 1         |       |              | 1      |
| Sacral agenesis      | 1            | 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 McIone 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 et al (Table 1).

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 2 cases (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.

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 S (Table 2).

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. In occult SD diastematomyelia occurred equally in dorsolumbar and lumbar regions (Table 8 and 9). These findings concur with Han JS et al.
Table 12: Spina bifida distribution in spine.

| Types       | Spina bifida cases | Distribution in spine | Total |
|-------------|--------------------|-----------------------|-------|
|             |                    | C     | D     | L     | Ls    |       |
| Open 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% (C), 7.14% (D), 20% (L), 31.43% (Ls), 38.57% (Total), 97.14%

Table 13: Distribution of spinal dysraphism in spine.

| Types       | Cases | Distribution in spine | Total |
|-------------|-------|-----------------------|-------|
|             |       | C     | D     | L     | Ls    |       |
| Open 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    |       |

Percentage: 100% (Total), 7.14% (C), 20% (D), 31.43% (L), 41.43% (Ls), 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% (C), 15.71% (D), 12.86% (LS), 12.86% (D), 7.14% (L), 10%

Table 15: Hydromelia association.

| Type          | Hydromelia | Total |
|---------------|------------|-------|
|               | Present    | Absent|
| Open SD       | 15         | 41    | 56    |
| Occult SD     | 7          | 7     | 14    |
| Total         | 22         | 49    | 70    |

Percentage: 31.43% (Present), 68.57% (Absent), 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 | Total |
|-------------------|---------------|-------|
|                   | Present       | Absent|
| Open SD           | 25            | 31    |
| Occult SD         | 5             | 9     |
| Total             | 30            | 40    |

Percentage: 42.86% (Present), 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 (5 cases). Occult spinal dysraphism 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 | Hypertrichosis | Silky hair | Palpable mass | Dermal sinus | Capillary hemangioma | Rudimentary tail | Atretic meningocele |
|-----------------|---------------|----------------|------------|---------------|--------------|----------------------|------------------|----------------------|
| Occult SD (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                                     |
| Occult SD                     | 6                                      |

Table 20: comparison of Ct and MRI in spinal dysraphism.

| Characteristics             | CT       | MRI       |
|-----------------------------|----------|-----------|
| **Open spinal dysraphism**  |          |           |
| Meningomyelocele            | +        | ++++      |
| Myelocele                   | +        | ++++      |
| Meningocele                 | +        | ++++      |
| **Occult spinal dysraphism**|          |           |
| Spinal lipomas              | ++       | ++++      |
| Diastematomyelia            | ++       | ++++      |
| 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 Breeningstall 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, myeloclele 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.6–9 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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