Research Article

Clinical and Radiological Outcomes After Surgery for Spinal Dysraphism: The Value of Follow-up Magnetic Resonance Imaging in 36 Patients

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Abstract

Background: Magnetic resonance imaging (MRI) is central to the preoperative characterization of tethered cord and spinal dysraphism, but the clinical significance of persistent anatomical abnormalities on postoperative imaging is uncertain. We examined the relationship between postoperative spinal MRI and short-term neurological outcomes in a heterogeneous surgical series.

Methods: In this retrospective observational study, 36 patients who underwent surgery for spinal dysraphism or tethering were evaluated using preoperative clinical and MRI findings, the documented operation, follow-up neurological assessments, and postoperative MRI. Clinical follow-up occurred at a median of 6 months (range, 5–9), and postoperative MRI was obtained at 4–9 months. Imaging outcomes were described separately from clinical recurrence, and cases with symptom-triggered imaging were distinguished from uncomplicated follow-up.

Results: Of 36 patients, 19 (52.8%) were male and 17 (47.2%) female; median age was 6.5 months. Primary myelomeningocele repair accounted for 14 (38.9%) and lipoma-associated disease for 10 (27.8%). In all 34 patients with documented pre- and postoperative conus levels, the vertebral level remained unchanged. Residual lipomatous tissue after surgery was described in 9 cases; hydromyelia resolved in one case. Two patients (5.6%) developed clinically symptomatic recurrence requiring repeat untethering at approximately 4 and 5 months, respectively, despite unchanged conus levels.

Conclusions: At short-term follow-up, an unchanged conus level was common despite clinical stability or improvement and did not exclude symptomatic postoperative retethering. Postoperative MRI was valuable for documenting residual lesions and associated cord cavities, whereas clinical deterioration remained central to the assessment of recurrent tethering. These observations support clinically directed imaging interpretation and selective baseline imaging in complex dysraphism rather than relying on conus level alone

Keywords: Clinical, Radiological Outcomes, Spinal Dysraphism, Magnetic Resonance Imaging

Introduction

Tethered cord represents pathological fixation of the spinal cord that may result in neurological, orthopedic, or urological dysfunction, either in association with congenital dysraphism or after previous spinal surgery [1–3]. The anatomical substrates are heterogeneous and include thickened or fatty filum terminale, intradural lipoma, myelomeningocele, meningocele, dermal sinus, and postoperative adhesions [2–5]. Clinical manifestations range from cutaneous stigmata in otherwise neurologically intact infants to progressive pain, motor deficits, gait disturbance, and sphincter dysfunction [2,3].

MRI defines the level of the conus and depicts associated lesions such as lipoma, dysraphic bony anatomy, and syringohydromyelia before surgery [4]. After operative release, however, a low-lying conus or residual nonresectable tissue may persist without representing unsuccessful untethering [1,6]. Consequently, interpretation of postoperative MRI requires correlation with the neurological course, particularly when symptoms recur.

Despite the established diagnostic role of preoperative MRI, postoperative vertebral conus position may remain unchanged after surgical release. The study therefore evaluated postoperative anatomical findings separately from clinical recovery and from symptomatic recurrence.

We studied 36 surgically treated patients with spinal dysraphism or tethered cord. Our objectives were to describe postoperative MRI findings, examine the concordance of conus position with clinical outcomes and symptomatic retethering, and characterize the clinical and radiological follow-up across the principal dysraphism subgroups.

Materials and Methods

Study design and patients

This retrospective observational study included 36 patients who underwent surgical treatment for spinal dysraphism or tethered cord at Zagazig University Hospitals, Egypt, between 2013 and 2018. Each individual contributed one index surgical episode to the patient-level analysis; subsequent untethering was recorded as a

follow-up event. The cohort comprised children and one adult, and was intentionally heterogeneous with respect to dysraphism type and surgical indication.

Clinical variables

Age at index surgery, sex, presenting skin abnormalities, pain, leg weakness, gait or orthopedic findings, urinary and bowel symptoms, anal tone when available, prior spinal repair, and relevant operative findings were abstracted from individual records. For infants, ordinary diaper wetting or soiling was not classified as urinary or fecal incontinence. Neurological outcomes were described as improved, unchanged, or deteriorated based on the recorded examination, with individual domains considered separately. Symptomatic retethering was defined by new or progressive clinical symptoms attributed to recurrent fixation and corroborated by subsequent operative findings when a repeat operation was performed.

Magnetic resonance imaging and surgical variables

Preoperative MRI was reviewed for conus location and dysraphic pathology, including intradural or subcutaneous lipoma, meningocele or myelomeningocele, filar abnormalities, and cord cavitation. Postoperative MRI was used to describe the conus level, residual lipoma or other lesions, and changes in syrinx or hydromyelia. Vertebral lesion location was not substituted for conus level. Reoperation and clinically suspected retethering were coded separately from unchanged postoperative anatomy. MRI obtained in response to postoperative deterioration was identified separately from scheduled imaging. The dominant operative categories included meningocele or myelomeningocele repair with untethering, lipoma excision with untethering, filum sectioning, adhesiolysis, and excision of a dermal sinus or cutaneous appendage. In one cervical lipoma case, excision was recorded without separately confirmed untethering; this case contributes to the broader surgical dysraphism description, not a procedure-specific untethering success rate.

Outcomes and statistical analysis

The principal imaging outcome was the paired change in vertebral conus level among patients with both measurements documented. Other descriptive clinical endpoints were neurological change, clinically symptomatic retethering, reoperation, and the presence of residual structural abnormalities. Counts and proportions were calculated using explicit denominators; age and follow-up are presented as medians and ranges because of the skewed age distribution. As every evaluable paired conus measurement was unchanged, no between-group test of conus displacement was meaningful. The small number of recurrent events and the variable indications for MRI also precluded reliable estimation of diagnostic sensitivity or specificity for retethering; no inferential p value was generated for these endpoints. Reporting was informed by the STROBE guidance for observational studies [8].

Results

Patient characteristics and surgical pathology

The analysis included 36 patients, with 19 males and 17 females. Median age was 6.5 months (range, 0.4 months to 33 years). 28 patients (77.8%) were younger than 5 years. Clinical and spinal MRI follow-up were documented at a median of 6 months (range, 5–9). The most common diagnostic groups were primary myelomeningocele (14 (38.9%)) and lipoma-associated dysraphism (10 (27.8%)). Diagnostic categories are mutually exclusive for tabulation, while associated anomalies may overlap (Tables 1 and 2).

Presentation differed considerably by age and pathology. Infants with myelomeningocele often had congenital sacs and motor weakness, whereas older children with filar tethering or postoperative adhesions were more likely to present with leg or back pain and urinary concerns. Several children underwent surgery primarily because of a cutaneous manifestation despite preserved active lower-limb movements. Reduced anal sphincter tone was recorded in some infants without separately established urinary or bowel dysfunction.

Operative management and neurological course

Surgical procedures included primary repair of myelomeningocele or meningocele with untethering, partial or complete lipoma excision with cord release, filum sectioning, dermal sinus excision, and repeat adhesiolysis. Individual outcomes were generally stable or improved in the observed follow-up period. Among 19 patients with preoperative lower-limb motor deficits, 15 improved (78.9%; exact 95% confidence interval [CI], 54.4%–93.9%) and four had persistent deficits without documented recovery. Separately, a patient with new adhesion-related postoperative weakness improved after repeat release. In patients with pre-existing deficits, motor recovery was often incomplete and persistent sphincter hypotonia could coexist with improvement in leg movements. Pain relief after surgical treatment was noted in several older children and adults.

Two patients (2 (5.6%); exact 95% CI, 0.7%–18.7%) developed new or recurrent symptoms after the index surgery and underwent repeat release at approximately 4 and 5 months. Adhesions were confirmed at reoperation in both. In these patients, the postoperative MRI recorded an unchanged conus level; one had no residual lipoma following initial excision and the other had a small lumbar syrinx described on MRI. The post-reoperation assessment in the second patient was immediate rather than prolonged. Both cases were classified

as clinical recurrence requiring surgery, rather than radiological proof of retethering.

Postoperative MRI and clinical correlation

Paired preoperative and postoperative conus levels were documented in 34 of 36 patients (94.4%). The conus remained at the same vertebral level in all 34 patients (100%; exact 95% CI, 89.7%–100%), including patients with motor improvement, persistent deficits, and the two patients requiring adhesiolysis. The filum-associated tethering case had a conus at L3. A paired conus-level comparison was unavailable for the cervical lipoma and thoracic meningocele cases. Consequently, absence of conus ascent could not discriminate between a favorable postoperative neurological course and symptomatic recurrent tethering in this cohort.

Residual lipoma after partial resection was recorded in 9 (25.0%) cases, consistent with the decision to retain adherent tissue rather than pursue complete removal at the expense of functional neural structures. In one child with caudal regression syndrome, the preoperative hydromyelia extending to the thoracic region resolved on follow-up MRI. In another patient a small L2 syrinx was recorded after recurrent symptoms; a paired preoperative cavity measurement was not available. No further operation was documented as being prompted solely by persistence of low conus position or residual lipoma at scheduled imaging (Table 3). A representative pair of preoperative and postoperative spinal MR studies from the study cohort illustrates a subcutaneous-to-intradural lipomatous connection, a low-lying conus, and a postoperative residual lesion (Figures 1 and 2).

Clinical follow-up was documented at 6 months in 30 patients, at 5 months in one, at 7 months in two, at 8 months in two, and at 9 months in one. The two early MRIs associated with symptomatic recurrence at 4 and 5 months were clinically indicated and should not be interpreted as routine surveillance. The varying imaging indications and limited observation period restrict conclusions about the subsequent clinical utility of a postoperative MRI baseline.

Table 1. Demographic and follow-up characteristics (N = 36)

Characteristic	Value
Male / female	19 (52.8%) / 17 (47.2%)
Age at surgery, median (range)	6.5 months (0.4 months–33 years)
Younger than 5 years	28 (77.8%)
5 to <20 years	7 (19.4%)
20 years or older	1 (2.8%)
Clinical follow-up, median (range)	6 months (5–9)
MRI timing, median (range)	6 months (4–9)
6-month clinical and MRI evaluation	30 (83.3%)
Other clinical follow-up time points	5 months: 1; 7 months: 2; 8 months: 2; 9 months: 1

Table 2. Principal dysraphism categories

Principal diagnostic / treatment category	Patients, n (%)
Primary myelomeningocele repair with untethering	14 (38.9%)
Secondary tethering after previous MMC repair	3 (8.3%)
Lipoma-associated dysraphism / tethering	10 (27.8%)
Meningocele with tethering	2 (5.6%)
Filum-associated tethering without other assigned dysraphism	3 (8.3%)
Congenital tail-like appendage	2 (5.6%)
Dermal sinus	1 (2.8%)
Caudal regression with hydromyelia	1 (2.8%)
Total	36 (100.0%)

Table 3. Clinical and postoperative MRI findings

Finding	Number (%) or description
Paired conus-level documentation	34 (94.4%)
Preoperative motor deficits	19 (52.8%)
Motor improvement among preoperative deficit group	15/19 (78.9%; 95% CI 54.4%–93.9%)

Unchanged conus level among evaluable patients	34/34 (100.0%; exact 95% CI 89.7%–100%)
Residual lipoma after partial resection	9 (25.0%)
Resolution of preoperative hydromyelia	1 (2.8%)
Small lumbar syrinx described in postoperative assessment	1 (2.8%)
Symptomatic recurrence with surgically confirmed adhesions	2/36 (5.6%; 95% CI 0.7%–18.7%)
Repeat untethering after the index procedure	2 (5.6%)
Recurrence timing	Approximately 4 and 5 months after index surgery
Early symptom-triggered MRI	2 patients, at 4 and 5 months

Representative magnetic resonance imaging

The preoperative and postoperative MRI findings of an illustrative patient with lumbosacral lipomatous dysraphism are shown in Figures 1 and 2.

Figure 1. Preoperative lumbosacral MRI. Multiplanar T1- and T2-weighted images demonstrate a posterior subcutaneous lipomatous lesion extending toward and communicating with the intradural compartment through a dysraphic posterior defect. The lower cord is positioned abnormally low, with the conus documented at L3. The intradural extension of the fatty lesion provides the structural correlate of tethering.

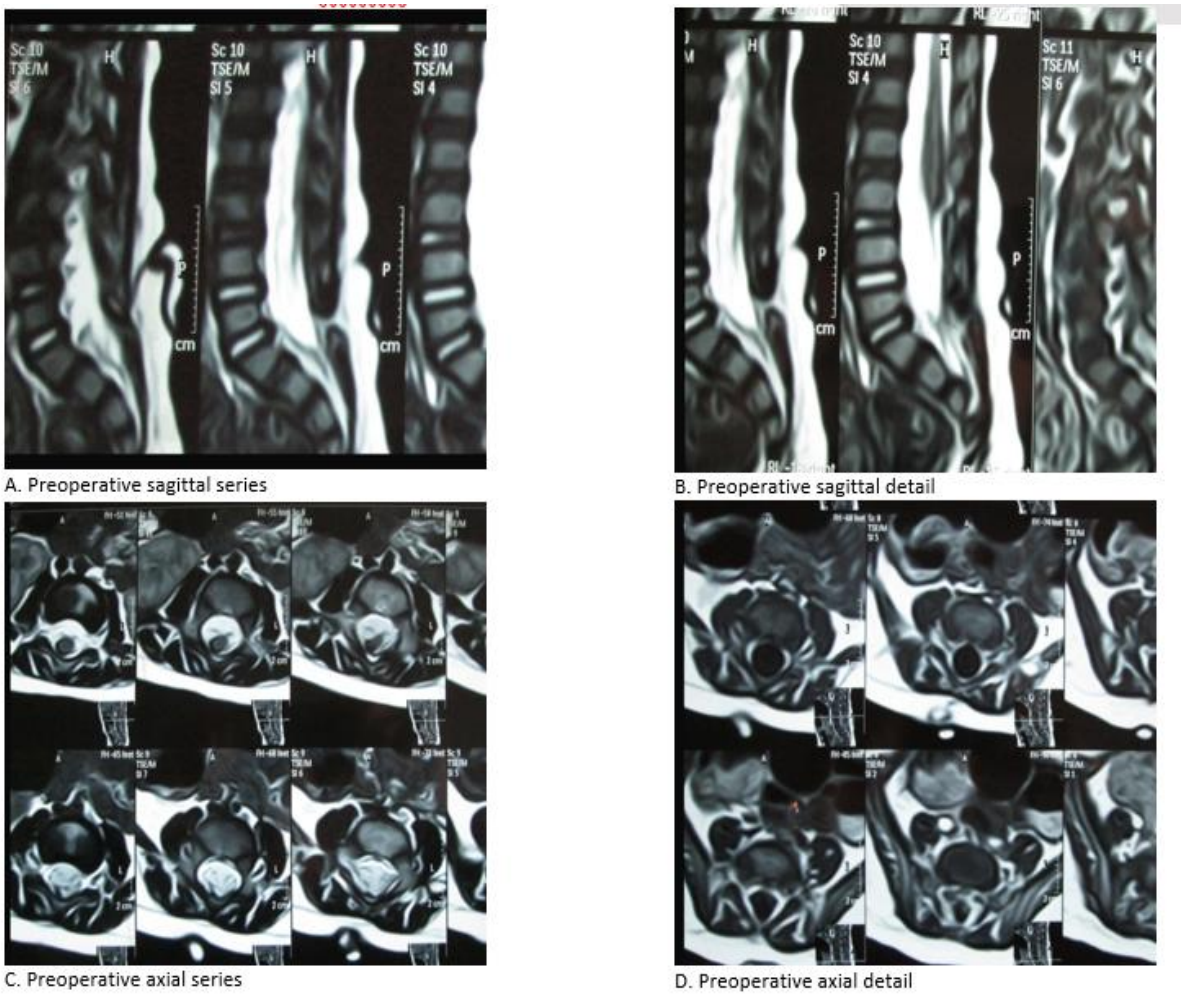
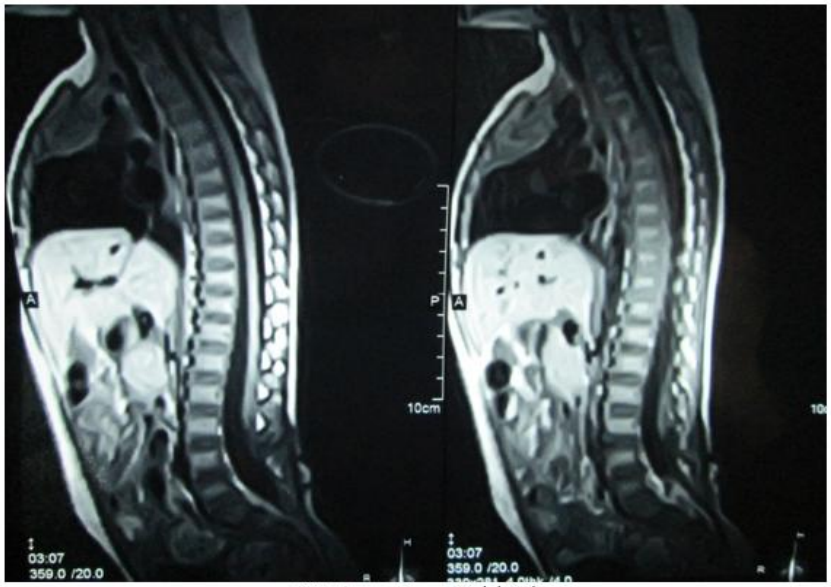
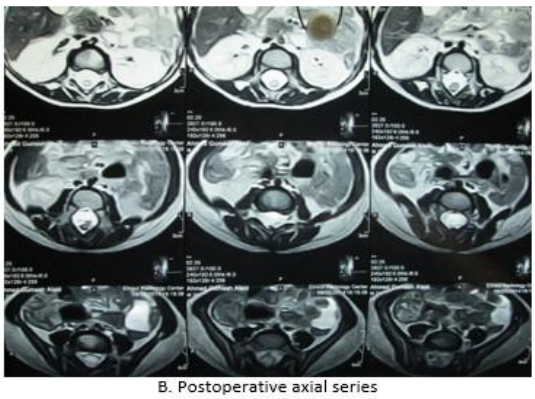


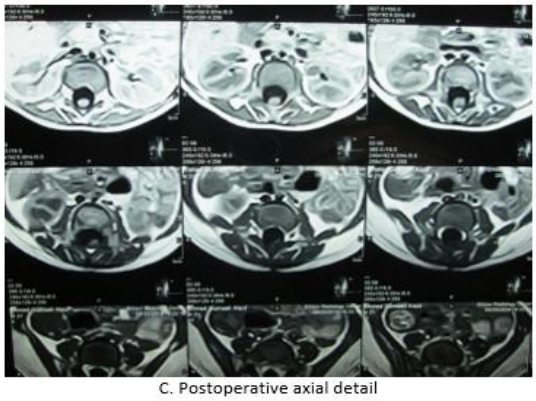
Figure 2. Postoperative lumbosacral MRI in the same patient following untethering and partial lipoma resection. (A) Sagittal images illustrate the postoperative lumbosacral anatomy. (B, C) Axial series show the operated spinal canal and residual lipomatous tissue. The conus remained at the preoperative vertebral level (L3), as documented during clinical and radiological follow-up.



A. Postoperative sagittal detail



B. Postoperative axial series



C. Postoperative axial detail

Discussion

Three findings emerge from this retrospective analysis. First, postoperative stability of conus level was observed in every patient for whom paired vertebral levels were documented. This does not demonstrate technical failure because successful release of pathological tension does not require cranial migration of the conus [1,6]. Second, residual lipomatous tissue and postoperative cord cavities provided anatomical information but did not, by themselves, constitute clinical retethering. Third, two patients developed clinically important recurrence despite unchanged conus level, illustrating the distinction between structural findings and neurological progression.

Anatomical findings on postoperative MRI must be interpreted in the context of the original dysraphic lesion and the neurological examination. Follow-up imaging can document residual lesions or cavitary change, whereas repeat intervention for symptomatic tethering depends on the clinical course and operative assessment [1,2,4]. The surgical aim of untethering is to relieve pathological traction while preserving function. Published series of children with tight or fatty filum and of patients with secondary tethering have documented both neurological benefit and the possibility of recurrent symptoms requiring further surgery [2,3]. In our cohort, the two reoperated patients had new pain or weakness attributable to adhesions and were treated on clinical grounds despite unchanged radiological conus level. In complex lipomatous malformations, deliberate subtotal resection may leave visible lipoma at follow-up; this residual is more appropriately described as a postoperative baseline than as evidence of immediate recurrence [1,6].

Neurological outcomes should be evaluated by domain. Stability is a meaningful postoperative result in patients with intact neurological function, whereas partial recovery may be observed in patients already exhibiting motor deficits. Persistent abnormal anal tone does not by itself establish urinary or fecal incontinence, particularly during infancy; objective functional measures require age-appropriate clinical and, when indicated, urodynamic assessment. Accordingly, the present analysis distinguishes clinical bladder symptoms from isolated sphincter tone findings and avoids imputing dysfunction from diaper use.

Strengths and limitations

The main strength of this study is the patient-level assessment of neurological and MRI findings, including recognition of two clinically confirmed postoperative adhesion-related recurrences and direct attention to residual structural lesions. Limitations include the small, heterogeneous cohort and the short follow-up period, which limit assessment of late retethering.

Conclusion

In this series of 36 patients undergoing surgery for spinal dysraphism or tethering, the conus medullaris remained at its recorded vertebral level in all 34 patients with paired preoperative and postoperative measurements. Symptomatic postoperative retethering requiring adhesiolysis nevertheless occurred in two patients whose conus positions were unchanged. Postoperative MRI usefully characterized residual lipoma and cord cavitation, but the anatomical conus position alone was not a surrogate for clinical success or recurrence. Follow-up should prioritize serial neurological assessment, with MRI interpreted selectively in relation to the original pathology, new symptoms, and the need for a structural baseline.

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