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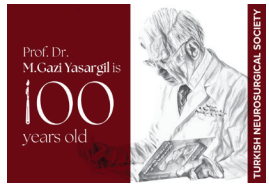

Incidence and Factors of Tethering After Sectioning the Filum Terminale

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ABSTRACT

AIM: To assess the incidence of retethering in patients who underwent surgery for tethered cord in our clinic.

MATERIAL and METHODS: We included patients who underwent surgical intervention for tethered cord in our clinic between 2010 and 2020, and were subsequently diagnosed with retethering during follow-up. Only those with available postoperative clinical follow-up data were included. The study analyzed the timing of surgery, gender, presenting symptoms, intraoperative findings, postoperative outcomes—including complications—and follow-up duration.

RESULTS: Over a 10-year period, 59 patients underwent surgery for tethered cord. Among them, 11 patients required reoperation for retethering at a median age of 5 years. The median interval between the initial and retethering surgeries was 47.6±43.20 months. Two patients were asymptomatic at the time of their initial surgery. Among the 11 patients with retethering, 3 (27.2%) presented with bladder or bowel dysfunction, 4 (36.3%) with neuro-orthopedic symptoms, and 4 (36.3%) with pain. Two patients experienced a second episode of retethering and required a third surgery, which occurred approximately 2 years after the second procedure.

CONCLUSION: The risk of retethering should be carefully monitored in patients with tethered cord, particularly during growth periods.

KEYWORDS: Tethered cord, Retethering, Filum terminale syndrome

ABBREVIATIONS: LSL: Lumbosacral lipomas

INTRODUCTION

Tethered cord syndrome occurs when the spinal cord fails to develop in coordination with the spinal column, leading to tension. This condition can result in bladder or bowel dysfunction, gait disturbances, orthopedic abnormalities, sensory deficits, and scoliosis (9,19,22). To prevent these complications, it is recommended to surgically release the thickened or fatty filum terminale responsible for the tension, even in asymptomatic children. However, early surgical intervention carries a risk of subsequent retethering. Therefore, long-term follow-up is necessary until the completion of growth.

The prevalence of retethered cord and the optimal follow-up strategy for patients at risk of retethering remain subjects of debate. This study aims to evaluate the incidence of retethering in patients who underwent surgery for tethered cord in our clinic.

MATERIAL and METHODS

This study was approved by the Clinical Research Ethics Board of Istanbul Yeni Yüzyıl University (2025/03-1503). A retrospective review was conducted on the medical records of 59 children who underwent surgery for a thickened filum

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terminale between 2010 and 2020 at Bursa Uludag University and Medicabil Hospital. Patients who required reoperation due to tethering were also examined. Those with radiological evidence of a tethered cord but no clinical findings were excluded. Patient records were analyzed for age at the time of surgery, gender, presenting symptoms, intraoperative findings, postoperative outcomes—including complications—and follow-up duration. For patients who experienced one or more episodes of tethering, the age at tethering, time to retethering, presenting symptoms, type of dural repair, and surgical outcomes were documented.

Statistical Analysis

The Shapiro–Wilk test was used to assess whether age and follow-up duration followed a normal distribution across patient groups. Since the variables did not exhibit a normal distribution, they were presented as median, minimum, and maximum values. Categorical variables were reported as frequencies and corresponding percentages. The Mann–Whitney U test was used to compare continuous variables between groups, while Fisher's exact test and the Fisher–Freeman–Halton exact test were applied for intergroup comparisons of categorical variables. Logistic regression analysis was conducted to identify factors associated with recurrence in patients with spinal dysraphism. All statistical analyses were performed using SPSS (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY, IBM Corp.), with a significance threshold of $\alpha = 5\%$.

RESULTS

Over a 10-year period, 59 patients underwent surgery for tethered cord. Gender distribution did not significantly differ between the retethered and non-tethered groups (p=0.187), whereas patient age showed a significant difference (p=0.039). The median age at surgery was 14 months in the retethered group and 9 months in the non-tethered group. The average diameter of the filum terminales in retethering group was 2.35 ± 0.6 mm. Although of the 11 patients who underwent reoperation, 6 had lipomyelomeningocele at the initial operation, 4 had fatty filum terminale and one had dermoid cyst, no significant differences were observed between the groups regarding pathology and detailed pathology findings (p=0.055 and p=0.185, respectively) (Figure 1). Similarly, neurological examination results, presenting symptoms, and postoperative complication rates did not show significant differences between groups (p>0.05). However, a significant difference was found in follow-up duration (p<0.001), with a longer follow-up period in the retethered group. The median follow-up duration was 72 months in the retethered group and 24 months in the non-tethered group (Table I).

A total of 11 patients underwent surgery for retethering at a median age of 5 years. The median interval between the initial surgery and the retethering operation was 47.6±43.20 months. Two patients were asymptomatic at the time of their first surgery. Among the 11 patients who developed retether-

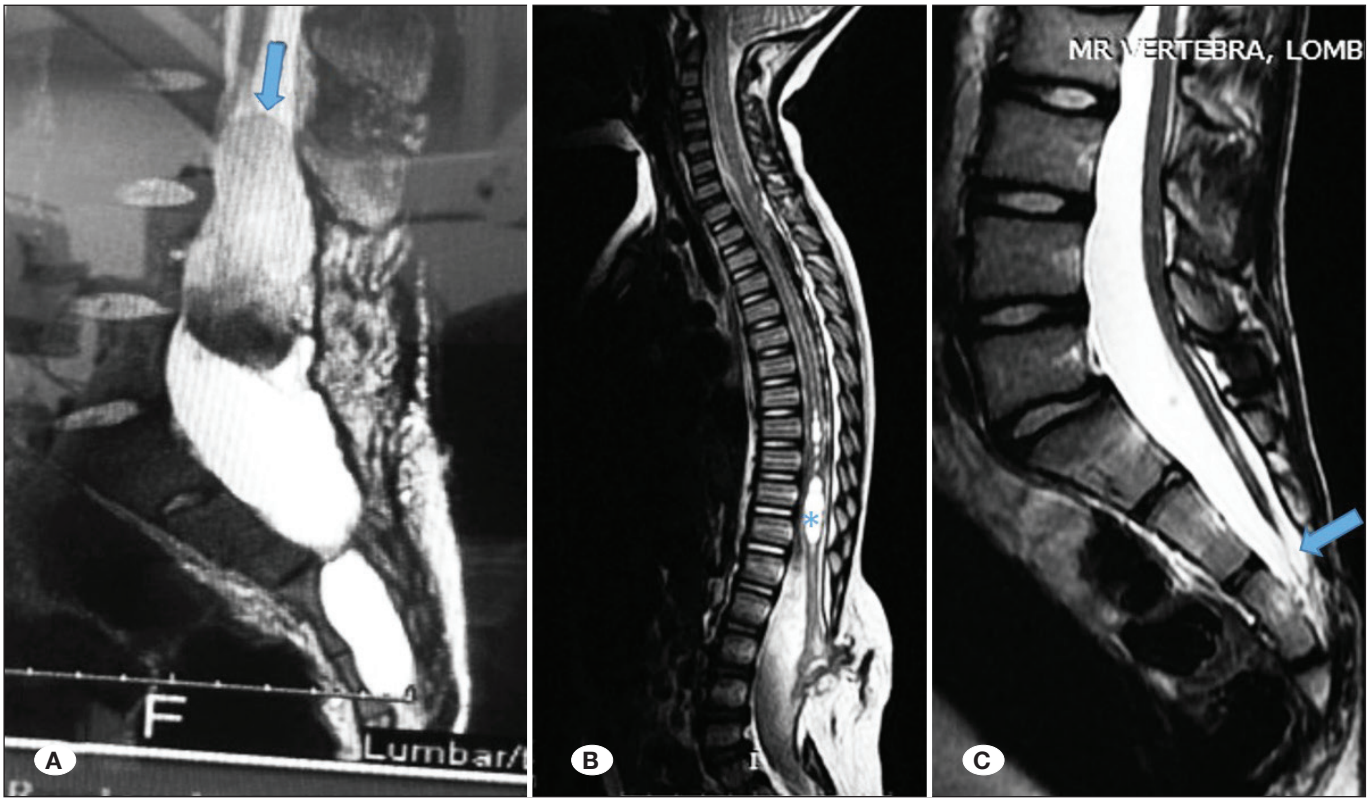

Figure 1: A) T2-weighted images showes an intradural dermoid cyst at L3-4 levels and tethered cord sticking to cyst (arrow); **B)** T1-weighted sagittal MRI revealed an appearance compatible with tethered spinal cord and syringomyelia (asterisk) secondary to lipomyelomeningocele. **C)** In the T2-weighted sagittal MRI section, fatty filum terminale ending at the S3 level is observed (arrow)

Table I: Demographic and Clinical Characteristics of Spinal Dysraphism Patients with and without Retethering

	Retethered (n=11)	Non-tethered (n=48)	p-value
Gender, n (%)			
Female	4 (36.40)	29 (60.40)	0.187[a]
Male	7 (63.60)	19 (39.60)	
Age (years), n (%)	14 (5–25)	9 (1–25)	**0.039[b]**
Pathology			
MMC	1 (9.10)	2 (4.20)	0.055[c]
MC	3 (27.30)	3 (6.30)	
Tethered	7 (63.60)	43 (89.60)	
Detailed pathology, n (%)			
Lipoma	6 (54.50)	34 (70.80)	0.185[c]
Fatty filum	1 (9.10)	8 (16.70)	
Dermoid-epidermoid	4 (36.40)	6 (12.50)	
Neurological examination, n (%)			
No deficit	7 (63.60)	30 (62.50)	>0.999[a]
Deficit	4 (36.40)	18 (37.50)	
Complaint, n (%)			
Urinary and gait incontinence	3 (27.30)	7 (14.60)	0.927[c]
Paraparesis	1 (9.10)	7 (14.60)	
Scoliosis	5 (45.50)	24 (50)	
Low back pain	1 (9.10)	4 (8.30)	
Hypertrichosis in the lumbar region	1 (9.10)	4 (8.30)	
No complaint	0	2 (4.20)	
Postop complication, n (%)	3 (27.30)	4 (8.30)	0.112[a]
Follow-up (months)	72 (36–132)	24 (1–84)	**<0.001[b]**

MMC: *Myelomeningocele,* ***MC:*** *Myeloschisis.*

ing, 3 (27.2%) presented with bladder or bowel dysfunction, 4 (36.3%) with neuro-orthopedic symptoms, and 4 (36.3%) with pain. Two patients experienced a second episode of retethering and required a third surgery, which occurred 2 years after their second operation. All dural repairs were performed with primarily; no dural graft was used. All of the patients were lumbosacral tethered cords. There were no any bony spicules in the affected segments.

To identify factors associated with recurrence in patients with spinal dysraphism, the variables listed in Table I were first analyzed using univariate logistic regression. Variables meeting the $p<0.25$ threshold were then included in a multivariate logistic regression model (2). Based on univariate logistic regression analysis, the factors that met this criterion were gender, age, detailed pathology, presence of postoperative complications, and follow-up duration (Table II).

The analysis indicated that the multivariate logistic regression model was a good fit for the data (Hosmer–Lemeshow test, $p=0.973$) and was statistically significant ($p<0.001$). The results showed that each additional unit increase in follow-up duration increased the risk of developing retethering in patients with tethered cord by 1.06 times. No significant effect was observed for the other variables included in the analysis.

A total of seven postoperative complications occurred across all tethered cord surgeries. No patients experienced lower extremity paresthesias or urinary incontinence. One patient developed a wound infection (1.7%), while five had cerebrospinal fluid (CSF) leakage (8.4%). A patient whose drain had been sutured was reoperated for removal of the drain. Among those with CSF leaks, two belonged to the retethered group.

Table II: Factors Linked to the Development of Tethering

	Univariate logistic regression analysis				Multivariate logistic regression analysis			
	Crude OR	95% CI		p	Adj. OR	95% CI		p
		Lower	Upper			Lower	Upper	
Gender (female)								
Female (Reference)	1	-	-	-	1	-	-	-
Male	2.67	0.69	10.39	**0.156**	3.54	0.54	23.25	0.188
Age (months)	1.14	1.02	1.28	**0.022**	1.03	0.88	1.21	0.685
Detailed pathology				**0.187**				0.782
Lipoma (Reference)	1	-	-	-	1	-	-	-
Fatty filum	0.71	0.07	6.74	**0.764**	0.53	0.01	>100	0.844
Dermoid-epidermoid	3.78	0.82	17.52	**0.090**	2.18	0.22	22.06	0.509
Neurological Examination								
Normal (Reference)	1	-	-	-	1	-	-	-
Deficit	0.95	0.24	3.71	0.944				
Postop complication								
No (Reference)	1	-	-	-	1	-	-	-
Yes	4.13	0.77	22.04	**0.097**	0.45	0.02	9.30	0.445
Complaint				0.961				
Urinary and gait incontinence (Reference)	1	-	-	-	1	-	-	-
Paraparesis	0.33	0.03	4.04	0.388	-	-	-	-
Scoliosis	0.49	0.09	2.56	0.395	-	-	-	-
Low back pain	0.58	0.04	7.66	0.682	-	-	-	-
Hypertrichosis in the lumbar region	0.58	0.04	7.66	0.682	-	-	-	-
No complaint	0.01	0.01	0.01	0.999	-	-	-	-
Follow-up duration	1.06	1.02	1.09	0.001	1.06	1.02	1.10	**0.005**

DISCUSSION

There are limited studies in the literature that investigate the long-term outcomes of tethered cord surgery. Both the management and treatment of retethering remain subjects of debate, and available research on the topic is scarce. In this study, we observed that the likelihood of detecting retethering increases with prolonged follow-up in patients who underwent surgery for tethered cord.

The reported incidence of retethering ranges from 2.7% to 15% (4,11). Some studies indicate that this rate rises as the follow-up period extends (14,17). A meta-analysis by Goodrich et al., which reviewed 608 patients from 13 studies, identified a significant positive linear correlation between follow-up duration and the incidence of retethering, showing an annual increase of 3.2%. No cases of retethering were detected within the first 2.1 years, whereas 57% of patients exhibited retethering during an 18-year follow-up period (5). In our series, the retethering rate was 18.6%. This higher incidence compared to previous studies may be attributed to an extended follow-up period or more rigorous patient monitoring made possible by advancements in technology.

Some studies have suggested that age is a risk factor for retethering. Bowman et al. reported that the tethering rate decreased from 7.4% at age 15 to 1.8% at age 20, though this may also be related to the cessation of spinal growth in their patient population (3). Retethering is generally observed to occur within 5 years after the initial surgery (12). In our study, we also followed our patients until they were transferred to the adult group at the age of 16, and the follow-up period was longer in the retethered group.

The retethering rate is reported to be lower in cases of filar lipomas, and higher retethering rates have been noted in lumbosacral lipomas (LSLs) compared to myelomeningoceles (MMCs) (1). Lee et al. found that symptomatic retethering was more commonly observed in lower-level MMCs (8). In cases of complex lesions, Samuels et al. reported a lower retethering rate in patients who underwent duraplasty compared to those who had primary closure (15), while Mehta et al. found no significant difference (10). Pang et al. emphasized the importance of the cord/sac ratio as a prognostic factor in their multivariate analysis (13). In our series, we did not find a significant relationship between the underlying pathology and retethering, which differs from the findings in the literature.

When retethering occurs, patients typically present with neurological symptoms, with urological and motor symptoms being more common than others (10,18). Abnormal urodynamic studies can be a sign of retethering. Tarcan et al. reported urological deterioration in 32% of patients during follow-up (21). In our series, neuro-osteopathic symptoms were the most frequent complaint in the retethering group. Urodynamic testing is performed preoperatively and during annual follow-ups in our series.

Retethering is diagnosed by excluding other potential causes, rather than being identified through radiological imaging. Prone magnetic resonance imaging and spinal sonography are recommended for diagnosing retethering (16,20). However, neurosurgeons should be cautious during follow-up, as the dentate ligaments prevent the filum terminale from moving upward after surgery. Close monitoring of patients with clinical assessments and evoked potentials, along with radiological evaluation based on symptoms, is necessary. In particular, the width of the P37 response is a useful parameter for detecting tethering but we could not get this data in our hospital.

Spinal column shortening is a surgical approach used for recurrent tethering, but we did not perform this procedure on any of our patients.

Complete untethering has been achieved in 93%–100% of tethered cord patients (6). All operetions were performed with neuromonitorisation. This high success rate may be due to surgeons opting for more aggressive surgical interventions in symptomatic patients.

The results of retethered cord surgery are generally reported to be favorable, with 26%–93% of patients showing improvement or stabilization of symptoms (7,14). In our series, in line with the literature, no deterioration was noted in patients who underwent surgery for retethering. Nine patients experienced a reduction in symptoms, and two patients' symptoms remained stable.

A key limitation of this study is that we did not assess the level of retethering, and radiologically confirmed retethered cases were excluded. Additionally, as not all patients had somatosensory evoked potential data during follow-up, we were unable to analyze and interpret this parameter in relation to retethering. All surgeries and follow-ups were performed by the same surgical team, which may have created a higher retethering rate in patients operated on the begining of the learning curve.

CONCLUSION

Retethering presents a significant clinical burden for both patients with tethered cord and their families. The literature reports highly variable data regarding the incidence rate, and severity of surgical complications, as well as long-term outcomes. During the follow-up of tethered cord patients, the possibility of retethering should be considered, particularly while the patients are still growing.

Declarations

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Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author by reasonable request.

Disclosure: The authors declare no competing interests.

AUTHORSHIP CONTRIBUTION

Study conception and design: MOT

Data collection: DB

Analysis and interpretation of results: DB

Draft manuscript preparation: DB, MOT

Critical revision of the article: MOT, DB

All authors (DB, MOT) reviewed the results and approved the final version of the manuscript.

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