

CLINICAL AND RADIOLOGICAL OUTCOMES OF MICROSURGICAL DETETHERING IN ADULT TETHERED CORD SYNDROME

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ABSTRACT

Objective: Tethered cord syndrome (TCS) is traditionally considered a pediatric disorder, yet an increasing number of adults are now diagnosed with symptomatic tethering. Adult presentations often differ from childhood cases, and the extent to which microsurgical detethering benefits this population remains a subject of clinical interest. This study aims to evaluate the clinical and radiological outcomes of microsurgical detethering in adults with TCS.

Materials and Methods: This retrospective study included patients aged ≥ 18 years who underwent detethering between 2015 and 2024. Preoperative variables included symptoms, neurological findings, cutaneous stigmata, magnetic resonance imaging (MRI) features, urodynamic results, and tibial nerve somatosensory evoked potentials latency. All patients underwent microsurgical filum sectioning or release of pathological adhesions with routine intraoperative neuromonitoring. Outcomes were assessed through postoperative clinical follow-up and MRI studies.

Results: Twenty-one patients (mean age 26.2 years) were included. Back pain (81%), urinary dysfunction (67%), and radicular pain (57%) were the most common symptoms. A low-lying conus was present in 95% of subjects, and a thick filum in 76%. Split cord malformation occurred in 38% of patients and syringomyelia in 24% of patients. At a mean follow-up of 21.3 months, leg pain resolved in all affected patients, urinary incontinence improved in 78% of patients, and syringomyelia decreased in 60% of patients. Only one cerebrospinal fluid leak occurred, and no retethering was observed.

Conclusion: Microsurgical detethering resulted in meaningful symptom relief and radiological improvement in most adult TCS patients, with low complication rates. These findings support surgical intervention as an effective treatment option for symptomatic adults.

Keywords: Tethered cord syndrome, filum terminale, congenital, spine

INTRODUCTION

Tethered cord syndrome (TCS), which typically presents in childhood and is traditionally considered a pediatric condition, is now being increasingly recognized in adults⁽¹⁾. Although the earliest descriptions of TCS were associated with abnormalities of the filum terminale, subsequent studies have demonstrated that lipomas, myelomeningocele, split cord malformations (SCM), and postoperative adhesions may also serve as etiological factors⁽²⁾. While congenital tension mechanisms constitute the primary cause of the disorder, cumulative mechanical stressors in adults such as prolonged sitting, strenuous activities, spine-loading movements, and pregnancy may precipitate the onset of TCS symptoms⁽³⁾. The most common reasons for adults to seek medical evaluation include low back pain, radicular complaints, sensory disturbances, and bladder dysfunction, all

of which arise from neural injury due to sustained traction of the conus and nerve roots⁽⁴⁾.

Diagnosis relies on clinical evaluation supported by magnetic resonance imaging (MRI) findings such as a low-lying conus, a thick or fatty filum, or other spinal anomalies. Importantly, the severity of radiological features does not always correlate with the degree of clinical impairment⁽⁵⁾. Accumulating clinical experience indicates that surgical intervention can prevent neurological decline and significantly improve, or even fully resolve, long-standing symptoms in challenging TCS cases⁽⁶⁾. However, questions remain regarding optimal timing of surgery and the predictability of postoperative improvement, particularly in adults with secondary tethering related to prior spinal malformations or surgical procedures⁽⁷⁾. Despite these uncertainties, recent studies consistently indicate that the most effective approach for halting progressive neurological

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deterioration and achieving favorable clinical outcomes in adults with TCS is surgical sectioning of the filum⁽⁸⁾. This study aims to assess the effectiveness of the surgical treatment we performed by analyzing the clinical and radiological data of our adult TCS patients.

MATERIALS AND METHODS

This retrospective study included adult patients who underwent surgical treatment for TCS at our institution between January 2015 and December 2024. Patients aged 18 years or older with clinical symptoms and radiological findings consistent with TCS were eligible for inclusion. Individuals with both primary TCS and secondary tethering etiologies such as myelomeningocele, SCM or lipomyelomeningocele were included. Pediatric patients, individuals who did not undergo surgery, and those with a postoperative follow-up period of less than three months were excluded from the study.

Preoperative data collected included demographic characteristics, presenting symptoms, presence of cutaneous stigmata, neurological examination findings, bladder or bowel dysfunction, MRI findings, urodynamic results, and somatosensory evoked potentials (SSEP). All patients underwent microsurgical detethering, typically via a single-level laminectomy with identification and sectioning of a tight or fatty filum terminale or release of pathological adhesions when present. Intraoperative neuromonitoring was routinely used in all cases (Figure 1A-1D). Postoperative data

included complications, duration of follow-up, and clinical and radiological outcomes.

Clinical improvement was assessed based on resolution or reduction of pain, sensory deficits, motor symptoms, and bladder or bowel dysfunction. Radiological improvement was defined as postoperative evidence of a released filum or reduction of associated syringomyelia when applicable. No formal statistical analysis was performed due to the descriptive nature of the study. The study was approved by the University of Health Sciences Türkiye, Gülhane Training and Research Hospital Non-Interventional Research Ethics Committee (approval no: 2025/9, date: 16.01.2025).

Statistical Analysis

Preoperative and 1 month postoperative overall pain visual analog scale (VAS) scores were compared using a paired-samples t-test after confirming approximate normality of within-patient differences. Effect size was calculated using Cohen's dz.

RESULTS

The average age of the 21 patients included in the study was 26.2 years, with 15 (71%) male and 6 (29%) female. Back pain was the most frequent presenting symptom (81%), followed by urinary incontinence (67%) and radicular pain (57%). One patient presented solely with urinary retention. Hypertrichosis was the most common cutaneous abnormality (33%), while dermal sinus tracts and myelomeningocele scars were each observed

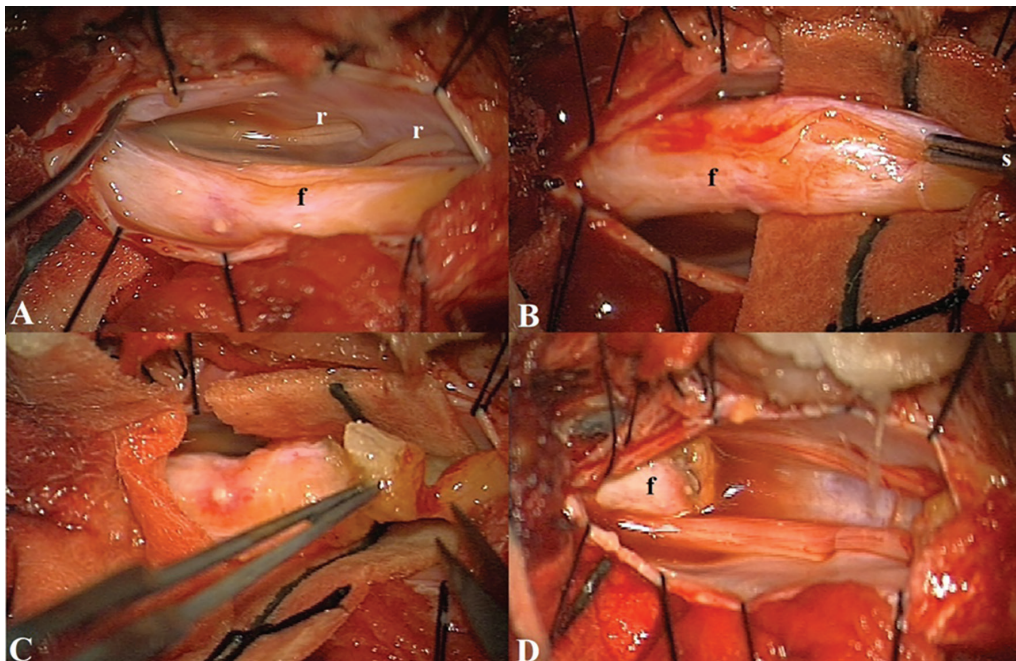


Figure 1. **A)** Intraoperative view of the lumbar region after dural opening, demonstrating a thickened and fatty filum terminale (f) and two lumbar nerve roots (r). **B)** After visual identification of the filum terminale (f), it is isolated from the nerve roots and stimulated with a bipolar neurostimulator probe (s) to confirm the absence of neural tissue and the safety of sectioning. **C)** Following confirmation that no nerve roots are present within the filum, coagulation is performed and the filum terminale is transected using microscissors. **D)** The filum terminale (f) after sectioning, demonstrating adequate release of tension

in 19% of cases. Hypoesthesia represented the most frequent neurological deficit on motor and sensory examination (24%). A conus medullaris terminating below the L2 level was defined as a low-lying conus, and this finding was identified on MRI in 95% of patients (Figure 2A-B). A thickened filum terminale

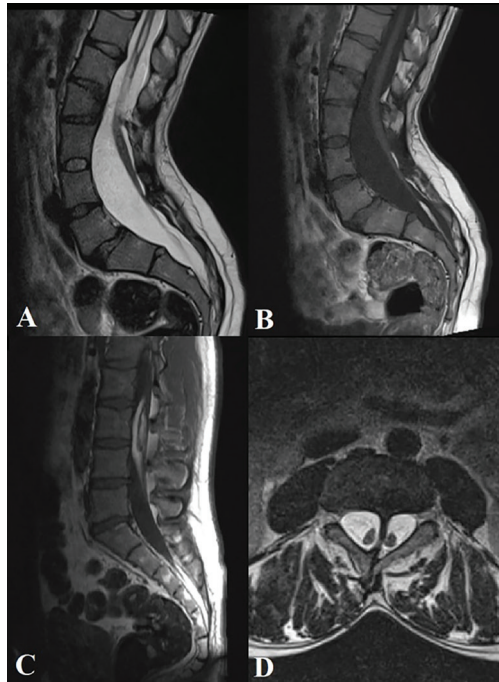


Figure 2. A) Sagittal T2-weighted lumbar MRI demonstrating a low-lying conus, a tight filum terminale, and a syrinx at the T12 level. B) Sagittal T1-weighted images of the same patient showing a fatty filum terminale. C) A filar lipoma at the L3-L4 level contributing to cord tension. D) Axial T2-weighted lumbar MRI revealing a bony septum dividing the spinal canal into two hemicords, consistent with split cord malformation. MRI: Magnetic resonance imaging

(>2 mm) constituted the second most common radiological feature (76%). SCM, a well-recognized anomaly associated with TCS, was present in 38% of the cohort (Figure 2C-D). In all patients with SCM, the septum responsible for dividing the cord was removed during the same procedure in which the filum terminale was sectioned, and the surgical goals were fully achieved. Syringomyelia was also detected among the radiological abnormalities, appearing in 24% of the patients.

Neurophysiological tests, although not diagnostic in isolation, supported clinical assessment and provided objective parameters for perioperative evaluation. Delayed tibial nerve SSEP latency was found in 38% of cases, and an equal proportion demonstrated impaired urodynamic studies.

The mean postoperative follow-up was 21.3 months (range, 3-62 months). Clinical reassessments performed on the first postoperative day, at one month, and throughout follow-up demonstrated that leg pain reported preoperatively by all symptomatic patients (12 patients) had resolved by the first postoperative month at the latest. The mean preoperative VAS score was 4.33 ± 2.58 , which decreased significantly to 1.24 ± 1.37 at 1 month postoperatively. Paired-samples t-test demonstrated a statistically significant reduction in pain scores following surgery (mean difference: 3.10 ± 2.49 ; $t(20) = 5.70$, $p < 0.001$). The magnitude of this improvement corresponded to a large effect size (Cohen's $d = 1.24$).

Urinary incontinence improved in 78% of affected individuals by the sixth month, and fecal incontinence either resolved or diminished to a socially non-limiting level in two of the three patients within the same period. By final follow-up, 59% of patients reported resolution of back pain. Among those with syringomyelia, postoperative MRI demonstrated a reduction in syrinx size in 60% of cases (Table 1).

Table 1. Summary of the clinical and radiological characteristics of the patients who underwent surgery for tethered cord syndrome

| Presenting symptoms | n | % |
|------------------------------------|----|----|
| Back pain | 17 | 81 |
| Radicular pain | 12 | 57 |
| Paresthesia | 6 | 28 |
| Urinary incontinence | 14 | 67 |
| Urinary retention | 1 | 5 |
| Fecal incontinence | 3 | 14 |
| Sexual dysfunction | 1 | 5 |
| Cutaneous findings | | |
| Hypertrichosis | 7 | 33 |
| Dermal sinus tract | 4 | 19 |
| Myelomeningocele scar | 4 | 19 |
| Neurological examination | | |
| Hypoesthesia | 5 | 24 |
| Motor deficit | 1 | 5 |
| Unilateral lower extremity atrophy | 1 | 5 |

Table 1. Continued

| Presenting symptoms | n | % |
|---|----|-----|
| MRI findings | | |
| Low-lying conus | 20 | 95 |
| Thick filum | 16 | 76 |
| Fatty filum | 6 | 28 |
| Split cord malformation | 8 | 38 |
| Syringomyelia | 5 | 24 |
| Dermal sinus tract | 4 | 19 |
| Lipomyelomeningocele | 4 | 19 |
| Myelomeningocele | 4 | 19 |
| Scoliosis | 3 | 14 |
| Hydrocephalus | 1 | 5 |
| Abnormal urodynamic findings | 8 | 38 |
| Delayed tibial nerve SSEP | 8 | 38 |
| Clinical and radiological improvements | | |
| Back pain | 10 | 59 |
| Radicular pain | 12 | 100 |
| Paresthesia | 2 | 33 |
| Urinary incontinence | 11 | 78 |
| Fecal incontinence | 2 | 66 |
| Shrinkage of the syrinx | 3 | 60 |

MRI: Magnetic resonance imaging, SSEP: Somatosensory evoked potentials

Early postoperative complications were minimal. Cerebrospinal fluid (CSF) leakage at the incision site occurred in only one patient and was successfully managed with additional sutures and dressing changes. No instances of retethering were identified during the entire follow-up period.

DISCUSSION

Adult TCS encompasses a wide spectrum of clinical manifestations, and its presentation often differs from that seen in children. Pain, particularly low back or radicular pain, consistently emerges as the most frequent complaint in adults, a trend reflected both in our cohort and in numerous published series^(7,9-11). The prominence of pain in adults likely reflects the cumulative effects of prolonged mechanical traction on the conus and lumbosacral nerve roots, which aligns with the suggestion that chronic tethering may impair spinal cord blood flow and mitochondrial function, ultimately contributing to progressive neurological dysfunction⁽¹²⁾. Although unusual presentations such as isolated unilateral calf atrophy have been described⁽¹³⁾, these rare manifestations are exceptions rather than the rule and were not encountered in our series. Urinary dysfunction is another major feature of adult TCS and is often a significant driver for seeking medical care. In our cohort, bladder symptoms were the second most common presenting complaint, consistent with earlier studies documenting high rates of urinary involvement in adults^(1,14,15). Reports vary widely

regarding the reversibility of bladder dysfunction following detethering, but many authors have observed partial or even substantial improvement in a notable subset of patients^(7,11). Our findings parallel these observations, showing recovery or meaningful improvement in most symptomatic individuals by the sixth postoperative month. While sensory or sphincter deficits tend to be less responsive and often require longer follow-up to demonstrate change, the degree of improvement we observed indicates that even long-standing neurological dysfunction may retain some capacity for reversibility. Radiological findings in our patients largely mirror those documented in the literature. Nearly all patients exhibited a low-lying conus and a thickened filum terminale, features that frequently correlate with structural tethering. Co-existing anomalies, particularly SCM, also appeared at notable rates in our cohort. This observation is consistent with other adult series reporting SCM among the most common co-malformations in TCS^(6,16). The recognition of such anomalies is clinically meaningful, as their presence may influence the surgical strategy. The literature includes examples where tethering has been exacerbated or triggered by prior spinal interventions, with arachnoid adhesions forming many years after the initial procedure⁽¹⁷⁾. These delayed presentations emphasize the importance of detailed preoperative assessment, especially in adults with complex operative histories. Surgical detethering remains the cornerstone of treatment for adult TCS, and our outcomes add to the growing evidence

supporting its efficacy. Across several published studies, pain has been the most consistently improved symptom after surgery, with many patients reporting early and durable relief^(2,8,9). Our findings align closely with these reports, as all patients with preoperative leg pain experienced resolution by the first postoperative month. Improvements in urinary dysfunction, while less uniform across studies, occurred in the majority of symptomatic individuals in our cohort. Reports from the literature suggest that bladder symptoms may recover to varying degrees but are less likely to show the dramatic early improvement seen in pain, a trend that matches the gradual but meaningful gains observed in our patients^(1,7,14).

Radiological improvement following detethering was also observed, most notably in patients with syringomyelia, where over half showed a reduction in syrinx size. This is consistent with other published work documenting significant decreases in syringomyelia after effective release of the tethered cord⁽¹⁸⁾. The improvement likely reflects restoration of CSF flow dynamics and reduction of traction forces on the spinal cord, which may promote gradual collapse of the syrinx cavity.

Neurophysiological testing served as a complementary diagnostic tool. Abnormal tibial SSEP latencies were observed in many of our patients, paralleling the high rates of electrophysiological abnormalities reported by authors in the literature⁽¹⁹⁾. Although these studies are not diagnostic on their own, they provide valuable objective data supporting clinical suspicion of tethering. Intraoperative neuromonitoring, used routinely in our surgeries, had a favorable impact on postoperative motor stability according to previous analyses⁽²⁰⁾. Our experience was similar, as no patient developed new permanent motor deficits, and the overall complication rate remained low.

The absence of retethering in our series may reflect a combination of careful surgical technique and relatively shorter follow-up compared with studies reporting recurrence rates as high as 16%⁽²⁰⁾. Even so, the lack of symptomatic or radiographic evidence of retethering during our follow-up period is encouraging. Many authors advocate for timely surgical intervention, recommending detethering within a few years of symptom onset to prevent irreversible neurological decline⁽²¹⁾. Our findings reinforce this concept, as earlier symptom duration appeared to correlate with better outcomes, particularly in pain resolution.

The overall pattern of improvement in our cohort, strong relief of pain, meaningful recovery in urinary symptoms, reduction of syringomyelia, and minimal complications, fits well within the established body of evidence supporting microsurgical detethering as the primary treatment approach for symptomatic adult TCS. This benefit extends to individuals with long-standing symptoms and structural anomalies such as SCM or lipomyelomeningocele, as shown in multiple published cohorts^(6,8,16).

Study Limitations

Nevertheless, several limitations must be acknowledged. Our study was retrospective and included a relatively small number of patients, which restricts the ability to identify predictors of surgical outcome or make strong statistical inferences. Variability in symptom duration, radiological features, and preoperative neurological status may also confound outcome interpretation. Despite these constraints, the overall consistency between our findings and those reported in the literature underscores the validity of our observations.

CONCLUSION

In this study, most adult patients with symptomatic TCS experienced meaningful improvement after microsurgical detethering. Pain tended to resolve early, while bladder symptoms and radiological abnormalities also improved in a considerable portion of the cohort. Patients with long-standing complaints or co-existing conditions such as SCM benefited as well, suggesting that symptom duration or anatomical complexity does not necessarily limit the potential for recovery. The procedure was safe in our experience, with only one minor complication and no cases of retethering during follow-up. Although the retrospective design and small sample size restrict the strength of our conclusions, the overall pattern of improvement aligns with growing evidence favoring surgical treatment in adults with TCS. Larger studies with systematic outcome measures may help clarify which patients are most likely to benefit and how postoperative recovery unfolds over time.

Ethics

Ethics Committee Approval: The study was approved by the University of Health Sciences Türkiye, Gülhane Training and Research Hospital Non-Interventional Research Ethics Committee (approval no: 2025/9, date: 16.01.2025).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: M.C.E., Concept: M.C.E., S.K., Design: M.C.E., Data Collection or Processing: M.C.E., S.K., Analysis or Interpretation: M.C.E., S.K., Literature Search: M.C.E., Writing: M.C.E., S.K.

Conflict of Interest: No conflict of interest was declared by the authors.

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