Comparison of Section of Filum Terminale and Non-neurosurgical Management for Urinary Incontinence in Patients with Normal Conus Position and Possible Occult Tethered Cord Syndrome

Paul Steinbok, M.B.B.S.

Department of Pediatric Surgery,
Division of Neurosurgery,
British Columbia's Children's Hospital,
Children's and Women's Health Centre,
Provincial Health Services Agency,
and Department of Surgery,
University of British Columbia,
Vancouver, Canada

Rajeev Kariyattil, M.Ch.

Department of Pediatric Surgery,
Division of Neurosurgery,
British Columbia's Children's Hospital,
Children's and Women's Health Centre,
Provincial Health Services Agency,
and Department of Surgery,
University of British Columbia,
Vancouver, Canada

Andrew E. MacNeily, M.D.

Department of Pediatric Surgery,
Division of Urology,
British Columbia's Children's Hospital,
Children's and Women's Health Centre,
Provincial Health Services Agency,
and Department of Surgery,
University of British Columbia,
Vancouver, Canada

Reprint requests:
Paul Steinbok, M.B.B.S.,
Division of Pediatric Neurosurgery,
4480 Oak Street, K3–159,
Vancouver, BC, Canada V6H 3V4.
Email: psteinbok@cw.bc.ca

Received, February 28, 2007.
Accepted, April 29, 2007.

OBJECTIVE: Patients with persistent urinary incontinence and a normal location of the conus on magnetic resonance imaging scans may have occult tethered cord syndrome (OTCS). We compare outcomes in such patients after filum section versus non-operative treatment.

METHODS: We performed a retrospective analysis of a consecutive series of children with refractory urinary incontinence and normal location of the conus who were offered section of the filum for treatment of possible OTCS.

RESULTS: Eight children, aged 4.4 to 9.8 years, underwent filum section, with one child undergoing two such operations. Clinical urological improvement occurred in seven children at a mean follow-up period of 3.1 years, with improved urodynamic findings in four of the seven children tested postoperatively. Other non-urological back or lower limb abnormalities improved in five out of six children with such findings. None of the patients underwent additional urological operations after filum section. Seven children, aged 3.1 to 13.5 years, all of whom had abnormal urodynamic findings, did not undergo filum section. At a mean follow-up period of 3.3 years, two patients had urological improvement and three patients had undergone bilateral ureteric reimplantations. Other non-urological back and/or lower limb abnormalities were present in five patients and did not improve. One patient had the filum cut after 8 years and improved thereafter.

CONCLUSION: Section of the filum in children with refractory urinary incontinence and OTCS may produce better urological outcomes than continued medical management. A definitive answer to the question of whether section of the filum is better than non-neurosurgical medical management for children with OTCS awaits the conclusion of a randomized controlled trial.

KEY WORDS: Filum terminale, Occult tethered cord syndrome, Surgery, Urinary incontinence

Neurosurgery 61:550–556, 2007 DOI: 10.1227/01.NEU.0000280030.38124.0E www.neurosurgery-online.com

The tethered cord syndrome secondary to a tight filum terminale is a well-accepted entity (2, 3, 6). In this condition, the filum is thickened and often fatty, and the conus medullaris ends lower than normal.

The concept of a so-called occult tethered cord syndrome (OTCS) was recently proposed. OTCS is characterized by clinical findings consistent with a tethered cord syndrome but with the conus ending in a normal position with or without a thickened filum. The most common clinical abnormalities include urological dysfunction, usually incontinence, and back pain, with minor or no neurological abnormalities in the lower limbs. OTCS as an entity has been espoused to explain the improvements reported after sectioning of the filum terminale in children with the conus ending in a normal position (4, 5, 7, 8, 13–15).

The above reports of beneficial effects of filum section in children with OTCS are either anecdotal or case series, and there is no strong scientific evidence that cutting the filum in such children is beneficial. The concept of

OTCS and the advisability of sectioning the filum terminale in a patient with neurogenic urinary incontinence and the conus in a normal position is still controversial, with much disagreement among pediatric neurosurgeons (1, 10, 12). This study compares outcomes in patients with possible OTCS after filum section versus those who did not undergo filum section.

PATIENTS AND METHODS

The databases of the Division of Neurosurgery and Urology were searched to identify children who met the following criteria: 1) referred to neurosurgery by a pediatric urologist because of persistent urinary incontinence despite medical treatment with a possible diagnosis of a tethered cord syndrome; 2) magnetic resonance imaging (MRI) scans and/or computed tomographic (CT) myelography showing a normal position of the conus, with the conus ending above the lower end plate of the L2 vertebral body; and 3) no other explanation for the urinary incontinence except a possible OTCS.

The neurosurgical clinic charts of the patients identified from the database search were reviewed. Patients were entered into the study if the option of cutting the filum had been discussed, as documented in the clinic chart. During the time covered by the study, children who fit the diagnosis of OTCS were offered the option of filum section as an unproven but possibly beneficial procedure. After discussion of the pros and cons, parents were advised to consider the option and decide whether to have their child undergo surgery or to continue with medical management. For all patients in the study, data were extracted regarding demographics, date of the neurosurgical clinic visit, urological findings, urodynamic studies, back or lower limb pain, other symptoms in the lower limbs, neurological and orthopedic abnormalities, and ability to touch the toes. The radiology reports and radiographic studies were reviewed to identify the level of termination of the conus, the size of the filum, the presence of fat in the filum, and other associated spinal and spinal cord abnormalities (e.g., a syrinx). The date and clinical and urodynamic outcomes at the time of the most recent follow-up evaluation were recorded. A change in the child's urinary continence from baseline to the time of follow-up was determined from review of the office/clinic charts, physician impression, and comparison of before and after 24-hour elimination diaries. For patients who underwent surgery, the operative report was reviewed to identify the level at which the surgery was performed, the amount of bone removal, the size of the filum at surgery, the presence of fat in the filum at surgery, and whether or not the filum retracted when sectioned. The latter three factors were subjectively determined by the surgeon.

The data were entered into an Excel (Microsoft Corp., Redmond, WA) spreadsheet for ease of analysis. The children treated by section of the filum were compared with those who were not treated with filum section. Only descriptive analysis was done because of the small number of patients.

The research protocol was approved by the Ethics Committee of the University of British Columbia. It is helpful for the interpretation of the results of this study to know that approximately 1200 patients were assessed annually at our institution for voiding dysfunction of some sort. The majority of these were treated with behavioral and dietary modification, medications, and/or biofeedback. Only a small select subgroup of patients who were refractory to these interventions went on to have urodynamics and spinal MRI performed each year. Voiding cystourethrograms were not performed routinely, but only selectively for children with pyelonephritis.

Urodynamic studies were performed using saline at body temperature, using a fill rate of 10% of predicted capacity for age per minute according to the Koff formula (capacity = [age + 2] $\times$ 30 mL). Compliance was defined as the change in pressure with a given change in volume ($\delta V/\delta P$). Normal compliance was defined by the following pressure-volume relationship: 95% of healthy children will store urine at less than 20 cm of H_2O pressure up to a volume according to the following: 17 $\times$ age + 55 mL.

RESULTS

Fifteen patients met the study criteria and were included in this analysis. Between 1993 and 2005, approximately 12,000 children with voiding dysfunction were assessed. The 15 patients in this study comprised eight who underwent filum section and seven who did not undergo filum section. Spinal MRI scans were performed in all patients, and CT myelography was also performed in one patient to rule out a possible abnormality that might have been missed on the MRI scan. The mean age was 8.0 years (range, 4.4–9.8 yr) for the surgical group versus 8.2 years (range, 3.1–13.5 yr) for the nonsurgical group. The male-to-female ratio was 5:3 for the surgical group and 4:3 for the nonsurgical group. In all patients, the urinary incontinence was diurnal, and all children had received behavioral and dietary modification, medications, and/or biofeedback under the care of a urologist for at least 1 year. There were two patients younger than 5 years at the time of neurosurgical assessment. One boy was 3.1 years old, had undergone multiple urological operations, and was referred for neurosurgical consultation because he also had associated multiple spinal anomalies. This boy is mentioned later in the text as the child who was initially treated without filum section and then many years later underwent a filum section. The other child younger than 5 years old was a 4-year-old boy who is described in detail below in the first case history. None of the patients, with the exception of the one mentioned above with the spinal anomalies, underwent urinary tract surgery before evaluation by the neurosurgeon for possible OTCS. The urinary incontinence was secondary in two patients in the medical group and primary in all of the other patients. Seven of the eight patients in the surgical group and all the six patients tested in the nonsurgical group had abnormal urodynamic findings at the time of the initial assessment (*Table 1*).

Seven of the eight children in the surgical group and five of the seven children in the nonsurgical group had additional clinical symptoms and signs, as detailed in *Table 2*. One of the most common findings, which was noted in 7 of the 12 children tested, was an inability to touch the toes on maximal forward flexion with the knees extended. On MRI scans and/or CT myelography, none of the patients had a thickened filum and one patient in the surgical group had fat involving the entire length of the filum. In three children, two of whom were in the surgical group, there were spinal radiographic abnormalities: multiple vertebral anomalies in one patient (nonsurgical group), small syrinx at T3–T11 in one patient, and bony spina bifida at L5 in one patient. In the sur-

TABLE 1. Baseline urodynamic findings for the surgical and nonsurgical groups, and postoperative urodynamic findings for the surgical group[a]

	Patient no.	Baseline urodynamics	Postoperative urodynamics	Change from baseline	Change in clinical incontinence
Surgical group	1	Normal capacity, instability	Normal capacity, instability resolved	Improved	Improved
	2	Small capacity, instability, poor compliance	Improved capacity and compliance, instability persistent	Improved	Improved
	3	Small capacity, poor compliance	Capacity, compliance improved, but new instability	Improved	Improved
	4	Large capacity, instability	Not done	Not done	Improved
	5	Large capacity, insensate bladder	Large capacity, insensate bladder	No change	Improved
	6	Normal	Normal	No change	No change
	7	Small capacity, poor compliance, instability	Instability, compliance improved, no change in capacity	Improved	Improved
	8	Small capacity, poor compliance	Small capacity, poor compliance, new instability	Worse	Improved
Nonsurgical group	1	Multiple early unstable contractions, small volume	N/A	N/A	Improved
	2	Large capacity, insensate bladder	N/A	N/A	No change
	3	Not done	N/A	N/A	Improved
	4	Reduced capacity and compliance with increased sensation	N/A	N/A	No change
	5	Large capacity, insensate bladder	N/A	N/A	No change
	6	Small capacity with instability	N/A	N/A	No change
	7	Small capacity	N/A	N/A	No change

[a] N/A, not applicable.

TABLE 2. Clinical abnormalities other than urinary dysfunction in the surgical and nonsurgical groups[a]

	Filum section (n = 8)	No filum section (n = 7)
Fecal incontinence	2	0
Unable to touch toes	6/8[b]	1/3[b]
Pain in back and/or lower limbs	2	1
Toe walking	1	1
Abnormal lower limb reflexes	2	0
Weakness lower limb	1	3
One foot smaller	0	1

[a] Some patients exhibited more than one abnormality.
[b] The denominator indicates the number of patients in whom this finding was sought.

TABLE 3. Outcomes for the surgical group versus the nonsurgical group

	Filum cut	No filum cut
Duration follow-up, mean (range)	3.1 yr (1–10 yr)	3.3 yr (4 mo–5 yr)
Improved incontinence	7/8	2/7
Improved urodynamics	4/7[a]	Not repeated
Other improvement	6/7[a]	0/5[a]

[a] One patient in the surgical group did not have repeated urodynamic assessments and four children, including two in the surgical group, had no clinical abnormalities except for their urinary dysfunction; thus, the numbers used as denominators.

gical group, two of the children were non-twin siblings and one child's father had similar symptoms as a child (Patient 3). One child in the nonsurgical group had an uncle with an intraspinal lipoma. No other children had vertebral abnormalities, cutaneous abnormalities, imperforate anus, or other coexisting anomalies that might be associated with a tethered cord and urinary incontinence.

The clinical outcomes are tabulated in *Table 3*. At a mean follow-up period of 3.1 years (range, 1.0–10.0 yr), seven of the eight patients who had the filum cut improved with respect to their urinary incontinence. There was no incontinence in one child, rare incontinence in four children, usually at night, and less improvement in two children. In five of the six children

who had other non-urological clinical findings as outlined in *Table 2*, there were improvements in these findings. The only child who did not improve was the one with normal urodynamic findings preoperatively. Postoperative urodynamic assessments were performed at 1 year or later in seven children and showed variable improvements in four (*Table 1*) and possible worsening in one. None of the patients underwent urological operations after the filum was sectioned. One child's condition improved initially after the filum was sectioned but deteriorated with respect to urinary continence 8 years later. At repeat surgery, the proximal cut end of the filum had adhered to the dorsal dura and this adhesion was lysed. Postoperatively, she improved again and had maintained her improvement at the time of her 1-year follow-up examination. In the group without filum section, at a mean follow-up period of 3.3 years (range, 4 mo–5 yr), two of the children improved with respect to urinary continence, with one becoming fully continent. None showed improvements in their other non-urological clinical findings. Three children in this group underwent bilateral ureteric reimplantations during the follow-up period. A fourth child, who had congenital lumbar spinal abnormalities, back pain, and toe walking, had already undergone bilateral ureteric reimplantations, vesicostomies, and closure of a vesicostomy before neurosurgical assessment. This child had a repeat vesicostomy and then augmentation cystoplasty and Mitrofanoff after being offered a filum section. After 8 more years, urinary incontinence persisted, in-turning of the feet developed, and the normal filum was cut. Postoperatively, the child claimed to have some "sensation" of bladder filling, and his toe walking, in-turning of the feet, and back pain improved. He went on to require a renal transplantation for renal failure.

In eight of the nine operations to cut the filum, including the patient from the nonsurgical group who later went on to filum section, the operations were performed at a single interlaminar space between L4 and S1, with removal of no bone (one patient with bifid spine), a single lamina (four patients), or the inferior part of the superior lamina and superior part of the inferior lamina (three patients) at one interlaminar level. In one patient, the conus was exposed initially via a L1 laminectomy, and the filum was cut after also removing the L2 lamina. At the time of operation, according to the subjective opinion of the surgeon, the filum appeared thickened in one patient, fatty in two patients, and tight in one patient. In four cases, the surgeon thought the edges of the filum had retracted after the filum was cut. Intraoperative electrophysiological monitoring was not performed routinely during the operations.

Illustrative Cases

Patient 4

Patient 4 (*Table 1*) was a boy who initially presented at 4 years of age with urinary and stool incontinence. He also had some discomfort in his calves and fatigued easily when running. His urological assessment had shown abnormal findings suggestive of upper motor neuron bladder dysfunction and hydronephrosis. On neurosurgical examination, the ankle jerks were absent, but the remainder of the neurological

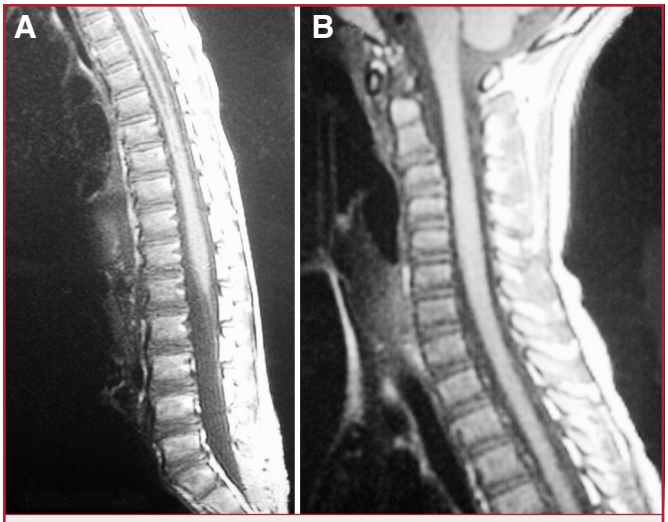

FIGURE 1. A *and* **B**, *sagittal MRI scans showing the conus ending at L1–L2, a normal filum, a small syrinx in the lower thoracic cord, and no Chiari malformation in Patient 4.*

examination findings were otherwise normal, as were his back examination results. An MRI scan of the spine showed the conus to end at L1 with a normal filum (*Fig. 1*). There was a small syrinx from T5 to T8, but no Chiari malformation. Six months later, the patient was being catheterized intermittently for urinary retention and a suprapubic cystostomy was advised by the urologists. Instead, it was opted to cut the filum. At the time of surgery, the filum looked normal and was cut. The cut edges of the filum did not retract. Postoperatively, the patient rapidly improved starting in the immediate postoperative period. At 3 years after surgery, he had no episodes of urinary retention and no urinary incontinence with a timed voiding schedule, on which he had been unsuccessful before surgery, and his hydronephrosis had improved. In addition, his leg fatigue and calf discomfort had disappeared, and his ankle jerks, although diminished, were present. The child refused a repeat urodynamic assessment. A repeat MRI scan showed no change in the syrinx.

Patient 3

Patient 3 (*Table 1*) was an 8-year-old girl who presented with secondary urinary incontinence, increasing toe walking, and pain in her legs. On examination, her heel cords were tight and she was unable to touch her toes. The neurological and back examination results were normal. Urodynamic findings were abnormal, with small capacity and increased compliance. An MRI scan of the spine showed normal results, with the conus ending at mid-L2 and a normal filum (*Fig. 2*). Her father had shown similar symptoms as a child; a CT myelogram showed normal results, but he had a bony S1 spina bifida occulta. Intradural exploration had been carried out from the conus to the bottom of the thecal sac, and no abnormalities had been found. A normal-appearing filum was cut. Postoperatively, the father improved dramatically: He could walk on his heels, his leg pain disappeared, and his urinary function improved. In light of this family history, the child had her filum cut. The filum appeared normal and did not retract. On the day after surgery, she noted sensation of bladder filling, which was new for her. At the time of her last follow-up evaluation 1.3 years later, she was fully continent except for rare nocturnal enuresis, her lower limb pain had disappeared, and her walking had improved

such that she no longer toe walked. Repeat urodynamic findings showed improvement.

DISCUSSION

The current series of children presenting with urinary incontinence and features consistent with a diagnosis of OTCS differs from other reported series in that it comprises two groups of patients: one group in whom the filum was cut and the other in whom the filum was not cut, but continuing management by a pediatric urologist was pursued. This was not a randomized trial, but it is probable that the groups were similar. During the time period of the study, parents were routinely told that the concept of OTCS and the option of cutting the filum when the conus ended in a normal position, especially if the filum appeared normal on MRI scans, were controversial. Cutting the filum was provided as an option, but parents were always asked to go home, think about it, and make a decision in a delayed manner. Approximately half of the parents chose to proceed with surgery.

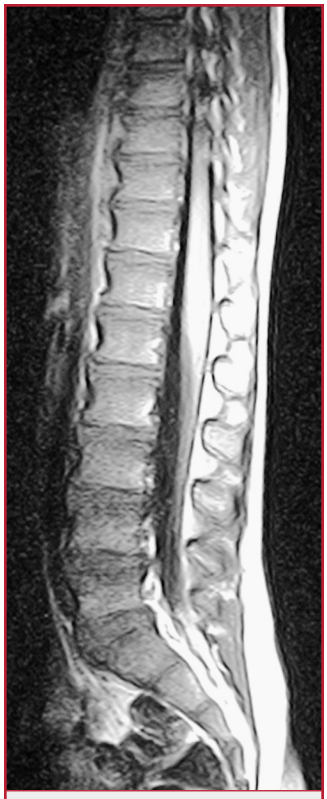

FIGURE 2. *Sagittal MRI scan showing the conus ending at L2 and a normal filum in Patient 3.*

The results of this study suggest that the outcome was better in the patients who underwent filum section compared with those who did not undergo filum section. In seven of the eight patients (88%) treated with section of the filum, improvement in urinary continence was demonstrated at a reasonably long follow-up period ranging from 1 to 10 years (mean, 3.1 yr). None of the children underwent bladder or ureteric surgery after the filum was cut. These results are consistent with other series reported previously, in which improvement rates ranged from 60 to 97% (4, 5, 7, 8, 13–15). On the other hand, there was urological improvement in only two of the seven children in whom this surgery was not performed. In addition, three of the seven children in whom the filum was not cut underwent bilateral ureteric reimplantations for persistent vesicoureteral reflux and urinary infection. One other child underwent vesicostomy and later augmentation cystoplasty and Mitrofanoff, and then developed renal failure. Many years later, the child underwent a filum section when new lower limb findings developed and the child started to have bladder sensation. One might question whether or not an earlier section of the filum might have affected bladder function more and avoided the poor urological outcome. In six out of seven children in the filum section group and in the child with filum section after initial urological management, other clinical abnormalities, such as lower limb weakness or pain, abnormal gait, or restricted forward flexion, improved after surgery. This never occurred in the absence of filum section.

It is interesting that the one surgical patient who did not improve urologically had normal preoperative urodynamic findings. This child also had back and lower limb pain, which, together with the urinary incontinence, suggested a possible OTCS. Thus, surgery was offered and, although there was no urological improvement, the back and lower limb pain disappeared after the operation. One might question whether or not the urological outcome in this case lends support to use of this test as a screening tool for OTCS. However, one must recognize that urodynamic studies are invasive, and the fact that the patient had normal urodynamic findings in the face of persistent incontinence suggests several possibilities. Urodynamics may simply be an insensitive tool for detecting subtle or intermittent bladder dysfunction, or clinical assessment of incontinence may be flawed. Currently, we do not advocate urodynamics as a screening tool for OTCS but consider urodynamics to be an adjunct to the assessment of pediatric voiding dysfunction. In general, we would be reluctant to recommend section of the filum terminale for a presumed OTCS in the face of normal urodynamic findings.

If OTCS is a real condition, one has to postulate that the conus can be tethered by the filum and does not have to be too low. This is reasonably easy to accept per se. It could be simply that the conus is slightly lower than it otherwise would have been had it not been tethered and could still be located normally above the lower endplate of L2. Whatever the location of the termination of the conus, one would expect that the filum would have to be less elastic than normal to pull on the conus in an abnormal fashion. Recognizing that in most cases of reported OTCS and in almost all cases in this series the filum was normal in diameter on the MRI scans, one would have to postulate that perhaps the MRI scans missed abnormal thickening of the filum or that the structure of the filum was abnormal even though the diameter was within normal limits. In this series, only one patient, in whom the MRI scan indicated a normal thickness of the filum, was thought at surgery to have a thickened filum, and discrepancy in the size of the filum on the MRI scan and at surgery has rarely been reported (5, 7). Thus, it is more probable that there is an alteration in the structure of the filum. In one of our patients, the filum was fatty on the MRI scan, although it was not abnormally thick, and at surgery one additional filum was fatty in appearance. There are some data on histopathological examination of the fila from patients with OTCS that indicate excess fibrous tissue and fat compared with normal fila in children (9, 11). If one accepts that the conus can be tethered by a grossly normal-appearing filum, which may be abnormal in structure, one would expect that there would be some evidence of tension in the filum at the time of surgery. Such tightness of the filum was observed in only one of our nine patients, and in only three did there appear to be any

retraction of the cut edges of the filum. Despite what appeared to be a lack of tension in the filum, most patients improved postoperatively. If one accepts that the improvement resulted from the operation, one has to postulate that in this condition of OTCS tethering is intermittent and not necessarily present in the prone position during surgery.

In the current series, one of the associated findings commonly observed in the children was a restriction in forward flexion of the back, with inability to touch the toes with the knees straight. This finding was also observed by the authors in children with the more well-recognized tethered cord syndrome, wherein the conus is too low and the filum is too thick. One might reasonably hypothesize that this is indicative of tension on the lower end of the spinal cord and may be a clinical indicator of tethering.

CONCLUSION

The results of this study suggest that section of the filum for children with refractory urinary incontinence consistent with OTCS may produce better urological outcomes than continued medical management. However, there is a caveat. This was not a randomized study, and there may be sources of bias and other mechanisms to explain the findings. A definitive answer to the question of whether or not section of the filum is better than urological medical management for children with OTCS awaits the conclusion of a randomized controlled trial.

REFERENCES

1. Drake JM: Occult tethered cord syndrome: Not an indication for surgery. **J Neurosurg** 104:305–308, 2006.
2. Hendrick EB, Hoffman HJ, Humphreys RP: The tethered spinal cord. **Clin Neurosurg** 30:457–463, 1983.
3. Hoffman HJ, Hendrick EB, Humphreys RP: The tethered spinal cord: Its protean manifestations, diagnosis and surgical correction. **Childs Brain** 2:145–155, 1976.
4. Metcalfe PD, Luerssen TG, King SJ, Kaefer M, Meldrum KK, Cain MP, Rink RC, Casale AJ: Treatment of the occult tethered spinal cord for neuropathic bladder: Results of sectioning the filum terminale. **J Urol** 176:1826–1830, 2006.
5. Nazar GB, Casale AJ, Roberts JG, Linden RD: Occult filum terminale syndrome. **Pediatr Neurosurg** 23:228–235, 1995.
6. Pang D, Wilberger JE Jr: Tethered cord syndrome in adults. **J Neurosurg** 57:32–47, 1982.
7. Selcuki M, Coskun K: Management of tight filum terminale syndrome with special emphasis on normal level conus medullaris (NLCM). **Surg Neurol** 50:318–322, 1998.
8. Selcuki M, Unlu A, Ugur HC, Soygur T, Arikan N, Selcuki D: Patients with urinary incontinence often benefit from surgical detethering of tight filum terminale. **Childs Nerv Syst** 16:150–155, 2000.
9. Selcuki M, Vatansever S, Inan S, Erdemli E, Bagdatoglu C, Polat A: Is a filum terminale with a normal appearance really normal? **Childs Nerv Syst** 19:3–10, 2003.
10. Selden NR: Occult tethered cord syndrome: The case for surgery. **J Neurosurg** 104:302–304, 2006.
11. Selden NR, Nixon RR, Skoog SR, Lashley DB: Minimal tethered cord syndrome associated with thickening of the terminal filum. **J Neurosurg** 105:214–218, 2006.
12. Steinbok P, Garton HJ, Gupta N: Occult tethered cord syndrome: A survey of practice patterns. **J Neurosurg** 104:309–313, 2006.
13. Warder DE, Oakes WJ: Tethered cord syndrome and the conus in a normal position. **Neurosurgery** 33:374–378, 1993.
14. Warder DE, Oakes WJ: Tethered cord syndrome: The low-lying and normally positioned conus. **Neurosurgery** 34:597–600, 1994.
15. Wehby MC, O'Hollaren PS, Abtin K, Hume JL, Richards BJ: Occult tight filum terminale syndrome: results of surgical untethering. **Pediatr Neurosurg** 40:51–58, 2004.

COMMENTS

The authors report results from a small number of patients undergoing surgical lysis of the filum terminale for the controversial diagnostic entity, occult tethered cord syndrome (OTCS). They also report similar patients from the urological clinic at their institution who were offered surgery but declined. Previously, almost 200 patients undergoing filum lysis for OTCS have been described in uncontrolled case series, with generally favorable results. The current report, however, represents the first case-controlled study of filum lysis for OTCS.

The critical issue with regards to OTCS is the denominator. How many school-aged children are sent to an urologist for voiding dysfunction? How many of these children are refractory to standard medical therapy, such as timed voiding and anticholinergic medications? Finally, what proportion of the latter is diagnosed with OTCS based on radiological and/or functional urodynamic criteria? Diagnostic criteria and referral patterns may make dramatic differences in the perceived incidence of OTCS and in the number of children undergoing intradural spine surgery in an attempt to correct it (2).

It is fascinating that the only child operated upon in this series, despite normal urodynamic bladder function, is also the only operated child who failed to improve. Although it is impossible to draw conclusions from such a small number of patients, this finding emphasizes the importance of identifying specific diagnostic criteria for OTCS and defining their sensitivity, specificity, and positive predictive value.

Despite inconsistent findings regarding the morphology of the filum terminale in their surgical series, Steinbok and colleagues speculate that intermittent pathological tension in the filum terminale causes OTCS. Of interest, the only two systematic studies of filum terminale morphology and histology report thickened and excessively fibrous fila terminale in this condition (1, 3).

Numerous confounding variables are present in this and other studies of surgical filum lysis for OTCS. Surgery for OTCS could dramatically increase the number of North American children undergoing filum lysis. Furthermore, clinical equipoise exists with regards to this indication (4). I agree with the authors that a prospective randomized trial is indicated.

Nathan R. Selden
Portland, Oregon

---

1. Selcuki M, Vatansever S, Inan S, Erdemli E, Bagdatoglu C, Polat A: Is a filum terminale with a normal appearance really normal? **Childs Nerv Syst** 19:3–10, 2003.
2. Selden NR: Occult tethered cord syndrome: The case for surgery. **J Neurosurg** 104 [Suppl]:302–304, 2006.
3. Selden NR, Nixon RR, Skoog SR, Lashley DB: Minimal tethered cord syndrome associated with thickening of the terminal filum. **J Neurosurg** 105 [Suppl]:214–218, 2006.
4. Steinbok P, Garton HJ, Gupta N: Occult tethered cord syndrome: A survey of practice patients. **J Neurosurg** 104 [Suppl]:309–313, 2006.

This is a retrospective study with small numbers that has been very carefully performed. The results are compelling. Although its tentative conclusion that filum sectioning is beneficial under the specified circumstances may not yet be considered a standard recommendation, it

certainly justifies the prospect of a larger randomized controlled study.

I would like to recommend the following in the authors' future efforts. First, "normal" filum diameter should be defined. Secondly, histology should be performed on a segment of the cut filum to specifically look for the amount and density of the collagen, fat, and other anomalous contents. Also, "normal" and "abnormal" appearance of the filum on magnetic resonance imaging scans should be defined. In this last context, we have found axial T2-weighted images cut sequentially from the conus to the end of the thecal sac most helpful. A thick, fatty, or otherwise densely fibrotic (proven by histology) filum appears distinctly stout and intensely black amongst the grayer, slender nerve roots. The thick black dot often has a contrasting bright "bloom" next to it that is decidedly not subtle.

I should also comment on the lack of a "tight" appearance of most of these fila at the time of surgery. The highly controlled and artificial condition for the child's spine during surgery has nothing to do with real life, in which unimaginable states of bending and stretching are routine antics for an active child. The intermittent tugging on the conus by an unyielding, though not too tight-looking, filum may actually be more harmful than chronic sustained tension, a phenomenon related to the physiological adaptation of conductive membranes under changing versus constant conditions.

Dachling Pang
Oakland, California

This provocative article addresses a very controversial area in pediatric neurosurgery, namely the problem of a child with undefined urinary incontinence and no clear radiographic evidence of tethered cord. To date, a number of anecdotal reports have suggested that a subset of these children seem to benefit from filum terminale sectioning, which carries a very low rate of morbidity.

The current report is a nonrandomized series of such patients, in whom the decision to operate or not was largely made by the parents. This obviously introduces bias, as acknowledged by the authors. Perhaps some issue of the severity of incontinence or associated signs or symptoms may have pushed the clinician and, therefore, the patients' parents to lean toward or away from surgery. However, pending a more formal randomized trial, this report offers the most convincing evidence to date to support the value of surgery in this setting. It also raises the even more difficult issue of what to do with the thickened filum with normal conus level in asymptomatic children or younger children who have not yet achieved bowel and bladder continence.

It is also interesting that the degree of filum separation in the operated patients did not clearly predict success of the procedure. On the basis of this and other reports, it would seem reasonable to offer filum sectioning in the setting of an incontinent child with abnormal urodynamic studies, even if the magnetic resonance imaging scans are not convincing for tethering.

Leslie N. Sutton
Philadelphia, Pennsylvania

Steinbok et al. describe a series of 14 children affected by urinary incontinence and other nonurological back or lower limb abnormalities. All patients had a normally located conus medullaris, and all were offered surgical section of the filum terminale. The families of eight patients chose surgical treatment; six refused surgical treatment and were managed medically. In the first group, seven out of eight patients had improved with a mean of 3 years after filum section. In the second group, only two patients improved. The two groups were not randomized. However, in spite of this major bias, this study remains a well written, concise, and informative report that compares, for the first time, two treatment modalities (surgical versus nonsurgical) in two similar groups of patients affected by probable OTCS in which the only criteria for treatment modality was parental choice. These results are interesting and warrant further larger, multicentric, randomised studies. If the effectiveness of surgical management of urinary incontinence was confirmed, the whole management and pathophysiology of this clinical entity should be reconsidered. The authors do not consider the role of intraoperative monitoring and stimulation to identify the filum among the sacral rootlets that come into vision through an L4–L5 laminotomy. Identification of a thick, fatty filum is relatively easy anatomically, but isolation of a normal filum could be more difficult through a limited approach on a pure anatomical basis and the role of intraoperative monitoring for a safe procedure should not be underestimated.

Giuseppe Cinalli
Naples, Italy

In this article, Steinbok et al. suggest that filum section in children with normal location of the conus medullaris may improve urinary incontinence. They have conducted a retrospective analysis as well as they could despite inherent limitations. I would like to note, however, that the outcome assessment was purely qualitative and the changes in urinary incontinence were based on the physicians' notes in the office and clinic charts. The addition of a nonsurgical group does not provide statistical analysis in this retrospective analysis of a small number of patients. As the authors concluded, we should await the conclusions of a randomized study.

Tae Sung Park
St. Louis, Missouri