Minimally invasive tethered cord release in adults: a comparison of open and mini-open approaches

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Object. Symptomatic tethered cord and associated anomalies such as diastematomyelia rarely present during adulthood but can cause significant pain as well as motor, sensory, and bladder dysfunction. As with children, studies have shown that surgical detethering may provide improvement in pain and neurological deficits. Typical surgical management involves an open laminectomy, sectioning of the filum terminale, and exploration of the split cord malformation. Such open approaches, however, cause significant paraspinal muscle trauma and scarring. Recent advances in minimally invasive techniques allow for access to the spine and thecal sac while minimizing associated muscular trauma. The authors present a comparison of open versus minimally invasive surgery to treat adult tethered cord syndrome.

Methods. Six adult patients underwent surgical release of a tethered spinal cord (2 of them also had diastematomyelia). The mean age of the patients was 47.78 years (range 31–64 years). All medical records and images were retrospectively reviewed. Three of the patients underwent traditional open laminectomies for detethering (open group) while the other 3 patients underwent minimally invasive (mini-open) spinal cord detethering. The length of the incision, length of stay, estimated blood loss, and complications were compared between the 2 groups.

Results. All 6 patients had tethered spinal cords, and 1 patient in each group had diastematomyelia. The mean estimated blood loss during surgery (300 ml in the open group vs 167 ml in the mini-open group, p = 0.313) and the mean length of stay (7 days in the open group vs 6.3 days in the mini-open group, p = 0.718) were similar between the 2 groups. The incision length was half as long in the mini-open group versus the open group. However, 1 patient in the mini-open group developed a postoperative pseudomeningocele requiring surgical revision, whereas the open group had no revision surgeries.

Conclusions. Cases of symptomatic diastematomyelia and tethered cord in adults can be safely and effectively explored through a mini-open approach. In this small case series, the authors did find that the mini-open group had an incision that was 50% smaller than the open group, but they did not find a significant clinical difference between the groups. (DOI: 10.3171/2010.3.FOCUS1077)

Key Words • minimally invasive approach • diastematomyelia • tethered cord • laminectomy

The onset of symptomatic TCS in combination with diastematomyelia during adulthood is rare.13,21 Patients typically present with a variety of symptoms including low-back pain, leg pain, lower-extremity weakness, sensory deficits, bladder dysfunction, and/or sexual dysfunction.1,5,8–10,14 Just as in cases of TCS in children, there is evidence that surgical detethering leads to improvement in symptoms.1,2,5,7,8,10,14,20 A wide lumbosacral laminectomy is the standard approach used to explore the split cord malformation and to section the filum terminale. We present a comparison of the use of a minimally invasive (mini-open) approach with an expandable tubular retractor versus an open approach to treat 6 adults (3 in each group) with TCS (with and without diastematomyelia).

Abbreviations used in this paper: EBL = estimated blood loss; LOS = length of stay; TCS = tethered cord syndrome.

Methods

This retrospective study was approved by the University of California, San Francisco, Committee on Human Research. Six adult patients were evaluated for symptomatic TCS. The mean age was 47.7 years (range 31–64 years). All medical records and images were retrospectively reviewed.

Three of the patients underwent traditional open laminectomies for detethering (open group) while the remaining 3 patients underwent a minimally invasive approach using an expandable tubular retractor (mini-open group). The choice of the surgical approach was selected by the surgeon, and the patients were not randomized. The mean ages of the 2 groups were comparable (43.3 years in the open group and 52 years in the mini-open group, p = 0.535). One patient in the minimally invasive group had undergone a detethering operation as a child,
and we performed a revision detethering of her cord. Two patients in the open group also had prior detethering surgeries in the past, and we performed revision detethering of the cord. One patient in each group had a diastematomyelia in addition to a tethered cord.

The incision length, EBL, LOS, and the postoperative complication rates were compared between the 2 groups.

**Results**

The mean EBL was not statistically different between groups (300 ml in the open group vs 167 ml in the mini-open group, p = 0.313). The mean LOS was likewise not statistically different between groups (7 days for the open group vs 6.3 days in the mini-open group, p = 0.718). The incision length was half the size in the minimally invasive group (4–5 cm) compared with the open group. One patient in the mini-open group developed a pseudomeningocele, requiring readmission for surgical revision while no patients in the open group suffered surgical complications (Table 1).

**Illustrative Case**

**History and Examination.** This 55-year-old woman had a 6-month history of continuous low-back and bilateral leg pain. These symptoms began without any precipitating factors. She denied any significant motor weakness, sensory deficits, or bowel/bladder dysfunction. Her surgical history was notable for a remote history of a left clubfoot. She also reported that she had undergone ligation of a sacral meningeal cyst via an open lumbosacral laminectomy approach 12 years earlier. On a visual analog scale for pain (0–10, with 10 being worst), she reported a score of 10 for both back and leg pain.

The patient had a body mass index of 29.2. She was under fluoroscopic guidance, a 4–5-cm midline skin incision was made from the L1–2 disc level to the L2–3 disc level (Video 1).

**Operation.** Under fluoroscopic guidance, a 4–5-cm midline skin incision was made from the L1–2 disc level to the L2–3 disc level (Video 1). The incision was extended through the fascia using monopolar electrocautery. The L2 spinous process was removed with a rongeur. Serial tubular dilators were used to dilate the paraspinal muscles at the L2 level, and a single expandable tubular retractor (Pipeline, DePuy Spine, Inc.) was placed. This retractor allowed exposure from the inferior aspect of the L-1 lamina to the superior aspect of the L-3 lamina. The operating microscope was then brought into the field, and a midline laminectomy of the entire L-2 lamina was performed. The dura was exposed and opened in the midline. Exploration revealed a split cord malformation at the level of L-1 (Fig. 2). The right hemicord was larger than the left and had a thickened caudal extension extending into the filum. The left hemicord rejoined the right hemicord after approximately 3 cm and had no separate filum. Several nerve roots arose from the right hemicord, and intraoperative electromyography was used to distinguish the nerve roots from the filum. Once identified, the filum was coagulated and divided. Exploration of the split cord malformation revealed a fibrous connective tissue band separating the 2 hemicords. This tissue was dissected free. The dura was closed, and a subfascial drain was placed (connected to a gravity bag). The incision was closed in layers. The total operative time was 208 minutes, and the EBL was 200 ml.

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>EBL (ml)</th>
<th>LOS (days)</th>
<th>FU (mos)</th>
<th>Approach</th>
<th>Diagnosis</th>
<th>Specific MRI findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31</td>
<td>200</td>
<td>8</td>
<td>53</td>
<td>open</td>
<td>TC</td>
<td>fatty filum; no lipoma; scoliosis</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>500</td>
<td>9</td>
<td>20</td>
<td>open</td>
<td>diastematomyelia w/ TC, after previous detethering operation as a child</td>
<td>fatty filum; no lipoma; scoliosis; no lipoma</td>
</tr>
<tr>
<td>3</td>
<td>63</td>
<td>200</td>
<td>4</td>
<td>12</td>
<td>open</td>
<td>TC, after previous lipoma resection &amp; previous detethering as a child</td>
<td>diastematomyelia w/ fibrous band between hemicords; intradural lipoma; fatty filum</td>
</tr>
<tr>
<td>mean</td>
<td>43.3</td>
<td>300</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4†</td>
<td>37</td>
<td>100</td>
<td>7</td>
<td>3</td>
<td>mini-open</td>
<td>TC</td>
<td>fatty filum; no lipoma; diastematomyelia w/ fibrous band between hemicords; syringomyelia within conus &amp; distal spinal cord; subcutaneous lumbosacral lipoma</td>
</tr>
<tr>
<td>5</td>
<td>55</td>
<td>200</td>
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<td>diastematomyelia w/ TC</td>
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<tr>
<td>6</td>
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<td>lipoma w/ TC</td>
<td>intradural lipoma attached to conus</td>
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<tr>
<td>mean</td>
<td>52</td>
<td>167</td>
<td>6.3</td>
<td></td>
<td></td>
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</tbody>
</table>

* The mean age, EBL, and LOS of the 2 groups were not significantly different (p > 0.05). Abbreviations: FU = follow-up; TC = tethered cord.
† The patient in Case 4 had a postoperative pseudomeningocele requiring revision surgery.
strength and intact sensation throughout her lower extremities. However, due to output of clear fluid from her subfascial drain, we suspected that her dural repair was not watertight. Because of this, a lumbar subarachnoid drain was placed on postoperative Day 2. Her lumbar drain was clamped after 72 hours of drainage, and it was subsequently removed after no evidence of further leakage. The patient was mobilized and discharged home on postoperative Day 7 in good condition. A postoperative MR image showed typical postoperative changes.

At the 15-month follow-up, the patient reported improvement in her preoperative symptoms, with mildly improved low-back and leg pain as well as increasing strength in her feet. She was able to heel- and toe-walk with only mild difficulty. She continued to have difficulty with tandem walking, however, which was thought to be due to her history of bilateral club feet. Her most recent postoperative visual analog scale pain score was 8 for both back and leg pain.

Discussion

Typical detethering procedures involve making a wide laminectomy for adequate exposure of the thecal sac and underlying neural elements. The muscle dissection associated with this approach can be extensive and can lead to significant blood loss and postoperative scarring. Mayer et al. reported paraspinous muscle atrophy and decreased trunk strength after spinal surgery, while Sihvonen et al. correlated instances of “failed back syndrome” with paraspinous muscle denervation and atrophy. They postulated that such iatrogenic paraspinous muscle injury could lead to increased biomechanical strain postoperatively. Minimally invasive approaches to the lumbar spine reduce the amount of muscle dissection and trauma. Studies have shown decreased markers of tissue injury, such as C-reactive protein, interleukin-6, and creatine-phosphokinase, when comparing minimally invasive lumbar decompression techniques with open approaches.

Previous studies of surgical detethering in adult patients with a tethered cord showed that pain is the most effectively treated symptom with success rates of 48%–100%. Other deficits, such as motor weakness and sphincter dysfunction, are more difficult to treat. In our illustrative case, the patient’s presenting complaint was low-back and leg pain, and she was found to have distal lower-extremity weakness on preoperative examination. Her pain was mildly improved postoperatively.

Tubular retractor systems have been effectively used for intradural spinal procedures, including repair of a spinal dural arteriovenous fistula and resection of intradural tumors. These reports have shown excellent outcomes with minimal complications. Tredway et al. also reported the use of a tubular retractor system for detethering of the spinal cord in 3 patients. In each case, they performed an inferior L-4 and a superior L-5 laminotomy that allowed adequate exposure for dissection of the filum and nerve roots, electromyography, and dural closure. They

![Fig. 1. A and B: Preoperative sagittal and axial T2-weighted MR images showing a tethered cord and T12–L1 syrinx (A) and diastematomyelia (B). C: Postoperative sagittal T2-weighted image with fat suppression showing the complete L-2 laminectomy and detethered cord.](image1)

![Fig. 2. Intraoperative photographs. A: Intraoperative view of the lumbar tethered spinal cord through the expandable retractor system. B: The larger right hemicord (labeled 1) can be distinguished from the smaller left hemicord (labeled 2).](image2)
reported no complications, and all 3 patients remained symptom-free at follow-up.

Our report is the first to demonstrate the use of a mini-open approach with an expandable tubular retractor to explore diastematomyelia in adults and release a tethered cord. The use of this mini-open approach allowed for a reduction in the size of the incision to 4–5 cm in a patient with a body mass index of 29.2.

Furthermore, this is the first study to compare open and minimally invasive (mini-open) tethered cord release. With such a small cohort, statistical comparisons are not ideal. Interestingly, we did not find a significant difference in intraoperative blood loss or LOS when we compared the 2 surgical approaches. The minimally invasive group had a higher complication rate as 1 patient had to have revision surgery for pseudomeningocele repair. Cerebrospinal fluid leaks have been reported after traditional open detethering procedures in the past at a rate of 5%–15%.10,14 We have found, however, that closing the dura through a tubular retractor is technically more difficult than closing the dura in an open case. The tubular retractor limits the angles of approach with the needle driver.

The main advantage of performing this surgery through a mini-open transspinous approach is to reduce the length of the incision and the related scar tissue. However, we cannot demonstrate a clinical difference when we compared the minimally invasive approach with the open approach to treat tethered spinal cords in adults.

**Conclusions**

This is the first report of the use of minimally invasive techniques for both detethering of the spinal cord and exploration of an associated diastematomyelia, and to compare the results with open cases. Symptomatic diastematomyelia and tethered cord in adults can be safely and effectively explored through either an open or a minimally invasive (mini-open) approach. The length of the incision is reduced by 50% with the use of the mini-open approach, but there does not appear to be a clinically significant difference in the blood loss or LOS when comparing these approaches.

**Disclosure**

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Author contributions to the study and manuscript preparation include the following: Conception and design: Gupta, Mummaneni. Acquisition of data: Wu, Potts. Analysis and interpretation of data: Wu, Potts. Drafting the article: Potts. Critically revising the article: Wu, Potts. Manuscript submitted March 15, 2010. Accepted March 24, 2010.

**Supplemental online information:** Video: http://mfilestone.akami.com/21490/wmv/digitalwbc.download.akami.com/21492/wm/digitalsource-na-regional/FOCUS10-77.ax (Media Player).

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**References**


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