Journal of Clinical Neuroscience 44 (2017) 315–319

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Technical note

Mini-open spinal column shortening for the treatment of adult tethered cord syndrome

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ARTICLE INFO

Article history:
Received 22 April 2017
Accepted 21 July 2017

Keywords:
Tethered cord syndrome
Spinal column shortening
Minimally invasive

ABSTRACT

Tethered cord syndrome (TCS) is a challenging entity characterized by adhesions at the caudal spinal cord that prevent upward movement during growth and result in stretching of the cord with a concomitant constellation of neurologic symptoms. Although growth in height stops in adulthood, some patients still develop progressive symptoms; many underwent detethering as a child or adolescent, resulting in significant scar tissue and re-tethering. Recent strategies have focused on spinal column shortening to reduce tension on the spinal cord without exposing the previous de-tethering site. Mini-open and minimally invasive approaches avoid the large dissection and exposure associated with traditional approaches and are associated with reduced blood loss, shorter hospital stay, and similar outcomes when compared to conventional open approaches. We describe a technique for mini-open spinal column shortening. Using intraoperative navigation pedicle screws were placed at T10, T11, L1, and L2. A mini-open 3-column "egg shell" decancellation osteotomy of T12 was performed through a transpedicular approach with preservation of the superior and inferior endplates. This procedure was performed on a 28 year old male with recurrent TCS and neurogenic bladder. Postoperative imaging showed a reduction in spinal column length of 1.5 cm and evidence of decreased tension on the spinal cord. At last follow-up he was recovering well with improved urinary function. Spinal column shortening for adult TCS can be safely achieved through a mini-open approach. Future studies should compare the efficacy of this technique to both traditional de-tethering and open spinal column shortening.

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1. Introduction

Tethered cord syndrome (TCS) is a common form of spinal dysraphism in which adhesions at the caudal spinal cord prevent upward movement of the cord during growth. Although this commonly can be tethered by the filum terminale itself, many times, a lipoma is associated with the spinal cord and anchors the spinal cord in an aberrant caudal position. In the growing spinal column, this tether prevents the spinal cord from ascending to its normal position in adulthood, resulting in spinal cord dysfunction as the patient grows. In the adult, however, there no longer is any further growth of the spinal column, but many times, adult will nonetheless have progressive worsening symptoms despite de-tethering years or decades ago as a child. The progressive symptoms occur (despite no further growth of the patient) because daily normal motion of flexion, extension, and bending slowly pull and tug on the tethered, resulting in dysfunction. Thus, even without growth of the spinal column, the tethered cord can result in symptoms because of the tension of the spinal cord, especially if scar tissue progressively thickens and becomes less compliant. This anomaly results in abnormal stretching of the spinal cord that causes progressive symptoms including pain, motor or sensory dysfunction, and bowel or bladder dysfunction. For decades, standard treatment has involved microsurgical detethering of neural elements, with recurrence in nearly half of patients [1–8]. Furthermore, revision surgical de-tethering for recurrent TCS has a high risk of complications including neurologic injury, cerebrospinal fluid (CSF) leak, and impaired wound healing [3,4,9,10]. This is because the spinal cord itself often times must be dissected off the dura, which can cause dysfunction and damage because the spinal cord is adherent to the dura. Moreover, the lower lumbar wound is often abnormal from the patient's prior surgery or dysraphism. This allows for poor wound healing and a higher risk of CSF leak postoperatively. Because of the abnormal blood supply and poor wound healing to this local tissue, the risk of infection is also a concern. In addition, after revision de-tethering, the spinal cord may simply re-tether again because of the scar tissue and inflammation from sur-

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http://dx.doi.org/10.1016/j.jocn.2017.07.037
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gery, resulting in the patient having the same symptoms as before surgery. Thus, revision surgical de-tethering remains a suboptimal surgical option for adult patients with TCS who have had prior de-tethering with a spinal cord adhered to the dura.

Spinal column shortening in adults represents an alternative to the morbidity of detethering for patients with TCS. Kokubun [11] first reported a case of spinal shortening as a treatment for low-lying conus medullaris, which was followed by Güven et al. [12] who described a transpedicular decancellation osteotomy in patients who had undergone multiple surgeries with postlaminectomy kyphosis and fibrosis-related tethered cord. In a cadaveric model, Grande et al. [13] showed that shortening the spinal column through a thoracolumbar osteotomy reduced tension on the spinal cord, lumbosacral nerve roots, and filum terminale. Hsieh et al. [14] reported on the use of vertebral column resection (VCR) in two patients with multiply recurrent TCS with good outcomes at over 12 months in each case. However, all these manuscripts reported on standard, open procedures, not minimally invasive or mini-open ones.

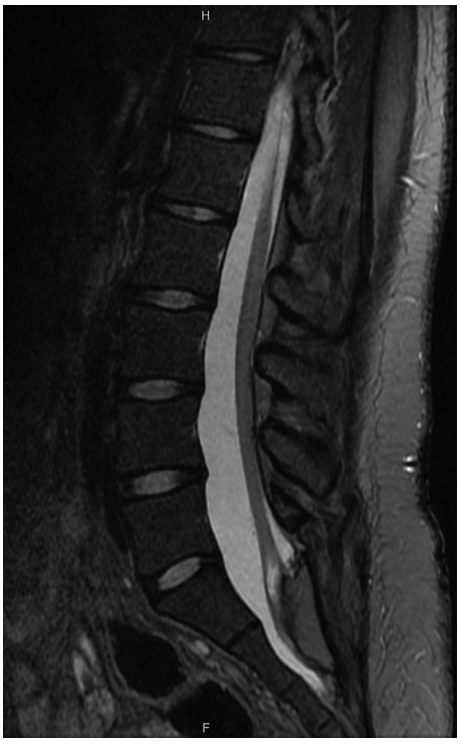

Fig. 1. Preoperative MRI in an adult presenting with recurrent tethered cord syndrome. T2-weighted MRI shows the spinal cord tethered at the S1–S2 level with an associated lipoma. The patient underwent L3–S1 laminectomies for excision of this lipoma and untethering of the spinal cord 15 years prior to this MRI, but developed worsening urinary symptoms prompting neurosurgical evaluation.

Minimally invasive surgery (MIS) techniques have increased in popularity given comparable outcomes with traditional open approaches [15–25]. In addition, they are associated with less blood loss and shorter length of stay [26,27]. Mini-open approaches are a hybrid of true MIS and open surgery in that the surgeries are carried out with less tissue dissection, but not necessarily through a tube. We have used the mini-open approach to perform spinal column shortening in the adult for TCS, decreasing the muscular dissection and morbidity associated with the procedure. We report the use of a mini-open VCR in an adult patient with TCS who had a de-tethering as a child. This approach provides a similar reduction in vertebrae height with a less invasive procedure and potential for lower blood loss, shorter operative time, and less morbidity by decreasing the amount of paraspinal muscular dissection.

2. Methods

2.1. Surgical procedure

After induction of general anesthesia the patient was placed prone on a Jackson table. The T12 level was localized by X-ray and a single skin incision only was made down the midline from approximately T10 to L2, but the fascia was left intact (Fig. 2A). A reference arc was placed on the L3 spinous process and an intraoperative O-Arm spin with Stealth navigation (Medtronic, Memphis, TN) was performed for registration of navigation. Intraoperative navigation was used to identify the entry points through the fascia for the pedicle screw placement. Pedicle screw entry sites were drilled and tapped using navigation guidance through the fascia. K-wires were then placed into the pedicles of T10, T11, L1, and L2 and used to dilate the soft tissue overlying the facets at these levels with a minimally invasive retractor tube system (MetRx, Medtronic, Memphis, TN). Facet location was confirmed by intraoperative Stealth navigation (Fig. 2B). Facets were denuded with monopolar cautery then drilled with a high speed burr followed by placement of allograft to facilitate facet arthrodesis (Fig. 2C). Pedicle screws were percutaneously placed at T10, T11, L1, and L2 with placement confirmed by intraoperative O-arm. The fascia overlying T11-12 and T12-L1 was then opened to

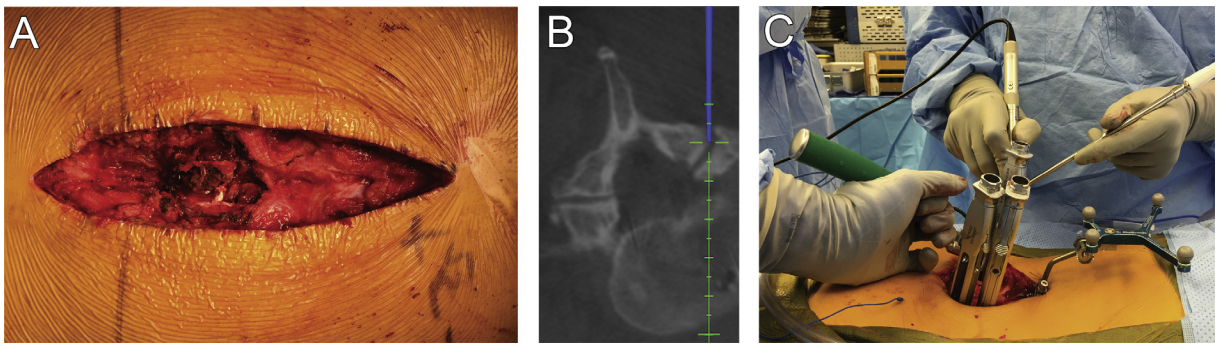

Fig. 2. Intraoperative photographs for mini-open spinal column shortening. For T12 spinal column shortening, a single skin incision is made down the midline from approximately T10 to L2 with the fascia left intact except at the level of the VCR (A). An intraoperative O-Arm spine is performed to facilitate Stealth navigation for pedicle screw placement and facet localization (B). K-wires placed in the pedicles at the levels above and below the VCR are used to dilate the soft tissue over the facets at these levels with a minimally invasive retractor tube system. Facets are denuded with monopolar cautery and drilled with a high speed burr (C). Allograft is then placed to facilitate facet arthrodesis.

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