Published in final edited form as:

J Pediatr Orthop. 2017 ; 37(7): e415–e420. doi:10.1097/BPO.0000000000001008.

Delayed dural leak following posterior spinal fusion for idiopathic scoliosis using all posterior pedicle screw technique

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Abstract

Background—In pediatric patients, pedicle screws are malpositioned 5–15% of the time. Complications associated with malpositioned screws are infrequently reported in the literature. We present a series of adolescent idiopathic scoliosis patients who presented in a delayed fashion with positional headache and chronic dural leak adjacent to the pedicle screw tract.

Methods—Scoliosis databases at two centers were reviewed, and cases of delayed positional headaches following posterior spinal fusion for adolescent idiopathic scoliosis were identified. Demographic and clinical data were collected.

Results—Out of 322 patients, four patients presented with positional headaches at a mean of 12.8 weeks following posterior spinal fusion surgery for AIS, with an interval time to diagnosis of 5 months. CT myelogram demonstrated severe pedicle screw malposition in one patient, and minimal malposition in three patients (less than 2mm violation). The patients had delayed presentation with positional headaches secondary to dural leak. All patients successfully underwent revision surgery with repair of the dural leak. At the time of latest follow-up, all patients are asymptomatic.

Conclusion—Pedicle screw malposition can result in dural leaks. Patients may present in a delayed fashion with positional headaches and an acquired Chiari malformation. Clinical suspicion should prompt imaging of the brain or cervical spine followed by CT myelogram to determine site of leak. This is a rare complication from pedicle screw malposition.

Keywords

pedicle screw; malposition; dural leak; adolescent idiopathic scoliosis; acquired Chiari malformation

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CONFLICT OF INTEREST: Dr. Larson has a consulting agreement with K2M which provides research support.

Level IV, Case series.

INTRODUCTION

Pedicle screw fixation has become the standard of care for correcting spinal deformity in the pediatric population. Improved coronal balance, patient-reported outcomes, and maintenance of correction over time have been reported with pedicle screw constructs (1, 2). Pedicle screws allow for 3-column control of the spine, but also may be malpositioned up to 10–15% of the time (3, 4). The long-term consequences of screw malposition are not well-studied. A thorough understanding of potential complications is imperative for preoperative counseling, early recognition and proper treatment.

Intracranial hypotension is a known cause of orthostatic headaches and can occur due to CSF leak through a defect in the spinal cord dura mater (5, 6). Intracranial hypotension can cause downward displacement of the cerebellum, mimicking a Chiari Type I malformation (5). Spine surgeons are familiar with dural leaks, but there are few reports describing this complication in pediatric patients after routine pedicle screw placement for spine fusion.

We present four patients who presented with CSF leak at least 2 weeks after spinal fusion for adolescent idiopathic scoliosis (AIS) resulting in orthostatic headaches. This study may raise awareness of delayed positional headaches as a potential complication to facilitate early recognition and treatment.

MATERIALS AND METHODS

After obtaining Institutional Review Board approval, a review of all patients undergoing posterior instrumented fusion for adolescent idiopathic scoliosis at two international centers between 2008 and 2013 was performed, specifically searching for patients who developed low-pressure headaches resulting from cerebrospinal fluid leak after spinal fusion. Demographic information was collected, preoperative and postoperative radiographs were analyzed, and index procedures were carefully reviewed. Postoperative course was evaluated, including presentation of low-pressure headache syndrome, method of diagnosis, treatment, and complications. Final clinical and radiographic outcomes were reviewed.

RESULTS

Four patients treated by three different surgeons were identified who developed delayed positional headaches after posterior spinal instrumentation for AIS. No patients had a history of collagen disease or autonomic dysfunction. One patient had a preoperative history of migraine headaches. The index procedure was performed at the two reporting institutions in 3 of the cases. The fourth patient was referred for treatment following fusion surgery performed at an outside facility. During this time period, one center performed 145 primary posterior spinal instrumentations with pedicle screws for AIS, and the 2nd institution performed 177. Thus, the rate of this complication at the two centers was found to be 3/322, or 0.9% of cases. The details of the four cases are outlined (Table 1). All three patients treated primarily at our institutions had screws placed using standard free hand/fluoroscopic technique with anatomic landmarks and palpation with intraoperative neuromonitoring (SSEPs and MEPs) for the index procedure with no intraoperative evidence of CSF leak. All revision cases were performed with SSEPs and MEPs, which were stable throughout the

procedure. At revision surgery, all patients had dural flow after screw removal and underwent intraoperative repair of the dura. At mean of 2.25 years following revision surgery (range, 2–4), the headaches resolved for all four patients with no additional symptoms, junctional problems or further surgery performed. The one child with chest wall pain noted complete resolution after revision surgery.

Preoperatively, patient (#1) had a typical curve pattern and neurologic exam and routine preoperative magnetic resonance imaging (MRI) of his entire spine revealed no evidence of any neurologic or structural abnormalities (Figure 1). A brain MRI was obtained 15 weeks postoperatively that revealed an acquired Chiari I malformation (Figure 2). Computed tomography (CT) myelogram revealed a CSF leak originating from the right T3 pedicle screw with fluid accumulation in the ventral epidural space (Figure 3). In addition to screw removal, laminotomy, and dural repair at the time of revision surgery, fusion was extended one level cephalad to T2.

Patient #2 reported daily positional headaches 7 months after the index procedure which was performed at another facility (Figure 4). This patient reported a difficult postoperative course, including nausea and vomiting for one month postoperatively, severe right-sided chest and rib pain that persisted after hospital discharge despite gabapentin, physical therapy, TENS unit, and intercostal nerve block. Head MRI revealed a Chiari malformation but there was no preoperative MRI to determine whether this had developed after surgery (Figure 5). Revision surgery was performed, and a CSF collection was present surrounding the right T7, T8, and T9 screws as well as pseudarthroses at T10-11 and L1-2 which were revised (Figure 6).

Patient #3 first reported experiencing a headache 14 days after surgery, but this was not clearly postural and was attributed to his past history of migraine headaches. Three months after surgery, the patient had clearly worsening symptoms of headache in the upright position with improvement while lying down. CT myelogram demonstrated a meningocele at T6 and that the right-sided T6 pedicle screw violated the spinal canal medially, which prompted T6 screw removal and T5/6 right sided facetectomy where a dural tear with CSF leakage was observed and was repaired.

Patient #4 presented at ten weeks after index surgery with headache related to upright posture. Due to the uneventful recovery period and lag time between surgery and headache, conservative treatment was initiated. The headaches did not resolve four months after index surgery, so she underwent CT myelogram. This revealed contrast extravasation below the right sided T5 pedicle screw, which violated the medial border of the spinal canal. She underwent T5 screw removal and T4/5 facetectomy, and dural repair along the shoulder of the T5 nerve root.

DISCUSSION

Although spinal fusion for AIS is a routine procedure, complications are unfortunately common, with reported rates ranging from 6%–15% (7–15). A thorough understanding of all potential complications facilitates appropriate preoperative consent, early diagnosis, and

treatment and prompts efforts at preventative strategies. Patients presented with headache at a mean of 12.8 weeks (range 2 – 29 weeks) after the index surgery, with delay in diagnosis averaging 5 months (5 weeks – 17 months). CT myelogram facilitated the diagnosis, along with brain and/or cervical spine MRI changes consistent with acquired Chiari I malformation.

All dural leaks were found to be in association with a pedicle screw tract. In some instances, dural leak following spine surgery can be treated with a blood patch. Given the lengthy time since surgery and the presumed longstanding nature of the dural leak and concern for screw malposition, surgeons elected to proceed with exploration of the implants and direct dural repair. In one instance, the screws were severely malpositioned and completely intrathecal. In others, the amount of breach was modest. However, it remains unclear which malpositioned pedicle screws require revision (16).

Pedicle screw malposition using fluoroscopy and freehand technique is frequent. A systematic review of complications of pedicle screw fixation for AIS found a 15.7% rate of postoperative pedicle screw malpositioning (15). If every patient has 15–20 screw placed, this would mean each patient likely has at least one malpositioned screw. Similar rates have been reported by other studies (3, 4, 17). While breaches are often tolerated without causing known harm (15) (18), medial wall violation can result in durotomy and/or neurologic injury (8, 9, 13). Hicks et al. found four reports of intraoperative dural leaks during screw placement with 0.35% rate of dural breach per screw inserted (15). Two of four were not directly repaired, and none developed negative sequelae. Likewise, Diab et al. reported 3 intraoperative thecal penetrations, 2 of which resulted from medial pedicle screw breach (14). All were treated with local dural sealant during index surgery and had no adverse postoperative clinical sequelae occurred (14). Adjunct methods such as intraoperative CT navigation, screw stimulation, or rapid prototype models may lower the risk of screw malposition and potentially reduce the risk of a dural breach. As unexpected return-to-OR becomes a ‘never-event’, many surgeons advocate that increased focus needs to be placed on prevention of malpositioned implants, even if only a small percentage result in active patient symptoms.

Orthostatic headaches after spinal fusion for AIS patients have been reported. Dede et al. described a patient with orthostatic headaches five days after index surgery. Symptoms resolved after removal of a medially malpositioned screw and treatment of the CSF leak with local dural sealant (19). Mac-Thiong et al. described two AIS patients with orthostatic headache due to meningeal irritation from pedicle screws misplaced completely within the spinal canal. Revision surgery and screw removal did not reveal CSF leak, but headaches resolved postoperatively (20).

There have also been some atypical and delayed cases of CSF leak described in the adult population. Shields et al. described a case of posterior reversible encephalopathy syndrome (PRES) in an adult resulting from CSF leak after rib resection and T4-5 discectomy. PRES is characterized by postural headaches, altered mental status, seizures, and visual disturbances, all of which resolved after revision with dural repair (21). Additionally, Rahmathulla et al.

described a case of delayed dural erosion from a crosslink causing postural headaches 11 years after index surgery (22).

Although other possibilities exist, such as pseudotumor cerebri, dural leak is the most compelling explanation for the headaches in this series of patients, particularly given that symptoms resolved after spinal revision surgery. Three of these leaks occurred at the upper end of the construct and were all at the right upper thoracic area, which is known to have a high occurrence of small (type C and D) pedicles and highest rate of screw malposition (23, 24). Interestingly, the presentation was delayed. Headaches are common in adolescents and in the postoperative period. It is unclear whether the headaches developed over time or were not recognized by the patient or healthcare providers in the immediate postoperative period. Delayed presentation may imply erosion into the dural over time rather than an acute injury.

The diagnosis of low-pressure headache caused by CSF leak should be considered in patients presenting with persistent delayed postural headache following posterior spinal instrumentation and fusion for adolescent idiopathic scoliosis. Diagnosis can be made with CT myelogram showing CSF fluid collection, pedicle screw malposition, and source of CSF leak, while MRI can reveal acquired Chiari I malformation and other signs of intracranial hypotension. Since Chiari malformation is common in adolescents with scoliosis, unless there is change from preoperative status, Chiari malformation on postoperative MRI does not necessarily indicate a dural leak. Complete resolution of symptoms can be anticipated following revision surgery with dural repair.

Acknowledgments

FUNDING: ANL was supported by an NIH from the National Institute of Arthritis and Musculoskeletal and Skin Diseases. (R03 AR 66342). No other support was received for this manuscript.

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Figure 1.
Preoperative and initial postoperative radiographs of 17 year old male who underwent posterior spinal fusion for treatment of adolescent idiopathic scoliosis.

Figure 2.

A) Preoperative MR of the cervical spine showed no evidence of Chiari malformation. B) Brain MR obtained at 15 weeks postoperatively reveals descent of the brainstem, flattened pons, and findings consistent with an acquired Chiari malformation.

Figure 3.

Axial (a,b) and sagittal CT myelogram images (c) obtained prior to revision surgery show the screw approaches the dura. The right T3 pedicle screw was removed and a dural leak was noted by the exiting nerve root. The dura was repaired and the fusion extended to T2.

Figure 4.
15 year old female presented with positional headaches two years following spinal fusion surgery for AIS. Radiographs at presentation.

Figure 5. Axial CT myelogram (a,b) and coronal imaging (c) shows dural penetration and screw malposition.

Figure 6. Radiographs following revision surgery at 4 years postoperatively. The positional headaches had resolved. Improved coronal alignment was achieved at the time of revision surgery.

Table 1

Case	Age	Gender	Classification	Instrumentation	Levels	Presentation	Time of diagnosis	Interval time to diagnosis	Diagnosis	Level of leak	Treatment	Etiology	Follow-up after Revision
1	17	M	Lenke 2BN (right main thoracic 58°)	Solera 5.5/6.0, Medtronic	T3 – T12	10 weeks	15 weeks	5 weeks	CT myelogram	Right T3	Hemilaminectomy, facetectomy, pedicle removal, dural repair, fusion extension	Linear dural deficiency, no breech	Asymptomatic
2	15	F	Lenke 1BN (right main thoracic 56°)	Pangea 6.0, Depuy Synthes	T3 – L2	7 months	2 years	17 months	CT myelogram (multiple malpositioned pedicle screws)	Right T8	Laminectomy, dural repair, entire construct revision	Medial breech, intradural screw	Asymptomatic
3	19	M	Lenke 6CN (right main thoracic 37°, thoracolumbar 52°)	Solera 5.5/6.0, Medtronic	T6 – L3	2 weeks	12 weeks	10 weeks	CT myelogram (medial malpositioned pedicle screw)	Right T6	Facetectomy, screw removal, dural repair	Medial breech into spinal canal	Asymptomatic
4	15	F	Lenke 1A- (right main thoracic 50°)	Solera 5.5/6.0, Medtronic	T5 – L1	10 weeks	16 weeks	6 weeks	CT myelogram (medial malpositioned pedicle screw)	Right T5	Facetectomy, screw removal, dural repair	Medial breech into spinal canal	Asymptomatic