

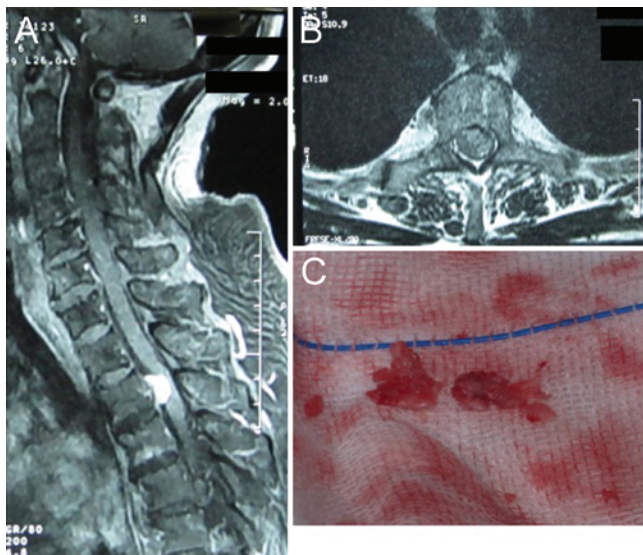


FIG. 2. A 69-year-old woman with a T-2 calcified meningioma. A ventral tumor was found on a sagittal MR image (A). An axial MR image (B) showing the same mass. The tumor was removed piecemeal (C).

deficit are most likely to occur in dorsal tumor cases. The psammomatous type of tumor can be removed piecemeal. But the total calcification type of tumor should sometimes be removed piecemeal to protect the spinal cord. In our case series, calcified meningiomas were pathologically diagnosed in all of the patients, or the tumor could not be confirmed as ossified meningiomas because the diagnosis of ossified meningioma is confirmed by observing bone trabecula. Ossified meningiomas were also diagnosed in some patients, who will be discussed in another case series in the future.

In their report of 97 spinal meningiomas, Levy et al.¹ found only 4 cases of calcification. Three of these 4 patients had a “disastrous surgical outcome.” Roux et al.² reported on 3 ossified meningiomas among 54 spinal meningiomas, with an even worse outcome. In our series, the surgical outcome was much better.

In conclusion, we believe that the preoperative diagnosis, location, and pathological type of calcified meningioma are important to patient outcome.

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Transposas approach

TO THE EDITOR: We read the article by Cahill and co-authors¹ with interest (Cahill KS, Martinez JL, Wang MY, et al: Motor nerve injuries following the minimally invasive lateral transposas approach. *J Neurosurg Spine* 17:227–231, September 2012), but we have some points regarding the analysis and conclusions drawn by the article.

In particular, 2 cases of femoral nerve injury with attendant quadriceps injury were reported upon. A rate of 4.8% quadriceps palsy was noted with lateral transposas approaches to the L4–5 level. The authors state that the injuries occurred “during dilation of the psoas muscle for the approach to the L4–5 disc space.” However, we are not certain how this conclusion can be drawn.

First, the methods state that a posterior interbody procedure (transforaminal lumbar interbody fusion [TLIF] or posterior lumbar interbody fusion [PLIF]) would be performed in such cases, but it is not discussed in the actual case description. For both patients, what was done at L4–5, a TLIF? Was the patient examined prior to performing the other procedure(s)? Is it possible that the TLIF caused an L-4 palsy?

Generally, after new a neurological injury it is reasonable to obtain images in the patient to determine the cause. Was imaging performed? A critical analysis of the MRI sequences can show tracts through the psoas that lead to the L4–5 foramen, which could explain the palsy on the basis of technical error.

Second, was the attending surgeon performing the procedure, or was the resident/fellow operating in these cases? Third, one case was a multilevel (L2–5) procedure. It is possible that the L3–4 transposas surgery caused an L-3 palsy and not the attempted L4–5 approach. Was a postoperative electromyography (EMG)/nerve conduction study performed at 6–12 weeks postoperatively to characterize the neural injury?

In addition to the questions posed above, critical analysis of preoperative radiographs and MRI studies can reveal details that would have contributed to intraoperative difficulty. Transitional lumbosacral anatomy (hemisacralization of the sacrum, L-6 vertebrae, and so on) has been shown to be a risk factor for unsuccessful treatment of L4–5 performed using the transposas approach.⁴

Additionally, we disagree with the statement “In this retrospective analysis, we estimated that the overall rate of femoral nerve injury for the ... L4–5 level was 4.8%....” Of the palsies, one surgery was a multilevel procedure (L2–5) with an aborted L4–5 and one was an aborted single-level L4–5. Of the successful L4–5 levels, the authors reported no femoral nerve palsies. It is very possible that the mul-

tilevel (L2–5) case with a quadriceps palsy resulted from the L3–4 surgery due to L-3 neural injury. We would urge the authors to reconsider their published rate of palsies. One could consider the rate to be 1 of 41 L4–5 single-level procedures, or 2% in your series.

Further clouding the conclusions that one can draw from the paper are omitted details such as: what neuromuscular agent was given for anesthesia? And at what time after induction was the approach to L4–5 made? If rocuronium was used, it is quite possible that residual agent could lead to fatigue and/or unreliable readings during neural injury. Houten et al.² reported quadriceps palsy after transpoas surgery without EMG changes. Perhaps further investigation of induction agents and neural agents after transpoas surgery is indicated. In our center we always insist on the use of succinylcholine when performing transpoas surgery. Additionally, what neuromonitoring system was used? Did the authors use directional nerve-seeking probes when approaching L4–5? Directional neuromonitoring has been shown to decrease the rate of complications associated with the lateral transpoas approach.⁵

Finally, in the discussion portion of the paper the authors point out that “the [femoral nerve] trunk [is] found in the center of the disc space in 15% of specimens in one cadaveric study.” This datum is used to support the assertion that one can “minimize this complication [femoral nerve palsies] through judicious use of the minimally invasive lateral fusion procedure at the L4–5 level....” We found that the nerves within the poas move with limb range of motion in a recent study.³ They are lightly tethered within the poas and the act of dissection moves the nerves significantly. Thus, the location of the neural elements after poas dissection is probably even more variable. It is important to note that one may retract nerves in peripheral nerve surgery and in PLIF. Is there some inherent physiological difference between the nerves inside the canal and within the poas that does not allow retraction during transpoas surgery? Gentle, judicious dissection within the poas with nerve mobilization if necessary, patient selection (avoid transitional lumbar anatomy), and directional neuromonitoring can probably avoid nerve palsy when treating L4–5 via the transpoas approach.

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Disclosure

Dr. O'Brien reports direct stock ownership in Spinicity and ownership in Stryker, and he is a consultant for Globus and NuVasive. Dr. Smith reports no conflict of interest.

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RESPONSE: We thank the authors for raising several important points regarding our case series and results with the lateral interbody fusion procedure. Our group previously reviewed objective, patient-driven data, which demonstrated that the incidence of lumbosacral plexus sensory symptoms following the minimally invasive lateral approach was likely to be underreported.² In this article we defined the incidence of postoperative abdominal flank bulge (4%), which appeared to be more common with approaches to upper lumbar vertebrae. We also report a higher incidence (4%) of femoral nerve injury with procedures that included the L4–5 level. This finding is entirely consistent with prior case reports and, more importantly, with the reported neuroanatomical location of the subcostal nerve within the abdominal muscle layers and the femoral nerve within the poas muscle.^{1–5}

We agree that there are numerous ways to injure a nerve during spine surgery. We considered all of the possible alternative explanations suggested by the authors for quadriceps weakness—including but not limited to TLIF-related nerve injury, foraminal nerve injury via the lateral approach, injury to the femoral nerve from the lateral approach at a level other than L4–5, and transitional lumbosacral anatomy. We would like to reinforce the important finding that intraoperative real-time EMG monitoring indicated that the femoral nerve was activated during the transpoas approach at the L4–5 level. In our multiple-surgeon series of lateral interbody fusions we have only had femoral nerve injury when the procedure involved the L4–5 level and when associated with positive activation.

We would also like to address several of the other issues raised by the authors. At our institution the attending surgeon is present, responsible, and intimately involved for the duration of the procedure. Fluoroscopy and directional EMG probes are routinely used. We did not have postoperative MRI studies available for review, but the postoperative CT scan suggested the appropriate trajectory toward the midpoint of the disc space. We rely heavily on fluoroscopy to achieve this goal. In our institutional experience we have not seen an L-4 palsy at the level of the nerve root or dorsal root ganglion during an L3–4 or L4–5 PLIF procedure that resulted in significant quadriceps weakness. The femoral nerve is created primarily by contributions from the L-2, L-3, and L-4 roots, and it requires a more distal injury—such as the femoral nerve itself—to impact motor function to the extent seen in these cases. Regarding mobilization of the nerve, we would definitely agree that a technique that involves shallow docking of

the retractor and direct visualization and manipulation of the femoral nerve can be safely performed. Although not discussed in the manuscript, a shallow docking approach has been adopted as a technique when the neuromonitoring indicates that a safe corridor through the muscle is not present due to the anterior location of the femoral nerve. We do appreciate the feedback but believe that our interpretation of the results is the simplest, most realistic, and consistent with prior literature on femoral nerve injuries.

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Reduction of atlantoaxial subluxation

TO THE EDITOR: We read with great interest the article by Dr. Suh and colleagues⁷ (Suh BG, Padua MRA, Riew KD, et al: A new technique for reduction of atlantoaxial subluxation using a simple tool during posterior segmental screw fixation. Clinical article. *J Neurosurg Spine* 19:160–166, August 2013). They introduced a novel technique using a T-shaped rod tool to facilitate reduction after the placement of screws in C-1 and C-2. We found their surgical pearl of substantial value in practical use. However, a few questions need answering before the audience can safely apply the innovation.

How was the reducibility determined preoperatively? Is there any caveat that the slipped atlantoaxial complex cannot be successfully reduced? As the authors describe in the introduction, any attempt at reduction might not always be easy. Solid purchase of each screw, including C-1 lateral mass screws and C-2 pedicle screws, is fundamental.⁴ The polyaxial screw head allows easy connection of the construct but might limit the power of reduction. Positioning the patient with a Mayfield head holder allows less manipulation of the atlantoaxial complex.

Maintenance of a successfully reduced atlantoaxial subluxation might also be difficult.⁵ In some extreme cases, the highly mobile atlantoaxial complex requires a tremendous force of fixation to overcome the instability. Failure of fixation could happen within weeks after successful instrumentation and wiring (Fig. 1). Moreover, extension of the fixation construct to the occipital skull may raise the complication rate.⁶ What are the salvage strategies when there is pseudarthrosis and recurrence of subluxation?

Reduction and fixation of the atlantoaxial complex is always challenging.^{1–3,8} Although the authors demonstrated a useful tool, each individual case requires a tailor-made preoperative plan and cautious execution when reduction is attempted.

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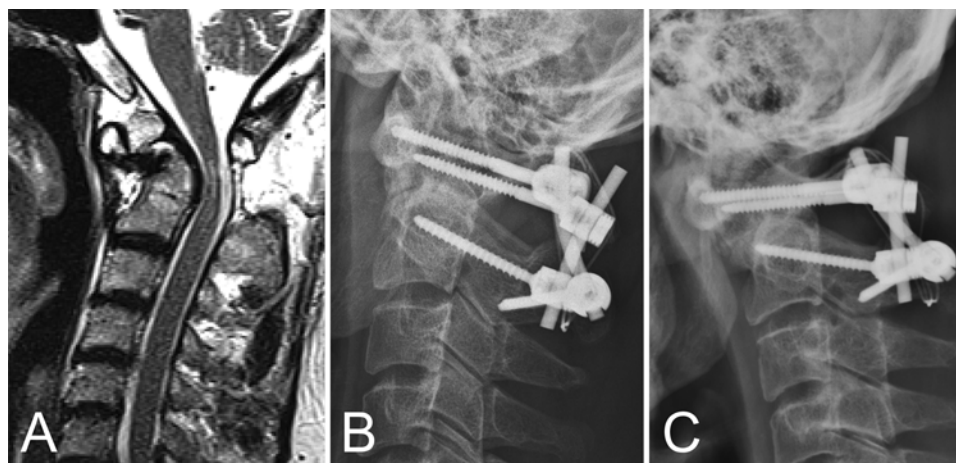


Fig. 1. A: Preoperative MR image. B: Three days postoperative radiograph demonstrating successful reduction of atlantoaxial subluxation. Fixation was made by C-1 lateral mass screws, C-2 pedicle screw, C-2 laminar screw, and wiring with autologous iliac bone graft. C: Six weeks postoperative radiograph demonstrating loss of reduction.