More nerve root injuries occur with minimally invasive lumbar surgery: Let’s tell someone

Nancy E. Epstein

Department of Winthrop Neuroscience, Winthrop University Hospital, Mineola, New York, USA

E-mail: Nancy.e.epsteinmd@gmail.com

*Corresponding author

Received: 03 November 15   Accepted: 04 November 15   Published: 25 January 16

Abstract

Background: In a recent study entitled: “More nerve root injuries occur with minimally invasive lumbar surgery, especially extreme lateral interbody fusion (XLIF): A review”, Epstein documented that more nerve root injuries occurred utilizing minimally invasive surgery (MIS) versus open lumbar surgery for discectomy, decompression of stenosis (laminectomy), and/or fusion for instability.

Methods: In large multicenter Spine Patient Outcomes Research Trial reviews performed by Desai et al., nerve root injury with open discectomy occurred in 0.13–0.25% of cases, occurred in 0% of laminectomy/stenosis with/without fusion cases, and just 2% for open laminectomy/stenosis/degenerative spondylolisthesis with/without fusion.

Results: In another MIS series performed largely for disc disease (often contained nonsurgical disc herniations, therefore unnecessary procedures) or spondylolisthesis, the risk of root injury was 2% for transforaminal lumbar interbody fusion (TLIF) versus 7.8% for posterior lumbar interbody fusion (PLIF). Furthermore, the high frequencies of radiculitis/nerve root/plexus injuries incurring during anterior lumbar interbody fusions (ALIF: 15.8%) versus extreme lumbar interbody fusions (XLIF: 23.8%), addressing disc disease, failed back surgery, and spondylolisthesis, were far from acceptable.

Conclusions: The incidence of nerve root injuries following any of the multiple MIS lumbar surgical techniques (TLIF/PLIF/ALIF/XLIF) resulted in more nerve root injuries when compared with open conventional lumbar surgical techniques. Considering the majority of these procedures are unnecessarily being performed for degenerative disc disease alone, spine surgeons should be increasingly asked why they are offering these operations to their patients?

Key Words: Extreme lateral interbody fusion (XLIF); minimally invasive surgery (MIS); nerve root injuries; lumbar surgery; percutaneous procedures; posterior lumbar interbody fusion (PLIF); posterolateral fusions (PLF); transforaminal lumbar interbody fusion (TLIF)

INTRODUCTION

Frequency of root injuries with open lumbar surgery versus minimally invasive transforaminal lumbar interbody fusion (TLIF)

In this editorial, the higher incidence of nerve root injuries that occurs utilizing minimally invasive surgery
(MIS) versus open lumbar surgical techniques addressing disc disease, stenosis, and instability is reviewed [Tables 1-3]. In Desai et al., Spine Patient Outcomes Research Trial (SPORT) studies, a 0.13–0.25% frequency of nerve root injuries followed open diskectomy, a 0% incidence occurred with open laminectomy/stenosis with/without fusion, whereas the frequency was 2% for laminectomy/stenosis/degenerative spondylolisthesis with/without fusion [Table 1]. Alternatively, in a MIS fusion study, 2% of patients sustained root injuries with MIS transforaminal lumbar interbody fusion (TLIF) versus 7.8% with posterior lumbar interbody fusion (PLIF) performed largely for degenerative disc disease or spondylolisthesis [Table 1]. When bone morphogenetic protein (BMP) was added to MIS TLIF, 45.8% (11/24 patients) of patients exhibited transient postoperative radiculitis [Table 1]. Notably, many of these patients undergoing MIS TLIF likely required no surgery or decompression alone without fusion to largely address degenerative disc disease. Nevertheless for the MIS TLIF or MIS PLIF operations often performed unnecessarily, patients sustained high frequencies of transient or permanent nerve root injuries.

**EVEN HIGHER FREQUENCY OF RADICULITIS WITH MINIMALLY INVASIVE ANTERIOR LUMBAR INTERBODY FUSION (ALIF) AND EXTREME LATERAL INTERBODY FUSION (XLIF)**

Patients undergoing either anterior lumbar interbody fusion (ALIF) or extreme lateral interbody fusion (XLIF) cannot demonstrate a preoperative neurological deficit or significant radiographic neural or cauda equina compression as these procedures do not provide direct access to the spinal canal (at least not deliberately and therefore cannot include neural decompression). Therefore, many

**Table 1: Nerve root injuries with lumbar surgery; series with 300 patients or more**

| Author (reference) year | Number of patients | Type of surgery | Average follow-up duration | Outcomes Complications | Nerve root injuries Frequency Type |
|-------------------------|--------------------|-----------------|----------------------------|------------------------|-----------------------------------|
| Choi 2013[2]            | 233                | MIS percutaneous transforaminal endoscopic diskectomy (measure exiting nerve root to the facet; working zone: If narrow choose another method) |                          | 213 no root injury 20 root injuries Smaller working zone for the latter | 20 (4.3%) |
| Kaushal and Sen 2012[14] | 300                | Endoscopic diskectomy for lumbar discs (MIS); followed 12-24 months |                          | 1.7% discitis 1.7% durotomy | 2 (0.7%) root injuries |
| Desai et al. 2012[6]    | 389                | Lumbar laminectomy ± fusion/degenerative slip Followed 12 months |                          | 10.5% durotomy | Root injury 2% + durotomy 0% – durotomy |
| Desai et al. 2015[5]    | 409                | Open lumbar laminectomy ± fusion for stenosis/ no slip Followed 43.8 months |                          | 37 (9%) durotomy longer LOS/surgery, higher EBL, younger surgeon | 0% nerve root injuries with or without durotomy |
| Desai et al. 2011[4]    | 419                | Open lumbar laminectomy with/without fusion for stenosis; Followed 43.8 months |                          | 38 (9%) durotomy | 0% with or without durotomy |
| Evaniew et al. 2014[11] | 431                | MIS versus open diskectomy cervical/lumbar (4 cervical/10 lumbar trials) Followed average 12 months |                          | Cervical durotomy 4 MIS/7 open Lumbar durotomy 25 MIS/16 open 115 (7.68%) complications 115 (49.18%): Durotomy 115 (13.11%): Bleeding | 1.39% cervical root injuries 3 MIS/3 open 2.25% lumbar root injuries 6 MIS/3 open 11/115 (9.83%) nerve root injury |
| Verla et al. 2015[23]   | 1498               | Primary lumbar fusion Follow-up average 24 months |                          | | |
| Desai et al. 2012[8]    | 792                | Open lumbar diskectomy (13 centers - 11 states) Follow-up 41.3 months | Differences in duration of surgery, durotomy, LOS, reoperation rates | Comparable root injuries 2/792 (0.25%) | |
| Desai et al. 2011[6]    | 799                | Open diskectomy Average follow-up 12 months | 25 (3.1%) durotomy Longer OR time; EBL, LOS | Root injuries 1/774 (0.13%) durotomy 0/25 (0%) no durotomy | |
| Ahmadian et al. 2013[3] | 2310               | XLIF lumbar plexus/nerve root injuries: 18 MEDLINE studies |                            | 304 (13.2%) XLIF root/plexus injuries Root injury 0.3% | |

MIS: Minimally invasive surgery, LOS: Length of stay, XLIF: Extreme lateral interbody fusion, EBL: Estimated blood loss
of us argue from the get-go that these procedures are not warranted. Here, additionally, the argument is that they are also not safe. In a study by Ahmadian et al. in 2013, XLIF resulted in a 13.2% incidence of plexus injuries versus a 0–3.4% incidence of root injuries [Table 1].[1] A study by Hrabalek et al. in 2014 showed an even higher rate (23.8%) of radiculitis following MIS XLIF versus a 15.8% incidence of radiculitis after MIS ALIF [Table 2].[14] When assessing these frequencies of root injuries/radiculitis, one has to ask whether MIS ALIF or MIS XLIF are worth it? What about the high frequencies of these permanent nerve root deficits? Is there a “value added” for unnecessary surgery, which is associated with increased risks to previously normal neural function. As spine surgeons, we should be better monitoring the lack of safety/efficacy of MIS ALIF and XLIF MIS procedures, and not condone those operations that clearly “do harm.”

ROOT INJURIES FOR OPEN LUMBAR LAMINECTOMIES WITH/WITHOUT FUSIONS

The frequency of lumbar root injuries with open surgical procedures remains very low whether performed...
for disc disease, stenosis, or spondylolisthesis. The Desai et al. SPORT report in 2011, for 419 patients undergoing initial open decompressive laminectomies for stenosis with/without fusions, revealed that none sustained nerve root injuries (0%) [Table 1]. In a later SPORT trial by the same author, the 389 patients undergoing decompressive lumbar laminectomy for degenerative spondylolisthesis with/without fusion (not a MIS study) exhibited a durotomy rate of 10.5%, and the frequency of nerve root injuries was comparably low with durotomy (2%) or without (0%) durotomy [Table 1]. Of interest, in these three SPORT studies, the higher incidence of dural tears was correlated with more operations being performed by less experienced surgeons. It was unfortunate that they did not keep track of the use of the operating microscope that was left to “surgeon discretion,” as its absence likely contributed to the incidence of both dural and neural injuries in everyone’s hands.

**Higher incidence of root injuries with minimally invasive lumbar fusions (ALIF, TLIF, XLIF, PLF)**

Multiple MIS lumbar fusion (ALIF, TLIF, XLIF, posterolateral fusion (PLF)) series cite high frequencies of nerve root injuries (up to 9.85%) sustained in patients undergoing surgery for degenerative (disc disease, stenosis, and degenerative spondylolisthesis). In Hsiang et al.’s modification of the MIS TLIF utilizing ipsilateral pedicle screws, but contralateral percutaneous transpedicular facet screws, the latter resulted in a 5% (2 patients) incidence of root injuries warranting screw removal [Table 2]. Nevertheless, how could the authors conclude that this modified technique was safe and effective? Furthermore, Mehta et al. in 2011 concluded that any MIS interbody device applied to address disc disease or spondylolisthesis, resulted in a high incidence or nerve root injury whether utilizing the TLIF (2%) or PLIF (7.8%) approaches [Table 2]. Here, the authors themselves concluded MIS interbody fusions should only be performed where posterolateral traditional decompressions/fusions will not suffice. Why not take their advice? As several studies cite high frequencies of pseudarthrosis with TLIF (including a pseudarthrosis rate for bilateral screws from 2.5% to 23.1%), why should one believe Omidi-Kashani et al.’s 100% TLIF fusion rate or their minimal 1 of 51 frequency of partial L5 root injury rate?

**Root injuries for open diskectomy**

In the SPORT study by Desai et al. in 2011, out of 799 patients undergoing initial open lumbar surgery for diskectomy alone, the frequency of neural injury was 1/774 (0.13%) without durotomy, and 0/25 (0%) with durotomy [Table 1]. Of interest, in these three SPORT studies, the higher incidence of dural tears was correlated with more operations being performed by less experienced surgeons. It was unfortunate that they did not keep track of the use of the operating microscope that was left to “surgeon discretion,” as its absence likely contributed to the incidence of both dural and neural injuries in everyone’s hands.

**Root injuries with endoscopic minimally invasive diskectomy**

Multiple studies cited varying frequencies of root injuries occurring with MIS endoscopic diskectomies. In Kaushal and Sen in 2012, out of a series of 300 posterior lumbar MIS endoscopic diskectomies, 5 patients sustained dural tears, 5 had discitis, and 2 exhibited new nerve root injuries [Table 1]. Choi et al. cited root injuries occurring in 20 (4.3%) of 233 MIS percutaneous transfemoral endoscopic diskectomies and correlated these with a narrowed “working zone” (e.g., distance on magnetic resonance imaging between the existing root and the facet at the lower disc level) [Table 1]. In 2014, Evaniew et al. described a 2.25% root injury rate for different types of MIS versus open lumbar diskectomy procedures; rates were substantially higher with the MIS procedures [Table 1]. In the latter study, the authors themselves could not support the routine use of MIS for cervical or lumbar diskectomies due to their greater major and minor morbidities. Why should we?
XLIF procedures [Table 3].[20] Corroborating this pathoanatomical finding, Ahmadian et al. study in 2013, involving a review of 18 series, found that 304 (15.2%) of 2310 patients sustained root/plexus injuries during XLIF [Table 1].[1] When Hrabalek et al. in 2014 further compared the complication rates of MIS ALIF (120 patients; overall 26.6% complication rate) versus the newer MIS XLIF (88 patients; overall 25% complication rate) addressing disc herniations from the T12 to L5 levels, 15.8% of ALIF versus 23.8% having XLIF exhibited new postoperative radiculitis [Table 2].[14] The high incidence of plexus/nerve root injuries with XLIF should prompt spinal surgeons to strongly questions why these procedures should still be offered.

**INADEQUATIES OF MINIMALLY INVASIVE LUMBAR SURGICAL APPROACHES; 10% CONVERT TO OPEN SURGERY**

Wang et al. in 2012 observed a 10% conversion rate (5 of 50 patients) for patients initially undergoing full endoscopic unilateral, interlaminar lumbar diskectomies.[24] These failures were attributed to MIS affording, poor placement of the MIS retractor, inadequate exposure particularly with lateral recess stenosis, poor hemostasis, and a higher incidence of cerebrospinal fluid fistulas. All of these shortcomings can certainly contribute to the risk of nerve root injury [Tables 1-3].

**ELECTROPHYSIOLOGICAL MONITORING OF LUMBAR SURGERY TO HELP AVOID ROOT INJURIES**

Many spine surgeons routinely use intraoperative neural monitoring. Modalities utilized include; electromyography [EMG], often including sphincter function, and somatosensory-evoked potentials [SEPs]. Motor-evoked potentials [MEPs] are typically reserved for higher lesions (e.g. involving up to the T12-L2 levels during lumbar operaitions).[10,22] We obtain real-time feedback in the operating room as our monitoring physiologist/interpreter is present. We are immediately alerted if there is any neural and/or cauda equina compromise. If changes occur, they are typically very transient and are immediately acted upon (e.g. cessation of dissection/manipulation). Duncan et al. in 2012 underscored the need to monitor TLIF as the placement of the interbody device resulted in significant SEP changes, providing clear physiological evidence that these procedures can result in significant cauda equina compression and are not really “safe” [Table 2].[10] In addition, Valone et al. in 2014 observed that lumbar nerve root injury/weakness, variously attributed to operative manipulation/decompression, occurs in up to 30% of spinal deformity cases [Table 3].[22]

**NERVE ROOT INJURIES DUE TO BONE MORPHOGENETIC PROTEIN IN LUMBAR FUSIONS**

Several studies now document that the application of recombinant human BMP-2 (rhBMP-2) in lumbar fusion procedures can produce neural injury not only documented clinically, but also histopathologically.[3,9,21] Dmitriev et al., in their 2011 article, demonstrated the significant negative impact of applying rhBMP-2 near neural structures.[9] In another study, Corenman et al. retrospectively evaluated the results of TLIF performed with BMP-2 for patients with discogenic pain syndromes; 11 (50.6%) patients exhibited unexplained postoperative radiculitis, whereas 4 needed additional surgery [Table 2].[9] In the review article by Tannoury and An in 2014, they noted that rhBMP-2 resulted in adverse events involving nerve root injury/radiculitis when utilized to perform cervical or lumbar fusions.[21] Although all of these authors cite “real concerns” about the off-label use of BMP in spinal surgery, where is the momentum to remove this product from the shelves?

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Ahmadian A, Deukmedjian AR, Abel N, Dakwar E, Uribe JS. Analysis of lumbar lpectropathies and nerve injury after lateral retroperitoneal transpsoas approach: Diagnostic standardization. J Neurosurg Spine 2013;18:289-97.
2. Choi I, Ahn JO, So WS, Lee SJ, Choi IJ, Kim H. Exiting root injury in transforaminal endoscopic discectomy: Preoperative image considerations for safety. Eur Spine J 2013;22:2481-7.
3. Corenman DS, Gillard DM, Dornan GJ, Strauch EL. Recombinant human bone morphogenetic protein-2-augmented transforaminal lumbar interbody fusion for the treatment of chronic low back pain secondary to the homogeneous diagnosis of discogenic pain syndrome: Two-year outcomes. Spine (Phila Pa 1976) 2015;40(Suppl 1):S57-63.
4. Desai A, Ball PA, Bekelis K, Lurie J, Mirza SK, Tosteson TD, et al. SPORT: Does incidental durotomy affect long-term outcomes in cases of spinal stenosis? Neurosurgery 2011;69:38-44.
5. Desai A, Ball PA, Bekelis K, Lurie J, Mirza SK, Tosteson TD, et al. SPORT: Does incidental durotomy affect long-term outcomes in cases of spinal stenosis? Neurosurgery 2015;76 Suppl 1:S57-63.
6. Desai A, Ball PA, Bekelis K, Lurie J, Mirza SK, Tosteson TD, et al. Surgery for lumbar degenerative spondylolisthesis in spine patient outcomes research trial: Does incidental durotomy affect outcome? Spine (Phila Pa 1976) 2012;37:406-13.
7. Desai A, Ball PA, Bekelis K, Lurie JD, Mirza SK, Tosteson TD, et al. Outcomes after incidental durotomy during first-time lumbar discectomy. J Neuurosurg Spine 2011;14:467-53.
8. Desai A, Bekelis K, Ball PA, Lurie J, Mirza SK, Tosteson TD, et al. Spine patient outcomes research trial: Do outcomes vary across centers for surgery for lumbar disc herniation? Neurosurgery 2012;71:833-42.
9. Dmitriev AE, Lehman RA Jr, Symes AJ. Bone morphogenetic protein-2 and spinal arthrodesis: The basic science perspective on protein interaction with the nervous system. Spine J 2011;11:500-5.
10. Duncan JW, Bailey RA, Baena R. Intraoperative decrease in amplitude of somatosensory-evoked potentials of the lower extremities with interbody fusion cage placement during lumbar fusion surgery. Spine (Phila Pa 1976) 2012;37:E1290-5.

11. Evaniew N, Khan M, Drew B, Kwok D, Bhandari M, Ghert M. Minimally invasive versus open surgery for cervical and lumbar discectomy: A systematic review and meta-analysis. CMAJ Open 2014;2:E295-305.

12. Faundez AA, Schwender JD, Safriel Y, Gilbert TJ, Mehbod AA, Denis F, et al. Clinical and radiological outcome of anterior-posterior fusion versus transformaminal lumbar interbody fusion for symptomatic disc degeneration: A retrospective comparative study of 133 patients. Eur Spine J 2009;18:203-11.

13. Gologorsky Y, Skovrlj B, Steinberger J, Moore M, Arginteanu M, Moore F, et al. Increased incidence of pseudarthrosis after unilateral instrumented transformaminal lumbar interbody fusion in patients with lumbar spondylolisthesis: Clinical article. J Neurosurg Spine 2014;21:601-7.

14. Hrabalek L, Adamus M, Gryga A, Wanek T, Tuček P. A comparison of complication rate between anterior and lateral approaches to the lumbar spine. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub 2014;158:127-32.

15. Hsiang J, Yu K, He Y. Minimally invasive one-level lumbar decompression and fusion surgery with posterior instrumentation using a combination of pedicle screw fixation and transpedicular facet screw construct. Surg Neurol Int 2013;4:125.

16. Kaushal M, Sen R. Posterior endoscopic discectomy: Results in 300 patients. Indian J Orthop 2012;46:81-5.

17. Lindley EM, McCullough MA, Burger EL, Brown CW, Patel V. Complications of axial lumbar interbody fusion. J Neurosurg Spine 2011;15:273-9.

18. Mehta VA, McGrattan MJ, García-Ambrossi GL, Parker SL, Sciubba DM, Bydon A, et al. Transformaminal versus posterior lumbar interbody fusion: Comparison of surgical morbidity. Neurol Res 2011;33:38-42.

19. Omidi-Kashani F, Ghayem Hasankhani E, Noroosii HR. Instrumented transformaminal lumbar interbody fusion in surgical treatment of recurrent disc herniation. Med J Islam Repub Iran 2014;28:124.

20. Spivak JM, Paulino CB, Patel A, Shanti N, Pathare N. Safe zone for retractor placement to the lumbar spine via the transpsoas approach. J Orthop Surg (Hong Kong) 2013;21:77-81.

21. Tannoury CA, An HS. Complications with the use of bone morphogenetic protein 2 (BMP-2) in spine surgery. Spine J 2014;14:552-9.

22. Valone F 3rd, Lyon R, Lieberman J, Burch S. Efficacy of transcranial motor evoked potentials, mechanically elicited electromyography, and evoked electromyography to assess nerve root function during sustained compression in a porcine model. Spine (Phila Pa 1976) 2014;39:E989-93.

23. Verla T, Adogwa O, Fatemi P, Martin JR, Gottfried ON, Cheng J, et al. Clinical implication of complications on patient perceived health status following spinal fusion surgery. J Clin Neurosci 2015;22:342-5.

24. Wang B, Liu G, Liu W, Cheng I, Patel AA. Full-endoscopic interlaminar approach for the surgical treatment of lumbar disc herniation. The causes and prophylaxis of conversion to open. Arch Orthop Trauma Surg 2012;132:1531-8.