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Josip Buric

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# Relationship between psoas muscle dimensions and postoperative thigh pain. A possible preoperative evaluation factor

Josip Buric

Villa Torri Hospital, Bologna, Italy

## Abstract

### Introduction

Advanced intraoperative neuromonitoring (IONM) is used to attenuate postoperative complications and side effects of extreme lateral interbody fusion (XLIF). Specific factors relate to the presence of postoperative injury are not well understood. This study aims to identify intraoperative variables with correlations to new postoperative anterior thigh/groin sensory changes.

### Methods

Twenty-nine patients with various degenerative lumbar conditions were treated with XLIF at a single institution. Mean age was 59 years, 69% were female, and 21% had undergone previous lumbar surgery. A total of 47 levels (mean 1.6, range 1-3) were treated with XLIF. Supplemental pedicle screw and rod fixation was used in 24 patients (83%). Dynamically-evoked electromyography was used in all cases. Analysis of baseline demographic and treatment variables were performed at a per patient basis (n=29), whereas analysis of intraoperative variables were performed at a per levels treated basis (n=47).

### Results

Within 24 hours postoperative, 10 (34%) patients experienced anterior thigh/groin sensory changes (4 reported pain only, 5 reported pain plus other sensory changes, and 1 paresthesia without pain). Symptom resolution occurred at 1 month postoperative for 4 patients, at 3 months postoperative for 2 patients. At 3 months postoperative, 6 patients had complete symptom resolution, 3 patients had symptom improvements, and 1 patient had no change in perioperative symptoms. Psoas dimension in the lateral-latero direction were significantly smaller for patients with postoperative sensory changes ( $p=0.025$ ), and similarly, patients with postoperative sensory changes had a significantly higher ratio of psoas muscle in the anterior-posterior to lateral-latero directions ( $p=0.026$ ).

### Conclusions

In addition to IONM, MRI evaluation of psoas shape, position, and dimension may be of help in preoperative planning of a safe XLIF access and eventually, predict those cases with higher risk of approach-related post-operative events.

KEYWORDS: INTRAOPERATIVE NEUROMONITORING, XLIF, PSOAS, EMG

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## Introduction

Extreme lateral interbody fusion (XLIF) has been reported in the literature for the treatment of a wide range of spinal pathologies intended to minimize the risks and morbidity associated with conventional posterior and anterior approaches to the spine.<sup>1-4</sup> This retroperitoneal, 90° lateral approach technique utilizes a transpsoas access to the disc space, and places the psoas muscle and nerves of the lumbar plexus at risk for injury. Advanced intraoperative

neuromonitoring (IONM), including dynamically-evoked electromyography (EMG) and free-run EMG, is used to attenuate approach related postoperative complications.<sup>5</sup>

However, even with advanced techniques for IONM, the close proximity of the surgical working space places at risk of injury the motor and sensory nerves of the lumbar plexus and surrounding anatomy, and occasionally results in new postoperative weakness of the hip flexors and/or sensory changes to the upper

medial thigh/groin area.<sup>6-8</sup> Varying rates of sensory changes following XLIF have been reported in the literature, and there is not yet a consensus regarding factors associated with upper medial thigh pain.

Thus, the purpose of this study was to evaluate pre- and intra-operative variables significantly correlated with newly developed post-operative pain or motor or sensory events due to surgical positioning of the laterally-delivered interbody cage.

## Methods

Intraoperative and postoperative clinical data were collected prospectively for 29 consecutive patients treated with XLIF at a single institution between 2012 and 2013. Mean age at time of surgery was 59 years (range 32 to 82) and 69% were female. Six (21%) patients had a history of previous lumbar surgery (2 fusion, 4 decompression). All patients were treated for one or more degenerative lumbar conditions, most commonly for degenerative disc disease (23, 79%), listhesis (8, 28%), and/or stenosis (6, 21%). Complete cumulative indications for surgery are presented in Table 1. Preoperative symptoms included low back pain (LBP) in 90% of patients, bilateral or unilateral radiculopathy in 86%, and other various symptoms (neurogenic claudication, motor deficits, palsy) in 28% of patients.

Preoperative magnetic resonance imaging (MRI) was obtained for all patients to evaluate dimensions in both the antero-posterior (AP) and latero-lateral (LL) directions. IONM for all cases included dynamically-evoked electromyography (EMG). In this technique, as previously described,<sup>1,9</sup> three sequential dilators were placed at various depths of the psoas, rotated 360°, and direction of the lowest threshold (anterior, posterior, medial) was noted (EMG threshold, defined as the number of milliamperes required to depolarize a nerve, decreases with increased proximity to the nerve). Free-run (spontaneous) EMG readings throughout the duration of each case were also recorded.

Within 24 hours postoperative, patients were examined and asked to describe the presence of any new symptoms, such as pain or sensory disturbance in the

region of the anterior abdominal wall, groin or front thigh or weakness of the hip and thigh. If positive, the patients were classified in surgical events (SE) group. Unless a new SE was noted, this examination concluded each patient's participation. Patients with SE were actively followed at additional intervals (1 week, 6 weeks, 3 months) until symptoms were resolved or deemed permanent.

Statistical analysis included ANOVA and Pearson's chi-squared/Fishers' Exact tests. Analysis of baseline demographic and treatment variables were performed at a per-patient basis (n=29), whereas analysis of intraoperative variables were performed at a per-levels treated basis (n=47). Significance was accepted for p<0.05.

## Results

A total of 45 disc levels were treated (mean 1.6 per patient, range 1-3) with XLIF: 6 (13%) at L2-3, 14 (31%) at L3-4, and 25 (56%) at L4-5. The XLIF portion of one case was aborted due to the inability to find a safe passage through the psoas based on unfavorable EMG readings, and the patient received only instrumented posterolateral fusion. However, as the

Table 1. Patient demographic information.

	Patients (n = 29)
Age (years) – mean ± SD	59.1 ± 11.7
Female – n (%)	20 (69.0)
Previous lumbar surgery – n (%)	6 (20.7)
Diagnosis	
Degenerative disc disease	23 (79.3)
Listhesis	8 (27.6)
Stenosis	6 (20.7)
De novo scoliosis	3 (10.3)
Preoperative symptoms – n (%)	
Low back pain	26 (89.7)
Radiculopathy	25 (86.2)
Other <sup>1</sup>	8 (27.6)

Abbreviations: n, number of patients; SD, standard deviation. <sup>1</sup>“Other” preoperative symptoms include: neurogenic claudication, palsy, and/or motor deficit.

approach to the spine was performed and a postoperative SE was noted, this patient was included for analysis in the current study. Supplemental pedicle screw and rod fixation was used in 24 (83%) patients, an additional direct decompression was performed in 1 patient, and a Smith-Petersen osteotomy was performed in 1 patient. Blood loss for all patients was less than 50 cc, with the exception of one patient who experienced an intramuscular hematoma of the abdominal wall muscles requiring revision, resulting in 300 cc blood loss.

### Nerve detection

Alert-level EMG feedback (ie. nerves were identified within close proximity) during the approach to the spine was given in 16 of the 47 (34%) levels treated. Close nerve proximity was detected in 0% of cases at L2-3, in 13% at L3-4, and in 56% at L4-5 ( $p=0.003$ ). Direction of lowest threshold was noted as posterior in all 16 cases, with a mean threshold value of 9.7 mA.

### New postoperative surgical events (SE)

New postoperative anterior thigh/groin SE were present in 10 of 29 patients treated at 20 levels within 24 hours postoperative, 9 of which were approach-related (31%). In the remaining case, a deficit was noted on the contralateral side due to intraoperative malpositioning of the cage. Patient-level descriptions of SE and resolution are shown in Table 2. At 1 month postoperative, symptoms were still present in 5 (17%) patients and by 3 months postoperative, symptoms were still present in 4 (14%) patients. By one year postoperative, 3 (10%) patients had persistent symptoms, though milder in severity and able to be controlled with adequate pharmacological pain therapy.

### Factors affecting new postoperative surgical events (SE)

Age, gender, previous lumbar surgery, and preoperative symptoms were similar between patients with and without postoperative SE. On average, patients who experienced postoperative SE were treated at more levels compared to those with no SE (2.0 v. 1.4,  $p=0.039$ ). Analysis on a levels-treated basis showed no significant differences in specific lumbar levels treated or retraction time between patients with and

without postoperative SE (Table 2, Table 3). Also, no significant differences were found between cage sizes implanted in patients with and without postoperative SE (Table 2). Alert-level EMG feedback during the approach was also found to have no significant association with presence of postoperative SE ( $p=0.905$ ). Psoas dimensions in the LL direction were significantly smaller for patients with postoperative SE ( $p=0.025$ ), and similarly, patients with postoperative SE had a significantly higher ratio of psoas muscle AP:LL dimension ( $p=0.026$ ).

## Discussion

XLIF has gained in popularity in the last decade as a

Table 2. Patient-level symptom description, cage-size and resolution.

Patient Number	SE Description	Levels treated (IONM registered)	Cage size / level	SE Location	Resolution
2	Pain	L2-3, L3-4 (L4-5)	10 x 22 x 50 L	Anterior thigh	3 months
3	Pain and quad palsy	L3-4 (L4-5)	10 x 22 x 55 L	Contralateral thigh	Improved
4	Pain	L3-4 (L4-5)	8 x 18 x 55 L	Anterior thigh	3 months
7	Pain	L4-5	10 x 22 x 50 L	Anterior thigh	1 month
10	Pain	L2-3, L3-4 (L4-5)	10 x 22 x 55 L	Anterior thigh	1 month
14	Pain and tingling	L3-4, L4-5	10 X 18 X 55 L 8 x 18 x 55	Anterior thigh	1 month
17	Pain and burning	L4-5	10 x 18 x 45 L	Anterior thigh	Improved
25	Paresthesia	L3-4 (L4-5)	10 x 22 x 55 L	Anterior thigh	1 month
26	Pain and paresthesia	(L2-3), L3-4, L4-5	8 x 22 x 50 L	Inguinal area	Improved
27	Pain and hyposthesia	(L4-5)	8 X 22 X 55 L		Improved

minimally invasive alternative for the treatment of a broad range of lumbar spinal pathologies. Previous literature has reported that in comparison to conventional, open approaches, XLIF results in less intraoperative blood loss, lower complication rates, shorter hospital stays, and faster return to normal activities.<sup>1-4</sup> Compared to anterior approaches for interbody fusion, the lateral approach reduces the risk of injury to the major vascular structures, and possibly, avoids retrograde ejaculation or vaginal dryness in males and females, respectively.<sup>10,11</sup> The stand-alone lateral approach also avoids complications associated with posterior lumbar fusion approaches, such as posterior muscle denervation, nerve root injuries and dural leaks.<sup>12</sup>

As is the case with all surgical procedures, XLIF is not without potential adverse events. As the technique utilizes a 90° lateral, trans-psoas approach to the spine, retraction of the psoas muscle posteriorly is required in order to establish and maintain a working corridor to the spine.<sup>6-8</sup> This can place significant pressure on the motor and sensory nerves of the lumbar plexus, potentially leading to new postoperative neurological deficits. New upper medial thigh sensory deficits following XLIF in most cases are transient and resolve within the short-term postoperative period.<sup>2</sup> The use of advanced IONM allows for the establishment of a safe working corridor by providing real-time, dynamic information on both the position and distance of motor nerves with respect to the instrument.<sup>9</sup> However, due to the close anatomic proximity of the surgical working space to the ilioinguinal, iliohypogastric, and lateral femoral cutaneous nerves, risk of postoperative neurological deficit can

only be mitigated but not eliminated with IONM.<sup>13</sup>

Previous studies have reported varying rates of postoperative neurologic events (motor or sensory) between 0.6 to 33.6% following XLIF.<sup>2,9,13,14</sup> Tohmeh et al. reported new upper medial thigh sensory loss in 18% of patients and hip flexion weakness in 28% of patients.<sup>9</sup> Most of these cases of postoperative events have been described as transient, due to trauma to the psoas during the approach as opposed to injury to the nerve roots. Some authors regard them more as a side effect of the lateral approach rather than a complication. The majority of these injuries have been reported to resolve without additional intervention, usually after 3 months postoperative, and a drastically lower number of these cases have been reported in the literature to be permanent. In a large series of 600 patients by Rodgers et al, the incidence of permanent neurologic injury was 0.7%, while Pumberger et al. found 1.6% of patients with sensory deficits after 1 year postoperative.<sup>13</sup> We found it difficult, if not impossible, to establish if these new events were due to a nerve lesion or merely due to surgical trauma of the psoas muscle. This was specifically true for short-term weakness events and pain while long-term pain and sensory loss or otherwise disturbances could more easily be attributed to a nerve lesion. In the current study, 9 (31%) patients experienced new approach-related groin and/or thigh event, characterized as pain, sensory reduction or loss and muscle weakness in 9 of the 10 patients. The symptoms were transient and resolved within 3 months for 6 of the 10 patients, while persisting at 1 year for 3 patients (10%).

Specific factors related to the presence of postoperative SE following XLIF are not well understood. It has been previously reported that there is an increased risk of injury when treatment was inclusive of the L4-5 level due to a more anteriorly positioned lumbar plexus in the psoas muscle however, other reports have been conflicting.<sup>2,13,15</sup> In the current study, while alert-level EMG feedback was given significantly more frequently at L4-5 compared with other levels, there were no significant differences in postoperative incidence of SE probably due to a relatively small group numbers that may not have adequately powered this study to detect the difference. Number

Table 3. Levels-treated comparison of intraoperative variables between patients with and without postoperative sensory changes (SE).

	No SE (n=27)	SE (n=20)	p-value
Retraction time (min) – mean ± SD	31.5 ± 2.2	27.4 ± 2.5	0.217
Alert-level EMG response – n (%)	13 (41.9)	7 (43.8)	0.905
Psoas dimensions – mean ± SD			
Anteroposterior	38.1 ± 2.0	37.3 ± 2.4	0.814
Lateral	31.9 ± 1.8	25.6 ± 2.1	<b>0.025*</b>
Ratio AP:Lateral	1.3 ± 0.1	1.7 ± 0.2	<b>0.026*</b>

Abbreviations: n, number of patients; SD, standard deviation.

of levels treated was significantly higher in the current study among patients with postoperative SE compared to those without, which corroborates with previously published reports in the literature.

The most significant finding of this study regarded the correlation of new post-op SE with psoas dimensions and shape. Specifically, patients with postoperative SE had a mean psoas latero-lateral measure on preoperative axial MRI images, of 25.6 mm, which was significantly less than the average measure of 31.9 mm for patients with no postoperative SE ( $p=0.025$ ). As psoas measures in the AP direction were statistically similar between patients with and without postoperative SE (37.3 mm v. 38.1 mm), patients with a postoperative SE also had a higher AP:LL psoas dimension ratio ( $p=0.026$ ), reflecting a more anteriorly elongated psoas, as seen on axial MRI images. This association between psoas morphology and neural anatomy has also been previously described by Smith et al.<sup>16</sup> In their study of feasibility of XLIF in treating transitional L5-6 levels, they found that the ability to establish a safe working corridor to the spine was limited in levels where surrounding psoas muscle was in a laterally detached, “teardrop shape” as evaluated on preoperative axial MRI. To our knowledge, this is the first report that provides quantitative data on the relationship between psoas morphology and risk of postoperative SE in non-transitional lumbar levels (L2-3, L3-4 and L4-5).

Finally, it is important to note that postoperative motor and sensory deficits are not exclusive to the XLIF procedure, but has also been extensively reported in the literature for other approaches, both open and minimally invasive (MI). In particular, permanent neurological deficits have been reported to be as high as 6.1% for posterior lumbar interbody fusion (PLIF),<sup>17</sup> 4.1% for transforaminal lumbar interbody fusion (TLIF),<sup>11</sup> 3.6% of posterior instrumented fusion (PLF),<sup>18</sup> and 6.5% for endoscopic anterior lumbar interbody fusion (ALIF),<sup>19</sup> and 1.5% for open ALIF.<sup>20</sup>

## Conclusions

Real-time, dynamic IONM during XLIF helps to

minimize rates of new postoperative surgical events. Postoperative surgical events were found to occur more frequently in patients treated at multiple levels as well as in the patients with a higher anterior-posterior to latero-lateral psoas dimension ratio. In addition to IONM, MRI evaluation of psoas shape, position, and dimension may be of help in preoperative planning of a safe XLIF access and eventually, predict those cases with higher risk of approach-related post-operative events.

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## Disclosures

The author acts as a proctor for NuVasive.

## Corresponding Author

Josip Buric, Villa Torri Hospital, Viale Quirico Filopanti, 1240126 Bologna, Italy.  
joburic77@gmail.com.

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