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ORIGINAL ARTICLE

Risk factor of contralateral radiculopathy following microendoscopy-assisted minimally invasive transforaminal lumbar interbody fusion

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Abstract

Purpose Microendoscopy-assisted minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) is an advantageous method for treating lumbar degenerative disease; however, some patients show contralateral radiculopathy postoperatively. This study aims to investigate its risk factor.

Methods A total of 130 cases who underwent microendoscopy-assisted MIS-TLIF at L4–5 level were divided into symptomatic and asymptomatic groups according to the presence of postoperative contralateral radiculopathy. Both preoperative and postoperative radiographic parameters, as well as their changes were compared between the two groups, including lumbar lordosis (LL), surgical segmental angle (SSA), disc height (DH), contralateral foramen area (CFA) and contralateral canal area (CCA). Screw breach on contralateral L4 pedicle and decompression method (ipsilateral or bilateral canal decompression through unilateral route) were also analyzed as potential risk factors. Receiver operating characteristic (ROC) curve was drawn for the risk factor to determine the optimal threshold for predicting postoperative contralateral radiculopathy. Besides, clinical outcome assessment, involving Visual Analog Score (VAS) for back and leg, Japanese Orthopaedics Association Score (JOA) and Oswestry Disability Index (ODI), was also compared between the two groups before surgery and at final follow-up (at least 3 months after the surgery for asymptomatic patients or final treatments of contralateral radiculopathy for symptomatic cases).

Results Postoperative contralateral radiculopathy occurred in 11 (8.5%) of the 130 patients. Both preoperative and postoperative CFA as well as its change were significantly decreased in symptomatic group compared with asymptomatic group (all $P < 0.05$). For the remaining four parameters (LL, SSA, DH, CCA), their preoperative, postoperative and change values showed no statistical difference between the two groups (all $P > 0.05$). Neither screw breach nor decompression method revealed statistical association with this complication (both $P > 0.05$). Based on ROC curve, the optimal threshold of preoperative CFA was 0.76 cm^2. At final follow-up, significant improvement in VAS (back and leg), JOA and ODI was observed in both groups compared with preoperative baseline (all $P < 0.05$), while no difference was found between the two groups (all $P > 0.05$).

Conclusions Preoperative contralateral foramen stenosis is the risk factor of contralateral radiculopathy following microendoscopy-assisted MIS-TLIF. If preoperative CFA at L4–5 level is not larger than 0.76 cm^2, prophylactic measures, including both indirect and direct decompression of contralateral foramen, are recommended.

Keywords Risk factor · Contralateral · Radiculopathy · Minimally invasive surgery · Transforaminal lumbar interbody fusion

Introduction

Microendoscopy-assisted minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) has been demonstrated as a preferred alternative over open surgery due to a variety of advantages, including less iatrogenic injury,

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minimized neural retraction and reduced hospitalization [1–3]. For those revealing bilateral radiculopathy or unilateral radiculopathy with bilateral nerve root compression, unilateral transforaminal approach at the incision side is used to implant interbody cage. Thus, indirect decompression of contralateral foramen can be achieved via increase of its height, width and area [4–6]. Besides, tubular working channel can be angled directly to facilitate direct decompression of contralateral lateral recess [7, 8]. Thus, thorough canal decompression can be accomplished through unilateral-approach microendoscopy-assisted MIS-TLIF theoretically. Unexpectedly, there are some patients suffering from contralateral radiculopathy postoperatively, affecting surgical outcome adversely. To the best of our knowledge, stenosis aggravation of contralateral foramen and over-restoration of segmental lordosis are related with it after unilateral open TLIF. However, few literatures have focused on contralateral radiculopathy following microendoscopy-assisted MIS-TLIF [6, 9, 10]. The aim of this retrospective study is to analyze its risk factor.

Patients and methods

Clinical data

From January 2010 to January 2017, a total of 130 patients suffering from lumbar degenerative disease with single surgical level of L4–5 were included in this study. After failure of conservative treatments for more than 6 weeks (medication and physical therapy), microendoscopy-assisted MIS-TLIF was performed by different surgeons in one single center. Patients upon the diagnosis of congenital spinal canal stenosis, infectious spondylitis, spinal tumor or acute lumbar fracture were excluded. All enrolled patients were divided into two groups: symptomatic group comprised those who presented with new or aggravated exiting nerve root symptoms of the leg contralateral to the incision side, including pain, hypoesthesia, paresthesia or motor weakness within 1 week after surgery; while asymptomatic group comprised those without any contralateral radiculopathy after operation. The postoperative follow-up period for asymptomatic group ranged from 3 to 87 months (29.1 months in average). In symptomatic group, the follow-up after final treatment (conservative medication or revision surgery following the occurrence of contralateral radiculopathy) lasted from 12 to 58 months (27.4 months in average).

Surgical procedures

Following general anesthesia, patient was evenly positioned prone on radiolucent table. Under fluoroscopic guidance, pedicle images of operated vertebrae were confirmed and then four corresponding paracentral transverse incisions were made to insert Jamshidi needle, which was first placed at lateral margin of pedicle and then slowly advanced into the contralateral margin along pedicle route. Inner stylet of Jamshidi needle was removed to allow Kirschner wire to be inserted into pedicle. After dilating decompression incision gradually, the fixed 20-mm diameter working channel was inserted at incision side. Ipsilateral laminotomy and partial facetectomy along with removal of ligamentum flavum were performed under microendoscopy. For those requiring bilateral canal decompression, tubular working channel was angled to the opposite side to remove inner lamina, ligamentum flavum, and part of the facet joint, achieving direct decompression of contralateral lateral recess (Fig. 1). Following sufficient discectomy and preparation of endplates, appropriate bullet-type interbody cage filled with autologous bone and remaining bony particles were packed into the center of intervertebral space. Pedicle screws and rods were then inserted through incisions percutaneously. Proper bilateral intervertebral compression was applied before tightening the screw-rod construct. Finally, closure in layers was performed following wound hemostasis and irrigation.

Postoperative management

After anesthesia recovery, administration of non-steroid anti-inflammatory analgesics, as well as methylprednisolone, was used to relieve pain and eliminate inflammation of nerve root caused by manipulation disturbance. To prevent deep vein thrombosis, antithrombotic compression stocking and intermittent foot pump were initiated within several hours following surgery. When motion of bilateral lower extremities improved, active ambulation was also encouraged.

Radiographic parameter assessment

Lumbar lordosis (LL) and surgical segmental angle (SSA) were assessed using lateral plain radiographs in neutral position before and after surgery. LL was measured as angle between two upper endplates of L1 and S1, while SSA was defined as angle between upper endplate of L5 and lower endplate of L4 (Fig. 2). Based on preoperative and postoperative images from 320-detector-row CT scanner (Toshiba AquilionOne Dynamic Volume, Ottawara, Japan; 2-mm slice thickness with 2-mm interval), disc height (DH), contralateral foramen area (CFA) as well as contralateral canal area (CCA) were evaluated. DH was measured as distance between the center of L5 upper endplate and L4 lower endplate from the central sagittal view. CFA was defined as area of the intervertebral foramen at L4–5 level using sagittal view at the center of contralateral pedicle, and it was bounded by the surfaces of pedicles in both L4 and L5 and the surface of posterior longitudinal

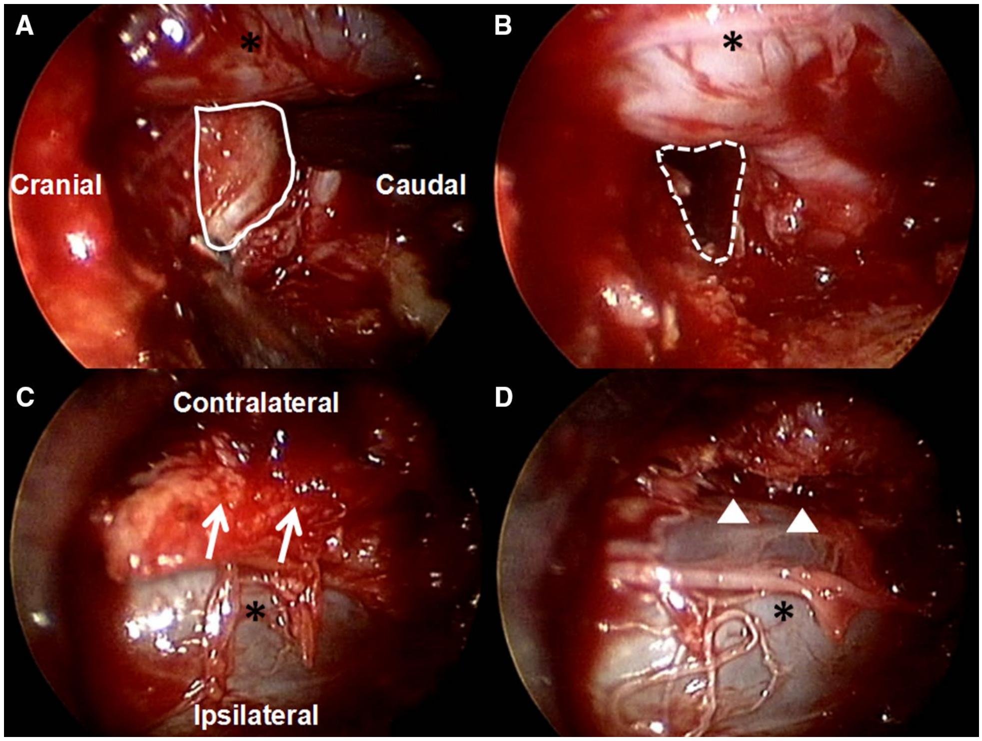

Fig. 1 Bilateral canal decompression through unilateral approach at L4–5 level during microendoscopy-assisted MIS-TLIF. **a** The dural sac (asterisk) was compressed by ipsilateral herniated disc (white line). **b** After discectomy, the compression was removed (white dotted line). **c** The dural sac was compressed contralaterally (white arrow). **d** Sufficient contralateral decompression was achieved through unilateral approach (white arrowheads)

ligament (intervertebral disc) anteriorly and the surface of ligamentum flavum posteriorly. CCA was calculated as half cross-sectional area of canal at L4–5 level contralaterally using transverse view at the middle of DH, and it was bounded by the surface of annulus fibrosus anteriorly and the surface of ligamentum flavum posterolaterally and the midline medially (Fig. 2). According to the criteria evaluating accuracy of pedicle screw placement introduced by Rajasekaran [11], all patients were analyzed with respect to breach of contralateral L4 pedicle wall by screw either medially or inferiorly. Screw placement was graded on CT image as follows: grade 0, no pedicle perforation; grade 1, only the threads outside the pedicle (less than 2 mm); grade 2, core screw diameter outside the pedicle (2–4 mm); and grade 3, screw entirely outside the pedicle. All radiographic data were measured using image post-processing workstation (Vitrea 2.0, Vital Images, Minnesota, USA). Continuous variables were measured three times by three independent assessors, who were all blinded to included cases, and the mean values were used. While categorical indicators were jointly determined after discussion of the same three case-blinded observers.

Clinical parameter assessment

For both symptomatic and asymptomatic groups, visual analogue scale (VAS) of back and leg, Japanese Orthopaedic Association Score (JOA) and Oswestry Disability Index (ODI) were blindly measured by one independent assessor before surgery and at final follow-up.

Statistical analysis

Comparison on continuous variables (expressed as mean ± standard deviation) inter-groups and intra-group was tested by independent and paired t test, respectively, while Chi-squared test and Fisher exact probability method were utilized to perform intergroup comparison of categorical data (expressed as frequency). Receiver operating characteristic (ROC) curve was used to determine optimal threshold of prognostic factor to predict postoperative contralateral radiculopathy. The value corresponding to optimum Yuden Index was the targeted one. Statistical analysis was performed using SPSS software (IBM, New York, NY, USA), and significance difference was defined as $P < 0.05$.

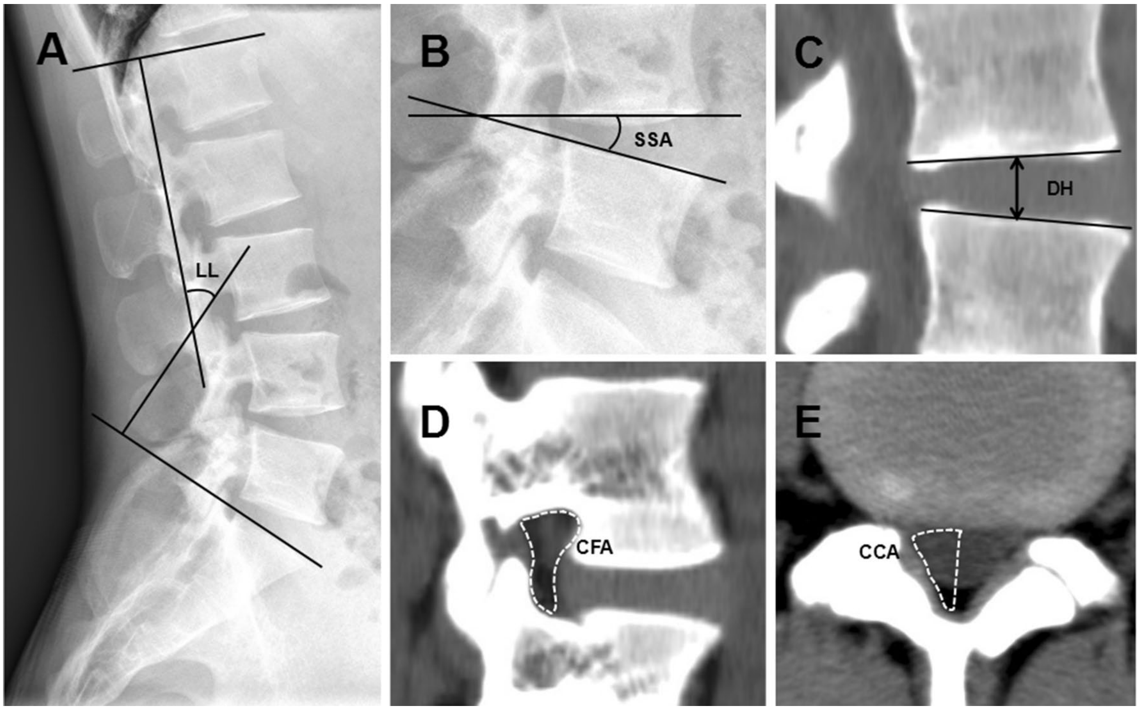

Fig. 2 Measurement of radiographic parameters. **a** Lumbar lordosis (LL): the angle between L1 and S1 upper endplates. **b** Surgical segmental angle (SSA): the angle between upper endplate of L5 and lower endplate of L4. **c** Disc height (DH): the distance between the center of L5 upper endplate and L4 lower endplate from the central sagittal view. **d** Contralateral foramen area (CFA): the area of intervertebral foramen at L4–5 level using sagittal view at the center of contralateral pedicle. **e** Contralateral canal area (CCA): contralateral half of the cross-sectional area of vertebral canal at L4–5 level using transverse view at the middle of DH

Results

Eleven patients out of 130 cases showed contralateral radiculopathy after microendoscopy-assisted MIS-TLIF, thus its incidence was 8.5%. The most common cause was aggravation of contralateral foramen stenosis (eight patients), followed by contralateral herniated nucleus pulposus combining with foramen stenosis worsening (two patients), and then contralateral herniated nucleus pulposus combining with screw malposition (one patient) (Fig. 3). Eight patients recovered from conservative management, while the remaining three cases underwent revision operations, including discectomy under percutaneous transforaminal endoscopy or microendoscopy. There was no statistical difference of preoperative baseline data between symptomatic and asymptomatic groups (Tables 1 and 3).

Statistical difference was found in preoperative CFA between the two groups ($P < 0.05$). The difference in postoperative CFA was even greater ($P < 0.001$), as CFA showed downward trend in symptomatic group but upward tendency in asymptomatic group. Additionally, the difference of CFA before and after surgery was significant in both groups (symptomatic: $P = 0.019$, asymptomatic: $P < 0.001$, Table 2). No significant difference was found in LL, SSA, DH and CCA between the two groups either before or after surgery (all $P > 0.05$). However, significant difference of the parameters above before and after surgery was found in both groups (all $P < 0.05$) except LL in symptomatic group ($P = 0.79$, Table 2). When referring to changes of these five parameters between preoperation and postoperation, significant difference was found only in CFA between symptomatic and asymptomatic groups ($P < 0.05$), but not in the remaining four parameters (all $P > 0.05$, Table 2). In addition, screw breach on contralateral L4 pedicle wall was not associated with postoperative contralateral radiculopathy (all $P > 0.05$, Table 2). Complication incidence following ipsilateral or bilateral canal decompression through unilateral route was 8.1 and 8.6%, respectively (3/37 versus 8/93), with no statistical difference ($P = 1.000$). Based on ROC curve, The preoperative CFA corresponding to optimal Yuden Index (0.339) was 0.76 cm^2 (sensitivity 0.818, specificity 0.521). Thus, if preoperative CFA was equal to or less than 0.76 cm^2, the possibility of postoperative contralateral radiculopathy would obviously increase.

At final follow-up, a significant improvement in VAS (back and leg), JOA and ODI was found compared with preoperative baseline in either symptomatic or asymptomatic group (all $P < 0.05$). However, differences of the clinical scores between the two groups at final follow-up showed no statistical significance (all $P > 0.05$, Table 3).

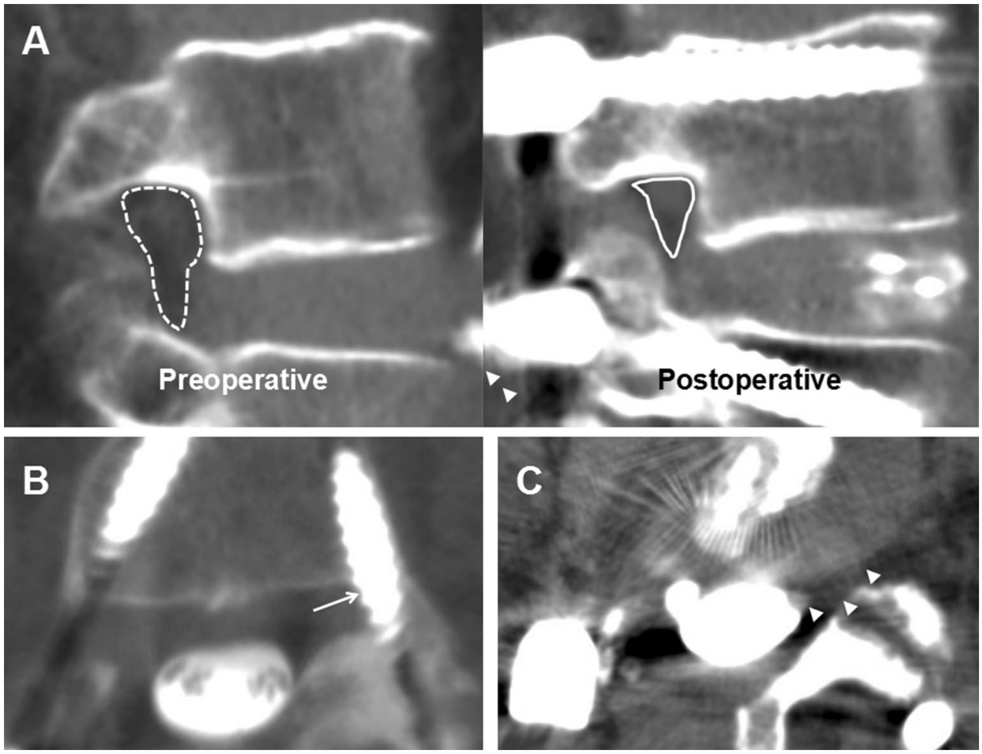

Fig. 3 Causes of contralateral radiculopathy after microendoscopy-assisted MIS-TLIF. **a** Contralateral foramen stenosis after surgery (white line) compared with preoperation (white dotted line). **b** Contralateral pedicle breach by screw malposition (white arrow). **c** Nucleus pulposus reherniation at contralateral side (white arrowheads)

Table 1 Demographic data between symptomatic and asymptomatic groups

	Symptomatic group	Asymptomatic group	*P* value
Age	66.7 ± 6.0	61.1 ± 10.9	0.098
Gender (male:female)	1:10	41:78	0.103
Preoperative diagnosis			0.507
Degenerative lumbar stenosis	6	80	
Degenerative spondylolisthesis	5	39	
Preoperative neurological symptom			0.748
Unilateral radiculopathy	6	74	
Bilateral radiculopathy	5	45	
Intraoperative decompression method			1.000
Ipsilateral canal decompression	3	34	
Bilateral canal decompression	8	85	

Discussion

Up to now, there have been few literatures regarding incidence of contralateral radiculopathy following transforaminal approach surgery. The incidence of contralateral radiculopathy is reported to be 2.0% after MIS-TLIF [9] and ranges from 1.9 to 5.9% following open TLIF [6, 10, 12], while our study reveals its occurrence rate of 8.5% after microendoscopy-assisted MIS-TLIF. The higher incidence may result from several factors, such as disease entity, surgical methodology and phase of surgeon's learning curve. Considering its relatively high incidence, postoperative contralateral radiculopathy seems an important complication and cannot be ignored by surgeons also because of its unpredictability [6]. Though it may be encountered by surgeons occasionally, contralateral radiculopathy following microendoscopy-assisted MIS-TLIF has not been well analyzed. Therefore, recognition of its associated risk

Table 2 Radiographic parameters between symptomatic and asymptomatic groups

	Symptomatic group	Asymptomatic group	*P* value
Preoperation			
Lumbar lordosis	43.25 ± 9.16	40.18 ± 14.28	0.486
Surgical segmental angle	7.18 ± 4.30	7.06 ± 4.25	0.930
Disc height	1.07 ± 0.29	1.03 ± 0.27	0.628
Contralateral foramen area	0.61 ± 0.15	0.77 ± 0.24	0.030
Contralateral canal area	1.04 ± 0.35	0.96 ± 0.31	0.428
Postoperation			
Lumbar lordosis	44.18 ± 10.86	43.4 ± 13.16[a]	0.849
Surgical segmental angle	7.77 ± 4.82[a]	8.55 ± 3.84[a]	0.533
Disc height	1.37 ± 0.22[a]	1.35 ± 0.22[a]	0.693
Contralateral foramen area	0.51 ± 0.11[a]	1.20 ± 0.33[a]	< 0.001
Contralateral canal area	1.35 ± 0.42[a]	1.39 ± 0.38[a]	0.743
Change			
Lumbar lordosis	0.93 ± 10.72	3.22 ± 10.00	0.471
Surgical segmental angle	0.30 ± 0.15	0.31 ± 0.20	0.816
Disc height	0.59 ± 3.16	1.48 ± 3.70	0.441
Contralateral foramen area	− 0.09 ± 0.11	0.43 ± 0.28	< 0.001
Contralateral canal area	0.32 ± 0.26	0.44 ± 0.33	0.244
Pedicle breach by screw			
Grade 0	10	105	1.000
Grade 1	0	8	1.000
Grade 2	0	5	1.000
Grade 3	1	1	0.163

[a]Comparing with preoperative value, $P < 0.05$

Table 3 Clinical parameters between symptomatic and asymptomatic groups

	Symptomatic group	Asymptomatic group	*P* value
Preoperation			
VAS (back)	5.1 ± 0.9	4.5 ± 1.6	0.077
VAS (leg)	5.3 ± 1.4	5.3 ± 1.6	0.884
JOA	14.0 ± 2.0	15.2 ± 3.6	0.292
ODI	47.6 ± 14.0	55.5 ± 14.0	0.075
Final follow-up			
VAS (back)	0.9 ± 0.8[a]	0.8 ± 1.1[a]	0.787
VAS (leg)	0.9 ± 1.8[a]	0.8 ± 1.2[a]	0.839
JOA	26.3 ± 2.3[a]	26.9 ± 2.8[a]	0.482
ODI	6.0 ± 4.3[a]	6.0 ± 7.6[a]	0.980

[a]Comparing with preoperative value, $P < 0.05$

factor is clinically required for precise prediction and early diagnosis of this complication.

Exiting nerve root compression by foramen stenosis is one important reason of neurological symptom [13], thus contralateral foramen decompression is crucial for relieving radiculopathy [4, 14, 15]. However, unilateral-approach microendoscopy-assisted MIS-TLIF can only achieve direct decompression to lateral recess but not foramen contralaterally. Thus, relieving contralateral foramen stenosis relies on indirect decompression [14, 16], namely increasing CFA following insertion of proper interbody cage. In our study, patients suffering from postoperative contralateral radiculopathy have less CFA compared with asymptomatic cases before surgery; meanwhile, exiting nerve root is more vulnerable to be compressed by shrinked foramen [17]. Once postoperative foramen stenosis is worsened due to the failure of indirect decompression, contralateral radiculopathy can occur [18]. This research firstly demonstrates that preexisting contralateral foramen stenosis is the risk factor of postoperative contralateral radiculopathy, which is similar with previous studies [6, 10]. According to the predictive threshold based on preoperative CFA values at L4–5 level, our study demonstrates that if it is not larger than 0.76 cm^2, the possibility of postoperative contralateral radiculopathy would dramatically increase. Therefore, some prophylactic measures are required to reduce this complication, even for cases revealing no contralateral neurological symptoms preoperatively. Firstly, restoration of DH should be enough to acquire sufficient indirect decompression of contralateral foramen; meanwhile, interbody cage with proper height needs to be placed centrally at surgical level and appropriate intervertebral compression also requires to be guaranteed. Secondly, if indirect decompression of contralateral foramen seems insufficient, direct decompression of foramen at opposite side is necessitated [4].

For unilateral open TLIF, segmental lordotic angle of surgical level is one risk factor for contralateral radiculopathy because its excessive increase postoperatively can worsen contralateral foramen stenosis and further compress exiting nerve root [6, 10, 14]. While in this study, SSA does not have any effect on this complication, possibly because of its relatively less increase following moderate percutaneous intervertebral compression. This result implies that appropriate restoration of segmental lordosis during microendoscopy-assisted MIS-TLIF may contribute to indirect decompression of contralateral foramen. Consistent with other study [6], LL and DH in the present study are proved not to be associated with this complication. Similarly, no correlation is found between our new assessment parameters (CCA, decompression method, screw breach) and postoperative contralateral radiculopathy. These results indicate that all those parameters exert no influence on postoperative compression aggravation of contralateral exiting nerve root.

In the present study, the main cause of postoperative contralateral radiculopathy is aggravation of contralateral foramen stenosis, which can be induced by superior or ventral subluxation of superior articular process in inferior vertebra, as shown in this series [19]. Additionally, extruded nucleus pulposus and screw malposition can also trigger postoperative contralateral radiculopathy due to mechanical compression and evident irritation on exiting nerve root. Based on this research and other associated literatures [9, 10, 14, 20, 21], some other prophylactic measures are recommended to prevent postoperative contralateral radiculopathy: for degenerative lumbar spondylolisthesis, proper distraction on operated level using contralateral pedicle screw-rod construct prior to interbody cage implantation is required; surgical manipulation around contralateral nerve root ought to be meticulous and any mechanical compression on contralateral nerve root, including local hematoma and free bony fragment should be avoided. This study also reveals that postoperative contralateral radiculopathy has no extremely negative and irreversible prognosis after at least 3 months follow-up, despite its relatively high incidence. Patients in both symptomatic and asymptomatic groups have comparable clinical scores at final follow-up, which improved significantly compared with baseline. Meanwhile, most contralateral radiculopathy cases can acquire significant symptom relief after conservative medication with no need of revision surgery.

However, several limitations of this study should be acknowledged. Firstly, only cases with lesion at L4–5 level are included and, thus, the predicted threshold is only useful in this level. Secondly, the effects of other possible risk factors may be underestimated due to the small sample size, especially in symptomatic group. Thirdly, radiographic parameter measurements can be affected by different body positions, leading to potential bias of results [22]. Lastly, follow-up period of some cases is short, so long-term influence on clinical outcome associated with this complication is unclear and needs thorough assessment. Therefore, high-quality studies with better design and larger sample size are needed to further justify our findings.

Conclusions

Postoperative contralateral radiculopathy following microendoscopy-assisted MIS-TLIF at L4–5 level is not rare and should draw surgeons' attention. Preoperative contralateral foramen stenosis is the risk factor of this complication. If CFA evaluated by preoperative CT is not larger than 0.76 cm^2, the probability of postoperative contralateral radiculopathy would be high. Thus, prophylactic measures, including both sufficient indirect and direct decompression of contralateral foramen, are recommended to prevent postoperative contralateral radiculopathy.

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Compliance with ethical standards

Conflict of interest No benefit in any form has been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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