Endoscopic transforaminal lumbar interbody fusion in the treatment of degenerative lumbar spondylolisthesis

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Research

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Abstract

Background Transforaminal lumbar interbody fusion (TLIF) has been widely accepted as a standard treatment option for the patients with lumbar spondylolisthesis with good clinical outcomes. However, some patients suffered from the back pain postoperatively. With the development of minimally invasive endoscopic methods in spine surgery, the current trend of evolution lumbar spinal surgery has been toward endoscopic procedures.

Purpose The purpose of this study was to evaluate the clinical outcomes and efficacy of endoscopic transforaminal lumbar interbody fusion (ELIF) in the treatment of degenerative lumbar spondylolisthesis by compare to the standard transforaminal lumbar interbody fusion (TLIF).

Methods A total of 93 patients with lumbar spondylolisthesis who had surgery from February 2016 to January 2018 were categorized into different groups depending on the procedure by ELIF or TLIF. The ELIF and TLIF procedures was performed, and the clinical outcomes of blood loss, operation times, hospital stay days, pain index, ODI score, the spondylolisthesis rate and reduction rate, and the disk height and intervertebral foramen height were recorded.

Results In ends 86 cases had follow-up at least one year and seven cases lost, and the follow-up rate and followed time were no difference between two groups ($P > 0.05$). The operational time was longer in ELIF than TLIF ($P < 0.01$).The hospital days and blood loss were significant less in endoscopic group than TLIF ($P < 0.01$). The pain index and ODI score, the spondylolisthesis rate and reduction rate, and the disk height and intervertebral foramen height were better than preoperational ($P < 0.01$), and there were no difference between two groups ($P > 0.05$). All patients achieved spinal fusion with no cases of cage extrusion, and no infection, and no dural tear of cerebrospinal fluid leakage complication. There were one case of radiculitis (man) at endoscopic group. CT-myelogram revealed the radiculitis patients had normal radiologic findings, and the patient was recovered by neurotrophy drugs and functional exercises after 3 months.

Conclusions Endoscopic lumbar decompression and interbody fusion procedures was an effective and safe measure in the treatment of the lumbar spondylolisthesis. Compare to open interbody fusion techniques, endoscopic lumbar interbody fusion was a minimally invasive surgery with less bold loss and earlier postoperative recovery.

Background

With the development of minimally invasive endoscopic methods in spine surgery, the current trend of evolution lumbar spinal surgery has been toward endoscopic procedures.[1–4] Transforaminal lumbar interbody fusion (TLIF) is a well-established technique for decompression and fusion by exposure of kambin triangle to access the disc space. Compared to posterolateral fusion which uses a midline exposure and to decompression and fusion, TLIF has the advantages of minimally invasive by just a unilateral facetectomy.[5] However, the procedure for exposure of Kambin triangle need to unilateral

facetectomy in TLIF, that damage the normal posterior structure of spine. Through the Kambin triangle, transforaminal endoscopic lumbar spine surgery has become population for its advantages.[6–9] Transforaminal endoscopic lumbar surgery has become attractive procedures for lumbar spine because it not only don't damage the spinal structures but also safe procedures with less trauma and faster recovery.[10, 11]

Endoscopic lumbar interbody fusion (ELIF) is a minimally invasive for decompression and interbody fusion through the Kambin triangle.[10, 12, 13] Kambin triangle is an anatomic safe corridor to the intervertebral disc space bounded medially by the traversing nerve root, laterally by the exiting nerve root, and caudally by the pedicle. For TLIF, exposure of Kambin triangle is accomplished by facetectomy, the inferior articular process is removed, and the par is maintained to protect the dorsal root ganglion on cage insertion. Although the ELIF performed the decompression and interbody fusion through the Kambin as TLIF, it preserved the facet joint intact by the endoscopic techniques. The pedicle screw insertion in ELIF was also a minimally invasive by percutaneous techniques, it preserved the musculotendinous attachments and the integrity of lumbar fascia.[14]

ELIF procedures just as TLIF with the transforaminal approach, and the difference was maintain the facet intact and preservation of musculotendinous attachments. [5, 15] Sufficient decompression with no retraction on the nerve ganglion, less postoperative pain and earlier functional recovery were the major advantages of the ELIF.[16–18, 14, 19] The purpose of this study was to evaluate the clinical outcomes and efficacy of ELIF in the treatment of degenerative lumbar spondylolisthesis by compared to TLIF in our clinical.

Materials And Methods

From February 2016 to January 2018, a total of 93 consecutive patients of degenerative spondylolisthesis (grade I-II) were had ELIF and TLIF because of back and leg pain. Ninety-three patients initially fulfilled the study criteria, and seven patients were lost to follow-up. Of the remaining 86 patients available for analysis, 42 cases had ELIF (group ELIF, included 20 men and 22 women with an average age of 51.73 ± 5.48 years), and 44 patients had TLIF (group TLIF, included 23 men and 21 women with an average age of 52.16 ± 5.39 years). The inclusion criteria were adult degenerative spondylolisthesis (grades I–II) which only one or two level fusion (L3/4, L4/5, or couple levels). Exclusion criteria included pathologic conditions of the lumbar spine (trauma, tumor, or infection). The two groups had similar age and sex distribution, level of pain, and the pain history (Table 1).

Table 1 Patients general data (Means ± SD)

Group	Gender		Older	Level			History
	Male	Female	(years)	L3/4	L4/5	L3/4,4/5	(years)
ELIF(42)	20	22	51.73 ± 5.48	11	19	12	3.16 ± 1.52
TLIF(44)	23	21	52.16 ± 5.39	10	21	13	3.28 ± 1.37

There was no significant difference between two groups (P > 0.05)

Surgical procedures

Under general anesthesia, all patients had nerve decompression, disc removed, bone graft and cage which packed with bone graft were inserted in the interbody space, and pedicle screw instrumentation was used. The TLIF procedure was performed in the standard fashion as reported in previous studies, and the ELIF procedures was performed under C-arm image step by step.[13,20,19] The endoscopic discectomy and nerve decompression was performed at first. After nerve decompression accomplished, the working tube for cage insertion was placed in the disc space, and rechecked by the endoscopic to ensure nerve and dual was safe and working tube was on the good position for subtotal discectomy and endplate preparation. Then, subtotal discectomy and endplate preparation was accomplished using a combination of straight and angled curettes and rasps. Then bone graft and expandable cage which packed with bone graft were inserted in the disc space. The expandable cage are inserted at a contracted height to allow safer entry into the disc space with less chance for impingement of the traversing and exiting nerve roots. The cage is then expanded in the interbody space to restore disc height and obtain interbody cage purchase. Maintaining the pars protects the exiting nerve root and dorsal root ganglion during cage insertion. Third, percutaneous pedicle screw were placement and compression be performed. Thorough release of the disc space and restoration of disc height aids in reduction of spondylolisthesis. If reduction of a spondylolisthesis is still desired, the rods can be fixed into the caudal vertebrae, and the pedicle screws from the cranial vertebra can be reduced to the rod. Fluoroscopic guidance should be used to ensure thorough discectomy and endplate preparation, bone graft and cage insertion, and percutaneous pedicle screw placement (Figure 1,2). Brace support was recommended for 4–6 weeks after surgery.

Figure 1 Male patients of 42 years old had the procedures of ELIF for the spondylolisthesis of L3/4 and L4/5. The figures show the cage position and pedicle screws was good position. The patients had good clinical outcomes and bone fusion at 12 months after operation. A1-A4 shows the endoscopic discectomy and cage insertion in L4/5 disc space. B1-B5 shows the endoscopic discectomy and cage insertion in L3/4 disc space. A5 and B5 shows the lumbar back skin of patient on pre- and post-operation. C1-C4 shows the patient pre-opertion images of x-ray and MRI. C5 and C6 shows the post-operation radiographs of lumbar spine.

Critical of clinical outcomes

Before surgery and at the one year follow-up, operation times, blood loss, hospital stays, pain (Visual Analog Scale, VAS), functional disability (Oswestry Disability Index, ODI), and Mac Nab criteria were quantified in follow-up. All patients had preoperative and post-operative plain radiographs, computed tomography (CT) scans, and magnetic resonance (MR) images. The focus was to evaluate five radiographic characteristics at follow-up: (1) percentage of slip and percentage of reduction, (2) height of disk space and intervertebral foramen, (3) cage position, and (4) fusion rate. Bone fusion was determined on the criteria of continuity of trabecular pattern, and the fusion rate assessed using CT-scan reconstruction.

Figure 2 Female patients of 39 years old had the procedures of ELIF for the spondylolisthesis of L4/5. The figures show the cage position and pedicle screws was good position (A, C ,D), nerve had better decompression (B), and the skin incision was small (E).

Statistical analysis

All measurements were performed by a single observer and are expressed as means ± SD. Using the SPSS 17.0 statistics software, classic t-test and chi-square test were performed.

Results

There was no intraoperative death in this series. In ends 86 cases had follow-up at least one year and 7 cases lost, and the follow-up rate was 93.3% (42/45) in the ELIF group and 91.7% (44/48) in the TLIF group. The followed time from 14 to 24 months (average 18 months), and average 18.42 ± 1.13 months on ELIF and 18.57 ± 1.24 months on TLIF ($P > 0.05$).

The operational time was longer in ELIF than TLIF (138.62 ± 30.54 minutes versus 87.84 ± 20.73 minutes, $P < 0.01$).The hospital days were significant less in ELIF group than TLIF (4.12 ± 1.64 days versus 9.36 ± 1.57 days, $P < 0.01$). The average blood loss were significant less in endoscopic group than TLIF (115.72 ± 20.83 mL versus 286.71 ± 50.68 mL, $P < 0.01$).

Table 2 Follow up time and operation date of patients (Means ± SD)

Group	Follow up[#]		Operation time[*]	Hospital days[*]	Blood loss[*]
	Rate	time	(Minutes)	(Days)	(mL)
ELIF	93.3% (42/45)	18.42 ± 1.13	138.62 ± 30.54	4.12 ± 1.64	115.72 ± 20.83
TLIF	91.7% (44/48)	18.57 ± 1.24	87.84 ± 20.73	9.36 ± 1.57	286.71 ± 50.68

Note: [*], significant difference ($P < 0.01$). [#], no significant difference($P > 0.05$)

The pain index of VAS improved from 7.56 ± 1.13 to 1.84 ± 0.89 ($P < 0.01$) in ELIF patients and improved from 7.82 ± 1.09 to 1.45 ± 0.91 ($P < 0.01$) in TLIF patients. The ODI improved from 72.48 ± 15.63 preoperatively to 21.37 ± 11.82 ($P < 0.01$) postoperatively in ELIF, and from 75.81 ± 18.49 preoperatively to 24.65 ± 17.36 ($P < 0.01$) postoperatively in ELIF. On the basis of Mac Nab criteria, there were 27 cases of excellent, 10 cases of good, 5 cases of general, and 0 cases of poor in ELIF group; there were 28 cases of excellent, 11 case of good, 5 case of general, and 0 cases of poor in TLIF group. The Mac Nab criteria in all patients was 84.1% of good or excellent (83.5% in PLIF and 84.6% in TLIF, $P > 0.05$).

The average of spondylolisthesis was 30.18 ± 7.24 % in preoperatively and 5.37 ± 2.14 % in postoperatively in ELIF ($P < 0.01$), and from 31.46 ± 8.31 % to 5.44 ± 2.76 % in TLIF ($P < 0.01$). The average of reduction rate was 75.23 ± 6.47 % in ELIF and 77.48 ± 5.98 in TLIF. The spondylolisthesis rate and reduction rate were similar between two groups ($P > 0.05$).

The average disk space height increased from preoperative 6.85 ± 2.36 mm in preoperatively to 11.27 ± 1.29 mm in postoperatively in ELIF, and from 6.91 ± 2.54 mm to 11.42 ± 1.63 mm in TLIF. The mean foramen height increased form 13.24 ± 1.72 mm in preoperatively to 16.75 ± 1.17 mm in postoperatively in ELIF, and from 13.41 ± 1.29 mm to 17.21 ± 1.73 mm in TLIF. The disk height and intervertebral foramen height were better than preoperational ($P < 0.01$), and there were no difference between two groups ($P > 0.05$).

Table 3 Clinical results date of patients (Means ± SD)

Group	ELIF$^{\$}$		TLIF$^{\$}$	
	Preoperative*	Postoperative*	Preoperative$^{\#}$	Postoperative$^{\#}$
VAS	7.56 ± 1.13	1.84 ± 0.89	7.82 ± 1.09	1.45 ± 0.91
ODI	72.48 ± 15.63	21.37 ± 11.82	75.81 ± 18.49	24.65 ± 17.36
Spondylolisthesis (%)	30.1 ± 7.2	5.3 ± 2.1	31.4 ± 8.3	5.4 ± 2.7
Disk space height (mm)	6.85 ± 2.36	11.27 ± 1.29	6.91 ± 2.54	11.42 ± 1.63
Foramen height(mm)	13.24 ± 1.72	16.75 ± 1.17	13.41 ± 1.29	17.21 ± 1.73

Note: $^{*,\#}$, significant difference ($P < 0.01$). $^{\$}$, no significant difference ($P > 0.05$)

All patients achieved spinal fusion with no cases of cage extrusion, and no infection, and no cerebrospinal fluid leakage complication. There were three cases of loss of disk space height and foramen height between the initial and final postoperative X-rays suggestive of cage subsidence over time. There were one case of radiculitis (man) at endoscopic group. CT-myelogram revealed the radiculitis patients had normal radiologic findings, and the patient was recovered by neurotrophy drugs and functional exercises after 3 months.

Discussion

Endoscopic and open procedure of lumbar spine has its advantages and limitations, and the decision about which been performed should mainly be based on the pathologic features of the lumbar.[21–23] Degenerative lumbar spondylolisthesis in adults is characterized by the loss of disk height across the affected segment with sagittal translational and is often coupled with rotational deformity.[5] The goal of the surgical treatment of spondylolisthesis was stabilization of the motion segment, decompression of neural elements, reconstitution of disk space height, and restoration of sagittal plane translational and rotational alignment.[24, 25] The endoscopic can provide a good surgical outcome for decompression with removing the pathogenic structures by minimal invasive procedures than open techniques.[20] With the data of this cases, the nerve decompression and lumbar interbody fusion reconstruction results were no difference between two methods. However, the patients with endoscopic procedures have less blood loss and faster recovery than open techniques.

Although surgical decompression alone often improves symptoms in the patients with degenerative spondylolisthesis, numerous studies have demonstrated the benefits of concomitant fusion with instrumented.[26, 27] The ability to reconstruct the lumbar spine after disc evacuation is a radical surgical option due to interbody fusion provide solid fixation of spinal segments while maintaining load-bearing capacity and proper disc height. For this reason, the good clinical results of spondylolisthesis not only depend on the sufficient nerve decompression, but also depend on restoration of lumbar lordosis and bone fusion. The original technique of lumbar interbody fusion was modified, transforaminal lumbar interbody fusion technique was developed, and the endoscopic lumbar interbody fusion procedures has been adopted.[15, 13] With the pedicle screw instrumentation, the endoscopic interbody fusion preserve the load-bearing capacity of the spine, restore the sagittal plane alignment, immediately produces a biomechanically stable postoperative spine, and use the compressive loading on the bone to enhancing the opportunity for arthrodesis.[28, 13] The results of this series cases show the rate of bone fusion was no difference between two methods, which means the interbody fusion can be accomplished under endoscopic procedures and got satisfied results.

Although lumbar spine spondylolisthesis presents a significant challenge for spinal surgeon when adopted the endoscopic other than traditional methods, the endoscopic was safe and effective for spondylosis patients as the results of this study. TLIF was recommended for lumbar spondylolisthesis because it is a quick and safe operation resulting in neurological improvement from removed the pathologic tissue and reconstruction the lumbar spine by direction view.[29][13] TLIF procedures had the facetectomy to performances the decompression and interbody fusion. ELIF maintain the facet joint intact, need more time to accomplish the nerve decompression and interbody fusion by endoscopic procedures.[30, 20] After performed the endoscopic procedures, ELIF need to placement the pedicle screws by percutaneous which need more time than open surgery. Then, the ELIF procedures had more operation times than TLIF in this series cases.

Endoscopic or open surgery has its superiority, as well as its disadvantages.[8, 31] The main shortage of open procedures was the facetectomy, and the main disadvantage of endoscopic need more times to complete the operation at initial cases. The advantages in open surgery was direct view and shot time of operation, and in endoscopic was minimally invasive and maintain the fact joint intact.[32, 4] For the block of iliac crest, it is difficult to performe ELIF in the segments L5–S1, and it is still a thorny problem for these patients using ELIF at now. Severe spondylolisthesis is the most challenging pathology of the lumbar spine to treat surgically because the risks of hemorrhage, and aggravation of neurological deficit are all relatively high, especially for the endoscopic procedures. Then, open surgery may be appropriate as effective and safe procedure treatment for severe spondylolisthesis than endoscopic procedures.

Conclusion

Based on the results of this study, endoscopic lumbar decompression and interbody fusion procedures was effective and safe measure in the treatment of the lumbar spondylolisthesis. Compare to open interbody fusion techniques, endoscopic lumbar interbody fusion was minimally invasive surgery with less bold loss and earlier postoperative recovery.

Declarations

Ethical approval and consent to participate

This study was approved by the hospital ethics committee of the First People's Hospital of Zhaoqing, Zhaoqing City, Guangdong Province, and all patients signed had informed consent.

Consent for publication

Author Denglu Yan, Zaiheng Zhang, and Zhi Zhang all agree to publication.

Availability of data and materials

The datasets are available under reasonable request.

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Conflict of Interest

Author Denglu Yan, Zaiheng Zhang, and Zhi Zhang declare that they have no conflict of interest.

Authors' contributions

DY participated in the design of the study and drafted the manuscript. ZZh participated in the design of the study and coordination and helped to draft the manuscript. ZZ participated in the design of the study

and performed the statistical analysis. All authors read and approved the final manuscript.

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Figures

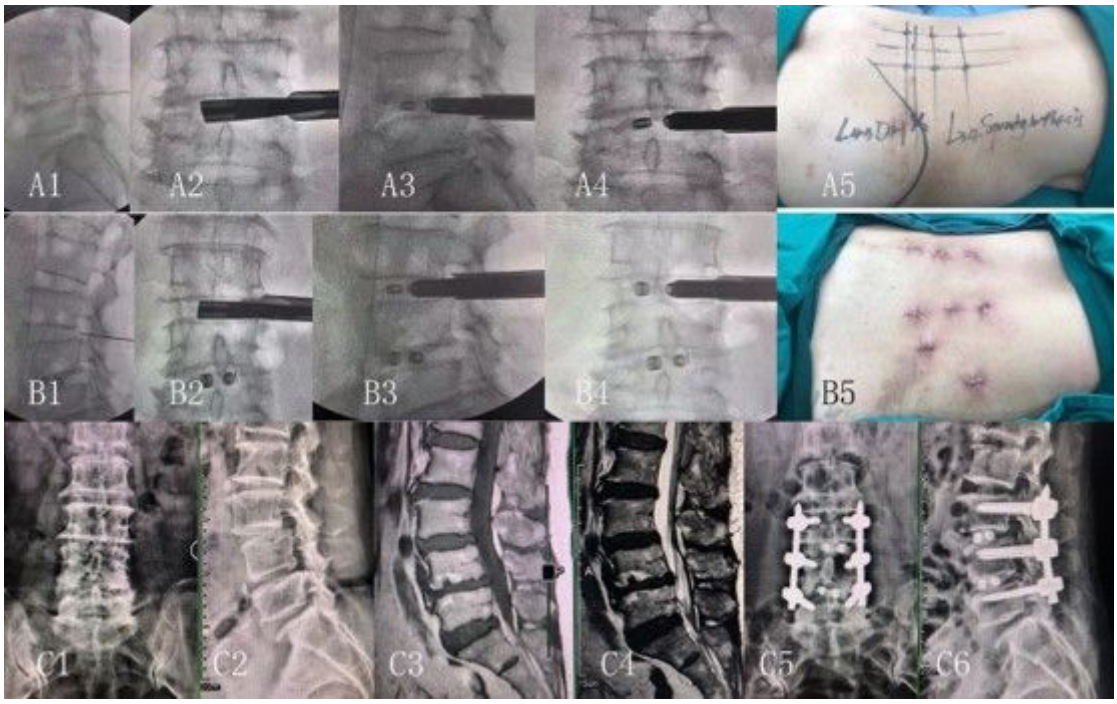

Figure 1

Male patients of 42 years old had the procedures of ELIF for the spondylolisthesis of L3/4 and L4/5. The figures show the cage position and pedicle screws was good position. The patients had good clinical outcomes and bone fusion at 12 months after operation. A1-A4 shows the endoscopic discectomy and cage insertion in L4/5 disc space. B1-B5 shows the endoscopic discectomy and cage insertion in L3/4 disc space. A5 and B5 shows the lumbar back skin of patient on pre- and post-operation. C1-C4 shows the patient pre-opertion images of x-ray and MRI. C5 and C6 shows the post-operation radiographs of lumbar spine.

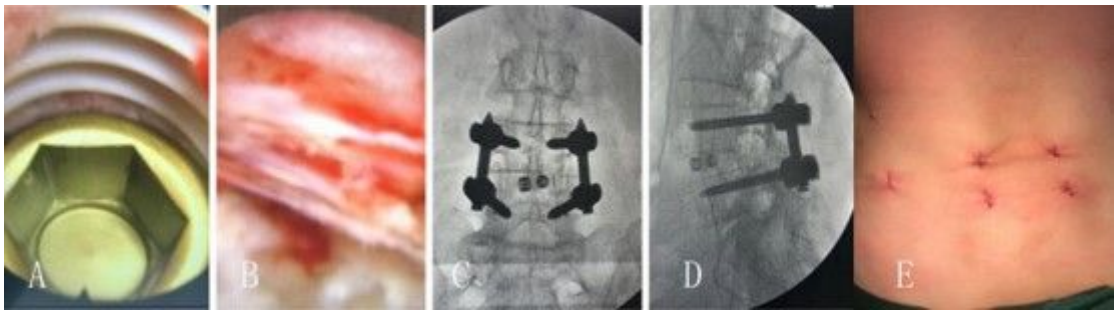

Figure 2

Female patients of 39 years old had the procedures of ELIF for the spondylolisthesis of L4/5. The figures show the cage position and pedicle screws was good position (A, C ,D), nerve had better decompression (B), and the skin incision was small (E).