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Original Article

Endoscopic interlaminar lumbar discectomy: How to decrease the learning curve

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ABSTRACT

Background: Herniated lumbar disc is a common cause of lumbosacral pain. Endoscopic interlaminar lumbar discectomy (ILD) is a well-established technique that provided comparable results to micro-discectomy. The aim of the study is to describe the learning curve of endoscopic ILD and explore measures that could improve effectiveness and decrease blood loss and operative time with accumulation of reasonable experience.

Methods: This retrospective cohort study included 65 patients presenting with symptomatic herniated lumbar disc who underwent endoscopic ILD. Patients were divided into two groups: Group I (standard technique) and Group II (modified technique). Collected data included patients' age, gender, preoperative manifestations, visual analog score (VAS) for pain, Oswestry Disability Index (ODI), disc level, operative time, intraoperative blood loss, complications, and follow-up data at 1, 6, and 12 months postoperatively. Primary outcomes included total operative time, amount of intraoperative blood loss, and post-operative improvement in pain. Secondary outcomes included intraoperative complications, rate of conversion to open surgery, and recurrence.

Results: Post-operative VAS and ODI improved significantly in both groups. Mean total surgical time and intraoperative blood loss were significantly lower in Group II compared to Group I ($P < 0.001$). The learning curves for operative time and intraoperative blood loss were shallow in Group I, and almost flattened in Group II. Complications were recorded in only three cases, and no symptomatic recurrences were reported.

Conclusion: The learning curve of endoscopic ILD was shallow with standard technique, indicating difficulties in mastering the procedure. The proposed modified technique helped reaching the required level of proficiency in the early phase of the curve, providing a significant reduction in operative time and blood loss, with comparable effectiveness and safety as the standard technique.

Keywords: Disc herniation, Interlaminar discectomy, Learning curve, Neuroendoscopy

INTRODUCTION

Disc prolapse of the lumbosacral region is one of the most commonly encountered conditions in neurosurgery. Surgical management largely contributes to alleviation of symptoms in selected indicated patients.[13] However, surgical intervention has been associated with scarring of the epidural space in approximately 10% of patients. This complication may evolve during operative steps, including dural sheath retraction and occasional partial resection of lamina and facet joints.[7,20,26,31]

The introduction of endoscopy into surgical fields provided a means for less invasive techniques, allowing better visualization of the surgical field, smaller incisions, paraspinal muscle splitting, and shorter hospital stays.[23,24,27,29] Two main endoscopic techniques of discectomy have been developed: The interlaminar lumbar discectomy (ILD) and the transforaminal approaches.[25,27] Each technique has its own advantages and drawbacks. The interlaminar approach provided superior results in discs that are calcified,[17,22] herniating,[9] migrating,[10] or recurrent[19,28,32] as well as in cases of foraminal stenosis.[34,39]

Although microscopic discectomy is still the gold standard technique for surgical management of disc prolapse, endoscopic techniques are promising alternatives that are increasingly used and provided comparable results to microsurgery.[14,26,27] Endoscopic techniques require a certain amount of experience that can be gained by performance of the procedure on convenient number of patients, a process known as the learning curve.[2,3]

During an early phase of learning curve, improvement in performance is observed with increased number of performed surgeries. A plateau phase then follows where the procedure is well mastered by the surgeon and higher number of performed cases will result in minimal change in quality of performance. The number required to reach the plateau phase differs from one procedure to another, and it is affected by the surgeon's prior experience in similar techniques.[1,38]

Despite being a well-established technique, few studies assessed the learning curve of ILD, and most of them provided controversial reports. The present study was conducted to describe the learning curve of endoscopic ILD and to explore measures that could improve effectiveness and decrease both blood loss and operative time with the progress of experience.

MATERIALS AND METHODS

Study design, settings, and ethical considerations

This retrospective cohort study was conducted on 65 patients presenting with symptomatic herniated lumbar disc and operated through endoscopic inter laminar approach, at Tanta University Hospitals during the period from October 1, 2015, to November 30, 2018. Ethical approval was obtained from the Institutional Review Board, Faculty of Medicine, Tanta University. Confidentiality of the patients' data was maintained by assigning code numbers to patients that were known only by the researchers.

Eligibility criteria

The present study included patients with symptomatic herniated lumbar disc for whom endoscopic ILD was indicated. The indication for surgery was based on radicular pain response and/or existing neurologic deficits. Magnetic resonance imaging 1.5 Tesla was obtained for all patients.

Data collection

The patients' data were thoroughly reviewed. The collected data included patients' age, sex, presenting manifestations, preoperative levels of visual analog score (VAS) for pain, and Oswestry Disability Index (ODI) as well as level of the herniated lumbar disc. In addition, operative details, including total operative time, the amount of intraoperative blood loss, and complications, were recorded. Data of follow-up at 1, 6, and 12 months postoperatively were collected as regard VAS, ODI, and symptomatic recurrence.

Surgical technique

In the current study, patients were divided into two groups according to the chronological order of the surgery. Group I was operated upon using the standard technique of endoscopic ILD, while a modified technique was used in Group II.

All patients were operated on using the EasyGo® endoscopic system (Karl Storz company, Tuttlingen, Germany) under general anesthesia with local lidocaine infiltration. All patients in Group I were positioned prone on Wilson frame. After initial sterilization of the skin, a spinal needle was inserted in place to confirm the level under fluoroscopic guidance [Figure 1a]. No specific medications to reduce the intraoperative bleeding were used in Group I. Surgical draping was done and skin incision 2 cm paramedian and 0.5 cm away from the midline was performed. Incision of the lumbar fascia was followed by local infiltration with lidocaine. Muscle splitting was achieved using successive tubular dilators of the system till reaching the target interlaminar space, which was confirmed by intraoperative fluoroscopy [Figure 1b and c].

The technique time-consuming steps were: Necessity to rongeur more from lamina to obtain full view of the nerve displaced by the offending disc, troublesome epidural bleeding requiring frequent suctioning, and necessity to introduce the least instrument set to keep the working channel less crowded. In Group II, these issues were overcome by (1) keeping the patient at knee-chest position with hip flexed to widen the interlaminar space and posterior disc height; (2) intravenous infusion of the anesthetic medication dexmedetomidine HCL (Precedex ®), an $\alpha 2$-adrenergic receptor agonist with a clinically proven effect (26) in reduction of intraoperative bleeding, (aiming to reduce epidural bleeding); and (3) rotation of the lenscope 180 degrees in the working sheath to obtain both better view of the nerve root and more space for surgical instruments [Figure 1d and e].

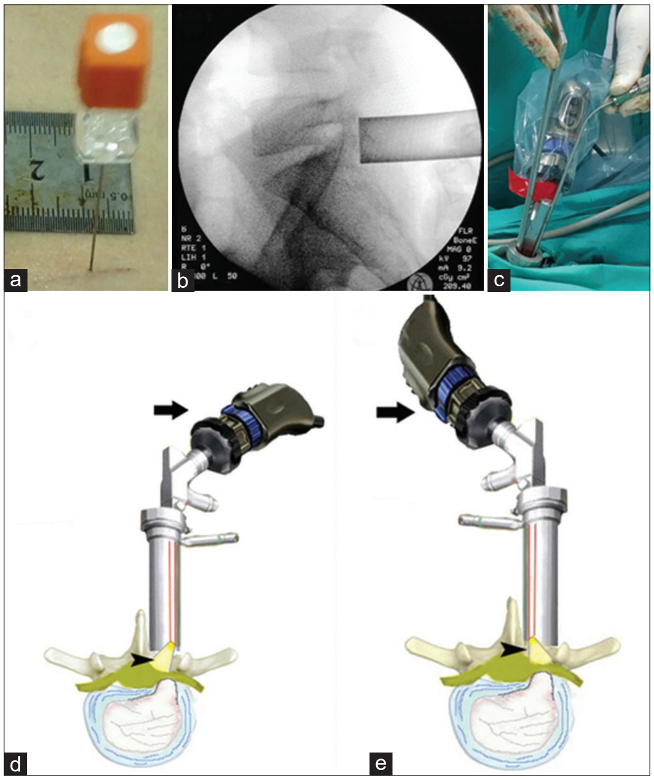

Figure 1: (a) Spinal needle is inserted for fluoroscopic level verification. (b) Intraoperative fluoroscopy confirming proper sheath location following dilatation. (c) The usual surgeon position ipsilateral to left level disc with an indispensable need for extra-long instruments. (d) A diagram showing the ipsilateral camera-lens complex yields good illumination (black arrowhead) but not the best for a far lateral disc. (e) An illustration showing the contralateral camera lens complex yields superior light (black arrowhead) and a better view for the extreme lateral disc herniation. Note the camera head is rotated up 180 degrees to match the surgeon side field (black arrow). Some camera firmware can rotate the image on display without rotation of the camera body.

Drilling of the lower part of upper lamina was done to fashion a keyhole corridor to access the root and corresponding disc. Ligamentum flavum was resected to reveal the nerve root that was retracted medially, and disc removal with rongeur was accomplished by standard methods [Figure 2a-h].

Outcomes

The primary studied outcomes included total operative time, amount of intraoperative blood loss, post-operative pain decline, and post-operative MRI [Figure 2d and h]. The pre- and post-operative VAS and ODI scores were used for pain functional assessment.[12,15] The studied secondary outcomes included intraoperative complications, rate of conversion to open surgery, and symptomatic recurrence during 12-month follow-up.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences software, version 26.0. Qualitative variables were represented as number and percentage and associations were tested using Pearson's Chi-square test for independence, Fisher's exact test, or Fisher-Freeman-Halton exact test as appropriate. All quantitative variables followed normal distribution. They were summarized as means and standard deviations, and differences between the groups were assessed using independent samples *t*-test. Pearson's correlation was conducted to examine relationship between experience and outcome measures. Multiple regression analysis was conducted to examine the effects of the disc level and the surgical technique on the total surgical time and intraoperative blood loss. $P < 0.05$ was adopted for significant results.

RESULTS

The mean age was 42 ± 9 years in Group I and 43 ± 8 years in Group II with no significant difference ($P = 0.608$). In both groups, male patients outnumbered the female patients (63.6% vs. 36.4% in Group I; and 62.5% vs. 37.5% in Group II), with no significant difference ($P = 0.924$). Motor weakness and radicular pain were the most common manifestations in both groups. Group I had significantly higher percentage of patients with motor weakness than Group II (100% vs. 84.4%, respectively; $P = 0.024$). On the other hand, Group II had a significantly higher percentage of patients with radicular hypoesthesia (81.3% vs. 54.5%, respectively; $P = 0.021$). The mean preoperative VAS was similar in the two groups (VAS = 7 ± 1, $P = 0.681$). There was no significant difference in pre-operative pain ODI between the two groups ($P = 0.318$). Nearly half the cases in Group I had disc prolapse at L5-S1 level, while nearly half the cases in Group II had disc prolapse at L4-5 level, with no significant difference ($P = 0.179$) [Table 1].

The mean total operative time was significantly lower in Group II compared to Group I (50 ± 4 vs. 68 ± 13 min, respectively; $P < 0.001$). Moreover, the mean amount of intraoperative blood loss was also significantly lower in Group II compared to Group I (42 ± 7 vs. 50 ± 10, respectively; $P < 0.001$). Wound infection was encountered in two cases in Group I and only one case in Group II ($P = 1.000$). Follow-up of patients showed an improvement in VAS and ODI scores at 6 months and further decrease at 12 months in the two groups. However, no significant difference was detected between the two groups at 1, 6, or 12 months postoperatively ($P > 0.05$). No recurrences were detected in patients during the follow-up period of 12 months [Table 2].

[Table 3] shows the degree and strength of correlation between surgical team experience (number of operated cases) and operative and post-operative outcomes. There was a strong, significant, negative correlation (r = –0.909, $P < 0.001$) between the number of patients and the total time of surgery in Group I (i.e., time decreased with increased number of patients). The correlation between surgical team experience and surgical time in Group II was weak and non-significant (r = –0.236, $P = 0.193$), indicating that increased number of cases did not affect the surgical time in this group. A moderate, significant, and negative correlation existed between the number of patients and amount of intraoperative

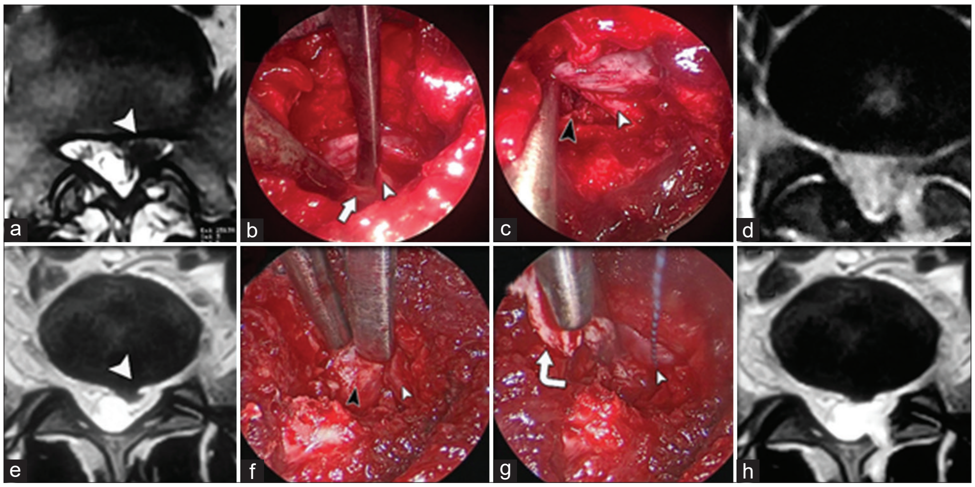

Figure 2: Same patient (a) pre-operative axial MRI showing left L5S1 herniated disc. (b) Intraoperative image with endoscope sheath position as shown in Figure 1d, the dissector is gently retracting the S1 root (white arrowhead) and passed underneath the remaining part of ligamentum flavum (white arrow). (c) Camera-lens complex in contralateral position [as shown in Figure 1e] showing full root path (white arrowhead) after annular incision and removal of the disc (black arrowhead). (d) Postoperative MRI is revealing adequate disc removal. Images are for another patient. (e) Axial MRI is showing L4-5 left herniated disc. (f) The L5 nerve root (white arrow) is retracted to reveal subradicular disc herniation (black arrow). (g) The nerve root (white arrow) is kept in retraction by cottonoid, followed by annulotomy and removal of the herniated disc by rongeur (curved white arrow). (h) Post-operative MRI is confirming the success of the procedure.

Table 1: Comparison of patients' demographics and pre-operative characteristics between the two studied groups (total number=65).

Parameters		**Groups**				***P*-value**
		Group I (*n*=33) (%)		**Group II (*n*=32) (%)**		
Patients' characteristics						
Age (years)	Mean±SD (range)	42±9 (25–57)		43±8 (25–58)		0.608
Gender	Female	12	36.4	12	37.5	0.924
	Male	21	63.6	20	62.5	
Pre-operative manifestations						
Diminished reflexes	Absent	33	100.0	30	93.8	0.238
	Present	0	0.0	2	6.3	
Motor weakness	Absent	0	0.0	5	15.6	0.024*
	Present	33	100.0	27	84.4	
Radicular hypoesthesia	Absent	15	45.5	6	18.8	0.021*
	Present	18	54.5	26	81.3	
Radicular pain	Absent	0	0.0	0	0.0	N/A
	Present	33	100.0	32	100.0	
Back pain	Absent	18	54.5	13	40.6	0.261
	Present	15	45.5	19	59.4	
Pre-operative VAS	Mean±SD (range)	7±1 (5–9)		7±1 (5–9)		0.681
Pre-operative pain ODI	Mean±SD (range)	70±6 (60–85)		68±8 (60–85)		0.318
Level	L3-4	1	3.0	3	9.4	0.179
	L4-5	13	39.4	18	56.3	
	L5-S1	19	57.6	11	34.4	

n: Number, SD: Standard deviation, VAS: Visual analog score, ODI: Oswestry disability index, N/A: Non-applicable, *Significant at P<0.05

Table 2: Comparison of operative details and post-operative course between the two studied groups (total number=65).

Parameters	Groups				*P*-value
	Group I (*n*=33)		**Group II (*n*=32)**		
Operative details					
Total time of surgery (minutes)	68±13 (55–95)		50±4 (45–60)		<0.001*
Intraoperative blood loss (ml)	50±10 (35–80)		42±7 (30–55)		<0.001*
Complications and management					
Wound infection	2	6.10%	1	3.10%	1.000
Follow-up					
Postoperative VAS (1 month)	3±1 (2–4)		3±1 (2–4)		0.639
Post-operative VAS (6 months)	2±0.1 (1–3)		2±1 (1–3)		0.325
Post-operative VAS (12 months)	2±1 (1–2)		1±1 (1–2)		0.538
Post-operative ODI (6 month)	23±9 (10–40)		24±4 (20–40)		0.544
Post-operative ODI (12 month)	16±7 (10–40)		14±5 (10–30)		0.103
Recurrence	0 (0.0%)		0 (0.0%)		N/A

n: Number; VAS: Visual analog score, ODI: Oswestry Disability Index, N/A: Non-applicable, *Significant at *P*<0.05

Table 3: Correlation between experience of surgical team (number of patients operated on) and VAS and ODI (total number=65).

	Number of patients	
	Group I	**Group II**
Total time of surgery (minutes)		
r	–0.909	–0.236
P	<0.001*	0.193
Intraoperative blood loss (ml)		
r	–0.712	–0.432
P	<0.001*	0.013*
Post-operative pain VAS (1 month)		
r	0.015	–0.407
P	0.935	0.021*
Post-operative pain VAS (6 months)		
r	–0.007	–0.070
P	0.969	0.705
Post-operative pain VAS (12 months)		
r	0.229	–0.212
P	0.199	0.245
Post-operative ODI (6 month)		
r	0.331	–0.118
P	0.060	0.520
Post-operative ODI (12 month)		
R	0.070	–0.194
P	0.699	0.287

VAS: Visual analog score, ODI: Oswestry Disability Index, r: Pearson's correlation coefficient, *Significant at *P*<0.05

blood loss in Group I (r = –0.712, $P < 0.001$) and Group II (r = –0.432, $P = 0.013$). A moderate correlation was noted also between experience and post-operative VAS at 1 month in Group II only (r = –0.407, $P = 0.021$). Other correlations between VAS and ODI scores with number of patients were weak and non-significant ($P > 0.05$). The learning curves for surgical time were shallow in Group I, but almost flattened in Group II [Figure 3]. On the other hand, the learning curves for intraoperative blood loss were shallow in both groups [Figure 4].

[Table 4] shows the results of multiple regression analysis that examined the effects of disc level and operative technique on total operative time and intraoperative blood loss. The modified operative technique was significantly ($P < 0.001$) associated with reduced operative time and blood loss, whereas disc level had no significant impact on them ($P > 0.05$).

DISCUSSION

The ILD has been shown to be an effective and safe surgical remedy for herniated lumbar disc.[24,26,28,29] Few studies addressed the learning curve of the procedure. Moreover, some studies included patients undergoing either ILD or transforaminal discectomy.[16,30] The present study was conducted to explore measures that could improve effectiveness and decrease blood loss and operative time with improvement of experience.

The mean operative time in our series was 68 ± 13 min in Group I and was reduced in Group II to 50 ± 4 min. This indicates that the measures adopted in the modified technique helped in reduction of the required time for ILD. These results were supported also by conducting multiple regression analysis that showed a significant association of the modified technique with operative time and intraoperative blood loss, regardless of the level of disc.

The operative time in both groups was shorter than that reported by Wang *et al.*,[35] which was 107.9 ± 20.8 min in the first ten cases and 68.5 ± 14.9 min in the second ten cases, but was closer to the third ten cases in their study (43.2 ± 12.7 min).

Xu *et al.*[36] reported similar durations to Wang *et al.*,[35] with mean operative times of 102.7 ± 17.2, 65.4 ± 11.5, and 57.4 ± 7.6 min in their sample of 36 patients who were divided chronologically into three groups. Hsu *et al.*[16] also reported a longer operative time of 86.5 ± 45.9 min in their series of endoscopic discectomy. However, this duration was for patients undergoing either transforaminal or interlaminar procedures, and the authors did not report operative time for each procedure. The mean operative time in Group II in the present study reached nearly the mean operative time described for open microdiscectomy that was 48.1 ± 9.2 min.[16]

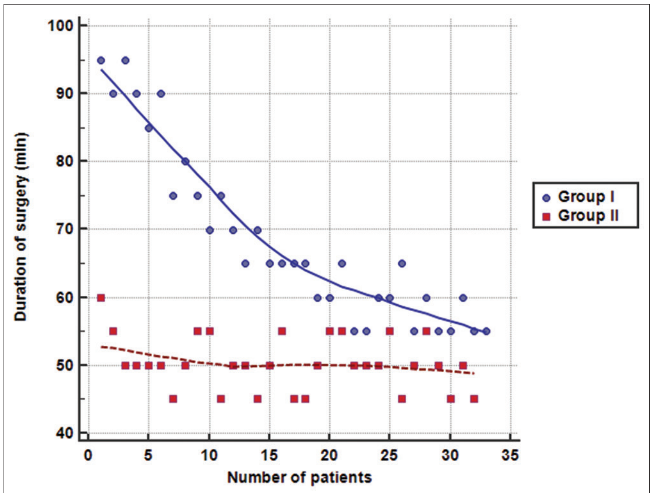

Figure 3: Scatter plot showing learning curve of total time of surgery in the studied groups.

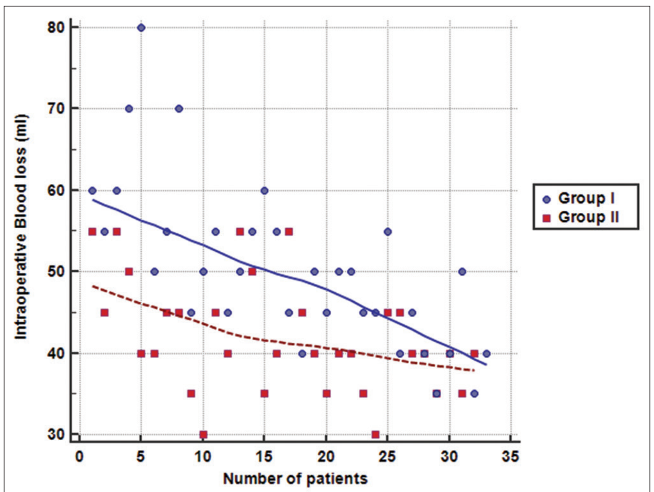

Figure 4: Scatter plot showing learning curve of amount of intraoperative blood loss in the studied groups.

The amount of intraoperative blood loss has not been assessed by most previous studies that evaluated the learning curve of ILD. Intraoperative blood loss was reduced from 50 ± 10 ml in Group I to 42 ± 7 ml in Group II. Xu *et al.*[36] found a significant decrease in blood loss from 70.6 ± 20.5 ml in the first 11 patients to 54.6 ± 7.6 ml in the second 11 patients. However, further decrease in their third group was slight (53.8 ± 13.3 ml).

Our results showed that increased experience of the surgical team (with the increased number of operated cases) was significantly and strongly correlated with decrease in the mean total operative time in Group I and the mean amount of intraoperative blood loss in Groups I and II. However, surgical team experience did not correlate significantly with operative time in Group II. It seems that the modified technique enabled the surgical team to attain the required level of proficiency faster, so the plateau of the learning curve was reached early. Consequently, further operated cases did not add significantly to the performance of the team and resulted in non-significant correlation with operative time in Group II.

The severity of pain decreased considerably at 6 and 12 months following surgery. Pre-operative VAS of about 7 ± 1 decreased to 2 ± 1 and 1 ± 1 at 12 months postoperatively in Groups I and II, respectively. Moreover, the mean pre-operative ODI score decreased from 70 ± 6 and 68 ± 8 in Groups I and II, respectively, to reach 16 ± 7 and 14 ± 5 at 12 months postoperatively. These findings indicate that both techniques were comparable in terms of pain control and functional outcome. Hsu *et al.*[16] reported similar

Table 4: Multiple regression analysis of the effects of experience (number of cases) and disc level on total operative time and intraoperative blood loss.

Model	Independent variables	Unstandardized coefficients		*t*	*P*-value	95.0% Confidence interval for B	
		B	SE			Lower bound	Upper bound
Total operative time	Constant	88.607	6.835	12.963	<0.001*	74.944	102.271
	Disc level	−0.686	2.020	−0.340	0.735	−4.724	3.351
	Technique (standard vs. modified)	−18.375	2.434	−7.548	<0.001*	−23.241	−13.509
Intraoperative blood loss	Constant	65.209	6.223	10.478	<0.001*	52.768	77.649
	Disc level	−2.228	1.839	−1.212	0.230	−5.905	1.448
	Technique (modified vs. standard)	−9.082	2.216	−4.097	<0.001*	−13.512	-4.651

B: Regression coefficient, SE: Standard error, *Significant at *P*<0.05

decline in VAS (from 7.7 ± 2.8 to 1.6 ± 2.2) and ODI scores (from 35.6 ± 10.1 to 6.4 ± 9.8) in patients undergoing endoscopic discectomy. These results are also comparable to the improvement achieved by open microdiscectomy.[16] Similarly, Sencer *et al*.[30] reported a significant decrease in VAS and ODI scores at 12 months postoperatively. Moreover, Xu *et al*.[36] reported a reduction in VAS scores in their patients at 3 months postoperatively.

No specific intraoperative complications were detected in our series, and conversion to open surgery was not mandated in any of our patients. A diversity of reported complications of endoscopic ILD includes unintended durotomy with potential pseudomeningocele, meningitis, and discitis.[8,33,40] The only post-operative complication encountered in our series of patients was wound infection reported in three cases; the rate of which did not differ significantly between the two studied groups. No recurrences were observed during the follow-up period of 12 months in any of our patients. Our findings are supported by those of Xu *et al*.[36] whose series of patients did not encounter any significant post-operative complications or recurrences. Wang *et al*.[35] also did not encounter recurrences in their series. On the other hand, Hsu *et al*.[16] reported nerve injury in one case out of the 22 cases that underwent ILD in their study. Sencer *et al*.[30] reported unintended durotomy 5.8% of their patients during the early phase of learning. The recurrence rate reported by other studies ranged from 3.3% to 4%.[6,11,18,21,30]

In the present study, the learning curve of endoscopic ILD for operative time in Group I and intraoperative blood loss in Groups I and II was gradual rather than steep, which agrees with the findings of the previous studies reporting endoscopic ILD as a challenging procedure that requires practicing to be mastered. The plateau for the curve of operative time was reached in Group I approximately after the 25th case, which is close to the number of patients (30 patients) recommended for passing the early phase of learning curve in endoscopic procedures.[5,35] Meanwhile, the plateau was not clear for intraoperative blood loss in Groups I and II, and a higher number of cases was likely required to reach it, [Figure 4]. The amount of blood loss in all cases was relatively small, with the largest amount (80 ml) being at the start of the learning curve. On the other hand, the learning curve for operative time in Group II was nearly flattened, with little change in the length of operative time among the cases. The early phase merged into the plateau which was reached earlier than Group I, approximately after the 15th case, [Figure 3].

A steep learning curve means that the procedure can be mastered after a relatively small number of patients. In this case, the first phase of the curve is short and gives way abruptly to the second phase. In a shallow curve, the first phase is prolonged and gradually merges into the second phase. Therefore, a shallow learning curve indicates that improvement of performance is gradual, and reaching the plateau phase where the procedure is mastered requires practicing on a large number of cases.[4]

Hsu *et al*.[16] reported that the learning curve of endoscopic transforaminal discectomy was steep and easy to master, while the interlaminar procedure was flat and hard to master. On the other hand, Wang *et al*.[35] reported that the learning curve of surgical time in their series of 34 patients was relatively steep. Xu *et al*.[36] also reported a steep learning curve for operative time, but a shallow curve for intraoperative blood loss.

Surgeons performing the procedure during the first phase of the learning curve are susceptible to experience difficulties, resulting in increased risk of complications during this stage and longer operative time than open surgery.[8,18,33,37] However, once this phase is overcome by gaining experience, the procedure is accomplished in a shorter time. To reach the second phase smoothly, it is recommended to gain more experience with the procedure, by attending workshops, and performing more cases.[35]

The interpretation of the learning curve in literature is variable. This could be attributed to the previous experience of surgeons with endoscopic or microscopic procedures and variable levels of herniated disc. Unfortunately, the details of the previous experiences of the surgical teams with endoscopic procedures or open discectomy were not reported by the previous studies to allow comparisons and test this hypothesis. Only Xu *et al*.[36] mentioned having experience with microscopic surgeries.

The present study had points of strength, including a convenient sample size of patients who underwent endoscopic ILD at different disc levels. However, larger sample size is required to describe the learning curve for intraoperative blood loss.

CONCLUSION

In conclusion, the learning curve of endoscopic ILD was shallow with standard technique, indicating difficulties in mastering the procedure and the need of practice on a relatively larger number of patients. Meanwhile, the proposed modified technique helped reaching the required level of proficiency in the early phase of the curve, providing significant reduction in operative time and blood loss, with comparable effectiveness and safety as the standard technique.

Declaration of patient consent

Institutional Review Board permission obtained for the study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Al Khathaami AM, Mohammad YO, Alibrahim FS, Jradi HA. Factors associated with late arrival of acute stroke patients to emergency department in Saudi Arabia. SAGE Open Med 2018;6:1-7.
2. Al-Eithan MH, Amin M, Robert AA. The effect of hemiplegia/hemiparesis, diabetes mellitus, and hypertension on hospital length of stay after stroke. Neurosciences (Riyadh) 2011;16:253-6.
3. Appelros P, Stegmayr B, Terent A. Sex differences in stroke epidemiology: A systematic review. Stroke 2009;40:1082-90.
4. Benzel EC, Orr RD. A steep learning curve is a good thing! Spine J 2011;11:131-2.
5. Carragee EJ, Han MY, Suen PW, Kim D. Clinical outcomes after lumbar discectomy for sciatica: The effects of fragment type and anular competence. J Bone Joint Surg Am 2003;85:102-8.
6. Carragee EJ, Spinnickie AO, Alamin TF, Paragioudakis S. A prospective controlled study of limited versus subtotal posterior discectomy: Short-term outcomes in patients with herniated lumbar intervertebral discs and large posterior anular defect. Spine (Phila Pa 1976) 2006;31:653-7.
7. Chae KH, Ju CI, Lee SM, Kim BW, Kim SY, Kim HS. Strategies for noncontained lumbar disc herniation by an endoscopic approach: Transforaminal suprapedicular approach, semi-rigid flexible curved probe, and 3-dimensional reconstruction CT with discogram. J Korean Neurosurg Soc 2009;46:312-6.
8. Chang SS, Fu TS, Liang YC, Lia PL, Niu CC, Chen LH, *et al*. Results of microendoscopic discectomy performed in the 26 cases with a minimum 3 years follow-up. Chang Gung Med J 2009;32:89-97.
9. Choi G, Lee SH, Raiturker PP, Lee S, Chae YS. Percutaneous endoscopic interlaminar discectomy for intracanalicular disc herniations at L5-S1 using a rigid working channel endoscope. Neurosurgery 2006;58 Suppl 1:ONS59-68.
10. Choi G, Prada N, Modi HN, Vasavada NB, Kim JS, Lee SH. Percutaneous endoscopic lumbar herniectomy for high-grade down-migrated L4-L5 disc through an L5-S1 interlaminar approach: A technical note. Minim Invasive Neurosurg 2010;53:147-52.
11. Chumnanvej S, Kesornsak W, Sarnvivad P, Paiboonsirijit S, Kuansongthum V. Full endoscopic lumbar discectomy via interlaminar approach: 2-year results in Ramathibodi Hospital. J Med Assoc Thai 2011;94:1465-70.
12. Fairbank JC, Couper J, Davies JB, O'Brien JP. The Oswestry low back pain disability questionnaire. Physiotherapy 1980;66:271-3.
13. Gibson JN, Waddell G. Surgical interventions for lumbar disc prolapse: Updated cochrane review. Spine (Phila Pa 1976) 2007;32:1735-47.
14. Gotfryd A, Avanzi O. A systematic review of randomised clinical trials using posterior discectomy to treat lumbar disc herniations. Int Orthop 2009;33:11-7.
15. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual analog scale for pain (VAS pain), numeric rating scale for pain (NRS Pain), McGill pain questionnaire (MPQ), short-form McGill pain questionnaire (SF-MPQ), chronic pain grade scale (CPGS), short form-36 bodily pain scale (SF-36 BPS), and measure of intermittent and constant osteoarthritis pain (ICOAP). Arthritis Care Res (Hoboken) 2011;63:S240-52.
16. Hsu HT, Chang SJ, Yang SS, Chai CL. Learning curve of full-endoscopic lumbar discectomy. Eur Spine J 2013;22:727-33.
17. Inui A, Sairyo K, Katoh S, Higashino K, Sakai T, Shiiba M, *et al*. Extruded lumbar osseous endplate causing long-term radiculopathy in an adult: An endoscopic excision. Minim Invasive Neurosurg 2006;49:55-7.
18. Jhala A, Mistry M. Endoscopic lumbar discectomy: Experience of first 100 cases. Indian J Orthop 2010;44:184-90.
19. Kim CH, Chung CK, Jahng TA, Yang HJ, Son YJ. Surgical outcome of percutaneous endoscopic interlaminar lumbar diskectomy for recurrent disk herniation after open diskectomy. J Spinal Disord Tech 2012;25:E125-33.
20. Kim HS, Ju CI, Kim SW, Kim JG. Endoscopic transforaminal suprapedicular approach in high grade inferior migrated lumbar disc herniation. J Korean Neurosurg Soc 2009;45:67-73.
21. Lee DY, Ahn Y, Lee SH. Percutaneous endoscopic lumbar discectomy for adolescent lumbar disc herniation: Surgical outcomes in 46 consecutive patients. Mt Sinai J Med 2006;73:864-70.
22. Matsumoto M, Watanabe K, Tuji T, Ishii K, Takaishi H, Nakamura M, *et al*. Microendoscopic discectomy for lumbar disc herniation with bony fragment due to apophyseal separation. Minim Invasive Neurosurg 2007;50:335-9.
23. Righesso O, Falavigna A, Avanzi O. Comparison of open discectomy with microendoscopic discectomy in lumbar disc herniations: Results of a randomized controlled trial. Neurosurgery 2007;61:545-9.
24. Ruetten S, Komp M, Godolias G. A New full-endoscopic technique for the interlaminar operation of lumbar disc herniations using 6-mm endoscopes: Prospective 2-year results of 331 patients. Minim Invasive Neurosurg 2006;49:80-7.
25. Ruetten S, Komp M, Godolias G. An extreme lateral access for the surgery of lumbar disc herniations inside the spinal canal using the full-endoscopic uniportal transforaminal approach-technique and prospective results of 463 patients. Spine (Phila Pa 1976) 2005;30:2570-8.
26. Ruetten S, Komp M, Merk H, Godolias G. Full-endoscopic interlaminar and transforaminal lumbar discectomy versus conventional microsurgical technique: A prospective, randomized, controlled study. Spine (Phila Pa 1976) 2008;33:931-9.
27. Ruetten S, Komp M, Merk H, Godolias G. Recurrent lumbar disc herniation after conventional discectomy: A prospective, randomized study comparing full-endoscopic interlaminar and transforaminal versus microsurgical revision. J Spinal Disord Tech 2009;22:122-9.
28. Ruetten S, Komp M, Merk H, Godolias G. Use of newly developed instruments and endoscopes: Full-endoscopic resection of lumbar

disc herniations via the interlaminar and lateral transforaminal approach. J Neurosurg Spine 2007;6:521-30.
29. Ruetten S. Full-endoscopic operations of the spine in disk herniations and spinal stenosis. Surg Technol Int 2011;21:284-98.
30. Sencer A, Yorukoglu AG, Akcakaya MO, Aras Y, Aydoseli A, Boyali O, *et al*. Fully endoscopic interlaminar and transforaminal lumbar discectomy: Short-term clinical results of 163 surgically treated patients. World Neurosurg 2014;82:884-90.
31. Shin KH, Chang HG, Rhee NK, Lim KS. Revisional percutaneous full endoscopic disc surgery for recurrent herniation of previous open lumbar discectomy. Asian Spine J 2011;5:1-9.
32. Smith JS, Ogden AT, Shafizadeh S, Fessler RG. Clinical outcomes after microendoscopic discectomy for recurrent lumbar disc herniation. J Spinal Disord Tech 2010;23:30-4.
33. Teli M, Lovi A, Brayda-Bruno M, Zagra A, Corriero A, Giudici F, *et al*. Higher risk of dural tears and recurrent herniation with lumbar micro-endoscopic discectomy. Eur Spine J 2010;19:443-50.
34. Tonogai I, Sairyo K, Higashino K, Sakai T, Katoh S, Yasui N. Minimally invasive endoscopic removal of a herniated nucleus pulposus that had migrated to the S1 nerve root foramen. Minim Invasive Neurosurg 2007;50:173-7.
35. Wang B, Lu G, Patel AA, Ren P, Cheng I. An evaluation of the learning curve for a complex surgical technique: The full endoscopic interlaminar approach for lumbar disc herniations. Spine J 2011;11:122-30.
36. Xu H, Liu X, Liu G, Zhao J, Fu Q, Xu B. Learning curve of full-endoscopic technique through interlaminar approach for L5/S1 disk herniations. Cell Biochem Biophys 2014;70:1069-74.
37. Yadav YR, Parihar V, Kher Y, Bhatele PR. Endoscopic inter laminar management of lumbar disease. Asian J Neurosurg 2016;11:1-7.
38. Yaqub BA, Shamena AR, Kolawole TM, Patel PJ. Cerebrovascular disease in Saudi Arabia. Stroke 1991;22:1173-6.
39. Yoshimoto M, Takebayashi T, Kawaguchi S, Tsuda H, Ida K, Wada T, *et al*. Minimally invasive technique for decompression of lumbar foraminal stenosis using a spinal microendoscope: Technical note. Minim Invasive Neurosurg 2011;54:142-6.
40. Zhou Y, Wang M, Wang J, Chu TW, Zhang ZF, Li CQ. Clinical experience and results of lumbar microendoscopic discectomy: A study with a five-year follow-up. Orthop Surg 2009;1:171-5.

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